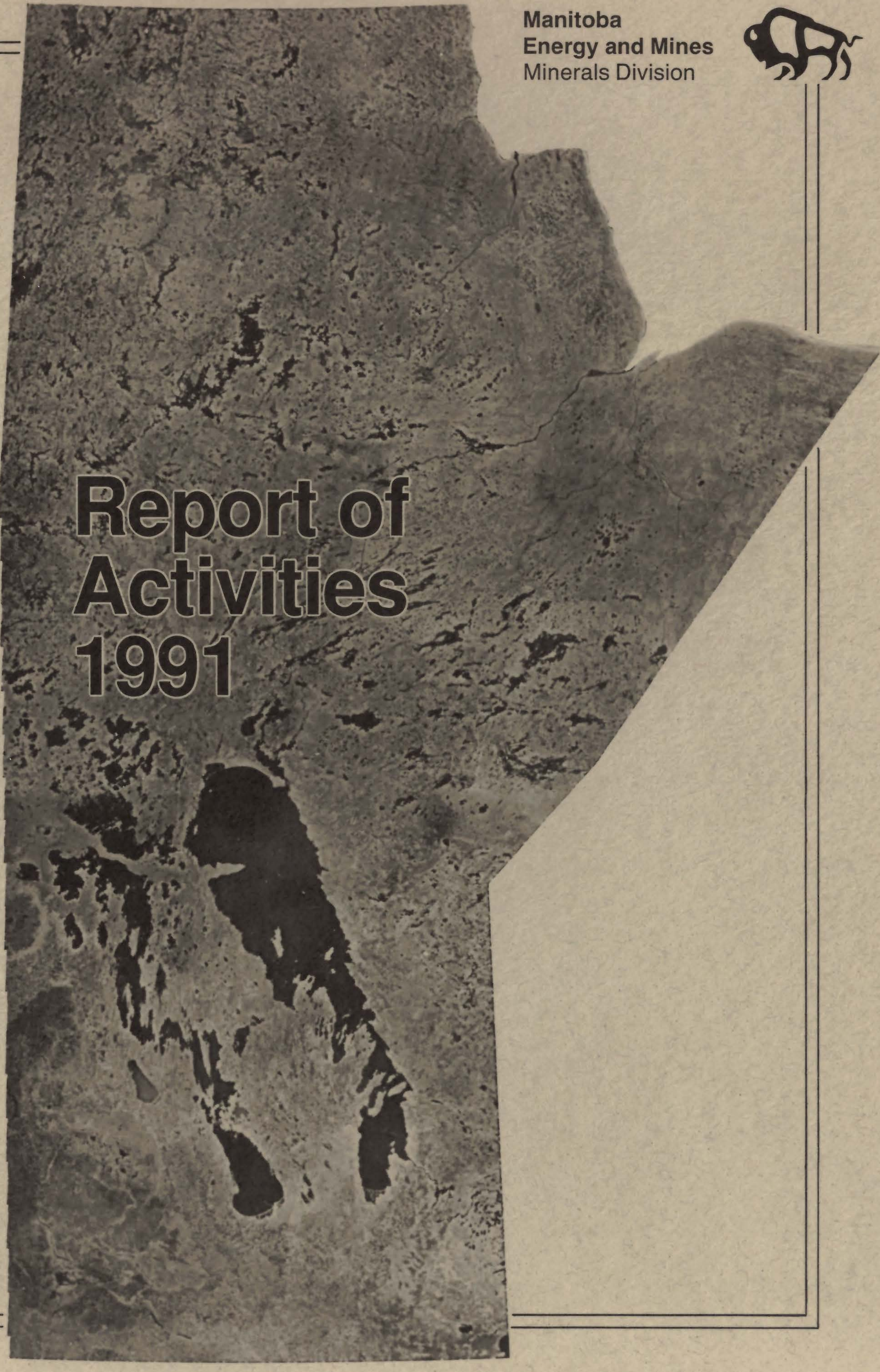
Manitoba
Energy and Mines
Minerals Division

Report of Activities 1991



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Manitoba
Energy and Mines

MINERAL RESOURCES

REPORT OF ACTIVITIES 1991

1991

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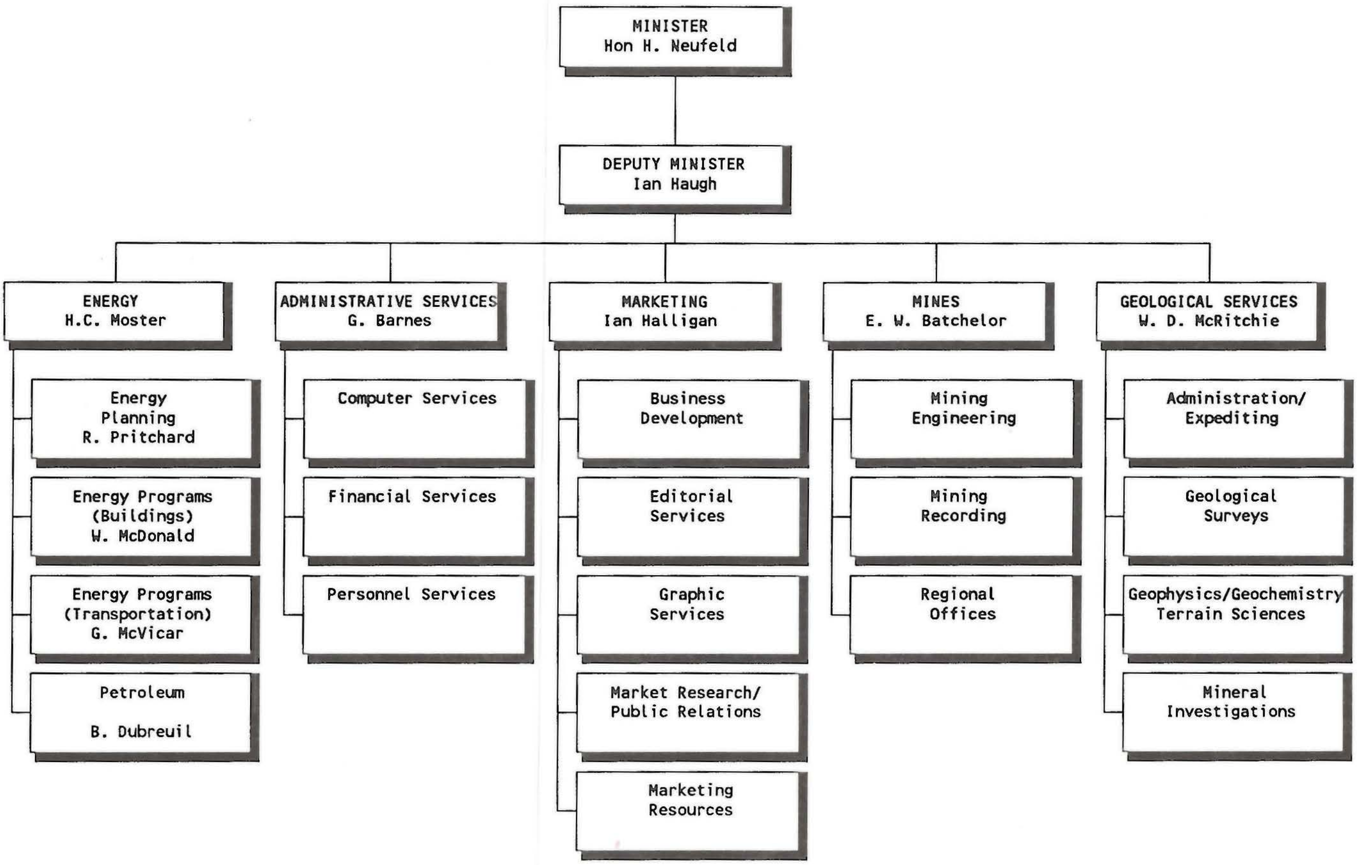
MANITOBA ENERGY AND MINES



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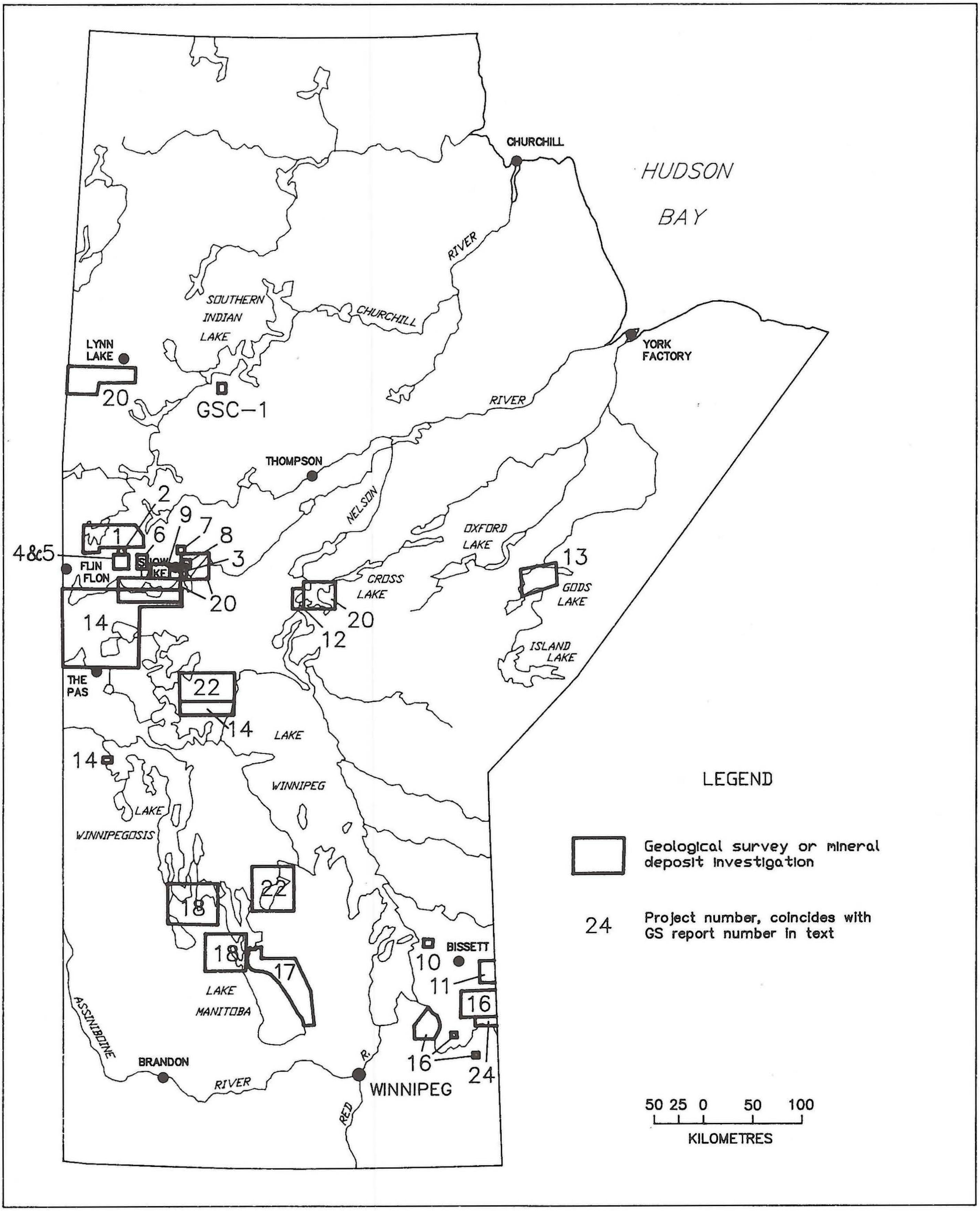
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INTRODUCTORY REVIEW

by W.D. McRitchie and J.M. Duke

McRitchie, W.D. and Duke, J.M., 1991: Introductory Review; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 1-3.

GEOLOGICAL SERVICES BRANCH

Significant budgetary constraints, entailing cutbacks to staffing and operational expenditures, limited the scope and scale of programming conducted by the Branch during 1991. To some extent the reduced level of field operations was further aggravated by delays in signing the new Mineral Development Agreement with Energy, Mines and Resources, Canada.

The new Partnership Agreement on Mineral Development (PAMD) was eventually signed on June 28th by the Honourable Jake Epp for Canada, and the Honourable Harold J. Neufeld, Minister of Energy and Mines for Manitoba. Under this Agreement, a total of $10 million dollars of federal and provincial minerals programming will be directed in support of the minerals industry, during the period 1990-1995. The federal funding is provided through the Western Diversification Office. As was the case with the earlier (1984-1989) Agreement, programming is to be delivered in parallel using the combined resources of the federal and provincial departments of Energy, Mines (and Resources), with efforts being directed in support of the exploration and development sectors of the industry, as well as projects related to marketing, promotion and public information.

On the positive side, the consolidation resulting from the fiscal constraints was offset to some extent by internal restructuring of the Department, and the Branch, and by the introduction of expanded services in Flin Flon, and plans for a new Regional Office in Thompson.

Geological Survey field programs in general, were strengthened by additional federal contributions through both EXTECH (the Exploration Science and Technology initiative), and the NATMAP (National Mapping) Shield Margin program, the latter being the first of a new generation of cooperative programs with the GSC, designed to elevate the profile of geological mapping across Canada. The Shield Margin project (NASMAP) will bring together the combined resources of the Manitoba and Saskatchewan Provincial Surveys, and the Geological Survey of Canada in upgrading the geoscientific database of the important copper and zinc producing Hanson/Flin Flon and Snow Lake Mining District over the next five year period. The main objective will be to develop a broad array of geological, geochemical and geophysical data files and maps for the region, thereby establishing the first minerals-oriented GIS in the province. Other extremely significant advances in the north-central sector of the province, were realized through completion of regional and high-resolution seismic profiles across the Thompson nickel belt, and regional seismic profiles from the Churchill/Superior boundary into Saskatchewan, including north/south cross lines up to Snow Lake, and across the southern margin of the Kisseynew Gneissic belt. These geophysical surveys represent the first stage in a major 5 year multidisciplinary study of the Trans-Hudson Orogen in Manitoba and Saskatchewan, conducted under the aegis of Canada's renowned LITHOPROBE initiative.

Manitoba and Canada also cooperated in mounting new aeromagnetic surveys in the Dawson Bay region, a multiyear program that will eventually complete magnetic survey coverage for the entire province, with principal focus being in the southwest region from The Pas to the 49th parallel.

In addition to mounting new field surveys, the Geological Services Branch also continued to provide input to the new Atlas of the Western Canada Sedimentary Basin, provided an initial outline of areas for consideration under the World Wildlife Federation's Endangered Spaces program, and sponsored support for the Mineralogical Society of Manitoba's Minerals Symposium held in Winnipeg August 29 to September 1st.

The ongoing definition of Manitoba's karst heritage in the Interlake region was again assisted by contributions from members of the Speleological Society of Manitoba. An atlas of these unique and little known features is now well advanced, with publication scheduled for early 1992.

The Branch continued computerization of its data collection, processing and publication functions, and for the first time released an electronic database of raw data stemming from the 1985-1989 investigations in the Lake Athapapuskow region. An even more ambitious project currently underway (under NASMAP), aims to produce coloured preliminary maps for distribution at the Branch's Mineral Activities Forum in November, based on information collected in the Elbow Lake region this summer.

Field workshops were conducted in the La Ronge and Glennie Lake Domain by the Friends of the Reindeer Zone, and in the Thompson/Cross Lake region by the Friends of the Nickel Belt. The latter was extended to include a two day demonstration of the geology of the Cross Lake area for the benefit of representatives from the Cross Lake Indian Band. Shorter tours and field demonstrations (8) were given to several company geologists wanting an introduction to the main mining camps, and/or specific aspects of the province's industrial mineral deposits.

Core retrieval programs continued at a low level throughout the province, and a new core storage facility was opened on the old Centennial Mine site, specifically to receive exploration drill core from the Flin Flon region.

Branch geologists attended technical meetings at Calgary, Regina, Saskatoon, Toronto and Fredericton giving presentations highlighting the province's geology and mineral investment potential. Three new reports were issued in the Mineral Deposit series, as well as a new 1:250 000 scale Bedrock compilation map covering the Churchill/Superior boundary in the Split Lake region. The volume covering the 1987 Trans-Hudson Orogen Symposium in Saskatoon, was finally published this year, and contains several benchmark papers authored by Branch geologists.

A total of 110 mineral inventory cards were either updated or compiled, and the Manitoba Oil and Gas Well Information system (MOGWIS) is now in the design and implementation phases (Phase II and III), with data verification (Phase IV) being well advanced. A full listing of publications generated by the Branch during 1991 is provided at the end of this volume.

Regrettably, cooperative research with staff of the University of Manitoba, and with researchers in other Canadian universities was severely limited by the reduced resources available to the Branch, and in most instances was limited to exchange of analytical expertise or laboratory facilities.

The format of the annual Open House is to be expanded this November with several talks being given by representatives from the mineral industry. The highly popular Core Shack is to be expanded, and the meeting will kick off with a workshop exploring the possibility of initiating cost-shared, joint, government/industry airborne geophysical surveys in the shield margin region.

Field Activities; District Summaries

The provincial field program during the summer of 1991, represented a scaled-down version of what had originally been planned for the first year of a four year cycle, coinciding with the initiation of the new federal/provincial partnership agreement on mineral development. 16 students were employed in support of the activities, however many projects were of limited duration, leaving more time for data analysis and computer processing in Winnipeg.

Priority was given to upgrading the geological database for the region feeding the Flin Flon smelter. Activities were therefore focussed within and adjacent to the Flin Flon/Snow Lake Mining District. Fieldwork in the Lynn Lake region was completed during the 1984-1990 period, and emphasis is now being given to compiling reports and maps stemming from these field investigations.

Recognizing the need to intensify efforts as much as possible around Flin Flon and Snow Lake, this region was chosen as the target for the new GSC Exploration, Science and Technology initiative (EXTECH), and the new NASMAP Shield Margin initiative entailing contributions from the GSC, as well as the Provincial Surveys in Manitoba and Saskatchewan. EXTECH investigations were focussed at Ruttan, and in the Snow Lake area, whereas provincial mapping and deposit documentation concentrated on areas around Elbow Lake, North Star Lake and Snow Lake where extensive new exposures were created by the 1989 forest fires.

Elsewhere in the province, a start was made in the documentation of mineral occurrences in the northern Superior Province. New exposures in the English Lake (Wanipigow) area (also resulting from the 1989 forest fires) were mapped in detail. Industrial mineral investigations concentrated on defining areas of high-calcium limestone in the region centered on The Narrows of Lake Manitoba, high purity dolomite in the Interlake region, and granite dimension stone in southeast Manitoba.

Thirty three holes were drilled during the summer, 12 being for combined stratigraphic and basement information in the Interlake region (1019.45 m), and 21 (362.24 m) for commodity assessments in the Narrows and Inwood areas.

FLIN FLON/SNOW LAKE DISTRICT

Geological mapping along the transition zone between the Flin Flon greenstone belt and the Kisseynew domain, focussed on the structural and stratigraphic relationships within this critical tectonic zone. Work by the GSB, University of New Brunswick and GSC found additional zones of iron and magnesium hydrothermal alteration north of the main greenstone terrane, and suggested that Missi age volcanism is more widespread than previously recognized.

1:20 000 scale mapping of the supracrustal rocks at the south end of Webb Lake confirmed the structural setting as a steep, south-dipping homocline, cut by north-trending shear zones, one of which, the Webb Lake Shear Zone, exhibits sinistral movement. Mineralization appears to be both synvolcanic VMS type, and later pyritic quartz veins emplaced within the shear zones.

1:5 000 scale mapping by the GSC and GSB in the Anderson Lake area covered most of the economically significant base metal deposits in this region. The stratigraphic settings of the mineralization are now accurately delineated, and a clear temporal relationship can be demonstrated between the mineralization and coeval subvolcanic intrusions and felsic volcanism. The structural setting of the region is complex, and major displacement zones appear to have had a long and complicated history of reworking.

1:15 840 scale geological mapping of supracrustal and plutonic rocks at Elbow Lake has been greatly facilitated by the creation of new exposures resulting from the 1989 forest fires. Detailed documentation of the lithologies, together with preliminary geochemical results seems to confirm the existence of three volcanic suites with distinct arc, back-arc and transitional chemistries. The nature and extent of the Elbow Lake Shear Zone is now better defined, as is its regional extent, and protracted history of development with several periods of syndeformational dyke emplacement. Most of the gold occurrences in this region appear to be associated with the Elbow Lake Shear Zone or related conjugate structures, and relatively late faults. It is still too early to explain the relative paucity of base metal deposits in this region, however current thinking is that this may be related to the geochemistry of the associated volcanic rocks, which differs from that of the base metal-rich arc assemblages at Flin Flon and Snow lake.

1:5 000 scale geological mapping was conducted in the North Star Lake region, which was also burned during the 1989 fires. The present studies are designed to provide a detailed geological framework for evaluating the region's mineral deposits and exploration potential. Volcanic assemblages include a wide range of felsic and mafic volcanic rocks, with local evidence of hydrothermal alteration associated with altered rhyolite flows, tuffaceous rocks and chemical sediments. The region appears to have been subjected to three periods of folding, as well as three ages of faulting. One of the most distinctive structural elements is a penetrative foliation that is axial planar to the F_1 isoclinal folds.

A brief study of the Wim deposit concluded that the mineralization ranges from disseminated to solid sulphide, and represents a massive sulphide type mineralization with a well developed alteration conduit. Lithologies similar to the host rocks are widespread around the margins of the Herblet Lake Gneiss Dome complex, providing numerous new targets for base metal exploration.

Examination of the sediment-hosted Bur and Kobar/Ruby deposits emphasized the difference in environments of deposition between these deposits and the rhyolite-associated volcanogenic massive sulphides that are more typical of this region. Recommendations suggest that exploration strategies be extended to include the search for similar deposits to the northeast.

Regional till sampling was resumed in the Snow Lake area to expand on sampling undertaken in 1990. One Hundred fifty-nine (159) till samples were collected from 145 locations, along with 145 samples of humus.

SOUTHEAST MANITOBA DISTRICT

The workplan for the southeastern sector of the province contains a broad range of investigations to be undertaken either individually, or with cooperation between the federal and provincial Survey organizations.

Detailed geological mapping was continued in the English Brook area where the 1989 forest fires had generated new exposures. Attention focussed primarily on the English Brook Magmatic Complex, and attempted to identify the original relationships between the lithologies, and assess the mineral potential of this relatively highly metamorphosed suite of felsic to ultramafic magmatic rocks. Hydrothermal alteration in the Rice Lake Group volcanic rocks was interpreted to indicate a potential for volcanogenic massive sulphide deposits.

New isotopic ages from the Wallace Lake area pointed to the existence of an older (3.0 Ga) tonalitic crust represented by boulders in the Conley Formation, and confirmed earlier ages for the main volcanics in the Rice Lake region at about 2.7 Ga.

A cooperative project between TANCO, the GSC and the GSB was mounted to evaluate the effectiveness of biogeochemical techniques for detecting near-surface occurrences of concealed rare-element pegmatite deposits.

THOMPSON AND NORTHERN SUPERIOR PROVINCE

Shoreline exposures at the west end of Cross Lake were mapped in anticipation of increased water levels resulting from Hydro's construction of a weir near the outlet of the Nelson River. The geology of this region is now much better defined, revealing an extended Archean history from 2.8 to 2.6 Ga, together with extensive evidence of reworking and dyke intrusion (1.883 Ga) during the Hudsonian orogeny.

The Branch continues to provide support and advice to company exploration programs targeted on the SW extension of the nickel belt. In the near future an open file describing the key lithologies and lithologic sequences in this region, that could have associated nickeliferous mineralization, will be issued.

Studies of mineral deposits in the Gods lake area concentrated on the geology of Elk and Jowsey Islands, both being past gold producers.

MANITOBA GENERAL

Four separate projects were conducted in areas underlain by Paleozoic carbonate rocks, as part of the stratigraphic mapping and core hole program. Drilling near Dawson Bay provided additional information on the configuration of the Devonian reefal structure at The Bluff; regional mapping of Silurian and Ordovician formations was extended to the Saskatchewan border providing correlations with counterparts in that province; several new holes were drilled in an east/west profile across the Grand Rapids Uplands to provide additional stratigraphic information and to provide stations for setting up groundwater monitoring instruments; and input into the compilation of information from Manitoba as part of the Western Sedimentary Basin Atlas Project, was continued. Consultation was also provided in support of the high-calcium limestone, and high-purity dolomite commodity drilling projects in the Interlake region and at the Narrows, Lake Manitoba. All core stemming from these projects will eventually be logged and integrated into the stratigraphic core hole index.

Industrial minerals evaluations focussed on identifying new occurrences of high-calcium limestone in the Winnipegosis and Narrows regions, south to Lily Bay, and on high-purity dolomites of the Fisher Branch Formation north of Inwood. At the latter location 22 holes were drilled to a depth of 15 m on a 1/4 mile grid near Sandridge in an attempt to prove-up approximately 100 000 000 tonnes of dolomite with a purity that would meet specifications for magnesium metal production. Analyses confirming the grade of this material and possible tonnages are currently in progress. Dimension stone investigations in southeastern Manitoba were extended to encompass several granitic plutons in the Bird and Winnipeg rivers areas. Only one site was deemed to contain material with potential for dimension stone development.

Lithoprobe

Phase III of the LITHOPROBE initiative will bring to Manitoba a revolutionary new capability for defining the deeper crustal structure in northern Manitoba. Regional VIBROSEIS reflection seismic profiles were completed across the Churchill/Superior Boundary Zone at Thompson (40 km), and from Jenpeg in the Superior Province, across the Flin Flon/Snow Lake greenstone belt, and the Saskatchewan border (360 km). Cross lines to Snow Lake and up the Sherridon road into the Kisseynew gneissic belt were also completed (142 km), as was a high resolution profile providing detailed shallow crustal information across the Thompson mines structure. Initial results appear very promising with numerous well-defined reflectors showing up in the raw, unprocessed data. A workshop reporting on the results of the initial geophysical surveys is scheduled for the Spring of 1992.

GEOLOGICAL SURVEY OF CANADA

The Geological Survey of Canada had an active year in Manitoba, with most projects characterized by extensive collaboration with the Manitoba Geological Services Branch.

The EXTECH project in the Snow Lake area, where personnel of the two surveys shared camp facilities and logistics, provides an excellent example of this renewed spirit of cooperation. As part of the GSC component of EXTECH, 1:5 000 mapping of the Chisel deposit and the host stratigraphy of the Anderson-Stall-Rod deposits was completed, and a GIS-based Expert System for Chisel-type massive sulphide deposits was developed. Ground radiometric and lithogeochemical work was undertaken to facilitate interpretation of the last year's airborne gamma ray spectrometry surveys. Lake sediment, lake water and till geochemical surveys were also completed in the Snow Lake area. Detailed till sampling in the vicinity of known base metal occurrences was undertaken to establish the scale of dispersal and geochemical signature. Quantitative interpretation of ground geophysical data from four sites near Snow Lake is nearing completion and bore hole geophysical surveys will be carried out this winter.

Excellent progress was also made in the second EXTECH area, the Rusty Lake belt. Characterization of the structural, stratigraphic and alteration attributes of the Ruttan deposit continued with 1:5 000 scale mapping of the previously unknown mine stratigraphy to the northeast. Detailed till sampling around and down-ice from the deposit was begun in order to characterize its geochemical signature. Geophysical bore hole logging will also be undertaken this winter at Ruttan.

The first project under the National Mapping Program (NATMAP) got underway along the shield margin from Snow Lake in Manitoba to Hanson Lake in Saskatchewan. Aeromagnetic gradiometer and VLF-EM surveys were undertaken in the Talbot Lake area (NTS 63J and 63K) were flown in September with digital products and maps scheduled for released in July 1992. Compilation of the GIS database for the NATMAP area commenced as did interpretation of existing geophysical data for the sub-Phanerozoic basement. Work initiated under NATMAP also included compilation of existing surficial maps at a scale of 1:100 000, and specialized studies of granitoid and mafic-ultramafic rocks.

Reflection seismic studies carried out as part of the Trans-Hudson LITHOPROBE transect across the Thompson Belt and along the southern margin of the exposed Flin Flon-Snow Lake-Hanson Lake Block yielded excellent data.

In southern Manitoba, surficial mapping and till sampling got underway in the Whiteshell area, and orientation work for future wide interval soil/till geochemical surveys was undertaken over the Phanerozoic terrane. Total field aeromagnetic surveying of NTS sheets 62F, G, H, J, K, N and 63C was undertaken as part of a larger program to complete coverage of the Prairies. The results of this survey, which was jointly funded by the Manitoba Department of Energy and Mines, will be available in March 1992.

Under its Environmental Geoscience Program, the GSC followed up last year's startling findings concerning outdoor radon levels in several communities in southern Manitoba. The very high levels observed in 1990 was correlated with the very low moisture content of the ground which was related in turn to abnormally low precipitation. This research will result in a model for the historical variation of radon levels with climate which will provide valuable input to a Health and Welfare Canada epidemiological study of radon hazards.

W.D. McRitchie
Geological Services Branch

J.M. Duke
Geological Survey of Canada
October 1991

GS-1 GEOLOGICAL INVESTIGATIONS IN THE KISSEYNEW - BATTY LAKES AREA (PARTS OF 63N/13, 14, 63N/1-4)

by H.V. Zwanzig

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, Minerals Division, Report of Activities, 1991, p. 4.

New geological work was started, and continuing projects were expanded, on the south flank of the Kisseynew gneiss belt. This work are being carried out jointly with the University of New Brunswick and the Geological Survey of Canada under the auspices of LITHOPROBE and NATMAP. The focus of the work is on the structural and stratigraphic transition between the Kisseynew gneiss belt and the Flin Flon volcanic belt, a critical tectonic zone in Trans-Hudson Orogen. Detailed structural mapping and structural analysis are being undertaken from Kisseynew Lake to Puffy Lake by UNB. U-Pb geochronology and geochemistry of granitic rocks, and isotopic studies are being conducted by GSC. Studies planned by Manitoba Energy & Mines will address remaining problems in lithostratigraphy, structure and mineral deposits. The current cycle of mapping exploits some of the excellent new exposures produced by the forest fire of 1989, recent road building and logging. New access is provided by the recently completed logging roads of REPAP Manitoba Ltd. However, regrowth in the burned-over areas and accumulating windfall is rapidly limiting access to some exceptionally good exposures in this part of the area.

During the first half of July outcrops were examined along short transects in areas that were previously mapped by Froese and Goetz (1981), Zwanzig (1984, 1988), Zwanzig and Lenton (1987), Schledewitz (1987, 1988), McRitchie (1986) and Ashton (1989). In addition, bedrock sampling and reconnaissance of new exposures were done along old and new logging roads, which were subsequently used in LITHOPROBE Line 7, across part of the Trans-Hudson Orogen.

The purposes of this years' field work were as follows:

(1) P. Williams of UNB and his post-graduate student, C. Dyck were introduced to the regional stratigraphy, current structural interpretations and problems to start structural mapping in the area, and to allow them to familiarize T. Norman, a postdoctoral fellow, with his project area at a later date.

(2) J. Whalen of GSC was assisted in doing reconnaissance sampling of granitic and metasedimentary units for petrographic, chemical and isotopic (Nd, O and Pb) analysis along part of LITHOPROBE Line 7. These will serve as a basis for more detailed studies.

(3) Granitic units were sampled for U-Pb zircon dating.

(4) New exposures of units with controversial origins were visited along logging-access roads to asses the need for further work.

(5) Logging-access roads were examined for suitability for VIBROSEIS surveys as part of the LITHOPROBE Trans-Hudson Orogen transect.

The most important preliminary geological conclusion from the 1991 field work is that patchy domains with Fe-Mg minerals seen on the new clean outcrops confirm the presence of widespread hydrothermal alteration with a potential for sulphide mineralization. The alteration predates metamorphism and may obscure the presence of early volcanic rocks (possibly equivalent to the Amisk Group in the Flin Flon belt) that appear to have a regional extent on the south flank of the Kisseynew belt. Secondly, fine grained pink gneiss derived from Missi rhyolite was observed north of the widespread occurrences previously reported (Zwanzig, 1984, 1988). A lithologically identical pink gneiss and amygdaloidal metabasalt were seen on the Friends of the Reindeer Zone field trip in the LaRonge area of Saskatchewan. Thus, it is concluded that Missi-age volcanism was more widespread in the southern part of Trans-Hudson Orogen than previously reported.

Access to the private roads and a road map were provided by REPAP Manitoba Ltd., whose help is gratefully acknowledged. These roads were also used successfully as LITHOPROBE VIBROSEIS lines.

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GS-2 GEOLOGY OF THE WEBB LAKE AREA (NTS 63K/15)

by D.C.P. Schledewitz

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

INTRODUCTION

The Webb Lake project was initiated in 1990 to take advantage of the high quality bedrock exposures resulting from extensive deforestation by forest fires in 1989. For a period of ten days, in 1991, mapping was conducted at the southern end of Webb Lake and inland areas to the west of Webb Lake. Bedrock exposures were much improved, since last year, by the effects of spring runoff and rain, which washed the outcrops clean of sooty carbon and charred lichen. Traverse access remained very good in the areas of intense fire damage. However mapping is slowed down in areas of less intense fire damage by windfall of the partially burned trees and dense regrowth of poplars and alders hampering the search for outcrops. The rate of regrowth provides a strong indication that projects in burnt areas should proceed as quickly as possible following the fire.

PREVIOUS WORK

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

GENERAL GEOLOGY

A sequence of Amisk Group supracrustal rocks, comprising volcanic, volcaniclastic and epiclastic rocks, and high level intrusive rocks occur in the Webb Lake area (Schledewitz, 1990). These supracrustal rocks, metamorphosed to upper green schist facies assemblages, are surrounded by an intrusive complex comprising gabbro, quartz diorite and tonalite. Fine grained variably quartz phyric tonalite, with areas of abundant xenoliths is the main intrusive rock type (Schledewitz, 1990). The inclusions are predominantly leucogabbro, gabbro and quartz diorite with minor rhyodacite and mafic flow rocks. The intrusive complex containing supracrustal rocks forms a northerly-trending belt that is ca 1.5 to 2.0 km wide and is flanked to the west and east by large bodies of variably quartz phyric hornblende-biotite-granodiorite.

During the 1991 field season the southern extension of the supracrustal rocks was examined at the south end of Webb Lake and along Webb Creek. The contact regions to the east and west with the hornblende-biotite granodiorite were also examined. 1:20 000 scale mapping was carried out in the area surrounding Webb Lake. On Webb Lake proper highly variable and discontinuous rock units required 1:10 000 scale mapping. They consist of remnants of massive and pillowed mafic flows, interlayered with lesser amounts of heterolithologic fragmental rocks and minor mafic sedimentary rocks with iron formation. These rocks were intruded by a grey-green plagioclase ± amphibole porphyry and a grey to pink quartz ± plagioclase porphyry. The quartz ± plagioclase porphyry commonly contains anastomosing veins and more rarely broad irregular shaped areas containing acicular amphibole and garnet. These assemblages and textures, and vein structures are interpreted to be recrystallization products of a (pre-metamorphic) volcanogenic alteration of the quartz ± plagioclase porphyry. Gabbro and fine grained mafic dykes and sills in part pre-date and postdate the porphyries. An intrusive complex of fine grained grey, xenolith-rich tonalite truncates these rocks ca 1 km south of Webb Lake. This tonalite complex, which is identical to the tonalite intrusive north of Webb Lake (Schledewitz, 1990), extends to the south where it appears to be an integral part of the Tee Lake Dyke Complex identified in the vicinity of Webb Creek immediately north of Elbow Lake (Syme, GS-4, this volume). The supracrustal rocks are also truncated by a post-tonalite stock of quartz gabbro that outcrops along the southwest corner of Webb Lake. The fine-to medium-grained, variably quartz phyric hornblende-biotite granodiorite, which lies to the east and west of Webb Lake, postdates all the above rock units.

STRUCTURE

The supracrustal rocks at Webb Lake define a steeply southerly-dipping homoclinal structure. Metamorphic layering intersects primary bedding at shallow angles suggesting large scale easterly-trending tight folds with a moderate southwesterly plunge. The small number of recorded facing directions cannot preclude the possibility of isoclinal folding. The steeply southerly-dipping homoclinal structure has been deformed by north-trending shear zones. One of these occurs near the centre of Webb Lake (Schledewitz, 1990) and another the "Webb Creek shear zone" occurs along Webb Creek, at the southwest end of Webb Lake (previously identified by McGlynn, 1959). The Webb Creek shear zone has a sinistral sense of displacement based on the presence of reverse-slip crenulation along the western margin of the shear zone.

MINERALIZATION

Several rusty trenches were observed along the west side, and within the western margin, of the northerly-trending Webb Creek shear zone south of Webb Lake (Fig. GS-2-1). It appears that two types of mineralization are present along and adjacent to the Webb Creek shear zone. One type appears to be synvolcanic massive sulphide mineralization (locations A, B, C, E, F, H , Fig. GS-2-1) where as the second appears to be related to the deformation and emplacement of pyritic quartz veins (locations D and G, Fig. GS-2-1) along the Webb Creek shear zone. The most northerly occurrences were described by McGlynn (1959) as the Webb Property "on the west shore of a small lake southwest of Webb Lake".

Two mineral showings (locations A and B) occur on the west side of the Webb Creek shear zone within a interlayered sequence of fine grained mafic flows and felsic volcaniclastic rocks; they are within the area delineated by McGlynn (1959). These rocks have been intruded by fine grained gabbro, fine grained tonalite, plagioclase porphyry and very fine grained to aphanitic felsic sills and dykes. The mineralization, which is mainly pyrrhotite and pyrite with minor chalcopyrite, occurs within lenses of pale green plagioclase and quartz. The mineralized zone in the most northern occurrence(location A, Fig. GS-2-1) is situated along the contact between a massive hornblende phyric mafic flow and a highly plagioclase phyric and amygdaloidal mafic flow. The second occurrence (location B, Fig. GS-2-1) is 30 metres south of location A and occupies the contact between a felsic volcaniclastic sediment and a basaltic unit with discontinuous plagioclase phyric zones. The felsic volcaniclastic rock has irregularly shaped zones containing rosettes of green amphibole and garnet; a possible indication of pre-metamorphic volcanogenic alteration related to the sulphide mineralization. Massive lenses of mainly quartz with veins and irregular patches of pyrrhotite with some pyrite and minor chalcopyrite are structurally underlain by a thinly layered zone defined by variations in plagioclase-quartz content and by biotite laminations.

The layered sequence containing these two sulphide occurrences has an exposed strike length of 80 to 100 m. To the west it is truncated by quartz gabbro and hornblende granodiorite. The layering may extend to the east under a small lake for approximately 100 m where it appears to be cut off by the Webb Creek shear zone.

The remaining mineral occurrences, (locations C, D, E, F and G), lie along the western margin of the Webb Creek shear zone (Fig. GS-2-1). Two rusty trenches were examined at location C. The mineralization comprises pyrrhotite, pyrite and trace chalcopyrite, which is disseminated or in veins within lenses of greenish grey plagioclase and quartz. The host rock is highly strained, schistose, interlayered plagioclase porphyry, massive felsic rock and tonalite. Transposition of original layering is indicated by the presence of detached hook shaped fold noses. This zone of felsic and intermediate rocks has an exposed

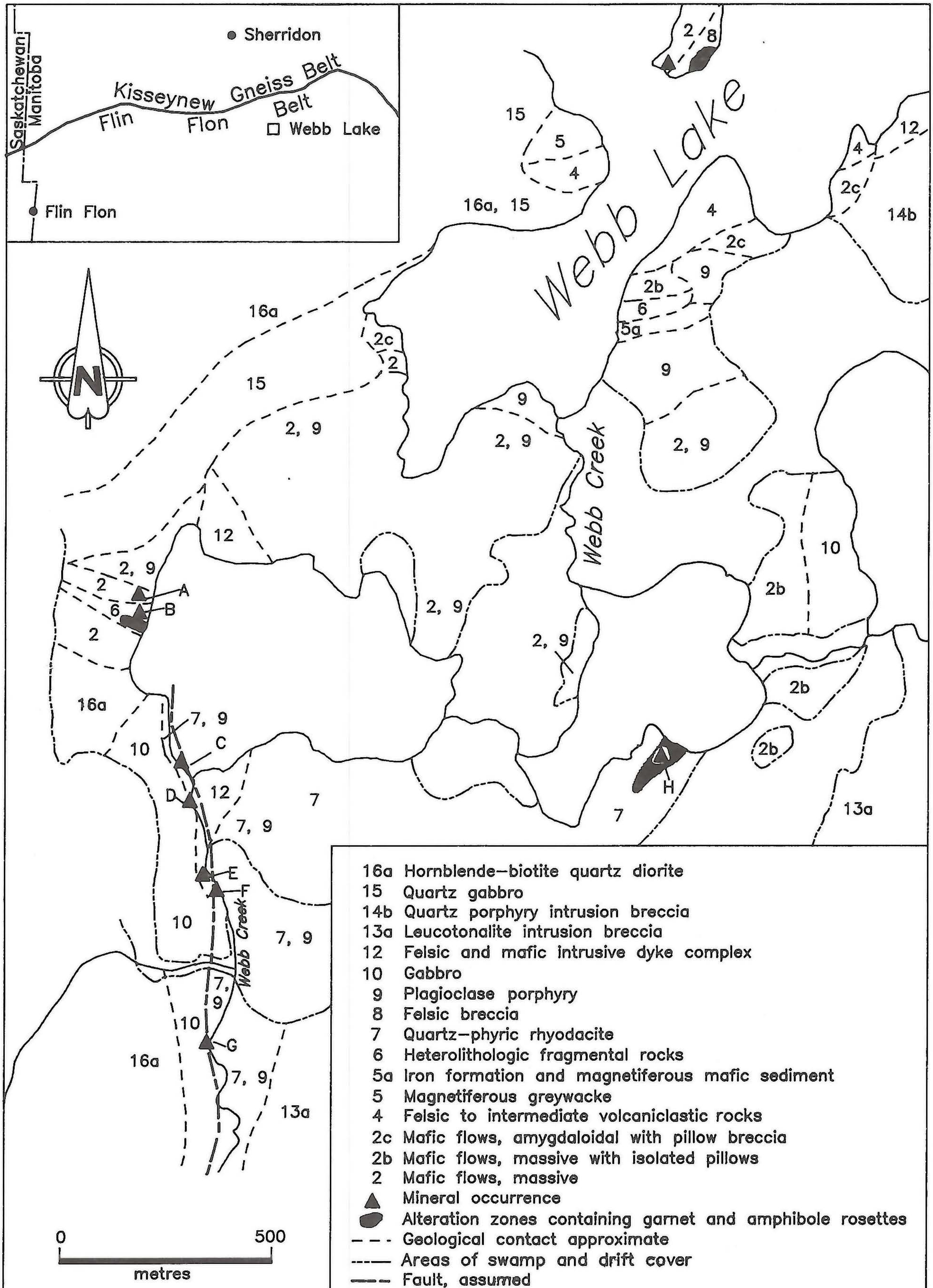

Figure GS-2-1: Simplified geology and mineral occurrences at the south end of Webb Lake and along Webb Creek.

width of 30 metres. To the west it is in contact with a fine grained mafic dyke. The contact between the mafic dyke and the highly strained felsic and intermediate rocks can be traced south along Webb Creek (Fig. GS-2-1) with mineralization consistently occurring in the felsic rocks. At location D, pits were observed in an area of large pyritic quartz veins. At location E, the contact zone between the mafic dyke rock and the sheared felsic and intermediate rocks is deeply weathered and contains abundant pyrite. A strong magnetic anomaly occurs in the immediate area suggesting massive pyrrhotite may also be present. At location F the shearing is braided and lenses of less deformed altered and mineralized rocks are preserved. A quartz porphyry in one of the less deformed lenses contains pyrite, rosettes of green amphibole and garnet. The sulfide-garnet-amphibole assemblage occurs as disseminations and in an anastomosing fracture pattern. Similar alteration and mineralization occurs in a rhyodacite at location H approximately 1 km northeast of location F. At location G, along Webb Creek, a highly sheared quartz porphyry contains zones of sericite schist, quartz and pyrite.

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GS-3 GEOLOGICAL SETTING OF BASE METAL MINERALIZATION IN THE ANDERSON LAKE AREA (NTS 63K/16SE AND 63J/13SW)

by A.H. Bailes and A.G. Galley*

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, Minerals Division, Report of Activities, 1991, p. 8-13.

INTRODUCTION

In 1991, and part of 1990, detailed mapping was jointly undertaken by the provincial and federal governments in the Anderson Lake area, south of the mining community of Snow Lake. The objective of this mapping program was to provide an improved geological data base for future mineral exploration in the Anderson Lake area, as well as to contribute to a better understanding of the depositional environment of base metal sulphide deposits throughout the Snow Lake area. The Anderson Lake mapping program is part of the federally funded EXTECH project.

The Anderson Lake area was mapped at 1:5 000 scale during one month in 1990 and two months in 1991 (Preliminary Maps 1991S-2 to 5). This mapping project, along with previous 1:5 000 scale mapping in 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) and Galley and Bailes (1989).

The 1:5 000 scale Anderson Lake area maps (Preliminary Maps 1991S-2 to 5) cover 48 km^2 of which thirty were covered during the 1991 field season. One of the most important results of the mapping program is that the stratigraphic setting of Cu-Zn mineralization in this area is now accurately delineated. This is significant as considerable exploration drilling is needed to replenish nearly depleted reserves of Cu-rich sulphide ore in the Snow Lake area. The continued economic viability of the mining community at Snow Lake may hinge on new reserves of ore being found in the near future.

GEOLOGICAL SETTING

The Early Proterozoic rocks of the Flin Flon belt comprise an island arc assemblage (Amisk Group), calc alkaline plutons, and an unconformably overlying sequence of terrestrial sedimentary rocks (Missi Group). U-Pb zircon ages date the Amisk Group at Flin Flon at 1886 Ma, plutons between 1860-1830 Ma and the Missi group at Snow Lake 1832 Ma (Gordon *et al.*, 1990). The rocks underwent polyphase deformation and attained peak metamorphic conditions at about 1815 Ma (Gordon *et al.*, 1990).

At Snow Lake the Amisk Group, as exposed between the Berry Creek fault and the McLeod Road fault, comprises approximately 6 km of mainly north-facing subaqueously deposited rocks, broadly folded by the northeast-trending Threehouse syncline and related folds (Fig. GS-3-1). The Amisk Group is intruded by the Sneath Lake and Richard Lake tonalite plutons that have U-Pb zircon ages of 1886 Ma and 1889 Ma respectively (Bailes *et al.*, 1988, 1990); these ages are consistent with the widespread interpretation that these tonalite plutons are synvolcanic (Walford and Franklin, 1982; Bailes, 1986, 1987).

Mafic volcanic rocks in the Anderson Lake area display arc tholeiite chemistry and are similar to basalt and basaltic andesite sequences that host base metal deposits at Flin Flon (Syme, 1990). Both the Anderson Lake and Flin Flon mafic lavas are enriched in LIL (large ion lithophile) elements and moderately to strongly depleted in HFS (high field strength) elements (Syme, 1990; Bailes, 1990), a feature characteristic of subduction related magmas (Saunders *et al.*, 1980; Gill, 1981; Tarney *et al.*, 1981).

The main Cu-Zn massive sulphide deposits in the Anderson Lake area occur within a one kilometre thick north-facing sequence of felsic volcanic rocks that display a strong chemical affinity to the underlying synvolcanic Sneath Lake pluton (Walford and Franklin, 1982; unpublished data, this study). This suggests a temporal affiliation between mineralization and emplacement of the Sneath Lake pluton. The pluton and the base metal-hosting felsic volcanic strata display low flat REE profiles and low contents of HFS elements (unpublished data, this study). This is quite different than Chisel Lake area Zn-Cu deposits, 10 km to the west, which are spatially associated with a sequence of volcanic rocks that display elevated contents of light REE and significantly higher concentrations of HFS elements (Bailes and Galley, 1989; Bailes, 1990). The implication is that base metal mineralization in the two areas may be affiliated with discrete, unrelated magmatic episodes (Bailes, 1990).

One of the objectives of the 1:5 000 scale mapping program in the Anderson Lake area was to determine the relationship between the Linda massive sulphide deposit and other base metal deposits in the Anderson Lake area. On the basis of its footwall alteration the Linda deposit occurs in a south-facing succession, whereas the other base metal deposits are in a north-facing sequence (Figure GS 3-1). One suggestion has been that the Linda deposit is on the south-facing limb of a major F_1 fold structure and within the same felsic complex as the other base metal deposits (Coats *et al.*, 1970; Jeffrey, 1982, unpubl.; W. Bleeker, pers com., 1991). Another possibility is that the Linda deposit is separated from the other deposits by a major fault structure as shown in Figure GS-3-1. Although this problem was not resolved, it has been demonstrated that strata hosting the Linda deposit are similar to those that occur within the north-facing portion of the sequence consistent with a fold structure interpretation.

RESULTS OF 1991 MAPPING

The 1:5 000 scale mapping clearly demonstrates that all the ingredients expected of a major base metal district exist in the Anderson Lake area, specifically, and in the Snow Lake area in general. Some of the more important results of the 1991 field program are:

1) the Anderson Lake and Stall Lake Cu-Zn massive sulphide deposits may occur at stratigraphically different positions in the volcanic succession, and this could expand the potential for base metal mineralization in this area;
2) the Sneath Lake pluton is clearly coeval with the base metal-hosting felsic volcanic sequence at Anderson Lake as the latter contains tonalite fragments from the pluton (Figure GS-3-2). This clearly indicates a temporal relationship between the base metal mineralization and emplacement of the pluton;
3) the Sneath Lake pluton is internally more complex than previous mapping indicated, with some phases extensively altered. Both the complexity and the alteration are features consistent with the synvolcanic character of the pluton;
4) the hanging wall sequence to the base metal-hosting felsic volcanic sequence at Stall Lake is more lithologically diverse to the east than to the west at Anderson Lake. It is composed of intercalated heterolithologic mafic breccias, rhyolite flows and breccia, mafic flows and mafic lapilli tuff that do not easily fit into stratigraphic subdivisions that were developed in 1990 for rocks north of Anderson Lake (Bailes, 1990), but which are similar to the hanging wall succession to the Chisel area deposits (Galley and Kitzler, 1990);
5) a zone of altered rocks characterized by abundant coarse actinolite identified southwest of the Anderson Lake mine in 1990 occurs in the hanging wall to the mine and not in the footwall, as was previously reported (Bailes, 1990). They are part of a laterally extensive hanging wall alteration zone that is particularly well developed in the vicinity of the Rod mine;
6) silicified, aphyric hanging wall basalts north of the Rod mine are indistinguishable from silicified Welch Lake basalts south of Chisel Lake. The similarity in appearance of these basalts suggests that the Rod mine hanging wall basalts may belong to the Welch Lake

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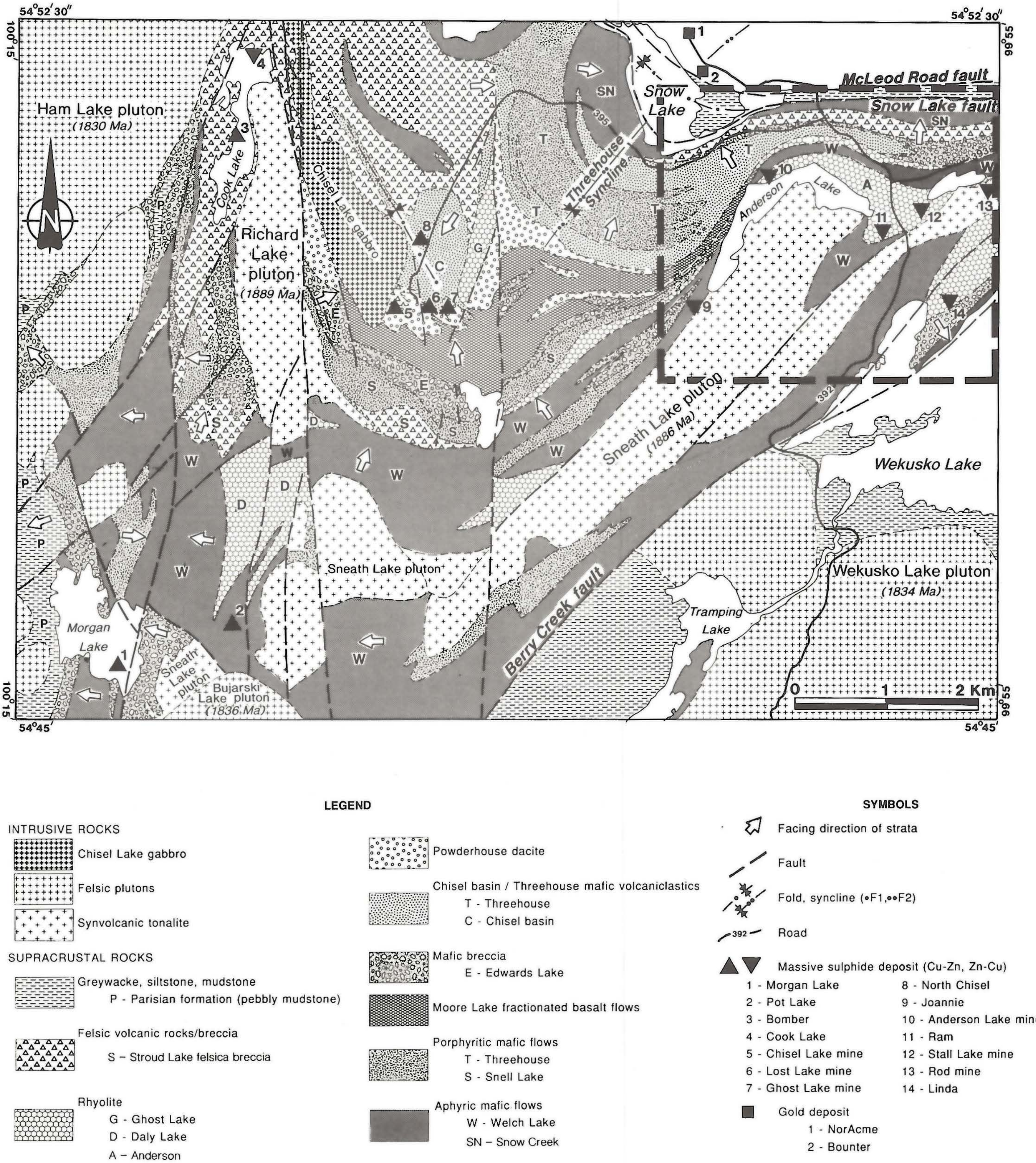

Figure GS-3-1: General geology of the Snow Lake area with Anderson Lake 1:5 000 scale mapping outlined by bold dashed line.

Figure GS-3-2: Subrounded cobble of Sneath Lake tonalite in felsic volcanic rocks 600 metres east-northeast of Rod mine. The rocks are cut by a late quartz vein.

sequence and, if so, this would place the mine-hosting felsic volcanic sequence within, rather than above, the Welch basalt as shown by Bailes (1990). A corollary of this would be that the mine felsic rocks in the Anderson Lake area occur at approximately the same stratigraphic position as the Daly Lake rhyolite, another base metal-hosting felsic sequence in the Welch Lake basalts (Hodges and Manojlovic, 1991);

7) an apophysis of fine grained quartz phyric tonalite from the Sneath Lake tonalite occupies a large area south of the Stall Lake mine and cuts across the Rod Lake orebody and into the hanging wall aphyric basalts. This tonalite has previously been considered to be part of the extrusive felsic sequence (H.B.E.D., unpublished maps; Minova, unpublished maps; Zaleski, 1989). The intrusion postdates footwall alteration and its presence may explain the absence of altered rocks associated with the Rod deposit (C. Rooney, H.B.M.S., pers com.);
8) rocks between the Berry Creek fault, on north Wekusko Lake, and the Rod mine site are much more strongly deformed than equivalent rocks to the north. The deformation is inhomogeneous with discrete zones of intense shearing locally defining probable fault structures. Some of these fault zones are likely genetically related to the Berry Creek fault; and
9) the Berry Creek fault displays features that indicate this structure has had a long and complicated history, with early ductile dislocation with dip slip movement, and later brittle deformation with left lateral strike slip movement.

SNEATH LAKE PLUTON

The Sneath Lake pluton is a broadly folded semi-conformable tonalite intrusion that is 1.5 km wide and over 16 km long. It stratigraphically underlies the major base metal sulphide deposits of the Snow Lake area (Figure GS-3-1). It has been widely interpreted to be the "heat engine" that drove the hydrothermal system responsible for base metal volcanogenic sulphide deposits and associated alteration in the Snow Lake area (Walford and Franklin, 1982; Bailes, 1986; Bailes, *et al.*, 1987, 1988; Galley *et al.*, 1990). The eastern 5 km of the Sneath Lake tonalite outcrops south of Anderson Lake and was mapped at 1:5 000 scale during the 1991 field season.

South of Anderson Lake the Sneath Lake pluton is internally complex, lithologically variable, altered, and contains fine grained marginal phases that are difficult to distinguish from extrusive felsic volcanic rocks. It consists of two major elliptical masses separated by a septum of mafic volcanic flows. Each of the individual masses is composed of several distinct phases of tonalite (Preliminary Maps 1991S-2 to 5). Quartz megacrystic, coarse grained tonalite and finer grained quartz porphyritic tonalite, both widely recognized west of the map area, are the main components of both masses. The more northerly body also contains a core and eastern margin of amphibole-rich mesotonalite and a northern margin composed of fine grained equigranular tonalite. The latter is similar to felsic extrusive flows, which were recrystallized during amphibolite facies regional metamorphism. The southern body contains a prominent apophysis of fine grained quartz phyric tonalite that was originally considered to be extrusive (H.B.E.D., unpublished maps; Minova, unpublished maps; Zaleski, 1989).

The eastern portion of the Sneath Lake pluton is prominently altered. This is manifest by abundant porphyroblasts of garnet, chlorite, biotite, staurolite, kyanite, amphibole and/or magnetite formed in the altered rocks during a post-alteration episode of amphibolite facies regional metamorphism. Disseminated pyrite and, more rare, chalcopyrite are present in some of the altered rocks. The alteration zones in the pluton appear to be spatially associated with more strongly altered rocks outside the pluton, suggesting that alteration within, and external to, the pluton was formed at the same time.

The Sneath Lake pluton has been proposed as the "heat engine" that drove the geothermal-hydrothermal system responsible for the base metal mineralization in the Anderson Lake area. This interpretation has been strengthened by a U-Pb zircon age of 1886 for the pluton (Bailes *et al.*, 1991). In 1991 distinctive fragments of Sneath Lake tonalite were found in the mine-hosting felsic volcanic rocks east of the Rod mine and along strike from the Linda deposit. This shows that not only is the Sneath Lake pluton synvolcanic, but it must have been emplaced prior to deposition of the mine-hosting felsic sequence. The fact that the pluton is barely a kilometre stratigraphically below this breccia unit, that it is chemically similar to the extrusive mine felsic rocks, and that one phase of the pluton intrudes across the breccia unit, tightly constrains the time of emplacement of the pluton and further supports the interpretation of the pluton as the driving force behind the mineralizing episode in the Anderson Lake area.

HANGING WALL SEQUENCE

Strata that overlie the mine-hosting felsic volcanic rocks of the Anderson Lake area consist of the following sequence of units:

top(N)
- basalt flows, felsic breccia and flows, and heterolithologic breccia (Snow Creek)
- heterolithologic mafic breccia
- mafic tuff, mafic tuff breccia, heterolithologic mafic breccia, rhyolite flows, rhyolite breccia, mafic flows (Three house)

- rhyolite flows, rhyolite breccia, pyroxene phyric mafic flows

bottom(S) - aphyric pillowed basalt flows (Welch?)

Aphyric basalt (Welch?)

North of the Stall Lake and Rod mine sites up to 600 metres of dominantly aphyric basalts form the immediate hanging wall to the mine-hosting felsic volcanic rocks. To the west this unit of flows gradually thins and is no longer present north of the Anderson Lake mine. Minor amounts of sparsely plagioclase phyric flows are also present in this unit north of the Rod mine.

North and east of the Stall Lake mine the upper part of the aphyric basalts is locally strongly silicified. The general appearance of the basalts and the manner in which they are silicified is very similar to Welch Lake basalts west of Anderson Lake. The fact that the upper contact of the basalt sequence is marked by a narrow barren pyrite/pyrrhotite sulphide unit, known to H.B.E.D. geologists as the Foot-Mud horizon (G. Kitzler, pers com, 1991), serves to substantiate this correlation as this same sulphide horizon marks the top of the Welch basalts to the west of Anderson Lake. The implication of this correlation is that the mine-hosting felsic rocks do not occur at the top of the Welch Lake sequence as was proposed previously (Bailes, 1990; Galley *et al.*, 1990), but rather form a domal complex within the Welch Lake basalt sequence; this is a comparable setting to that of the Raindrop massive sulphide deposits within the Daly Lake rhyolite complex (Manojlovic and Hodges, 1991) in the Welch Lake basalt sequence several kilometres to the west (Figure GS-3-1).

In the vicinity of the Rod mine the aphyric basalts are strongly overprinted by porphyroblasts of amphibole and garnet, and by spatially associated areas of silicification. Rocks with intense amphibole blastesis are locally characterized by minor disseminated chalcopyrite. This alteration is present to the west, but with less intensity.

Rhyolite and pyroxene phyric basalt

A one kilometre thick unit of aphyric to porphyritic rhyolite flows and breccia and intercalated plagioclase- and pyroxene-plagioclase-phyric flows overlies the aphyric basalt unit. West of the Anderson Lake mine this unit consists entirely of porphyritic basalt and minor mafic wacke; to the west these flows intercalate with aphyric fractionated iron rich basalts of the Moore Lake formation. To the east the porphyritic mafic flows decrease in abundance and are intercalated with felsic flows and breccias. North of the Rod mine site the base of this unit includes some gabbroic-textured massive pyroxene- and plagioclase-phyric mafic flows characterized by large, up to 2 cm diameter quartz amygdales. This unit is intercalated with Threehouse formation mafic lapilli tuff north of the Rod mine site.

Threehouse formation

The Threehouse formation north of the Anderson Lake mine consists of a basal 30 to 50 m of well-bedded mafic wacke and siltstone abruptly overlain by 250 to 300 m of unbedded to crudely-bedded scoria-rich mafic lapilli tuff and tuff breccia. These rocks are strikingly similar to the Chisel basin sequence that overlies the Chisel, Lost and Ghost lakes Zn-Cu deposits north of Chisel Lake (Bailes, 1990, Galley *et al.*, 1990). The Chisel basin sequence, however, displays a northerly facies change into a much more lithologically variable succession (Galley and Kitzler, 1990) that includes felsic volcanic rocks, heterolithologic mafic breccias and a variety of mafic flow rocks. A similar facies change occurs in the Threehouse formation east of the Anderson Lake mine site. At this location the mafic wacke, lapilli tuff and tuff breccia are gradually replaced by, and intercalated with, increasing amounts of rhyolite flows and heterolithologic mafic breccias. Thus the facies change in the Chisel basin sequence is not unique nor abnormal, and our definition of the Threehouse-Chisel basin formation needs to be expanded or modified to include these "aberrations" from the more "normal" or traditional succession. One of the problems with this "expanded" Threehouse sequence is that criteria previously used to distinguish this formation from underlying and overlying units are no longer as clear or reliable.

Heterolithologic mafic breccia

North of the Anderson Lake mine the Threehouse formation is overlain by 200 to 250 m of crudely- and thickly-bedded heterolithologic mafic breccia. The breccia contains fragments of dyke rocks that cut the Threehouse formation and for this reason was considered to be a separate unit (Bailes, 1990). However, to the east this unit is indistinguishable from other heterolithologic mafic breccias that occur widely in the Threehouse formation and, consequently, the upper contact of the Threehouse formation with the heterolithologic mafic breccia unit is not well defined in the eastern part of the map area.

Basalt flows, felsic breccia and flows, and heterolithologic breccia (Snow Creek)

The heterolithologic mafic breccia is overlain by a distinctive unit of basalt flows and associated felsic flows and breccia. The basalt flows are characterized by uniform grey-green weathering colour, virtual absence of vesicles, thin selvages on pillows, gabbroic-textured massive flows and lack of epidosite 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 Anderson Lake area, with chemical signatures similar to that of back arc basalts rather than the arc tholeiite chemistry typical of other basalts.

Felsic flows and breccia form a 100 to 150 m thick unit between the underlying unit of heterolithologic mafic breccia and the basalt flows. They include both aphyric and sparsely quartz phyric varieties. These felsic flows thicken to the east.

A narrow unit of heterolithologic breccia usually occurs between the felsic flows and breccia and the basalt flows in the east half of the area. The breccia is distinctive as it is composed of both felsic and mafic fragments.

The top of the Snow Creek formation is characterized by steep cliff escarpments, carbonate impregnated fractures, minor quartz veins and by low angle truncation of some units; these are all expressions of the Snow Lake fault that truncates the top of the sequence and structurally juxtaposes it against an overlying sequence of metamorphosed greywacke, siltstone and mudstone (Harrison, 1949; Bailes, 1990).

SETTING OF LINDA DEPOSIT

The Linda deposit is a low grade 13 million tonne massive sulphide deposit that occurs east of Anderson Bay on Wekusko Lake. The footwall alteration zone of this deposit occurs north of the deposit suggesting that the host strata face south (Zaleski, 1987). Detailed mapping of these rocks by Zaleski (1989) identified south-facing tops, but our 1991 mapping was unable to identify any conclusive top directions. Our 1991 mapping indicated that the strata that host the Linda deposit are similar to those that occur north of Stall Lake and that they include a sequence of massive basalt flows that are similar to the Snow Creek basalt. The massive basalts occur south of the Linda deposit and the Snow Creek basalts occur at the top of their part of the volcanic sequence; this supports a south-facing direction for the host strata to the Linda deposit. The tentative correlation of the massive basalt unit with the Snow Creek basalt will be tested by chemical analysis of these rocks as the Snow Creek basalt has a distinctive readily recognizable chemical signature.

Coats *et al.* (1970) and Jeffrey (1982, unpubl.) suggested that the Linda deposit occurs on the south limb of a major F_1 antiform and that it correlates with the same succession that hosts the Anderson Lake, Stall Lake and Rod deposits. W. Bleeker (per com., 1991) also argues that the ubiquitous presence of an S_1 cleavage in Snow Lake volcanic strata necessitates the presence of a major F_1 structure and that the Linda area is the most likely place for such a structure to occur. Although we found no direct evidence for such a F_1 fold structure in the area around the Linda deposit, the sequence of units on the peninsula that hosts the deposit is very comparable to that which occurs to the north of Stall Lake, and is in reverse order as would be anticipated on the south-facing limb of an F_1 fold structure. The existence or absence of this F_1 fold has important ramifications for exploration for base metal deposits as its presence would indicate that structural repetitions of the base metal-hosting sequence could occur south of the Sneath Lake pluton.

FAULTS

The eastern half of the Anderson Lake area is bounded to the south by the northeast-trending Berry Creek fault and to the north by the east-trending McLeod Road fault. In addition there are other less prominent faults and shear zones; for example the Snow Lake fault (just south of, and parallel to, the McLeod Road fault), a series of northeast-trending ductile shears that cross the Sneath Lake pluton, and a succession of unconnected(?) northeast-trending faults that traverse the northwest shore of Anderson Bay on Wekusko Lake and the swampy area to the northeast of Anderson Bay. The faults vary from syn- to late-metamorphic ductile shears, overprinted by metamorphic porphyroblasts, to later post-metamorphic brittle structures that in some instances include zones of pseudotachylite. Many of the fault structures join with the Berry Creek fault one kilometre east of the map area suggesting that they may be splays of the Berry Creek structure.

The Berry Creek fault, which can be traced on gradiometer maps for over 50 km to the southwest and 35 km to the northeast of the Anderson Lake area, represents one of the major fault structures in the Flin Flon volcanic belt. In the Anderson Lake area the Berry Creek fault displays a transition from ductile to late brittle deformation. The zone of ductile deformation varies in width from a few metres to several tens of metres and is commonly overprinted by upper greenschist facies mineral assemblages typified by amphibole porphyroblasts. The zones of brittle deformation are a few tens of centimetres wide and are not overprinted by metamorphic minerals. Several generations of carbonate impregnate rocks of the fault; the early generations are the protolith for the zones of amphibole blastesis associated with the fault. Movement associated with the ductile phase of deformation commonly displays dip slip motion, whereas the brittle phase typically displays sinistral strike slip motion.

Other fault structures in the Anderson Lake area display a similar temporal evolution, and many have large associated zones of carbonate alteration and amphibole blastesis. The latter are similar in appearance to some of the synvolcanic hydrothermal alteration zones; this raises the possibility that some fault zone alteration may have been mistaken for hydrothermal alteration and *vice versa*.

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GS-4 ELBOW LAKE PROJECT - PART A: SUPRACRUSTAL ROCKS AND STRUCTURAL SETTING

by E.C. Syme

Syme, E.C., 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.

INTRODUCTION

The Elbow Lake area comprises 250 km² within the Early Proterozoic Flin Flon metavolcanic belt, 65 km east of Flin Flon and 55 km west of Snow Lake (Fig. GS-4-1). It is part of NTS sheet 63K/15W, lying 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 supracrustal and plutonic rocks in a portion of the Flin Flon belt that was burned during the summer of 1989. The fire significantly improved the quality and quantity of bedrock exposure.

Reconnaissance work for the project was conducted in 1990 (Syme, 1990); 1991 is the first of two seasons expected to be required to complete the mapping. Responsibility for mapping in the Elbow Lake area is split between Manitoba Energy and Mines (Syme: supracrustal rocks) and the Geological Survey of Canada (Whalen: granitoid plutons; see GS-5, this volume). Previous work by Stockwell (1935), McGlynn (1959) and Galley *et al.* (1987) was reviewed by Syme (1990).

A large number of gold occurrences on Elbow Lake has attracted mineral exploration since the first discovery of gold in 1921 (Stockwell, 1935). The present project will attempt to place the deposits in a regional structural framework. The potential for volcanogenic massive sulphide deposits will be assessed through lithologic and geochemical analysis of the supracrustal rocks.

GENERAL GEOLOGY

Supracrustal rocks in the area comprise Amisk Group metavolcanic rocks and related intrusions, and a wide variety of relatively high level intrusive rocks of unknown affinity. The supracrustal rocks are centered on Elbow Lake and are surrounded by 5 separate granitoid plutons (Fig. GS-4-2).

Elbow Lake is transected by the Elbow Lake shear zone (ELSZ; Galley *et al.*, 1987), a north-northeast-trending structure up to 3 km wide (Fig. GS-4-3). Supracrustal rocks east of the ELSZ ("Centre Lake Domain") comprise a strongly deformed sequence of pillowed mafic flows and diabase, intruded by tonalite and heterogeneous gabbros. Primary structures are almost totally obliterated; the mafic rocks are strongly foliated, tectonically banded and recrystallized to upper greenschist facies assemblages.

West of the ELSZ ("Long Bay Domain") primary volcanic structures are preserved in west central Elbow Lake, the Long Bay - Long Lake area, and southwest Elbow Lake. In these areas a volcanic stratigraphy can be defined and the rocks are at lower to middle greenschist facies, but are hornfelsed in 1 km wide aureoles around the granitoid plutons. 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

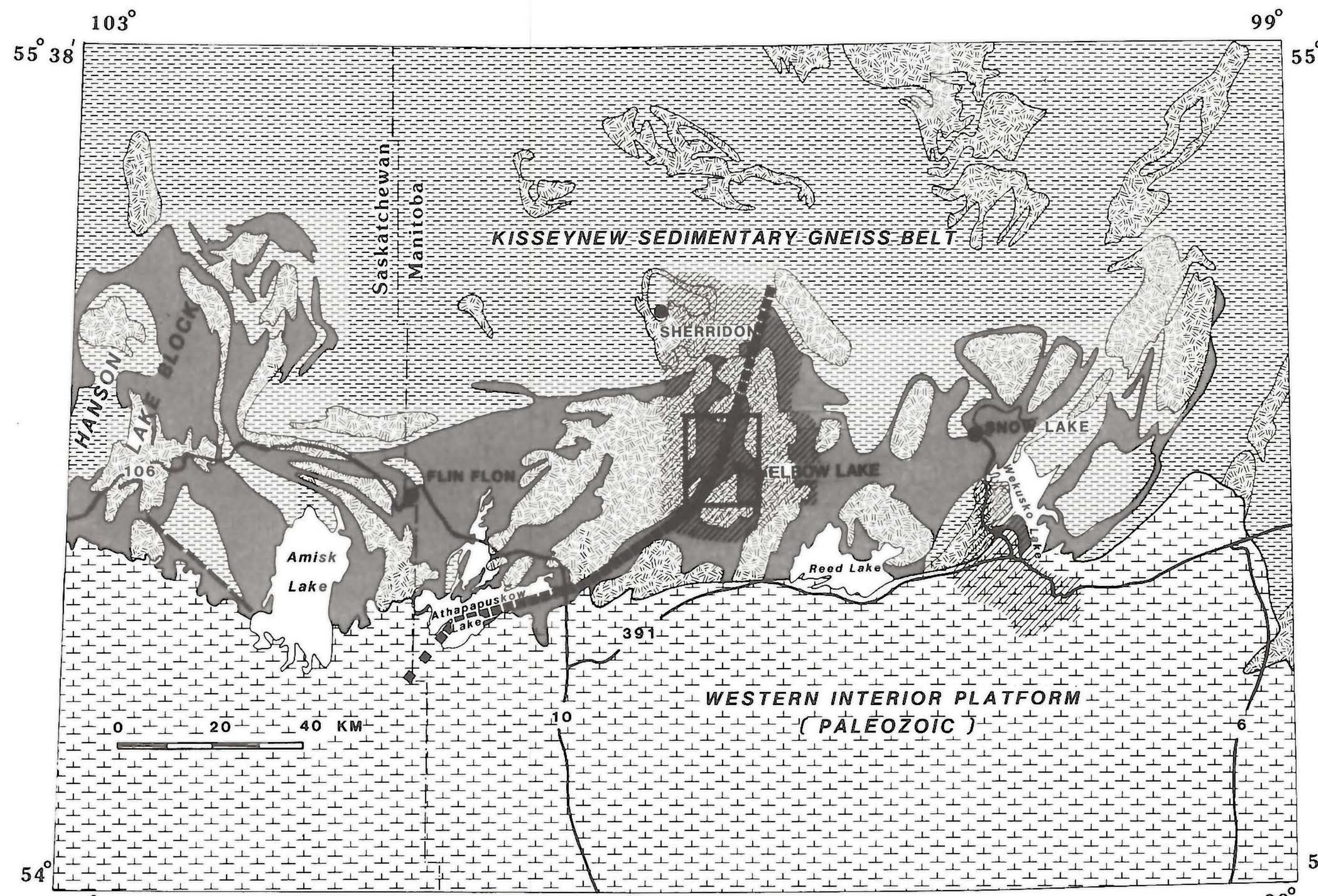


Figure GS-4-1: Simplified geological map of the Flin Flon belt with location of the Elbow Lake project area. Heavy dashed line represents the Elbow Lake - South Athapapuskow shear zone.

by high level intrusive rocks (dyke swarms) within which metavolcanic rafts are a minor component.

Major rock types in each of the two domains are described in the following sections; refer to Preliminary Map 1991F-3 for geographic locations.

CENTRE LAKE DOMAIN

The eastern portion of the Elbow Lake area is composed of very strongly deformed rocks representing a wide zone of intense ductile strain. Centre Lake Domain is dominated by mafic supracrustal rocks including basalt and diabase; these have been intruded by plug- and sill-like bodies of quartz-megacrystic tonalite, and later gabbro. 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.

Metavolcanic Rocks

Throughout the Centre Lake Domain pillowed mafic flows were intruded by abundant fine grained diabase dykes prior to the intense deformation that has produced extreme flattening of primary volcanic and intrusive structures. The result is that through much of the domain, mafic rocks can be identified only as mafic tectonite with sheets of foliated diabase. This deformation is spatially associated with the Gants Lake batholith: within 2 to 2.4 km of the batholith flows are strongly deformed, and grade to less deformed.pillowed flows to the west. These less-deformed flows occur in the Claw Bay area and east of Moen Bay.

CENTRE LAKE MAFIC TECTONITE

In the area between Claw Bay and the margin of the Gants Lake batholith (Fig. GS-4-2), basalt flows are recrystallized, fine grained (0.2-0.5 mm) and tectonically banded/laminated due to extreme attenuation of primary pillow structures. Locally, pillow selvages and amygdales are preserved in the deformed material, with individual pillows highly flattened (aspect ratios of 10-20:1). These tectonically banded pillowed flows commonly contain yellow epidosite domains and grey to dark green banded material derived from pillow margins and pillow selvages (Fig. GS-4-4). The epidosite domains in the cores of pillows are flattened into lenticular shapes which deflect the northwest-trending S_2 foliation. Diabase and, locally, tonalite dykes are parallel to S_2 and may be as narrow as a few centimetres; these too are strongly deformed and tectonically laminated. Open upright northeast-trending folds warp the S_2 tectonic lamination; these F_4 structures locally contain S_4 axial planar quartz veinlets or amphibole blasts.

Relict well preserved pillows are present only in a few small low-strain zones (for example, 1.2 km north of Claw Bay, and 850 m east of Centre Lake). These pillows weather dark grey green to black and are aphyric to sparsely plagioclase phyric (Fig. GS-4-5). Flow orientations determined in these low-strain zones are consistently to the north-northeast, at a high angle to the local S_2 flattening/foliation plane.

CLAW BAY BASALT

A gradational transition from strongly deformed, tectonically laminated flows to recognizable pillowed flows takes place approximately 700 southwest of Centre Lake, in the area south of Claw Bay (Fig. GS-4-2). West of the transition some pillowed flows show top orientations. At the transition the flows still appear to contain at least upper greenschist facies mineral assemblages, in contrast to lower grade assemblages in pillowed flows in the Long Bay Domain. Pillows in the better preserved areas weather light- to medium-green and are dominantly aphyric, with very thin selvages; some contain amygdales to 6 mm and radial pipe vesicles in pillow margins. Claw Bay basalt is considered to be the protolith of much of the mafic tectonite in the Centre Lake Domain.

West of Claw Bay, adjacent to the South Elbow Gabbro complex, pillowed flows weather grey green, are aphyric and only weakly amygdaloidal. Flow orientations outline an isoclinal, north-trending F_3 syncline.

MOEN BAY BASALTS

East of Moen Bay (Fig. GS-4-2) the metavolcanic assemblage differs from that in the Claw Bay area. The succession is intruded by diabase, plagioclase phyric diabase, and younger gabbros and ultramafic rocks, and is dismembered in a series of closely-spaced northeast-trending fault splays associated with the ELSZ. The basaltic rocks are in general strongly deformed, and stratification trends northeast, parallel to bounding faults. They are commonly porphyritic, similar to Tee Lake porphyritic basalts in the Long Bay Domain (see below). If the two mafic successions are in fact correlative they provide the only stratigraphic link between the two domains.

Plagioclase phyric pillowed flows extend in a northeast-trending band east of Marie Lake. These flows weather light greenish buff to buff and contain 5 to 10% plagioclase phenocrysts up to 4 mm. These flows are intruded by small to large diabase dykes, similar to other mafic units in the Centre Lake Domain.

Northeast of Moen Bay mafic flow units include aphyric pillowed flows, plagioclase-pyroxene phyric pillowed flows, plagioclase phyric pillowed flows and plagioclase phyric breccia.

Sheeted diabase and rhyolite

A highly distinctive unit comprising a diverse assemblage dominated by diabase, rhyolite, and leucotonalite occurs as an envelope 100 to 850 m wide around the tonalite stock east of Elbow Lake (Fig. GS-4-2). The unit is characterized by a striking compositional layering composed of "sheets" of the various constituent rock types "interlayered" on a scale of centimetres to metres (Fig. GS-4-6). Contacts between "layers" are intrusive. In most of the unit the rocks are highly strained, producing tectonic lamination within compositional layers and striking parallelism of those layers.

Constituent rock types in the sheeted unit include:

1. Diabase: weathers buff brown to green brown; fine grained; units generally less than 50 cm wide.
2. Tonalite: weathers light buff to white; leucocratic; fine grained (1 mm); equigranular tonalite dykes/layers appear to be finer grained equivalents of rocks in the nearby tonalite pluton.
3. Rhyolite: weathers white to buff; very fine grained; tectonically laminated; leucocratic; relatively siliceous.
4. Quartz phyric rhyolite or leucotonalite.
5. Basalt: weathers dark grey green; fine grained; well foliated, with partially flattened quartz-epidote amygdales.
6. Plagioclase phyric mafic breccia with lensoid fragments.
7. Boudinaged quartz-feldspar pegmatite veins.
8. Plagioclase phyric diabase: weathers buff to grey; relatively unfoliated; forms late, thick (1-2 m) dykes.
9. Epidosite: thin layers.
10. Gabbro: sparsely plagioclase phyric and coarsely plagioclase phyric types.

Individual components in the unit are 5 cm to 2 m thick, and are generally less than 50 cm thick; tonalite sheets are thickest. Layers are straight but discontinuous; some have flame-like or lensoid terminations. The unit is obviously strongly tectonized: quartz veins and tonalite sheets are boudinaged. Contradictory cross-cutting relationships between diabase and felsic rocks suggest that the mafic and felsic rocks are approximately contemporaneous. Latest dykes are cross-cutting quartz-megacrystic tonalite (similar to quartz-megacrystic tonalite in the pluton) and plagioclase phyric diabase.

The unit is discordant with respect to other supracrustal units in the Centre Lake Domain. The fact that it forms an envelope spatially associated with the tonalite stock strongly suggests that the two units are genetically related. The abundant rhyolite and fine grained leucotonalite in the sheeted unit may represent a dyke stockwork, which originated from the tonalite plug during an early stage of intrusion. It may be speculated that as the tonalite magma rose in the crust it intruded into and "ballooned" the earlier-formed dyke complex, producing the observed high strain and "sheeted" appearance in the unit.

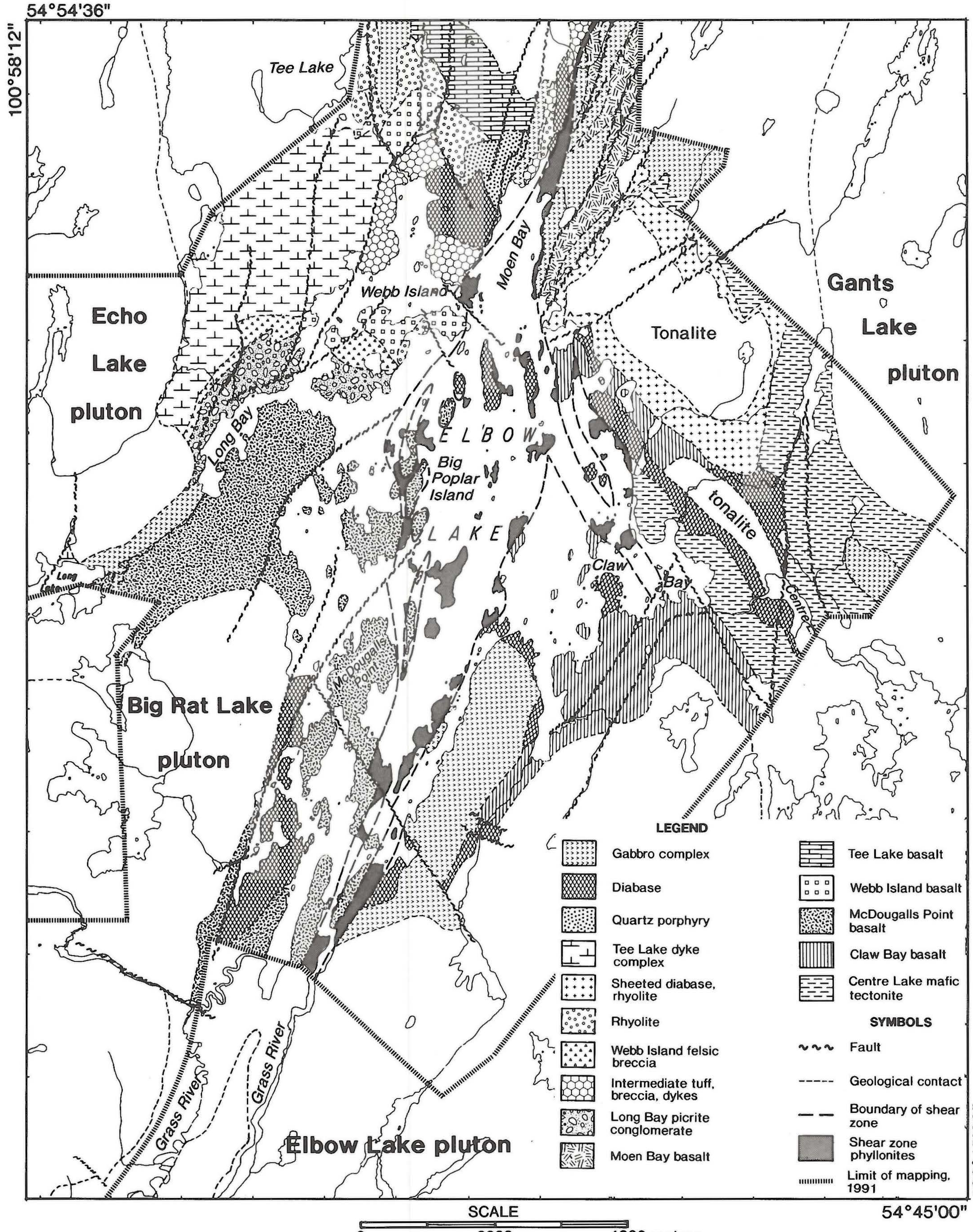


Figure GS-4-2: Simplified geological map of the Elbow Lake area; many minor intrusions in supracrustal rocks and internal contacts within plutons are omitted. For details see Preliminary Map 1991F-3.

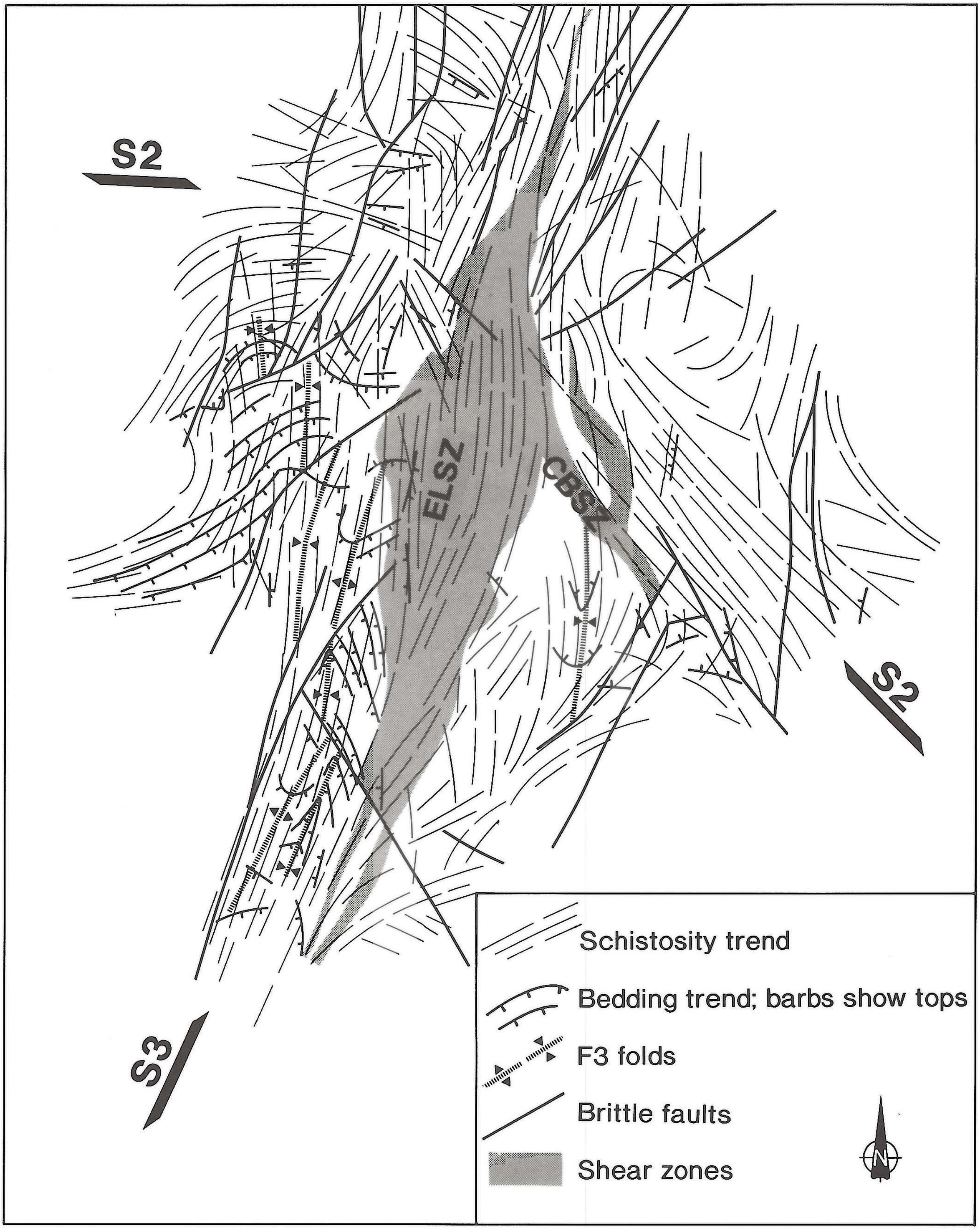
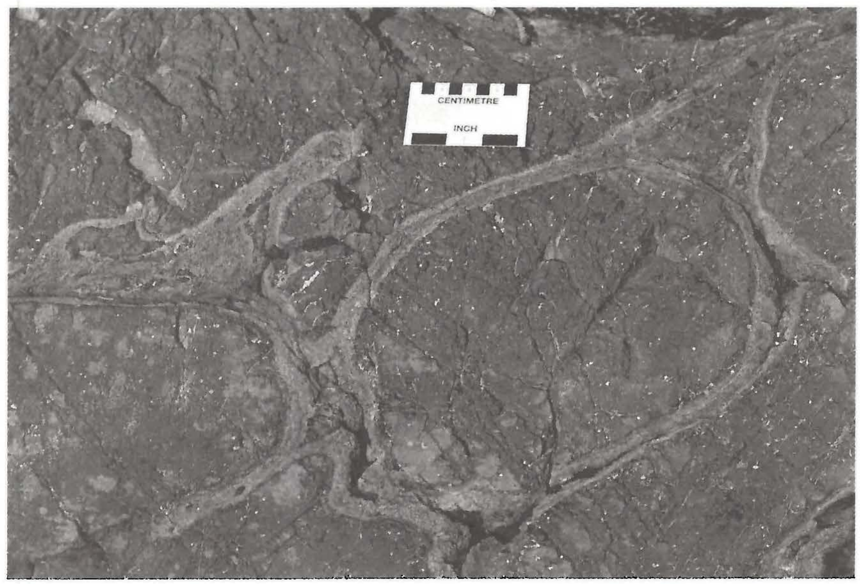


Figure GS-4-3: *Structure trend map of the Elbow Lake area. The S_2 regional foliation trends northwest (east of Elbow Lake) to west (northwest of Elbow Lake). S_2 is transected by a strongly developed north-northeast-trending S_3 fabric comprising an axial planar foliation and a shear foliation associated with the Elbow Lake shear zone. ELSZ: Elbow Lake shear zone; CBSZ: Clay Bay shear zone. Same area and scale as Figure GS-4-2, topography omitted.*

Figure GS-4-4: *Lensoid epidosite domains and flattened quartz amydales in Centre Lake tectonite.*

Figure GS-4-5: *Weakly deformed, sparsely plagioclase phyric pillowed flow, from a low-strain zone within the Centre Lake mafic tectonite.*



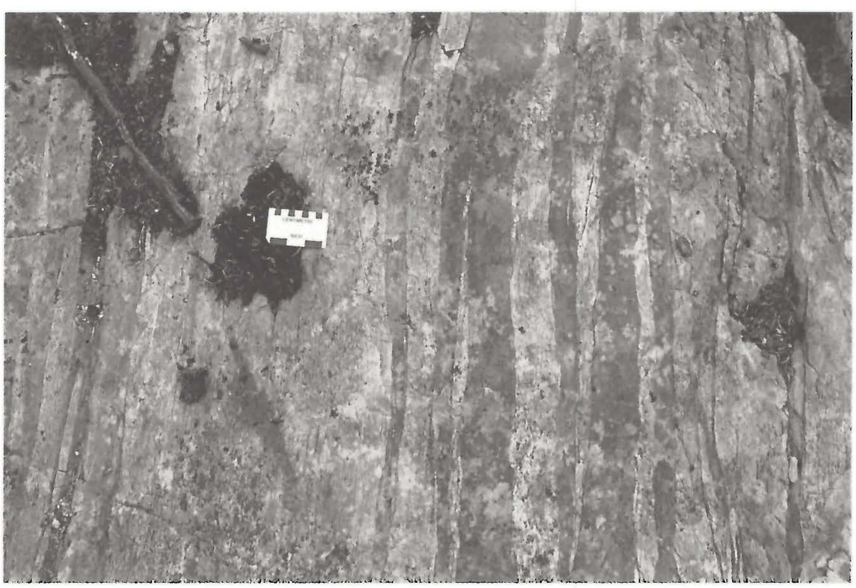


Figure GS-4-6: *Alternating "sheets" of rhyolite (light) and diabase (dark) in the "sheeted unit" east of Elbow Lake; this unit is interpreted as a highly deformed dyke complex peripheral to the East Elbow tonalite stock.*

Diabase

Diabase intrusions from a few centimetres wide to mappable units hundreds of metres in length are common throughout the Centre Lake Domain. Most of these diabases are deformed to the same extent as the basaltic country rocks, demonstrating that the diabase is pretectonic. All diabase is not the same age: for example, diabase dykes that are superficially similar can be shown to both pre-date and post-date the tonalite intrusions in the domain. At least some of the diabase is probably synvolcanic.

Textures in Centre Lake Domain diabases include aphyric, equigranular types and plagioclase phyric types. The largest body of aphyric diabase occurs along the south margin of a tonalite sill at Centre Lake. This diabase is clearly intruded by the tonalite. Plagioclase megacrystic diabase (with phenocrysts up to 2 cm) appears to be a rather late phase, postdating intrusion of the tonalite bodies. East of Moen Bay plagioclase phyric (2-4 mm) diabase is commonly associated with gabbroic intrusions.

Gabbro complexes

East of Moen Bay the banded mafic tectonites are intruded by mafic rocks including several types of gabbro, melagabbro, pyroxenite and peridotite. These intrusions coincide with magnetic anomalies in a large zone east of Moen Bay; they have not yet been mapped in their entirety. Rock types include:

1. "Spotted" gabbro with 50% equant to subhedral elongate green amphibole crystals (to 3 mm) and 50% finer grained, lath-shaped plagioclase.
2. Gabbro - intrusion breccia complex composed of poorly foliated, weakly pyroxene phyric to equigranular gabbro with amphibole after pyroxene 1 to 4 mm and lath-shaped plagioclase 1 to 1.5 mm; in places an intrusive complex with melagabbro, tonalite.
3. Coarse grained gabbro with euhedral 2 to 6 mm amphibole pseudomorphs after pyroxene and 1 to 3 mm plagioclase tablets.
4. Equigranular medium green pyroxenite.

Claw Lake Gabbro

The northern end of a large gabbro complex that lies east of Claw Lake was mapped in 1991; most of the body will be mapped next season. The complex intrudes tectonized mafic flows, but is itself almost undeformed. The complex is composed predominantly of mesocratic coarse grained (2-10 mm) gabbro with 40 to 50% blocky tabular plagioclase and 50 to 60% green equant to subhedral elongate amphibole, and a dark green melagabbro. The gabbro contains mafic pegmatite pods and veins, and is veined, brecciated and intruded by fine- to medium-grained quartz diorite.

SOUTH ELBOW GABBRO

A layered gabbro complex in the southern part of the Centre Lake Domain (herein termed the South Elbow Gabbro) is the largest and most complex mafic intrusive body in the map area. The intrusion is 5.3 km long and 1.3 km wide, emplaced in Claw Bay basalts and associated diabase (Fig. GS-4-2). The gabbro body is intruded on the south by the Elbow Lake tonalite stock (1869 +20/-9 Ma; P. Hunt, pers. comm. 1991). Assuming the Amisk Group at Elbow Lake is the same age as that at Flin Flon (1886 Ma; Gordon *et al.*, 1990), the South Elbow gabbro must then be approximately synvolcanic.

The intrusion is composed predominantly of gabbro, with subordinate pyroxenite and peridotite. The gabbro commonly displays well developed medium scale (5-50 cm) modal layering expressed as sharply bounded leucogabbro to anorthosite layers in a dominantly mesocratic gabbro. Gabbro pegmatite veins and pods are abundant; at least one large body of layered gabbroic pegmatite occurs in the centre of the gabbro complex.

Gabbro weathers buff brown to light green to cream, and has a 1 to 2 mm equigranular texture with subequal amounts of blocky to lath-shaped plagioclase and interstitial pale green to rusty green amphibole. It commonly contains abundant narrow shears and is veined and brecciated by white epidote. Outside the shear zones gabbro is unfoliated. Where not layered the gabbros are heterogeneous, massive, and appear to comprise more than one phase; they locally contain inclusions of green melagabbro. Green pyroxenite, black melagabbro and common irregular veins and pods of gabbro pegmatite cut the gabbro.

Ultramafic components of the complex include dunite, coarse pyroxenite and layered peridotite. The peridotites are distinguished by the presence of 1 to 3 cm pseudomorphs after pyroxene oikocrysts, which contain close-packed serpentinized olivine crystals to 3 mm.

Igneous layering in the South Elbow Gabbro consistently trends north to north-northwest, about 20° to 30° off the northeast elongation axis of the intrusion. If the body were an undisturbed stratiform intrusion, it would be expected that the layering and elongation axis would be parallel. The fact that they are not parallel suggests that the body is a fault-bounded sliver of a larger intrusion; the western margin of the gabbro is in fact truncated by the ELSZ and related structures. The eastern contact with diabase and basalt, however, is rarely exposed. In some instances there is evidence of shearing at or near the contact while in other places the contact appears to be structurally unmodified.

The South Elbow Gabbro is similar in lithology and layering characteristics to Limestone Narrows gabbro complex in the Athapapuskow Lake area (Syme, 1987). These and similar gabbros may represent a significant class of subvolcanic intrusions in the Flin Flon belt.

Tonalite

A tonalite stock emplaced within the supracrustal rocks east of Elbow Lake (Fig. GS-4-2) is 3 km long and 1.6 km wide. The tonalite is a white-weathering, quartz-megacrystic body containing 10 to 25% variably chloritized amphibole and biotite. Quartz forms equant irregular to oval megacrysts up to 2.5 cm long that stand out in relief from the groundmass. Biotite locally occurs as euhedral books to 6 mm. There is no obvious lithologic zoning within the intrusion. Contacts with the enclosing "sheeted unit" (see above) are invariably sharp, unbrecciated, and contain a tectonic foliation parallel to the margin of the body.

Foliation in the plug is generally weak and oriented east to northeast, except along the margins where there is a stronger foliation parallel to the northwest S_2 in the country rocks. The intrusion is offset along northeast-trending faults probably related to the late conjugate system that is synchronous with, or postdates development of, the ELSZ.

The sill-like tonalite bodies east of Elbow Lake are not continuous with the tonalite plug (Fig. GS-4-2). These rocks are white weathering, relatively fine grained, leucocratic and equigranular to quartz-megacrystic (quartz up to 5 mm). The tonalite contains a strong northwest-trending S_2 foliation and parallel high strain/shear zones. It is intruded by diorite and diabase dykes within the body and along the southwest margin, in contact with a thick unit of mafic intrusions.

Post-tectonic breccia

A wedge-shaped area of brecciated mafic tectonite occurs south of an elongate unnamed lake north of Centre Lake. The breccia is at least in part bounded by younger brittle faults. The breccia is unstratified, fragment supported, poorly sorted, with almost no identifiable matrix. Fragments include all lithologies in the Centre Lake mafic tectonite (tectonically laminated basalt, diabase, plagioclase phyric diabase), all of which were foliated prior to incorporation into the breccia. Fragments are commonly angular or tabular, and are up to 1 m across. Adjacent to the Gants Lake batholith the breccia includes fragments of granodiorite. The origin of the breccia is unknown; however it corresponds to an area in which F_3 structures are particularly well developed. Smaller zones of similar breccia also occur in F_3 folded rocks in the area northeast of Centre Lake.

LONG BAY DOMAIN

Unlike the Centre Lake Domain, the Long Bay Domain contains a recognizable volcanic stratigraphy in which primary structures are locally well preserved. The stratigraphic succession has been intruded by dyke swarms, folded and faulted, with the result that not all units can be confidently assigned to a stratigraphic position. Major units are described below, in order from oldest to youngest.

Tee Lake porphyritic basalt

The lowermost stratigraphic unit in the area north of Elbow Lake consists of northwest-trending porphyritic basalt flows and associated breccia, exposed in the northernmost part of the map area (Fig. GS-4-2). This unit is 900 m thick and is intruded by a granodiorite pluton. The basalts are apparently conformably overlain by the Tee Lake rhyolite.

The basalts weather medium grey and contain a few phenocrysts of plagioclase and pseudomorphs after pyroxene. The flows are intruded by abundant diabase dykes. Within 420 m of the granodiorite pluton the basalts are totally recrystallized (0.2-0.5 mm) and strongly attenuated, with oval epidosite augen and discontinuous epidosite lenses and stringers. Adjacent to the pluton pillow structures are almost totally obliterated.

Tee Lake rhyolite

Tee Lake rhyolite is the largest felsic volcanic complex in the Elbow Lake area. It is at least 600 m thick north of Webb Island, and extends from its contact with intrusive quartz porphyry west of Moen Bay, across a number of north-trending faults, to Tee Lake in the west (Fig. GS-4-2). While mapping is not yet complete, preliminary indications are that this unit extends into the Webb Lake area to the north (Schledewitz, GS-2, this volume).

North of Elbow Lake, Tee Lake rhyolite conformably overlies Tee Lake porphyritic basalt. It appears to be overlain in turn by intermediate and felsic volcanic and dyke rocks.

Tee Lake rhyolite is a complex of dominantly massive aphyric, quartz phyric and plagioclase phyric felsic rocks; there are few occurrences of felsic tuff and breccia. Most of the rocks are structureless so it is not possible to distinguish the relative proportions of flows and dykes; sharp contacts between rhyolites with different phenocryst populations indicate intrusive relationships. In general the rhyolite weathers white or cream and is very fine grained. Iron oxide gossan was noted in a number of outcrops east of Tee Lake and are noted on Preliminary Map 1991F-3.

Intermediate tuff, breccia and dykes

A complex unit of intermediate and felsic volcaniclastic rocks (tuff, lapilli tuff, and breccia), extensively intruded by synvolcanic dykes, is exposed in the large bay north of Webb Island (Fig. GS-4-2). These rocks are generally in fault or intrusive contact with other lithologies in the area, but there is some suggestion (east of Tee Lake) that they overlie Tee Lake rhyolite. Their stratigraphic relationship to Webb Island basalt (see below) is unknown. These rocks are distinct from all other volcanic units in the Elbow Lake area, representing a significant interval of intermediate to felsic pyroclastic volcanism, possibly calc-alkaline in character. Such andesitic rocks are exceedingly rare in the Flin Flon belt (Bailes and Syme, 1989; Syme, 1988).

Beds throughout the unit are generally poorly defined. They are marked by variation in fragment size and are crudely graded to finer grained bed tops. Interlayering of intermediate and felsic tuff is common on outcrop and map scale. Abundant rhyolite, andesite, basalt and diabase dykes are emplaced in the stratified rocks, commonly obliterating bedding features.

Intermediate tuff and breccia contain a large variety of intermediate and felsic rock fragments: plagioclase phyric and aphyric andesite, aphyric rhyolite, and pumice. Fragments are angular, up to a maximum of 20 cm long. Felsic breccia is composed of subangular, cream-weathering, weakly vesicular, aphyric rhyolite clasts supported by a brownish matrix. Pumiceous clasts locally occur in the matrix. Some felsic breccia is heterolithologic, containing, in addition to rhyolite, fragments of aphyric and plagioclase phyric andesite.

Felsic crystal-lapilli tuff, well exposed at the north end of the bay contains microvesicular, equant, subrounded lapilli (2-15 mm), plagioclase crystals (to 3 mm), and sporadic quartz crystals in a fine grained felsic matrix.

Webb Island basalt

Webb Island basalt occurs on the north side of Webb Island, and as rafts and small enclaves within the dyke complex southwest of Tee Lake (Fig. GS-4-2). The stratigraphic relationship of these basalts to volcanic units north of Webb Island is unknown.

On Webb Island the unit consists mainly of aphyric basalt, as amoeboid pillow breccia and thin intercalated pillowed flows. Some members are plagioclase phyric. The flows generally trend northeast and top northwest; however, Webb island is transected by a conjugate set of northeast- and northwest-trending faults and one fault block contains southeast-trending strata. These basalts weather green to buff brown and are commonly strongly flattened and foliated.

Southwest of Tee Lake there are sporadic enclaves and rafts of hornfelsed, black pillowed basalt in the Tee Lake dyke complex (Fig. GS-4-7). These basalts are correlated with the Webb Island basalts since they also appear to underlie Webb Island felsic breccia (see below). The proportion of pillowed flows in the Tee Lake dyke complex is small and primary structures are poorly preserved. Consequently stratigraphic correlation with better-preserved rocks on Webb Island is tentative.

Century rhyolite

Century rhyolite is a 150 m thick, massive, aphyric felsic flow exposed on central Webb Island (Fig. GS-4-2), west of the old Century Mine. The flow occurs within the Webb Island basalt succession and is conformably overlain by a plagioclase phyric pillowed member of that unit. The rhyolite flow strikes northeast and tops northwest; it is truncated by a late, northwest-trending brittle fault.

Primary structures in the flow include contorted flow banding, lobes, felsic hyaloclastite and local breccia. Much of the unit is strongly foliated and primary structures are not well preserved.

Webb Island felsic breccia

Webb Island felsic breccia is a maximum of 580 m thick on Webb Island and a minimum of 100 m thick west of Long Bay, where the unit is much more strongly strained (Fig. GS-4-2). The basal contact of this distinctive breccia trends northwest (and the unit tops southwest) on Webb Island, at a high angle to stratification in the underlying Webb Island basalt succession, which trends northeast. There is no evidence to indicate that this contact relationship is structural. If the contact is not structurally modified the felsic rocks must unconformably overlie Webb Island basalts. Webb Island felsic breccia is in turn overlain, perhaps again unconformably (see below), by Long Bay picrite conglomerates.

The breccia is dominated by subangular to subrounded felsic fragments: white, sparsely quartz phyric rhyolite and buff aphyric dacite. Buff aphyric andesite(?) is a minor clastic component. Bedding is thick, with local intercalation of well-bedded tuff. The unit is interpreted as felsic pyroclastic material, possibly reworked, that was deposited in a subaqueous environment.

Long Bay picrite conglomerate

The single most distinctive rock type in the Elbow Lake area consists of a coarse clastic assemblage of volcanic conglomerate, pebbly conglomerate and sandstone. Clastic components in these thickly stratified rocks include (in decreasing order of abundance) aphyric basaltic scoria, aphyric variably amygdaloidal basalt, diabase, gabbro, and pyroxenite; there are no felsic clasts. Preliminary chemical analyses of the scoria indicates that the volcanic components are high-magnesia basalts or picrites (12% MgO). The conglomerates have bedforms indicating they were deposited from subaqueous debris flows (Fig. GS-4-8).

The unit is at least 600 m thick on Webb Island, and extends from Webb Island west along the northwest shore of Long Bay, where it is best exposed (Fig. GS-4-2). It is truncated in the east by the ELSZ. The unit appears to unconformably overlie Webb Island felsic breccia (Syme, 1990). The nature of the top contact is also enigmatic: it is structurally overlain by McDougalls Point basalt but nowhere is the contact exposed; the two units may be in fault contact.

Figure GS-4-7: *Hornfelsed, black pillowed basalt with quartz amygdales; from a basaltic enclave within the Tee Lake dyke complex. Note interpillow epidosite (light).*

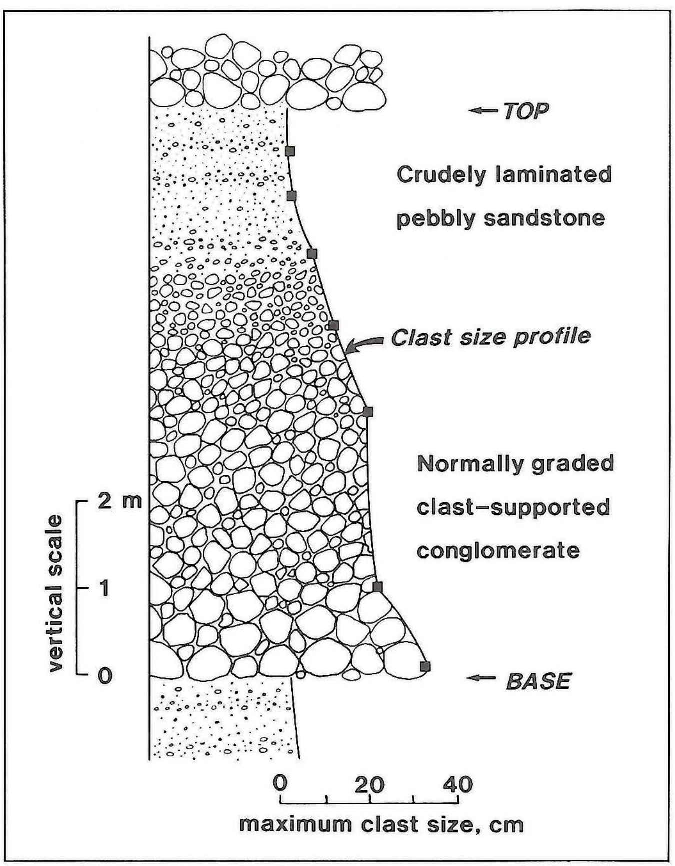


Figure GS-4-8: *Measured features in a typical graded bed, Long Bay picrite conglomerate.*

Conglomerates form coarse, clast-supported, poorly sorted pebble-cobble-boulder beds up to more than 10 m thick. The matrix includes granular basaltic material and intergranular white carbonate or yellow-green epidote. Clasts are subrounded to well rounded; few are subangular (Fig. GS-4-9). Most clasts are in the pebble to cobble size range, but particularly thick beds contain some boulders up to 1.4 m across. All clasts are mafic in composition and include:

1. Grey green to green scoria. These strongly vesicular clasts are abundant (to more than 50% of some beds), and form well rounded clasts.
2. Amygdaloidal basalt with 2 to 10 mm epidote-carbonate amygdales. Truncated concentric zoning defined by amygdale concentration indicates that some of the large boulders were derived from massive basalt lava flows.
3. Non-amygdaloidal basalt
4. Dark green, fine to medium grained (1 mm) melanocratic basalt/picrite.
5. Fine grained (1 mm) diabase.
6. Equigranular fine to medium grained (1-2 mm) gabbro.
7. Medium grained (2 mm) equigranular pyroxenite/melagabbro.
8. Light buff-green subangular basalt; possibly altered; and
9. Black, medium grained (2-3 mm) hornblendite derived from pyroxenite.

Bed contacts are generally well defined and sharp. Conglomerate occurs in thin nongraded beds and, most commonly, in thick normally graded beds (Fig. GS-4-9). Some beds have a zone of reverse size grading at the base of beds. Thick graded beds have sandstone/pebbly sandstone tops, which in rare instances is crudely laminated. Intercalated mafic sandstone and pebbly sandstone units are thin bedded (1-50 cm) to laminated. Thicker pebbly sandstone beds have parallel laminated tops; thinner (1-10 cm) beds include brown sandstone and grey-green interbedded fine grained sandstone-siltstone. Some beds contain normal grading and scours.

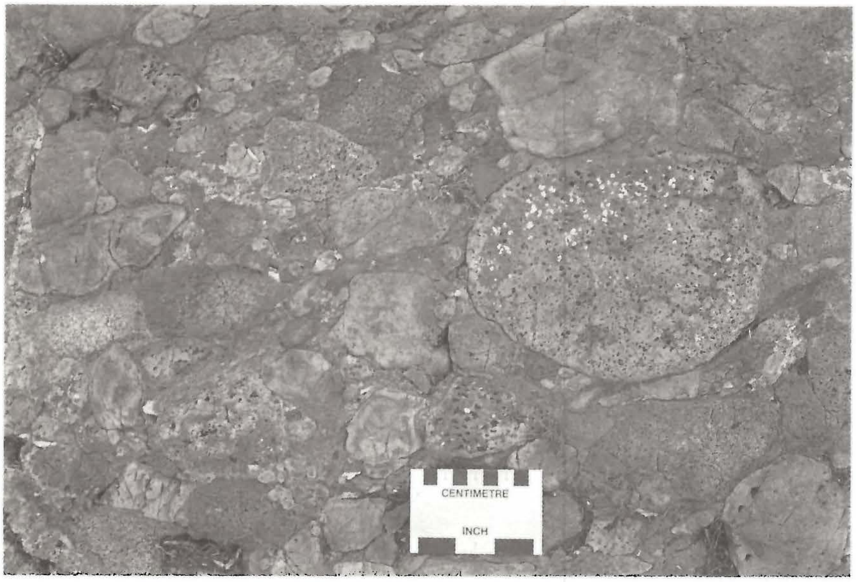


Figure GS-4-9: *Long Bay picrite conglomerate with rounded clasts of scoria, amygdaloidal basalt and non-amygdaloidal basalt. Note that the conglomerate is clast supported.*

The bedforms in Long Bay picrite conglomerates are typical of proximal subaqueous debris flow deposits. The clastic components were derived only from a mafic source including Mg-basalt or picritic flows, magnesian basalt pyroclastic material (scoria) and mafic subvolcanic intrusions (possibly cognate). Despite the ubiquitous occurrence and abundance of scoria in these conglomerates, the mixed nature of the deposits and the well rounded nature of most clasts (including intrusive lithologies) suggests that they include reworked material.

McDougalls Point basalt

McDougalls Point basalt is the most widespread and best preserved of the basaltic sequences on Elbow Lake. It is best represented on the large peninsula east of Long Bay, on Big Poplar Island and on McDougalls Point (Fig. GS-4-2). The sequence is at least 1100 m thick, and structurally overlies Long Bay picrite conglomerate; it is folded in north-northeast trending isoclinal F_3 folds. Much of the mafic phyllonite in the ELSZ between Big Poplar Island and the south end of Elbow Lake is interpreted to have been derived from McDougalls Point basalt.

McDougalls Point basalt is dominantly aphyric, but also includes plagioclase phyric and plagioclase-pyroxene phyric members. Apart from minor interflow sediment/tuff layers and extensive synvolcanic diabase/gabbro intrusions, there are no significant nonbasaltic members. In this aspect these basalts resemble lithologically and geochemically similar Millwater basalts (Syme, 1988) in the Athapapuskow Lake area.

Flows in the McDougalls Point basalt are dominantly thick and pillowed. Flows weather light buff to brownish buff, and are light grey on fresh surface. Pillows are medium to large in size (Fig. GS-4-10), and megapillows several metres in length are present locally (generally in the lower parts of flows). A characteristic feature of McDougalls Point basalt is the common presence of white to grey, massive to laminated chert in pillow interstices. Amygdales are few; many flows are nonamygdaloidal. Some massive flows are intercalated with pillowed flows, and these commonly have amoeboid pillow breccia flow tops.

Tee Lake dyke complex

Tee Lake dyke complex forms a large part of the Long Bay Domain southwest of Tee Lake (Fig. GS-4-2). The complex is composed of diabase, rhyolite, leucotonalite, plagioclase- and plagioclase-amphibole mafic porphyry, and plagioclase-quartz felsic porphyry dykes, emplaced in black, hornfelsed pillowed basalt flows. Dyke contacts are generally parallel, producing a large-to-medium scale compositional "layering" on outcrops. Age relationships are not clear: rhyolite, leucotonalite and plagioclase-amphibole porphyry cut at least some of the diabase, large bodies of leucotonalite are in turn cut by diabase, and quartz-feldspar porphyry dykes are youngest.

The contact between Tee Lake dyke complex and volcanic rocks in the southwest portion of Long Bay Domain is an abrupt lithotectonic zone 75 m to 120 m wide. The zone is characterized by a a distinctive unit of variably deformed gabbro intrusive breccia, and a strong platy penetrative fabric in the adjacent dyke complex rocks. The zone is offset along later north-trending faults. The fact that this lithotectonic zone separates fundamentally different terranes makes this narrow zone one of the more important, and oldest, structural breaks in the area.

Diabase

Diabase is as common in the Long Bay Domain as it is in the Centre Lake Domain. As in the Centre Lake Domain, there is certainly more than one age of diabase, and there are a variety of textural types.

Diabase in the Tee Lake dyke complex is fine- to medium-grained (0.5-1 mm), dark green to black, commonly with an equigranular texture in which pseudomorphs after primary calcic plagioclase laths are preserved. Small irregular bodies of diabase pegmatite occur in the larger diabase intrusions. Diabase dykes are both cut by, and cut, rhyolite dykes in the complex. Areas dominated by diabase contain small screens of pillowed flows; the flows are distinguished by a more heterogeneous weathering colour, presence of epidosite domains, aphanitic texture and, locally, the presence of quartz amygdales.

Diabase dykes and irregular mappable intrusions in McDougalls Point basalt are polyphase bodies similar to the fine grained diabase in the Tee Lake dyke complex.

A diabase intrusion 1.2 km in diameter occupies much of the peninsula north of Webb Island. This intrusion contains a large (300 m) inclusion of Long Bay picrite conglomerate, far from its stratigraphic position on southern Webb Island and Long Bay. The diabase contains equigranular, plagioclase-megacrystic and pyroxene-oikocrystic phases.

Diabase in the Moen Bay area includes relatively large, dyke-like bodies of plagioclase-megacrystic diabase and a plagioclase phyric diabase with smaller but more abundant plagioclase phenocrysts. The megacrystic diabase contains up to 2% phenocrysts up to 2 cm in diameter, in a 1 to 2 mm groundmass of tablet-shaped plagioclase and green equant amphibole. Intrusions of similar material

Figure GS-4-10: McDougalls Point basalt; pillows have relatively thick selvages and abundant interpillow white chert.

occur in the Centre Lake Domain (particularly in the Moen Bay area) and within the Elbow Lake shear zone. Those in the ELSZ are massive, poorly foliated bodies emplaced in mafic and felsic phyllonites; they appear to postdate at least some of the deformation in the zone as they are sheared only along contacts with the country rocks.

Leucotonalite

Fine grained leucotonalite is a common constituent of the Tee Lake dyke complex, and also occurs as small homogeneous intrusions in both the dyke complex and volcanic rocks in the Long Bay Domain. Leucotonalite weathers white, and has an equigranular 0.5 to 1 mm texture.

Quartz porphyry

Massive quartz porphyry forms an irregular, largely fault-bounded intrusion 1.2 km long, west of Moen Bay (Fig. GS-4-2). The porphyry contains 10 to 15% grey or lavender quartz phenocrysts (1-3 mm) in a light buff to cream weathering, fine grained (0.5 mm), crystalline groundmass. The porphyry is cut by a few diabase dykes. It is distinguished from the spatially associated Tee Lake rhyolite in that the rhyolite is commonly aphyric and aphanitic; quartz phyric phases of the rhyolite contain fewer and smaller quartz phenocrysts than the porphyry.

STRUCTURAL SETTING

Preliminary structural analysis indicates that there are four deformation events recorded in the Elbow Lake area, P_1 to P_4.

The oldest folds (F_1) identified in the Elbow Lake area trend approximately east and lack an axial planar foliation. One such structure is a refolded isoclinal anticline clearly outlined by bedding attitudes in Long Bay picrite conglomerates (Preliminary Map 1991F-3).

P_2 structures are dominated by a northwest-trending foliation (S_2) developed in two areas: east of Elbow Lake in the Centre Lake Domain, and northwest of Elbow Lake in the Long Bay Domain (Fig. GS-4-3). In the Centre Lake Domain supracrustal rocks have undergone intense ductile deformation, with strong flattening of primary structures and the development of the S_2 penetrative fabric oriented parallel to the margin of the Gants Lake batholith (Fig. GS-4-3). The orientation of this fabric with respect to primary stratification is not known: there is little nontransposed material in the domain. There are suggestions from rare low-strain zones that the volcanic stratigraphy trends northerly, at a high angle to the foliation associated with flattening. In Long Bay Domain, S_2 occurs as a west- to northwest-trending foliation developed predominantly in the Tee Lake dyke complex.

The S_2 regional foliation is transected by an S_3 fabric trending north-northeast through the centre of Elbow Lake (Fig. GS-4-3). P_3 structures include a series of isoclinal upright F3 folds in the Long Bay Domain (defined chiefly by pillow and flow orientations in McDougalls Point basalt), a well developed S_3 axial planar foliation, and the shear foliation associated with the ELSZ.

P_4 structures are currently recognized only in the southern Centre Lake Domain. There the S_2 foliation and tectonic lamination is refolded in northeast-trending, generally rather open F_4 minor folds, which in some instances contain axial planar foliation, fracture cleavage, or mineral-filled fractures.

Elbow Lake shear zone and related structures

The system of shear zones on Elbow Lake includes the ELSZ proper, the Claw Bay shear zone (CBSZ), and related smaller-scale shear zones and faults (Fig. GS-4-3). They dominate the structural pattern in the Elbow Lake area simply by virtue of size: at its maximum width east of Big Poplar Island the ELSZ is 2.6 km wide, narrowing to a few tens or hundreds of metres at the northern and southern boundaries of the map area. Hunt (1970), Galley *et al.* (1987) and Syme (1988) have proposed that the deformation/shear zone exposed on Elbow Lake is continuous with fault zones mapped by Podolsky (1951) through the Cranberry lakes and into Athapapuskow Lake. There the structure is termed South Athapapuskow shear zone (SASZ; Syme, 1988), and is more than 1 km wide. The zone trends southwest from Athapapuskow Lake into the sub-Paleozoic, to ultimately join the Namew Lake structure (Syme, 1988). Northeast of Elbow Lake the ELSZ is projected into the Kisseynew metasedimentary gneiss belt, where structures associated with the zone have been identified by Zwanzig (pers. comm. 1990). The exposed part of the ELSZ-SASZ is over 80 km in length, and has a general northeast trend through the Flin Flon belt (Fig. GS-4-1). The Berry Creek fault east of Snow Lake is a structure of similar size, orientation and complexity, and has a similar sense of movement to the ELSZ (Bailes, GS-3, this volume).

Characteristics of the shear zone system on Elbow Lake are as follows:

1. The ELSZ is discordant to lithologic boundaries and in some places crosses stratigraphy at a high angle (e.g. on Big Poplar island, east of Webb Island and on Chinaman Island);
2. The east and west margins of the ELSZ are abrupt. For example, on McDougalls Point, pillowed flows 150 to 300 m west are only

weakly to moderately flattened parallel to the ELSZ. High strain (shear) zones parallel to ELSZ occur within the less-strained flows. Flattening increases towards the west margin of the zone, so that the long axes of pillows are nearly transposed into a plane parallel to the ELSZ. At the west margin of the zone there are an increasing number of 1 to 2 m wide high strain zones within the flattened flows, followed by an abrupt transition to strongly foliated rocks (phyllonites) in the ELSZ proper;

3. Within the shear zone strain intensity is highly variable. Lens-shaped domains of less-deformed rock are common in the shear zone, and range in size from a few centimetres or metres to mappable domains nearly 2 km long by 300 m wide (e.g. on Big Poplar Island). The result at map scale is an anastomosing structure of considerable internal complexity;
4. The shear zone bifurcates on central Elbow Lake , with the main structure trending north-northeast and a subsidiary structure (Claw Bay shear zone, CBSZ) trending southeast. The CBSZ is itself bifurcated, with the western arm joining the ELSZ south of "Leaping Moose" Island and the eastern arm terminating east of Gold Dust Island. On "Leaping Moose" Island the shear foliation in ELSZ rocks is folded and crenulated, with axial planes parallel to the trend of the CBSZ (Fig. GS-4-11). This suggests that the two structures are not exactly the same age, and that the Claw Bay structure may be younger;
5. The predominant rocks within the shear zones are mafic phyllonites (chlorite-carbonate schists) and felsic phyllonites (quartz-sericite±carbonate schists) of which the protolith is unknown. Less strained rocks in the zones may have strongly attenuated and transposed primary structures such as pillows, amygdales and clasts;
6. Schistosity in the shear zones is generally parallel to the margins of the zones, and is steeply dipping to vertical. On Central Elbow Lake the S_3 axial planar foliation is parallel to the shear zone; north of Elbow Lake the S_2 regional foliation is southeast trending and is rotated into parallelism with the shear zone west of Moen Bay. The main schistosity in the shear zones is interpreted as a C fabric; S fabrics were not identified. In many places a younger southeast-trending kink banding is superimposed on the shear foliation. Quartz veins and pods occur within the foliation plane and are commonly boudinaged. Stretching lineations in the sheared rocks are generally subvertical, indicating a strong component of dip slip in the zone;
7. The shear zone is parallel to F_3 folds in the supracrustal assemblage, but on a smaller scale (e.g. on Big Poplar Island) the zone transects F_3 folds. This suggests that the folds and the shear zone are products of the same deformation event, with the shearing slightly postdating F_3 folding;
8. A horizontal component of dextral displacement can be documented in the ELSZ. The best evidence for this is the large-scale rotation of Long Bay picrite conglomerates into the ELSZ east of Webb Island. There, a bead-like train of little-deformed conglomerate domains occur in phyllonites on the western margin of the shear zone. The less-deformed domains are 150 m long, and are displaced northeast from the intersection of the main conglomerate with the shear zone. This transposition of the unit into the shear plane clearly demonstrates a sinistral component of shear. Minor structures within and at the margin of the zone in Moen Bay are consistent with this interpretation;
9. Deformation within the ELSZ includes a significant component of bulk flattening. Flow contacts and fragments are locally tightly chevron folded within a few tens of metres of the margin of the zone (e.g. on Chinaman Island). Within the shear zone, tectonic banding, relict primary structures, quartz veins cross-cutting foliation, and cross-cutting dyke rocks (see below) are locally isoclinally folded;
10. The shear zone has been the locus for dyke intrusion throughout its development. A wide variety of dykes including quartz phyric rhyolite, diabase, tonalite, aphyric andesite, aphyric basalt, plagioclase phyric basalt (Fig. GS-4-12), melagabbro, and white plagioclase porphyry are emplaced in the phyllonites; these dykes are generally confined to the shear zone and are not prominent in adjacent wall rocks. All dykes identified in the shear zone are deformed to some extent (boudinaged, foliated, transposed), and thus pre-date the final deformation within the zone. Early dykes which cross the shear foliation at a high angle are tightly folded and locally transposed; younger dykes emplaced subparallel to foliation cut the folded dykes. Large dykes of diabase, such as that exposed on Gold Dust Island, are more than 250 m wide and show much less internal strain than the phyllonites in which they are emplaced. They are sheared on the margins, however, and clearly do not postdate deformation. It is not known whether these diabases, which are typically sparsely plagioclase-megaphyric and identical to diabases outside the shear zone, postdate the onset of shearing or are simply less-deformed domains caught up in the shear zone;

Figure GS-4-11: Folded mafic phyllonite and enclosed quartz veins, "Leaping Moose" Island; axial planes of the folds are parallel to the trend of the Clay Bay shear zone.

Figure GS-4-12: *Straight-walled dyke of sparsely plagioclase phyric basalt emplaced slightly across foliation in mafic phyllonites of the ELSZ. Note that the dyke cuts across disrupted, transposed, boudinaged quartz veins in the phyllonite. The dyke is foliated and recrystallized, and thus pre-dates at least some of the deformation in the ELSZ.*

11. The ELSZ proper narrows abruptly (over 5 km) to the north, from 2600 m wide east of Big Poplar Island to 60 m wide north of Moen Bay. A large number of discrete, north- to northeast-trending faults splay off the ELSZ in the Moen Bay area; thus it is likely that there the displacement is spread over a large number of structures in a wide zone. Splay fault orientation with respect to the ELSZ changes systematically from south to north: at the mouth of Moen Bay faults are at a high angle to the ELSZ, whereas north of Moen Bay they are parallel to the ELSZ;
12. In the southern part of the map area the ELSZ truncates the western margin of the Elbow Lake tonalite. The plutonic rocks are thoroughly brecciated in the fault zone, with tabular slabs of tonalite and laminated fragments of schistose mafic tectonite (Fig. GS-4-13).

Conjugate brittle faults

A conjugate system of northeast- and northwest-trending brittle faults truncates F_3 folds and produces offsets in the margins of the ELSZ. These late structures are very narrow, and are almost never observed in outcrop.

The margins of the ELSZ are offset 100 to 300 m on the conjugate set east of Webb Island, south of Big Poplar Island and on McDougalls Point (Fig. GS-4-2). The southern part of the Claw Bay shear zone is abruptly truncated by one of these structures, indicating considerable displacement. Both dextral and sinistral types are present.

The two largest structures in this northeast- and northwest-trending conjugate set are the Grass River fault and McDougalls Point fault:

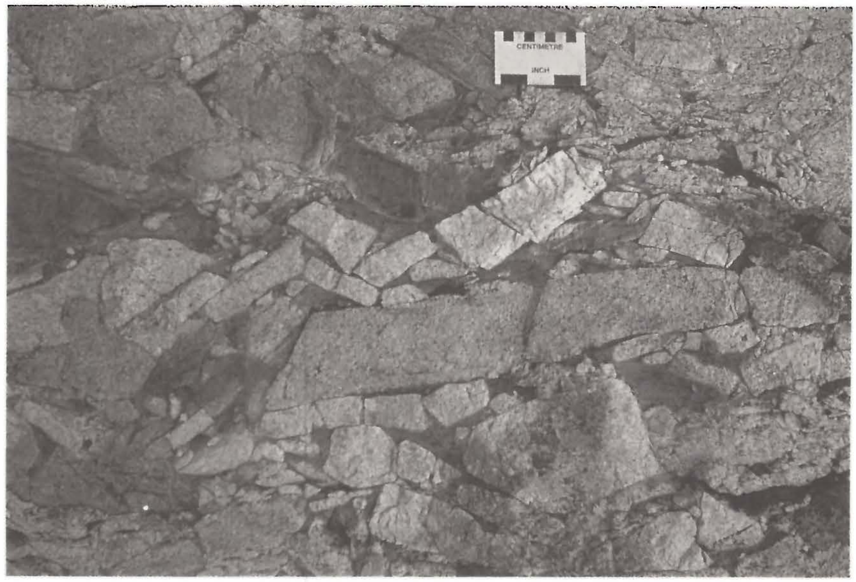


Figure GS-4-13: *Fault breccia adjacent to the ELSZ, at the truncated margin of the Elbow Lake tonalite, Grass River. Schistose mafic tectonite fragments from the shear zone are a minor but significant component of the breccia.*

1. The northeast-trending Grass River fault extends more than 10 km, from the southwestern boundary of the map area to central Elbow Lake. This fault outcrops in a number of places on southwest Elbow Lake. It is marked by a laminated felsic mylonite zone at least 10 m wide, and by brittle deformation in diabase west of the mylonite. The fault has a dextral component of displacement, and produces large offsets in isoclinal fold axes in the McDougalls Point area; it also apparently offsets the ELSZ;
2. The northwest-trending McDougalls Point fault extends over 8 km, from the southern boundary of the Map area to west of McDougalls Point, where it is truncated by the Grass River fault. This structure coincides with a prominent topographic linear in the Elbow Lake tonalite, produces a sinistral displacement of the tonalite-supracrustal contact, truncates and displaces F_3 fold axes, and clearly offsets the ELSZ on McDougalls Point. The fault probably has a significant vertical component of displacement: northeast of the fault the ELSZ is a single structure 600 m wide, whereas on the southwest side of the fault the ELSZ appears as two parallel shear zones 150 and 250 m wide. Nowhere does the fault plane outcrop; the fault zone is constrained by adjacent outcrops to be less than 20 m wide.

In addition to the conjugate northeast-northwest set of brittle faults, both the Centre Lake Domain and Long Bay Domain are also characterized by a set of north-trending, narrow, presumably brittle structures. These faults appear to be approximately the same age as the northeast-northwest set. Major north-trending structures include the Centre Lake fault (sinistral), Tee Lake fault (sinistral) and Long Bay fault (sinistral).

ECONOMIC GEOLOGY

Setting of gold deposits

The Elbow Lake area hosts a large number of gold occurrences (Preliminary Map 1991F-3), and has been intensively prospected since gold was first discovered in the district in 1921 (Stockwell, 1935). The setting of the deposits has been the subject of a number of investigations, summarized below.

Stockwell (1935) provides excellent, detailed descriptions of some 34 gold occurrences at Elbow Lake. He found that although some gold is associated with massive sulphides, the great majority of occurrences are in quartz veins within shear zones, commonly associated with felsic dykes. A genetic relation was held to be present between the gold deposits and large or small bodies of "quartz-eye granite" (now mapped as quartz-megacrystic tonalite).

McGlynn (1959) recognized two deposit types: quartz veins containing minor amounts of sulphides and gold; and, sulphide deposits with small amounts of quartz carrying minor gold and, in some deposits, copper and zinc. The quartz veins were found to occur in shear zones, most of which were parallel to regional fabric. The veins are commonly near small bodies of "quartz eye granite" or dykes of quartz-feldspar porphyry; McGlynn (1959) considered the relationship to reflect competency contrast control in the localization of shear zones and contained quartz veins. Sulphide deposits (disseminated and massive) are described to occur in schistose mafic rocks around the north end of Elbow Lake; these are dominantly iron sulphides with minor chalcopyrite and sphalerite. The gold occurs in quartz veins and lenses within the sulphides. McGlynn (1959) provides descriptions of 4 gold properties on Elbow Lake that had received attention subsequent to the investigation of Stockwell (1935).

Galley *et al.* (1987) report that gold occurs in epigenetic, sulphide-bearing, quartz-carbonate-albite veins in zones of intense deformation within the ELSZ or in discrete fault zones of similar age. Within the shear zones the mineralization is associated with felsic dykes, jasper-magnetite iron formation, mafic intrusions, and mafic or felsic phyllonite. Like McGlynn (1959), Galley *et al.* (1989) recognize that in most of the deposits mineralization is hosted by lithologies more competent than the surrounding rock. The host lithology is interpreted to have reacted in a more brittle fashion during shearing, providing open spaces for the formation of gold-bearing veins.

The emphasis of the current project has been on regional geology, so it is premature at this point to discuss controls on gold deposition at Elbow Lake. Of the 24 gold occurrences noted by Galley *et al.* (1987), fully 13, or 54%, occur within the Elbow Lake shear zone (as presently defined), 3 occur in or near northwest-trending conjugate structures, 3 occur in the north-trending fault set, 3 occur associated with northeast-trending structures, and 2 are in an unknown association. Century Mine, the only gold deposit to have been extensively developed, occurs in a northwest-trending structure that lies within or close to a mapped conjugate fault. Only two of the occurrences (the Mack and Van claims) lie in the Centre Lake Domain, and these are within about 400 m of the shear zone.

Potential for massive sulphide deposits

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 anomalous. Mapping in the Elbow Lake area will result in a more rigorous analysis of the massive sulphide potential.

One of the more significant results from previous mapping in the western Flin Flon belt is that the Amisk Group can be subdivided into arc tholeiite, back-arc, transitional and shoshonitic suites (Syme, 1990; Bailes and Syme, 1989; Syme, 1988). To date, massive sulphide deposits in Manitoba have been found only in the arc tholeiite portion of the Amisk Group. Similar results are reported from Snow Lake (Bailes, 1988). One of the objectives of this project is to investigate the geochemistry of the volcanic rocks at Elbow Lake, in order to determine which of the Amisk subgroups are present. Preliminary work, from samples collected in 1990, indicates that Webb Island basalts are similar to Flin Flon arc tholeiites, Claw Bay basalts are similar to Athapapuskow back-arc basalts, and McDougalls Point basalts are similar to Millwater transitional basalts. A more extensive sampling program was conducted during the 1991 field season. It is hoped that a confident geochemical subdivision of the volcanic rocks can be accomplished by fall 1992.

ACKNOWLEDGEMENTS

Assistance in the field and subsequently in the office was ably and cheerfully rendered by Reg Yaworski and Kyla King. J.B. Whalen (GSC) spent a month mapping granitoid rocks in the area (Whalen, GS-5, this volume). Alan Galley of the Geological Survey of Canada has graciously provided material from his field work at Elbow Lake in 1985-87.

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GS-5 ELBOW LAKE PROJECT - PART B: GRANITOID ROCKS

by J.B. Whalen*

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.

INTRODUCTION

As part of the post-fire mapping project being carried out by E. Syme in the Elbow Lake area (for location see Figs. GS-4-1 and 2 in GS-4, this volume), the author began this summer a geological and petrological study of the granitoid rocks. 1:20 000 scale geological mapping of the granitoids, which form about 50% of the rocks in the map area, is about 40% complete. In addition, petrographic, geochemical, isotopic (Nd, O and Pb) and U-Pb geochronological work is in progress. These granitoid studies will help constrain the timing of tectonic events and the tectonomagmatic evolution of the area. In addition, the economic potential of the various plutons is being evaluated.

The geological context of this area is outlined by Syme (1990; and GS-4, this volume). In general, the fire has vastly improved the quality and quantity of exposure in portions of the map area underlain by plutonic rocks. Metavolcanic rocks and related intrusions belonging to the Amisk Group are intruded by five separate granitoid plutons (Fig. GS-4-2), three of which are described below (see Preliminary Map 1991F-3).

DESCRIPTION OF PLUTONS

Big Rat Lake Pluton

The composite Big Rat Lake pluton covers an area of about 20 km^2 on the southwest side of the map area (Fig. GS-4-2). More than 75% of the outcrop area of this pluton has been examined, with only the areas bordering the west and south sides of Big Rat Lake remaining unmapped. Preliminary U-Pb zircon results on a sample of coarse grained, equigranular, hornblende-biotite granodiorite from the northeast margin of the pluton indicate that all phases are post-Missi (<1830 Ma) in age (P. Hunt, pers. com. 1991). Though all intrusive phases have a pervasive foliation primary contact relations can be established. Granitic units cut more mafic (diorite to granodiorite) varieties 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 diorite to granodiorite phases. The older, more mafic phases appear to be consanguineous components of a pluton, which 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 most felsic phases are exposed on the southwest side of the pluton. 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 cut only by some probably comagmatic granitic aplite dykes. Based on consistent variations in grain size, it has been subdivided into fine- to medium- and medium- to coarse-grained portions. A thin (100-500 meters), more biotite-rich and quartz-poor, hornblende-bearing marginal phase to this granite outcrops south of Separation Creek. This subunit is also characterized by the presence of ovoid to stretched (4 to 50 cm) fine grained, hornblende-biotite granodioritic inclusions, possibly reflecting marginal contamination or assimilation of older quartz diorite to granodiorite. Sharp intrusive contacts were observed between this younger marginal subunit and older medium grained granodiorite. This phase has not been identified north of Separation Creek, possibly because of poorer quality exposure in that area.

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 is variably foliated and sheared such that it is difficult to distinguish primary feldspar porphyritic texture from feldspar augen texture. From the margin inward there is a gradation in the granodiorite from coarse grained, equigranular through subporphyritic to porphyritic. As no intrusive contacts were observed between this granodiorite unit and other phases of this pluton, contacts are thought to be gradational. Adjacent to Elbow Lake, north of Separation Creek, these phases are apparently truncated by a fault. As the displaced or missing portions of the pluton have not been identified, this fault may be a fault with dip-slip movement, either normal or reverse.

Other units in the northeast portion of this pluton are uniformly medium grained and equigranular, but compositionally variable. There is variation from more felsic (quartz diorite to granodiorite) to more mafic (quartz diorite to diorite) toward the core. Boundaries were based on field estimates of quartz and mafic mineral content. Further work is required to resolve whether this reflects a regular zoning or pulses or batches of magma between which there are intrusive contacts or gradations over a short distance; based on work to date, the latter is thought to be the case.

There are a couple of areas of agmatite that consist of mainly rounded mafic igneous inclusions (5 cm - >3 m) in a matrix of diorite to quartz diorite (Fig. GS-5-1). Inclusions form about 40 to 60% of this unit. Some of these inclusions are obviously supracrustal rocks that 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, locally 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 the zoned units 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 normal displacement on this fault.

Echo Lake pluton

The composite Echo Lake pluton covers an area of about 16 km^2 on the northwest side of the map area (Fig. GS-4-2). Mapping of the southern portion of this pluton has outlined a number of phases, but further work is required to better resolve the nature and location of contacts. The northern end of this pluton has yet to be mapped. Though no radiometric age data are yet available, based on their massive character and ovoid outcrop pattern, phases in this pluton are thought to be the youngest in the area. These younger phases may be equivalent in age (1847 Ma; Gordon *et al.*, 1990) to plutons such as the Lynx Lake pluton south of Flin Flon that postdate regional D_2 deformation. Various subunits in 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 and well- foliated, coarse grained, hornblende-biotite granodiorite. Matrix grain size varies from very fine grained near the margins to medium grained in its interior. Textures exhibited by this unit, together with the presence of cross-cutting amygdaloidal mafic dykes, suggest that it was intruded at a relatively high level. Equigranular, coarse grained, hornblende-biotite granite occurs at a number of localities near the edge of the porphyritic granodiorite intrusion where it cuts both foliated and massive granodiorite. Its coarse grained texture and more felsic composition are

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Figure GS-5-1: *Ovoid mafic igneous inclusions in quartz diorite; agmatite unit of the Big Rat Lake pluton.*

unusual for what appears to be a marginal or contact phase of the granodiorite. It probably represents a younger phase that has been emplaced along the granodiorite contact, 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 phase 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 - 40%) of pyroxenitic inclusions. Pyroxenite occurs both as bands or schlieren and as massive angular blocks. Further mapping should enable subdivision from this unit of significant areas that consist almost exclusively of pyroxenite and melagabbro. 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 meters to a number of kilometers.

There is a close textural resemblance between the two more western phases. The division into two units is based on quartz content and the fact that the diorite to quartz diorite unit commonly contains mafic (basaltic or gabbroic) inclusions. In contrast, such inclusions are less common in the quartz diorite to granodiorite unit 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. Due to later deformation, these dykes generally can not be followed for any distance along strike. In contrast, only one generation of amygdaloidal basaltic dykes cuts the western massive granodiorite. These dykes can commonly be followed for up to 500 meters.

Elbow Lake pluton

The pluton covers an area of 250 km^2, only about 25% of which is located within the map area (Fig. GS-4-2). 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 which he considered to be the same age as other quartz-eye porphyritic plutons in the Flin Flon belt. This pluton does not contain the megacrystic quartz that is characteristic of other older subvolcanic tonalites, such as the Cliff Lake pluton and the tonalite on the eastern side of Elbow Lake. This fact and the lesser degree of deformation noted in this pluton versus the tonalite on the northeast side of Elbow Lake raises the possibility that the Elbow Lake pluton may be younger. Preliminary U-Pb zircon results from this pluton suggest that it is pre-Missi in age.

A number of reconnaissance traverses were carried out into the interior of this pluton from its northern and western sides. As well, exposures on the railway adjacent to the Grassy River south of the area were examined. This field work failed to identify distinctive mappable compositional or textural phases, a remarkable feature for such a large intrusion. There is some variation at the outcrop scale in the size and abundance of euhedral biotite phenocrysts and in the degree and nature of alteration. Further mapping of the central and eastern portion of the pluton may yet identify different mappable units.

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 the pluton there are areas of potassic alteration spatially associated with healed vein stockworks (Fig. GS-5-2). These veins have 1 to 3 cm selvages containing 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. Further field, petrographic and geochemical work is required to evaluate the nature of this alteration and its timing with respect to mylonite zones and quartz veining.

ECONOMIC GEOLOGY

In general, the vastly improved quality of outcrop resulting from the burn 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 to 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 (Fig. GS-5-2), areas with rusty quartz vein stockworks, and mylonitic shear zones, makes the Elbow Lake pluton the intrusion with the best economic potential. The northeastern zoned portion of the Big Rat Lake pluton and the southeastern foliated portion of the Echo Lake pluton also merit attention, based on the presence of cross-cutting faults and shear zones. The biotite granite phase in the Big Rat Lake pluton and the massive porphyritic granodiorite phase 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.

Figure GS-5-2: Potassic alteration veins cutting the Elbow Lake pluton; healed fractures have selvages containing pink-coloured feldspar and coarse grained secondary biotite.

CONCLUSIONS

Field work to date has outlined a remarkable diversity of granitoid rocks in this map area. Based solely on field observations (petrochemical and geochronological work is in progress), it appears unlikely that any of the five major plutons in the area are consanguineous portions of the same magmatic suite. In addition, it appears that a couple 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 was cut by various dykes prior to emplacement of a granitic phase. In the Echo Lake pluton, earlier gabbroic to granodioritic phases were penetratively deformed prior to emplacement of granodioritic to granitic phases. The high level nature of the younger phases in the Echo Lake pluton, as indicated by porphyritic textures in the granodiorite and amygdules in cross cutting mafic dykes, suggests that there may have been significant uplift and unroofing between the two magmatic pulses. Portions of plutons in the Elbow Lake map area merit prospecting to evaluate their precious metal potential.

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GS-6 GEOLOGY OF A PART OF THE NORTH STAR LAKE AREA (NTS 63K/15)

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

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.

INTRODUCTION

Detailed mapping of a part of the area burnt by forest fire in 1989 was initiated in 1990 (Trembath *et al.*, 1990a; 1990b). The mapping project was extended during 1991 to include more of the terrane underlain by supracrustal rocks (Fig. GS-6-1). Mapping was conducted using 1:5 000 scale airphotos and field data were plotted in the field on 1:5 000 mylar bases. The field maps have been digitized and are published at 1:10 000 scale as Preliminary Maps 1991F-1 and 1991F-2 .

Previous exploration in the area (A.F. 90488, 90489, 91607, 91608, 92828) indicated that the volcanic rocks had the potential to contain massive sulphide type deposits. In addition, Stockwell (1935) documented gold occurrences in the area southeast of North Star Lake. The present studies are designed to provide a detailed geological framework for evaluating the mineralization and to provide a geological base for a M.Sc. thesis, by the first author, on structural analysis of the area .

The area mapped in 1990 occupies the central portion of the map area (Fig. GS-6-1), therefore some information provided by Trembath *et al.* (1990a) is repeated here for completeness.

UNIT 1 'Contact Aureole'

The contact zone ('contact aureole') between the granodiorite and the volcanic and volcaniclastic sedimentary rocks is up to 700 m wide (Fig. GS-6-2). This zone consists of intermediate to felsic volcanic (sedimentary?) rocks that have undergone variable degrees of partial melting, *lit-par-lit* injection of granodioritic material, contamination, recrystallization, and intrusion by cross cutting granodiorite to aplitic dykes.

The western portion of this zone appears to be intermediate to dacitic in composition and the rocks are commonly banded. This banding, and the variable compositions that reflect the banding, appear to be the result of contamination caused by *lit-par-lit* injection of granodioritic material along the foliation. Rafts of country rocks in this portion of the 'contact aureole' are fine grained and composed of variable amounts of hornblende, plagioclase and quartz. The more intermediate country rocks can be slightly garnetiferous with red garnet aggregates up to 1 cm. This zone is also intruded by irregular and cross-cutting felsic dykes.

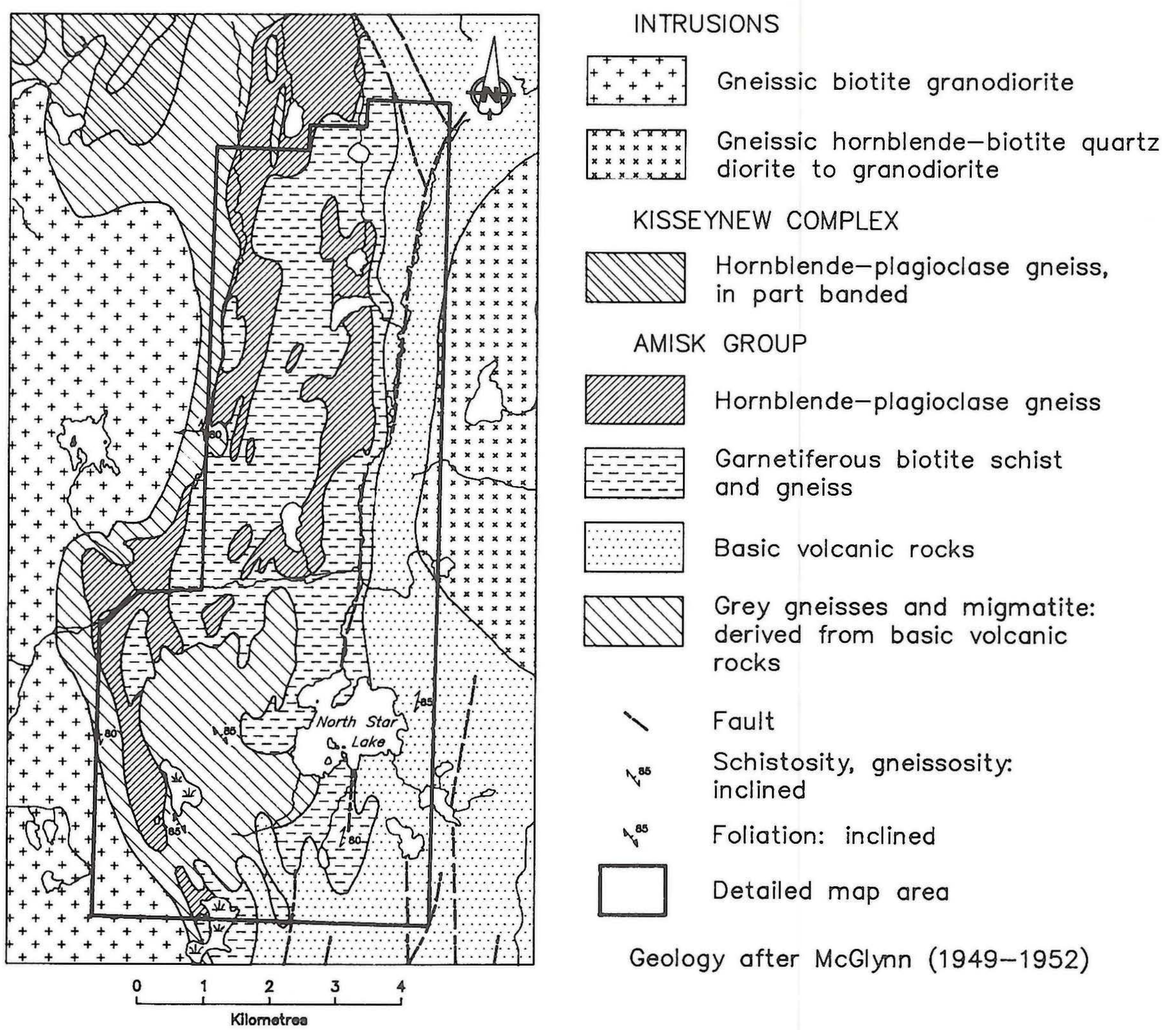

Figure GS-6-1: Geology of the North Star Lake volcanosedimentary belt (after McGlynn, 1959) and outline of area mapped at 1:5000 scale.

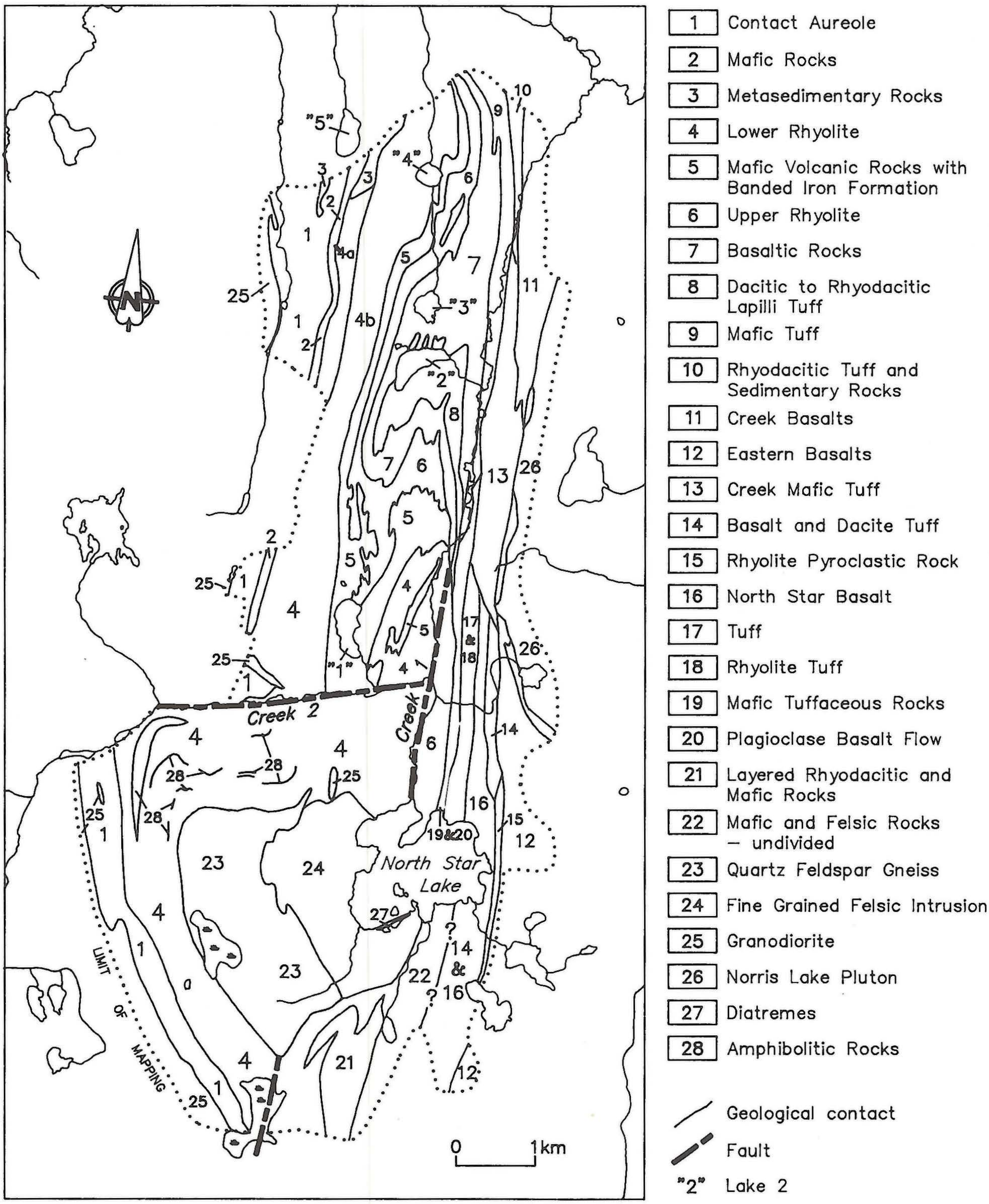

Figure GS-6-2: *General geology of the North Star area (after Norquay et al., 1991a: 1991b).*

The eastern portion of the 'contact aureole' consists mainly of felsic rocks that have undergone variable amounts of partial melting, as well as injection of granodioritic material into the highly irregular foliation. These rocks are fine grained and composed of quartz, muscovite, feldspar and biotite, as well as variable amounts of garnet and pale brown staurolite. Biotitic and garnetiferous mafic bands are common. Mafic layers are boudinaged and mafic xenoliths are present in the intrusive rocks. Cross-cutting granodioritic dykes are present, but not common.

UNIT 2 Mafic Rocks

This 150 m thick unit of predominantly intermediate to mafic, fine grained, medium grey to black amphibolite locally contains interlayered (infolded ?) fine- to medium- grained felsic layers. Both the amphibolitic and felsic layers are considered to be tuffs or tuffaceous sedimentary rocks. The amphibolitic rocks are composed of 50 to 80% amphibole, 20 to 50% plagioclase and minor quartz. The felsic rocks are quartz-rich with feldspar, muscovite, biotite and <2% fine- to medium- grained pale red garnet.

UNIT 3 Metasedimentary Rocks

This light to medium grey, fine grained, dacitic rock varies from near massive to finely laminated. It is composed of 75% feldspar, 10 to 20% biotite and 5 to 10% quartz. Locally, the rock is garnetiferous and red garnet aggregates up to 1 cm in size constitute up to 3% of the rock; garnet commonly occurs in metamorphic aggregates with feldspar and biotite. The rock is moderately foliated.

UNIT 4 Lower Rhyolite

This rhyolite unit is approximately 600 m thick, aphanitic to fine grained, varies in colour from slightly pink/orange to cream and in texture from massive to laminated/layered. This unit varies from massive rhyolite flows in the northern portion of the area to predominantly tuffaceous rocks in the area just north of Creek 2. The unit has been subdivided into three subunits: a) altered flows and pyroclastic rocks; b) flows and tuffaceous rocks; and, c) amygdaloidal flows.

a) Altered flows and pyroclastic rocks

These variably altered rhyolitic rocks vary in colour from grey to beige to cream; locally, there are areas of rusty weathered sulphide-bearing rock. This unit consists of tuff, lapilli tuff, tuff breccia and flows. The upper contact of this unit is distinguished by a marked visual change from altered to relatively unaltered rocks, as well as the presence of a rusty weathered layer up to 3 m thick.

The massive flow rocks and blocks in the tuff breccia are fine grained and aphyric. The less altered tuffaceous rocks are commonly indistinctly laminated and laminations are defined by up to 5% biotite whereas the more altered rocks in the unit contain up to 20% biotite and muscovite combined, and are moderately to strongly foliated. The uppermost part of this unit, which is well exposed west of Lake 2, is a 15 m thick distinctly layered zone of altered tuffaceous and chemical sedimentary rocks. Locally, this zone includes layers that consist predominantly of quartz and muscovite with pale brown staurolite and pale red garnet. One 50 cm layer within this zone contains up to 5% ghanite.

b) Flows and tuffaceous rocks

The northernmost exposures of this unit are predominantly flows with minor amounts of lapilli tuff, but towards the south there is a gradual increase in the amount of tuffaceous material. These rocks are either white grey or cream coloured, but locally they are slightly pinkish. Some sections are reddish or orange stained. Flow lobes are predominant in the northern portion of the unit.

The flows are cream coloured (commonly with a orange tint) aphanitic to fine grained, but locally quartz and/or feldspar phenocrysts can range up to 1 mm in size. The flows include weakly foliated to massive lobes that are commonly 2 to 3 metres thick. The lobes are generally lighter coloured and less foliated than the interlobe material. The lobes contain biotite wisps and finely disseminated biotite (up to 5%), whereas the remainder of the flow contains up to 10% biotite and commonly contains 1% garnet.

The interflow material is greyish and moderately foliated. It commonly contains round lapilli (<5 mm) particles composed of feldspathic material with a biotite-rich core as well as fine grained feldspar, quartz, biotite, ± muscovite, ± garnet.

The tuffaceous rocks, which are most common north of Creek 1, are fine grained, light grey to cream in colour and weakly foliated. Layering is indistinct, but locally can be distinguished on the basis of colour and variations in biotite and garnet contents; individual layers range in thickness from 10 cm to several metres. Biotite occurs as wisps that grade into laminations, but overall biotite constitutes 5 to 10% of the rock. These rocks include the 'biotite-rich volcanic rocks' and 'tuffaceous rocks' of Trembath *et al.* (1990a).

c) Amygdaloidal flows

These cream to white-grey rhyolites are generally aphanitic to very fine grained; quartz phenocrysts are rare. The unit is composed predominantly of rhyolite lobes that commonly contain ovoid cavities up to 1 cm in length and wisps (<2 mm) composed of fine grained biotite. The cavities are partially filled by biotite and quartz ± garnet. The interlobe material is medium grey, fine grained (<1 mm), has up to 10% biotite and in some sections is garnetiferous.

UNIT 5 Mafic Volcanic Rocks with Banded Iron Formation

Banded iron formation (BIF) occurs in a 100 m thick mafic volcanic sequence. In the southern portion of the unit the banded iron formation consists of two bands, 1 to 10 m thick separated by 1 to 30 m of mafic tuffaceous rocks. In the northern portion of the map area only one band of BIF has been recognized. Individual layers within the bands range from 1 to 120 cm thick. Compositional end members consist of: a) quartz; b) garnet (95%) -amphibole-chlorite-quartz; c) amphibole-chlorite ± quartz ± feldspar; d) magnetite (5-60%) - quartz; and e) green fibrous amphibole. In the southern portion of the unit a felsic layer associated with the BIF consists of plagioclase (50-90%), - quartz (<50%), - garnet (<5%), - acicular amphibole (<3%), - biotite (<10%), and - magnetite (<1%). Locally the BIF layers are repeated by isoclinal folds.

The volcanic rocks consist of massive to amygdaloidal basaltic flows, pillowed basaltic flows, amphibolites derived from these flows, mafic tuffaceous rocks, as well as a subordinate amount of intermediate flows and tuff. Massive, amygdaloidal and pillowed flows occur throughout the unit. Flow contacts are difficult to distinguish even where the massive portions are bounded by fragmental rocks, but massive portions of flows with 10 to 20 m thicknesses have been observed. Locally, pillowed flows, 3 to 20 m thick are interlayered with the massive and the amygdaloidal flows.

The flows and the amphibolites are fine grained, dark grey to black and are composed of 50 to 80% amphibole, 20 to 45% plagioclase and <5% quartz. The amygdaloidal rocks grade into and resemble the massive portions of the flows, but contain 5 to 35 percent subround amygdules. The amygdules are composed of plagioclase, quartz and minor biotite and/or amphibole.

The pillowed flows have distinct to indistinct pillow outlines. Pillows vary from a few tens of centimetres to 0.2 by 4.0 metres. Pillow rims consist of 1 to 3 cm thick dark coloured concentric zones. Locally, the pillowed flows contain epidosite altered pillow cores and epidosite lenses up to tens of centimetres in diameter.

Tuffaceous rocks are distinguished by their indistinct to distinct layers. Possible graded beds occur in a mafic lapilli tuff northeast of Lake 1. One to 5 cm thick tuffaceous layers of variable composition occur adjacent to the banded iron formation in the southern part of the unit near Lake 1.

UNIT 6 Upper Rhyolite

This 100 m thick unit consists predominantly of grey white/cream coloured to faintly brown or pink, very fine grained, near massive to indistinctly layered tuffs, and massive rocks with ovoid cavities. At several localities, for example 500 m northeast of Lake 1, there are distinctly layered tuffs. The near massive rocks with ovoid cavities are homogeneous and weakly foliated. Cavities in the massive rocks are usually <2 cm, but can range up to 7 cm in size, have smooth edges and have a thin quartz lining with cores that are commonly filled or partially filled by biotite. The near massive rocks are aphanitic to very fine grained and composed predominantly of feldspar and quartz; 1 mm quartz phenocrysts (tr-3%) occur locally. Near massive rocks appear to grade into amygdaloidal rhyolitic flows in the northern portion of the area (south of Lake 4).

Towards the south the massive rocks grade into rocks with 1 to 10 cm thick layers. These layers are defined by recessive weathering patterns and subtle changes in biotite content. Outcrops are limited in the third dimension, but the foliation commonly gives the impression of layers. The foliation planes (or planes of wide space cleavage/pressure solution) range from 3 to 20 cm apart and in some areas have an anastomosing pattern. This unit rarely contains rusty weathered zones.

The rhyolites of this unit are fine grained (0.1 to 0.5 mm) and consist of 35 to 70% feldspar, 20 to 50% quartz, 2 to 5% biotite, trace to 5% garnet and locally, trace magnetite. Locally, there are several tens of centimetre thick zones or bands that contain trace to 3% quartz phenocrysts (0.5 to 2.0 mm) and/or trace to 1% feldspar phenocrysts (<1 mm).

UNIT 7 Basaltic Rocks

This unit consists predominantly of medium grey to black, fine grained, massive to pillowed basaltic flows. These rocks contain epidosite pods and lenses up to several tens of centimetres in diameter that warp or deflect the foliation. Parts of this unit are monotonous fine grained amphibolites, but in the northern portion of the map area this unit consists of amphibolites with variable textures. In some parts of the unit, at the contact with Unit 8, there is a transition from basaltic flow rocks to polymodal fragmental basaltic rocks (unit 7b).

These basaltic flows are composed of 50 to 80 percent amphibole, 20 to 50 percent plagioclase with minor quartz and biotite. Locally, the amount of epidosite can range up to 10% of the rock. The amphibolites in the northern part of the map area include fine grained amphibolites, amphibolites with wisps of plagioclase and minor quartz, amphibolites with pyroxene megacrysts (≤15 mm), and amphibolite composed of up to 60% plagioclase aggregates up to 1 cm across. Epidosite pods and lenses occur in some of these amphibolites. Other amphibolites in this area have a gabbroic texture and are probably intrusions.

The fragmental basalts contain lapilli of amygdaloidal or porphyritic textured basaltic fragments. This unit contains some felsic lithic lapilli and is transitional into Unit 8. The fragments are supported by a matrix that is fine- to medium- grained, black and amphibole rich.

UNIT 8 Dacitic to Rhyodacitic Lapilli Tuff

This unit contains matrix supported lapilli to bomb sized dacitic to rhyodacitic fragments; andesitic fragments occur in some layers. The fragments, which constitute 20 to 50% of the rock by volume, are lineated and flattened with l >> s. The matrix is fine grained, composed of amphibole, biotite, feldspar and quartz and appears to be more mafic in composition than the fragments. Individual layers, defined by the range in size and the relative abundance of the larger fragments, vary in thickness from less than a metre to several tens of metres. The distribution of these rocks north of Lake 2 has not been delineated.

North of Lake 2 there is an area with strongly rusty weathered felsic rocks interfolded or interlayered with mafic rocks. One outcrop of felsic rocks has less rusty weathering rock and felsic fragments can be distinguished; this indicates that these rocks are probably the northern extension of Unit 8.

UNIT 9 Mafic Tuff

This dark green to black, amphibole-rich rock has vaguely defined layers that are distinguished on the basis of variations in plagioclase and quartz aggregate, and pyroxene phenocryst/megacryst concentrations. The layers vary in thickness from <1 cm to several tens of centimetres. Some layers contain mafic lapilli fragments that are lineated and flattened. The rock is characterized by a strong foliation.

The unit has abundant quartz veins that lie within the foliation. Epidosite pods and lenses lie in, but apparently postdate the foliation. The quartz veins are commonly boudinaged. The foliation is commonly crenulated.

UNIT 10 Rhyodacitic Tuff and Sedimentary Rocks

These beige, fine grained, laminated to bedded rocks are moderately foliated. Beds and laminations are determined by the relative amounts of biotite and feldspar. The rock is composed predominantly of feldspar, 5 to 25% biotite and up to 10% quartz. Towards the northern edge of the map area the unit has well defined beds that range in thickness from <1 to several centimetres.

UNIT 11 Creek Basalts

This unit is composed of dark grey to dark green fine grained, massive and pillowed basaltic flows and interlayered fine grained mafic tuff. The flows are generally massive, but locally they contain vaguely defined pillow outlines that have been flattened. Plagioclase and/or quartz filled amygdules are rare. The tuff layers are up to several metres thick and contain well defined laminations that are commonly 1 to 2 cm thick.

The rock consists mainly of amphibole (<60%) and feldspar (<40%). Up to 3 mm pyroxene megacrysts (<10%), and flattened to euhedral garnets (<5 mm) are present locally. Epidote occurs as discrete pods (<1 m long) throughout this unit.

UNIT 12 Eastern Basalts

This unit is composed of dark grey to dark green, very fine- to fine-grained, massive and pillowed basalt flows, flow breccia and tuff. Individual flows are several metres thick. Flow breccia is generally <4 m thick, and contains approximately 75% rock fragments that appear to be flattened in the direction of strike. Tuff is fine grained and is generally distinctly layered. Locally, feldspar phenocrysts occur in the flows. Epidote is a common constituent of the banded rocks (tuff), but is less common in massive and pillowed portions of flows.

UNIT 13 Creek Mafic Tuff

This grey to green, fine grained, laminated and massive mafic unit is predominantly tuff, but includes minor recrystallized flows. The laminations in the tuff are generally 1 to 4 mm thick. The rock is composed mainly of up to 60% amphibole and biotite and 40 to 50% feldspar. Megacrysts (<7 mm) of pyroxene locally constitute <5% of the rock. The laminated rocks commonly contain up to 5% garnet (<5 mm). Epidote-rich pods are rarely present, but hematite filled fractures are common.

UNIT 14 Basalt and Dacite Tuff

This unit of beige to green tuff has a maximum thickness of 250 m, and varies in composition from mafic in the north to dacitic in the south. The rock varies from thinly laminated (<1 cm) beige coloured felsic rock to fine grained black mafic layers. Locally, the rock has been silicified, elsewhere there are veins and lenses of quartz (up to 10 cm thick). This rock shows evidence of brittle deformation and small late faults are commonly found parallel to subparallel to rock layers. A shear zone (<5 m wide), which has been traced for approximately 650 m along strike, has disseminations and veinlets of pyrite (up to 2%) and chalcopyrite (trace).

UNIT 15 Rhyolite Pyroclastic Rock

This brown grey to greyish white rhyolitic pyroclastic unit is approximately 25 m thick in the south and up to 200 m thick in its northern extremity. The southern exposures include a 10 m thick western layer that consists of tuff breccia. Rock fragments are up to 5 x 25 cm , but are generally less than 2 x 20 cm; the largest fragments occur toward the centre of the tuff breccia layer. The rock fragments are white weathering and feldspar phyric whereas the matrix is grey weathered, biotitic and garnetiferous. The eastern part of this unit is fine grained, tuffaceous and becomes more thinly laminated towards its eastern margin. The northern part of this unit is a fine grained rhyodacitic rock with 20 to 40% white fragments that range in thickness from 2 to 4 cm and in length from 10 to 20 cm. Up to 5% garnets occur in the tuff matrix .

UNIT 16 North Star Basalt

This unit of grey to green basaltic flows is up to 200 m thick and consists of massive and pillowed flows, tuff and fragmental rocks. Individual flows, which are up to 10 m thick, commonly consist of a narrow basal fragmental zone, a massive zone that is overlain by distinct to indistinct pillows, and an upper zone of flow breccia and fine grained hyaloclastite and/or tuff. The tuff and fragmental zones are generally <3 m thick and can be followed along the general northerly strike of this unit. Locally, pillow shapes and flow organization indicate that tops are towards the west.

The flows contain up to 3 mm phenocrysts (5%) of feldspar and pyroxene (amphibolitized) in a fine grained groundmass that consists of approximately 50% amphibole and 50% feldspar. Near the western margin of the unit there are up to 2 cm quartz-filled amygdules and vugs.

UNIT 17 Tuff

This 200 m thick laminated to bedded tuff unit varies in colour from light grey to dark grey to brown. The composition of the unit varies from rhyodacitic to intermediate, but there appears to be more felsic material in the western part of the unit than in the east. Beds/layers up to 15 cm thick of very fine grained feldspathic material are common whereas laminations are commonly <3 mm thick and consist of fine grained biotite. Quartz veins and lenses, up to 10 cm thick, commonly strike parallel to laminations and bedding planes; minor faults commonly strike parallel or subparallel to the quartz veins.

UNIT 18 Rhyolite Tuff

This snow white to cream coloured rhyolite tuff has a maximum thickness of 75 m and has been traced along strike for approximately 2500 m. The rock is very fine grained and massive, but locally it is moderately to strongly foliated. Quartz and feldspar are the dominant constituents, but biotite (<10%) and garnet (<2%) are also present. Locally there are up to 15% quartz crystals (<8 mm in size) that exhibit a mineral lineation. Garnets are red, <1 cm

UNIT 19 Mafic Tuffaceous Rocks

This 100 metre thick unit is a dark grey to black, fine grained, layered mafic rock of variable composition.

Individual layers generally range in thickness from <1 cm to 5 cm and commonly are characterized by an abundance of plagioclase, pyroxene, or garnet. This unit differs from similar units in this area in that there is an abundance of white quartz veins (<5 mm), knots and lenses that are parallel or subparallel to layering in the rock. The quartz occurs mainly in several metre wide zones that also contain up to 80 cm long pods of epidote, which constitute about 20% of the zone. The contact with felsic tuffs to the west (unit 6) is either interdigitating or folded.

UNIT 20 Plagioclase Basalt Flow

This massive basaltic flow unit is less than 50 m thick and has been mapped for 450 m along strike. The rock consists of rounded to elongate aggregates of plagioclase (<1 cm) set in a fine grained groundmass of mafic composition. The aggregates range in composition from 5% to 20% of the rock. Pyroxene megacrysts (<1%) are not common.

UNIT 21 Layered Rhyodacitic and Mafic Rocks

South and southwest of North Star Lake there is a thick(?) sequence of fine grained layered rocks that are interpreted to consist of interbedded rhyodacitic rocks (tuffs?), mafic tuffs and mafic flows. The rhyodacitic layers vary in thickness from a few centimetres to 5 metres and in texture from well laminated to massive. The mafic rocks vary from fine grained layered amphibolite to feldspar porphyry with 2 mm plagioclase phenocrysts in a fine grained matrix of amphibole and feldspar. These rocks have been subjected to considerable deformation as evidenced by repetition of layers, well developed foliations and abundant boudinage and further work is required to elucidate the precursor rocks.

UNIT 22 Mafic and Felsic Rocks -undivided

This unit of mainly mafic volcanic rocks includes basaltic flows, and mafic and felsic tuff. The rocks in the area shown as unit 22 have not been systematically mapped and consequently their subdivision must await further fieldwork.

UNIT 23 Quartz Feldspar Gneiss

Medium grained pink-grey felsic gneiss is composed predominantly of quartz and plagioclase, but contains up to 20% biotite, 15% K-feldspar and 1% garnet.

The gneiss has a weakly to well developed foliation defined by micas and aggregates and rods of quartz and feldspar that are 4 to 10 mm in length. Locally, this unit resembles a felsic intrusion, whereas elsewhere it resembles altered felsic volcanic rocks.

UNIT 24 Fine Grained Felsic Intrusion

This unit consists predominantly of a grey, fine grained, massive to slightly foliated felsic intrusion that contains up to 90% quartz and feldspar and 10 to 15% biotite. Mafic xenoliths within this unit are medium grained, gneissic and range from <1 to >10 metres across. Some of the xenoliths probably represent boudinaged mafic dykes. Felsic rafts and blocks, up to tens of metres across, resemble felsic volcanic rocks. The xenoliths commonly exhibit a better developed foliation than the intrusion.

UNIT 25 Granodiorite

This unit, which occurs in the western extremity of the map area, is a pale grey to pale pink medium grained massive rock with up to 10% hornblende and/or biotite interstitial to quartz and plagioclase. On the east side of the intrusion dykes of this rock intrude amphibolitic and rhyodacitic rocks. Locally within the granodiorite, there are xenoliths of supracrustal rocks that are up to tens of metres across.

UNIT 26 Norris Lake Pluton

This medium grained massive hornblende-biotite-quartz-diorite pluton has been described by McGlynn (1959). At the contact with the volcanic rocks the intrusion has been contaminated by mafic volcanic rocks for several metres into the intrusion, but the number and size of partially assimilated xenoliths decrease inwards from the contact. Dykes of the same rock extend for up to 200 m into the supracrustal rocks. Although there is no obvious mineral fabric in the intrusion, there is a planar alignment of xenoliths that probably mimics the regional schistosity.

UNIT 27 Diatremes

Several diatremes occur south and west of North Star Lake (Preliminary Map 1991F-2). They occur in both volcanic and plutonic rocks and have widths of several metres to tens of metres, but a length of several hundred metres is inferred for the largest from outcrop distribution along the south shore of North Star Lake. Rock fragments in the diatremes are angular to subrounded, include amphibolitic, felsic volcanic, felsic intrusive, and metasedimentary rocks and range from <1 cm to several tens of centimetres. The matrix to the fragments, where present, varies in composition from ultramafic (amphibole) to felsic (quartz and feldspar).

UNIT 28 Amphibolitic Rocks

Foliated amphibolite occurs throughout unit 4, and in unit 6 adjacent to Creek 2 as several tens of centimetres to several tens of metres thick layers. Texturally, they vary from lineated massive amphibolite to irregular centimetre thick laminae. Locally, these rocks have a wispy texture defined by 1 by 15 mm white lenses that are deformed amygdales and/or plagioclase phenocrysts.

Although generally parallel to the foliation and layering in the rhyolitic rocks, the amphibolites also occur as slightly discordant sills and/or dykes. The amphibolites are not common in the upper rhyolite (unit 6) that structurally overlies the basaltic rocks of unit 5. Therefore, most of the amphibolites in unit 4 are interpreted to be genetically related to the immediately overlying basalts of unit 5 and to represent mafic tuffs, mafic flows or feeder dykes. Definitive volcanic textures were not observed in these amphibolites.

LATE FELDSPAR PORPHYRY DYKES

East-trending feldspar porphyritic dykes post date regional deformations. These dykes are characterized by up to 2 cm white feldspar (potassic ?) crystals, which constitute 50 to 80% of the rock, set in a dark brown matrix.

ALTERATION AND MINERALIZATION

Small areas and bands of metamorphosed hydrothermal alteration occur within the lower rhyolite. Biotite, chlorite, garnet and staurolite, and less commonly, kyanite and ferrogedrite (pseudomorphed by chlorite), were observed in zones characterized by <5 mm wide anastomosing fractures. South of Creek 2 there are several larger areas with dimensions of several hundred metres and similar mineralogy as above. In other places, there are 0.3 to 10 cm wide bands and small areas that contain variable amounts of biotite (5-15%), staurolite (tr-10%), garnet (tr-5%), chlorite (tr-3%), and feldspar more common then quartz; these zones occur within lithologic layers and are more than 100 m in length and up to 5 m thick. Less than 2 mm clots, or platelets, of muscovite cross-cut the main foliation of the lower rhyolite, particularly near and within rusty weathered areas.

Sillimanite occurs as aggregates up to 1.5 cm in size at one location 800 m west of Lake 3.

Rusty weathered zones and bands occur within the lower rhyolite west of Lake 1; trace to 1% pyrite was rarely found within these areas. One small area with trace to 2% pyrite and trace to 1% galena occurs within late vuggy quartz fractures and appear to be mobilizate in fractures that crosscut foliation. Traces of chalcopyrite were seen in a zone of possible silicification within the basalt.

At several locations in the northern portion of the map area there are occurrences of garnetite. These consist of up to 50% anhedral aggregates of pale red garnet (<4 cm) with the remainder of the rock composed of fine- to medium- grained quartz, biotite, muscovite and staurolite.

Structurally below the contact between the altered and relatively unaltered rocks of the lower rhyolite there is a zone of altered rocks, up to 150 m thick that was traced along strike for approximately 1500 m. 750 m west of Lake 2 there is a 15 m thick zone adjacent to the contact that contains layered rocks with abundant medium grained garnet, quartz, biotite and muscovite and one layer with ghanite; these rocks are interpreted to be a mixture of alteration products and pyroclastic rock. Adjacent to the contact there is a rusty weathered layer that is up to 3 m, but is usually <1 m in thickness. Where this zone is 3 m in thickness the structurally overlying rhyolite has distinctive orange to pink fine grained alteration that probably represents feldspathization. The feldspathized rock has late fractures that contain orange stains and fine to medium grained muscovite.

At the northern extremity of the map area there is a rusty weathered pyrite-bearing zone along strike from unit 4. In this area the rhyolites contain up to 3% fine grained muscovite, which imparts a sugary appearance to the rock.

GEOCHEMISTRY

Fourteen samples of rhyolite from map unit 4b were analyzed for major elements in the Energy and Mines Analytical lab. The SiO_2 contents range from 72.9 to 76.8%, Na_2O contents from 1.77 to 4.2%, MgO contents from 0.60 to 1.97% and K_2O contents range from 1.06 to 4.09%.

STRUCTURE

A distinctive structural feature in the area is a penetrative foliation (S_1) that is axial planar to isoclinal folds (F_1). Although F_1 structures with small amplitudes have been seen at several places throughout the map area, these structures are best developed within the BIF immediately northeast of Lake 4 (Fig. GS-6-3).

Folding of S_1 during the second deformation (D_2) produced open to tight folds (F_2) that have an associated vertical to subvertical axial planar spaced cleavage. A large F_2 S-fold is defined by units 5 to 8 in the area between Lakes 1 and 2 (Fig. GS-6-4). A similar S-fold can probably be outlined by unit 5 in the area immediately east of Lake 4. Pillows and lithic fragments deformed within S_1 define a l>>s fabric; the average ratios of the short, intermediate and long axes of lithic fragments in the area 600 m south of Lake 2 are 1:4:13 (Figs. GS-6-5, GS-6-6). This fabric was probably produced during D_2.

Refolding of S_1 during a third deformational event (D_3) produced several major and abundant minor Z-folds (F_3). A large F_3 structure occurs south of Creek 2 and a smaller structure deforms the limb of a F_2 structure south of Lake 4.

Figure GS-6-3: F_1 isoclinal folds developed in BIF, immediately northeast of lake 4.

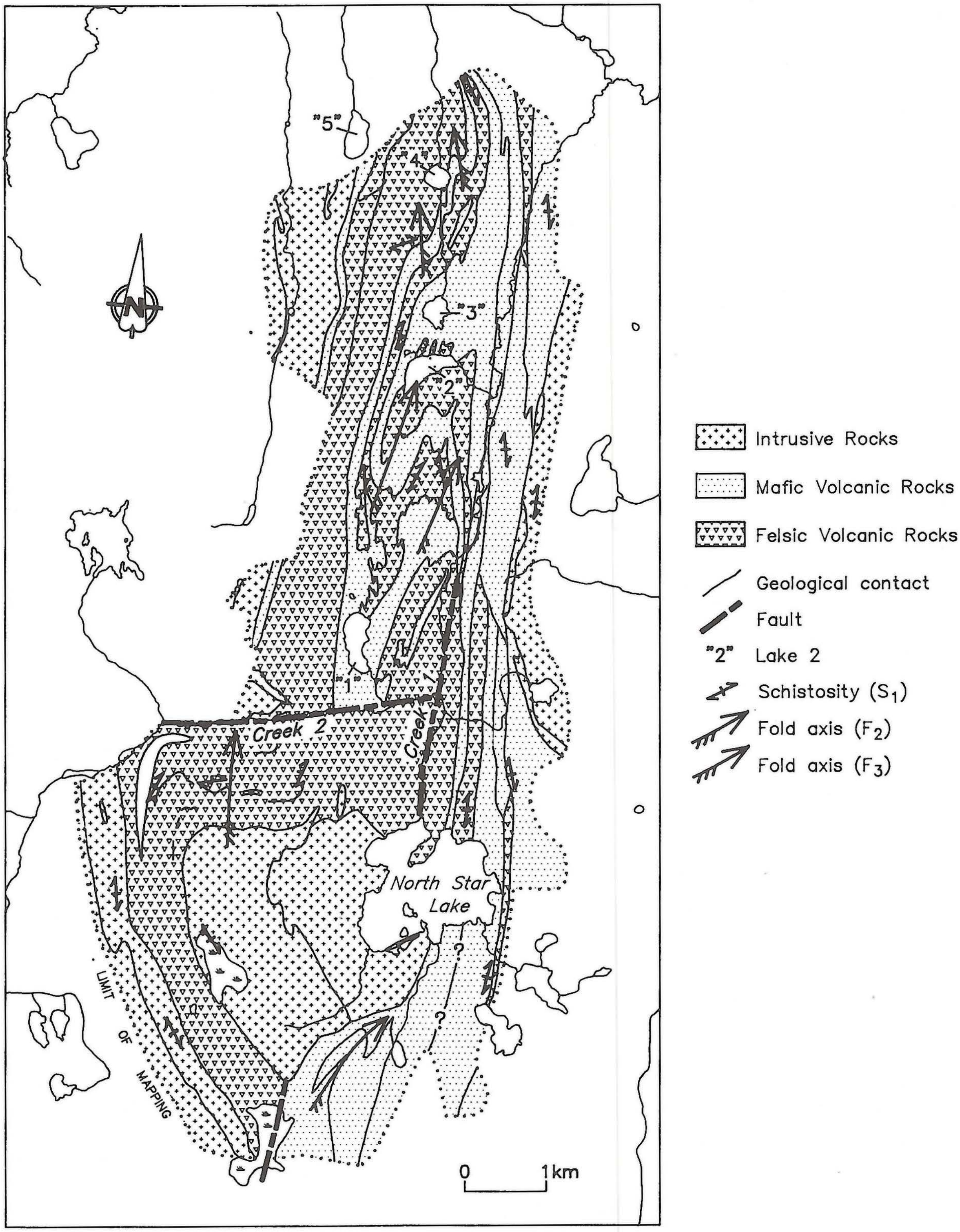

Figure GS-6-4: Schematic structural geology of the North Star Lake area.

Figure GS-6-5: *Long and short axes of lithic fragments, unit 8.*

An east-trending crenulation cleavage occurs locally in moderately to strongly foliated mafic rocks of units 7 and 9 in the northern portion of the map area.

There are at least three distinct ages of faults in the map area. The oldest faults, which postdate the S_1 fabric, are ductile, sinistral, and result in a slight warping of the S_1 fabric. These earliest faults usually strike 020° to 045° and have steep dips. Their relative age with respect to D_2 is unknown.

Younger faults in the area are brittle and have a predominantly sinistral offset. The older group of brittle faults usually strike 355° to 035° and have steep dips. They commonly contain fault gouge and at one location in unit 7 south east of Lake 4 pseudotachylite was observed.

The younger group of brittle faults predominantly have an east west azimuth and are steeply dipping, but their orientations can range between 055° and 135°. They commonly contain fault gouge as well as quartz, carbonate and epidote.

Although top determinations were noted in a number of places, systematic structural observations were not made and consequently facing directions are not known. In general, the long limb of the F_2 structure between Lakes 2 and 3 appears on the basis of the distribution of alteration to young towards the east. The north trending units northeast of North Star Lake are considered on the basis of flow morphologies to young westwards.

Figure GS-6-6: *Intermediate and short axes of lithic fragments, unit 8; down-plunge view of fragments (cf. Figure GS-6-5), same exposure as Figure GS-6-5.*

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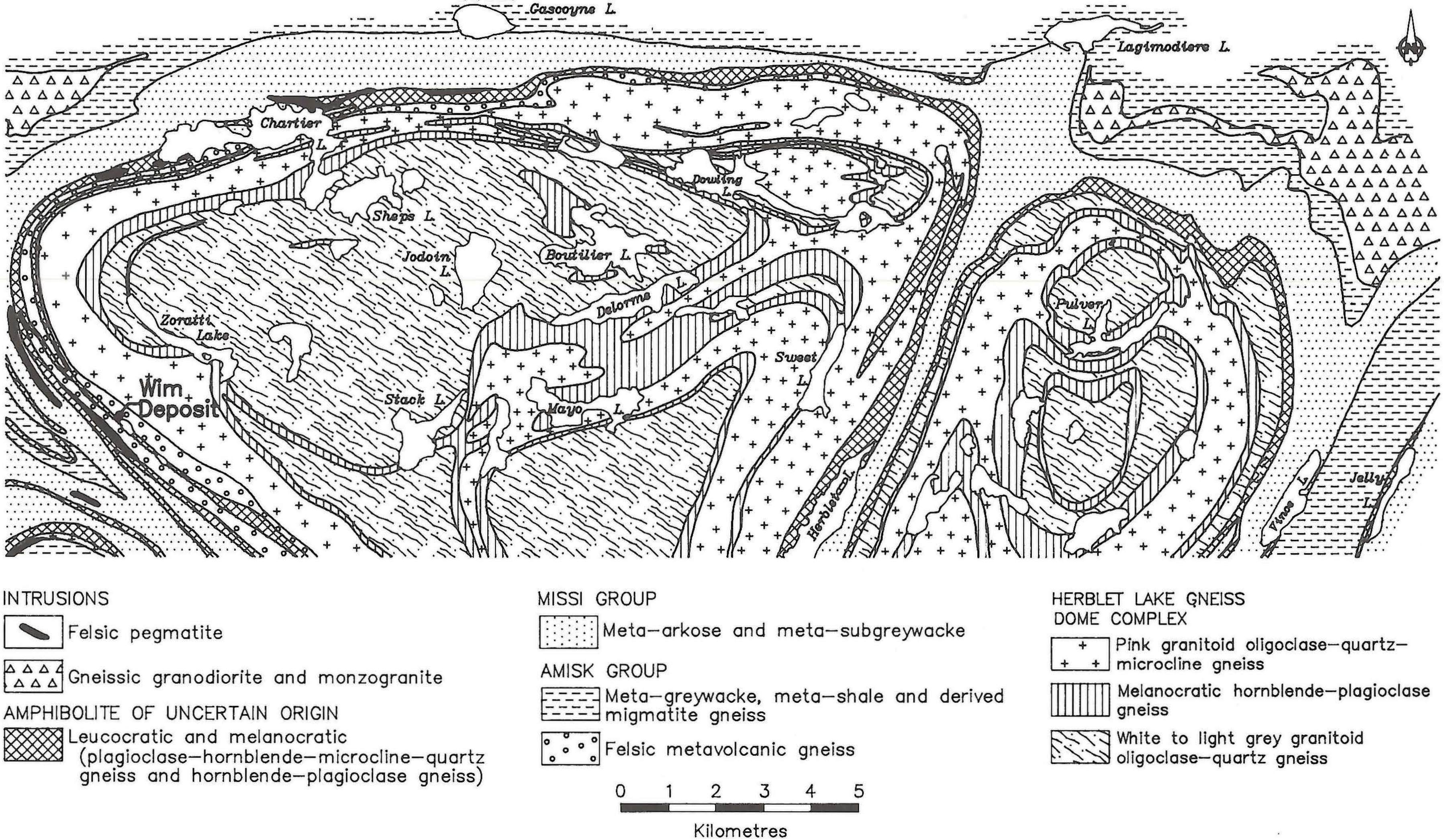

Figure GS-7-1: Location and regional geological setting of the Wim Cu deposit, Herblet Lake Gneiss Dome Complex.

GS-7 THE GEOLOGICAL SETTING OF THE WIM MASSIVE SULPHIDE TYPE CU DEPOSIT, SNOW LAKE AREA (NTS 63N/1)

by M.A.F. Fedikow and D. Ziprick

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, Minerals Division, Report of Activities, 1991, p. 41-42.

INTRODUCTION

The Wim Cu deposit occurs on the west flank of the Herblet Lake Gneiss Dome Complex approximately 16 km northeast of the town of Snow Lake (Fig. GS-7-1). The Wim deposit was discovered in 1962 by diamond drill testing of a ground EM anomaly outlined during the follow-up of an airborne EM survey flown in 1960. The mineralized zone is podiform with a maximum strike length of 305 m and a maximum width of 15.4 m. The mineralized zone dips 45° northeast at 034° Az and plunges 40° northwest at 344° Az. Undiluted geological ore reserve is 1,394,603 tonnes at 2.59% Cu, 0.4% Zn, 1.7 g/t Au and 8.2 g/t Ag.

Three weeks were spent mapping the gneisses in the immediate area of the deposit to ascertain the stratigraphic, structural and alteration characteristics of the host rocks to provide evaluation criteria for continued exploration in the gneiss domes. The map area is centered on three small lakes, Lake 1, Wim Lake, and Lake 2 (Preliminary Map 1991-S1).

STRATIGRAPHY

Bailes (1975) identified the host rocks to the Wim deposit as northwest-striking, northeast-dipping Amisk Group felsic volcanic gneisses, a stratigraphic unit that, in part, characterizes the rim gneisses to the Herblet Lake Gneiss Dome Complex (Fig. GS-7-1). Detailed mapping in the vicinity of the Wim deposit indicates these felsic gneisses can be subdivided into massive, aphyric fine- to medium-grained quartzofeldspathic ± biotite ± magnetite gneiss, quartz phyric rhyolite gneiss locally interlayered with rhyolite breccia, and quartz-feldspar-hornblende gneiss (Preliminary Map 1991-S1).

The aphyric, massive quartzofeldspathic gneiss, or massive rhyolite, is coarser grained adjacent to the contact with salmon pink orthoclase-quartz granitoid gneiss of the Herblet Lake Gneiss Dome Complex to the north of the deposit. South of the gneiss dome the massive rhyolite is interlayered with rusty weathered amphibole-plagioclase gneiss interpreted to represent mafic volcanic rocks. Disseminated iron sulphides, reflected by the rusty weathered nature of the amphibolite occur in an area characterized by a ground EM geophysical conductor (Preliminary Map 1991-S1). East of the deposit the amphibolite gneiss is altered to garnet-cordierite-anthophyllite along the trend of the geophysical signature of the Wim mineralized zone. Within the aphyric massive rhyolite, garnet-anthophyllite-pyrite alteration is observed on the north shore of Lake 1.

South of the deposit the aphyric, massive quartzofeldspathic gneiss is interlayered with quartz phyric rhyolite and rhyolite breccia. Phenocrysts in the quartz phyric rhyolite are rounded and 1 to 6 mm in diameter. Quartz phyric rhyolite is interlayered with monolithologic rhyolite breccia at the east end of Wim Lake (Preliminary Map 1991-S1). Rhyolite breccia is fragment supported with aphyric, elongate, unaltered angular rhyolite fragments. The fragments are lighter grey than the fine grained, aphyric siliceous matrix. The up-plunge surface projection of the deposit places the mineralization at or close to the contact between massive and quartz phyric rhyolite (Preliminary Map 1991-S1). A continuous, unaltered amphibole-plagioclase-magnetite unit south of the deposit is interpreted to represent a mafic intrusion.

At the southernmost extent of the map area massive aphyric quartzofeldspathic gneiss contains linear zones and diffuse patches of hornblende ± garnet. It is uncertain whether the amphibole-garnet zones in the rhyolite are related to the mineralizing process.

STRUCTURE

The rocks in the map area are foliated to gneissose; the salmon pink granitoid gneisses at the western edge of the gneiss dome are locally massive. The foliations trend northwest and have a moderately steep dip to the northeast; foliations shift to the north and northeast near the western end of the map area. This reflects the curvature of the rim gneisses around the northern edge of the gneiss dome. North-, northeast-, and northwest-trending lineations with 057° to 063° plunges were observed locally (Preliminary Map 1991-S1). The attitude of the northwest lineations is similar to the plunge of the Wim mineralization.

MINERALIZATION AND ALTERATION

The podiform or lensoid Wim orebody is characterized by recrystallized medium- to coarse-grained disseminated to solid pyrite, pyrrhotite, chalcopyrite and sphalerite. General proportions of the ore minerals are pyrite-trace to 70%; pyrrhotite-trace to 80%; chalcopyrite-trace to 40%; and sphalerite-trace to 7%. Chalcopyrite and iron sulphides are also present as fracture fillings, veinlets and laminae.

A variety of alteration types are present in outcrop as well as in drill core in the vicinity of the deposit (Preliminary Map 1991-S1). In outcrop, zones of iron oxide stain represent the predominant type of alteration, particularly in the general area of the up-plunge surface projection of the mineralized zone. Less common alteration types include garnet-cordierite-anthophyllite, muscovite-sillimanite and garnet zones along the north shore of Lake 2, 1 to 2 km south of the Wim deposit along the geophysical signature of the mineralized zone.

Exploratory drilling around the deposit intersected alteration with similar mineralogical constituents as those identified in outcrop. Medium- to coarse-grained anthophyllite-cordierite-sieve textured garnet with chalcopyrite cores and disseminated and vein chalcopyrite and pyrrhotite were intersected over core lengths of 15 to 20 m down plunge from the mineralized zone. Zones of "quartz-hornblende" gneisses identified in logs from holes drilled in the 1960's may refer to the anthophyllite-rich nature of the Wim alteration. The spatial relationship of the quartz-hornblende gneisses to the mineralized zone is indicated in Figure GS-7-2, a southeast looking cross section through the deposit. This cross section was constructed using HBED drill logs from 1960's drill holes supplied by HBED (Snow Lake).

CONCLUSIONS

The Wim Cu deposit is a disseminated to solid sulphide massive sulphide type deposit with a well developed alteration conduit. The deposit occurs at or near the contact between massive and quartz phyric quartzofeldspathic gneisses that are metamorphosed equivalents of rhyolitic pyroclastic and volcaniclastic rock mapped to the south in the Angus Bay-Wolverton Lake area by Froese and Moore (1980). The presence of rusty weathered rhyolites to the north in the Chartier Lake area, and to the south in the Wolverton Lake area, as well as drill-indicated graphite-iron and base metal sulphide layers in these rocks, indicate the presence of a regionally active mineralizing system(s) or aquifer(s). Residual exploration of the Wim rhyolites on the rim of the Herblet Lake Gneiss Dome Complex should concentrate on the down plunge extensions of previously defined mineralized zones.

ACKNOWLEDGEMENTS

Jerry Kitzler and Bill Salahub of Hudson Bay Exploration and Development Co. Ltd. (Snow Lake) are thanked for access to drill core from the Wim deposit. Liberal use has been made of a preliminary map of the Wim deposit area, including the location of some outcrop and alteration zones. This map was constructed by D.V. Ziehlke; permission from HBED to make use of this information is gratefully acknowledged.

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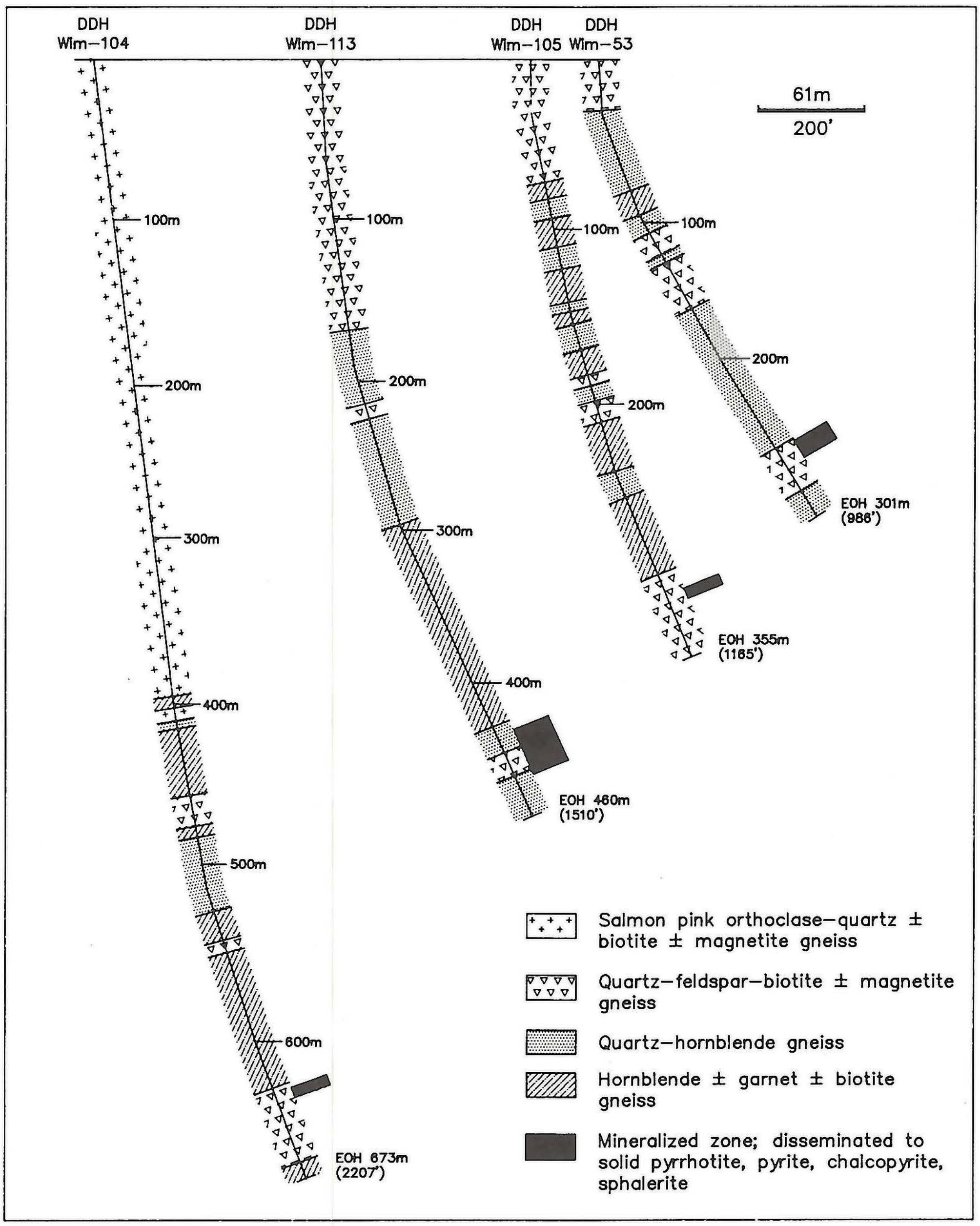

Figure GS-7-2: Geological cross section through the Wim Cu deposit. Section looks southeast.

GS-8 SEDIMENT-HOSTED ZN-CU (BUR ZONE) AND ZN-PB-AG (KOBAR/RUBY) MASSIVE SULPHIDE TYPE DEPOSITS, SNOW LAKE AREA (NTS 63J/13)

by M.A.F. Fedikow

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.

INTRODUCTION

Base metal massive sulphide type deposits in the Snow Lake mining camp (Anderson, Stall Lake, Rod, Linda, Osborne) have been demonstrated to occur within felsic to mafic volcanic and volcaniclastic rocks (Coats *et al*; 1970; Walford and Franklin, 1982; Studer, 1982; Zaleski and Halden, 1988; Bristol and Froese, 1990). The Bur Zone Zn-Cu deposit is a sedimentary rock hosted massive sulphide type deposit that occurs in Amisk Group epiclastic rocks. The Bur Zone deposit, discovered in 1980 by fill in diamond drill testing of a long strike length ground EM conductor, lies beneath a small lake and has no surface expression. Descriptions of the Bur Zone host rocks, mineralization and alteration are taken from drill logs, drill core logging and outcrop examination in areas adjacent to the mineralized zones. The Kobar Zn-Pb-Ag massive sulphide deposit occurs in a calc-silicate/epiclastic sedimentary sequence although alteration and the paucity of outcrop make the exact determination of the depositional environment for this deposit equivocal.

GEOLOGICAL SETTING OF THE DEPOSITS

The stratigraphic succession that includes the host rocks to both the Kobar and Bur Zone deposits has been assigned to Amisk Group greywacke, shale and siltstone (Froese and Moore, 1980) and also has been mapped as garnetiferous biotite gneisses and schists of sedimentary origin (Frarey, 1950). The northeast extension of these rocks was mapped as probable Missi Group arkose and subgreywacke (Bailes, 1975; Fig. GS-8-1).

The Bur Zone occurs in a thin wedge of greywacke-siltstone-argillite sandwiched between a composite intrusion to the west and a major granite intrusion to the east. The epiclastic sedimentary rocks continue along strike to the northeast and are characterized by long and short strike length ground EM conductors.

The Kobar deposit is a small noneconomic base and precious metal deposit that is exposed in a 50 m^2 area. Prior to overburden removal the deposit was buried beneath 1 to 2 m of clay-rich overburden. The deposit is hosted by calc-silicate and epiclastic sedimentary rocks that are situated adjacent to Amisk Group quartz phyric rhyolite and separated from Amisk Group(?) epiclastic sedimentary rocks by the McLeod Road Thrust Fault (Fig. GS-8-1). The rhyolites are intruded by white and pink felsic pegmatites and a composite gabbro-diorite-granodiorite intrusion. The epiclastic rocks are flanked to the east by a large granite intrusion.

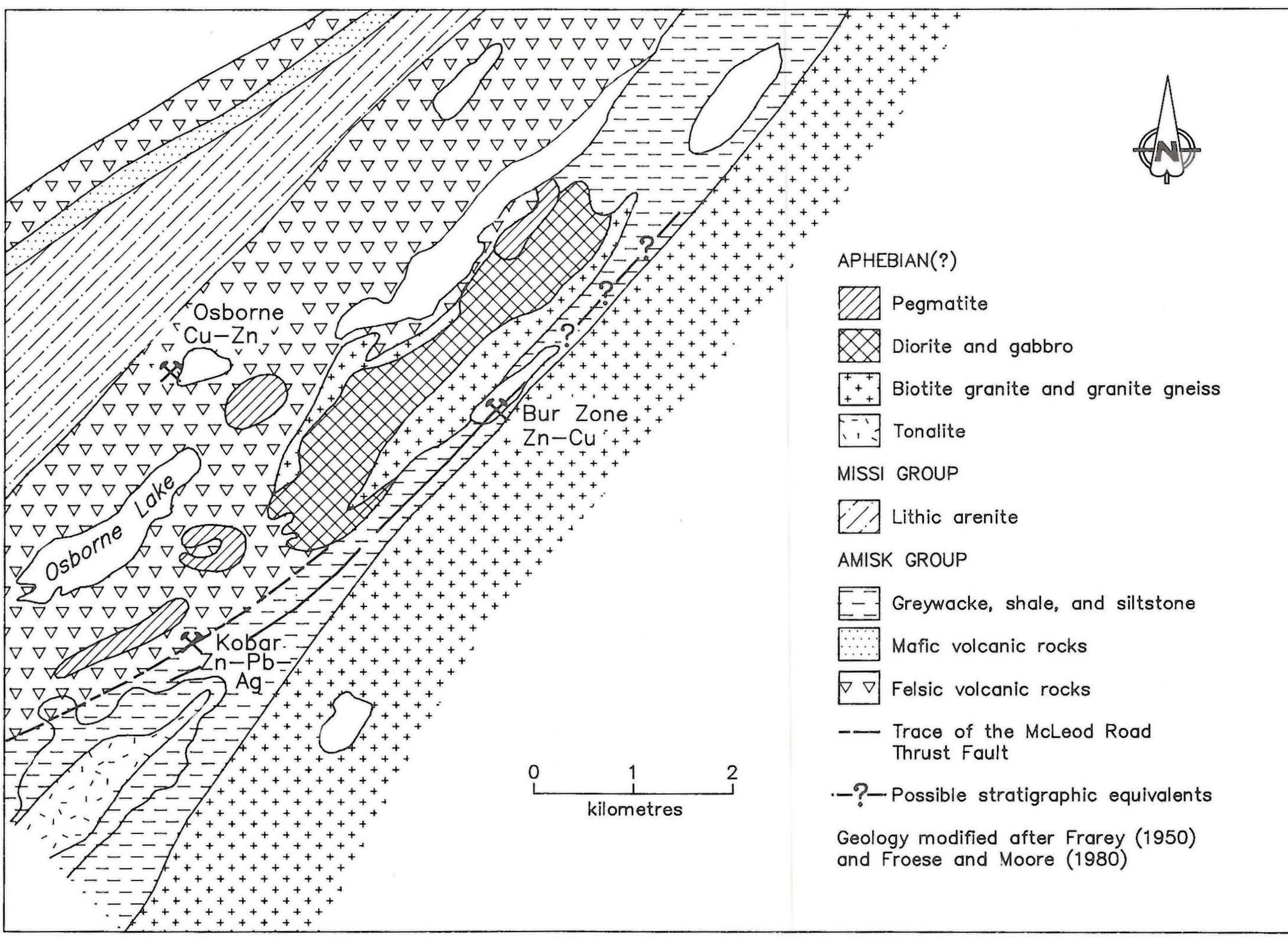

Figure GS-8-1: Regional geological setting of the Bur Zone, Kobar Zn-Pb-Ag and Osborne Cu-Zn massive sulphide type deposits, Snow Lake area.

Kobar Zn-Pb-Ag Deposit

Froese and Moore (1980) place the Kobar deposit on the north side of the McLeod Road Thrust Fault in Amisk Group rhyolite (Fig. GS-8-2). Examination of thin sections from the washed exposure at the deposit, and logs of holes drilled in and around the deposit, indicate the host rocks are calc silicates, greywacke and siltstone. The diamond drill holes, collared to test long and short strike length ground EM conductors (Fig. GS-8-3) intersected interlaminated biotite-, sericite-, sericite-chlorite ± graphite, graphite-, and garnet-biotite gneisses and schists. These rocks have been silicified, mineralized and are interlayered with quartzite, graphitic quartzite and limestone. Granite, syenite, aplite, hornblendite and pegmatite intrusions are common in the drill core (C.A.F. 90068, 90069, 90089). Detailed mapping around the mineralized zone places the mineralization at or near the contact between epiclastic/calc-silicate rocks and the quartz phyric rhyolite (Fig. GS-8-3).

Mineralization and Alteration

Mineralization at the Kobar deposit is characterized by disseminated to near solid sphalerite, galena, chalcopyrite, arsenopyrite, pyrite and pyrrhotite within garnet-biotite gneiss and schist (greywacke), garnetiferous quartzite and quartz-biotite gneiss (siltstone) and calc-silicate (altered limestone described in drill core?). Pyrrhotite, pyrite and galena also occur as blebs, veinlets, fracture fillings and disseminations in white quartz veins within the sulphide mineralization. These styles of mineralization are interpreted to represent sulphide mobilizate.

Polymetallic sulphide mineralization is documented from core intervals of variable lengths in many lithologies intersected by the diamond drill holes. Typical mineralized core intervals are: 1) 14 m of biotite-garnet gneiss with disseminated sphalerite and pyrite; 2) 3.2 m of garnetiferous quartzite with disseminated sphalerite, pyrite and galena; 3) 0.3 m of near solid sphalerite overlain by 0.4 m of pyritic quartzite and underlain by biotite gneiss with disseminated pyrite and sphalerite; and 4) 5.3 m of quartz-biotite gneiss with disseminated pyrite, chalcopyrite, sphalerite, arsenopyrite and galena. Numerous graphitic lithologies varying in core length from 0.3 to 11.9 m were also intersected.

Table GS-8-1 gives the results of the analysis of nine representative samples collected from trenches and dumps at the Kobar deposit. In addition to high Cu, Pb, Zn and Ag the mineralization also contains 3 to 195 ppm Cd, 59 to 663 ppm Sb, 2 to 11 ppm Bi, 5 to 38 ppm Co (analysis by ICP-AAS) and 50 to 9000 ppb Hg (analysis by hydride/AAS). Despite conspicuous Hg enrichment in the mineralization a mercury vapour survey conducted over the deposit was negative (Fedikow and Amor, 1990).

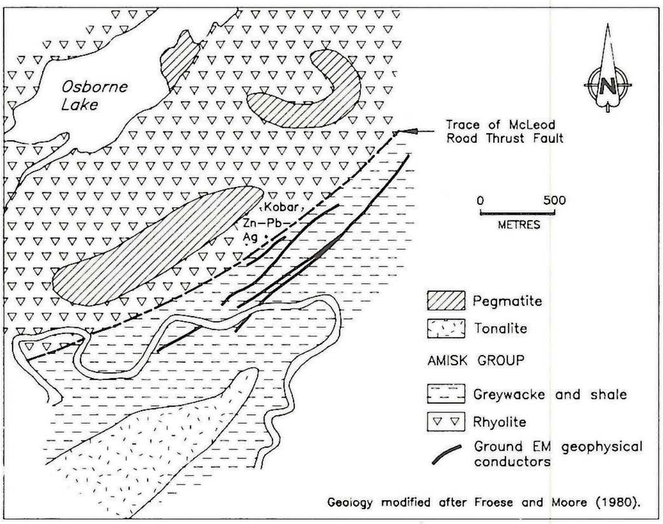

Figure GS-8-2: General geological setting of the Kobar Zn-Pb-Ag massive sulphide type deposit.

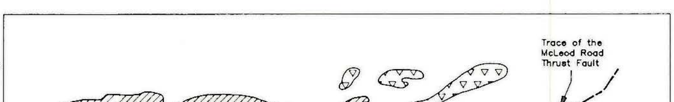

Figure GS-8-3: Detailed geology of the Kobar Zn-Pb-Ag massive sulphide type deposit.

Bur Zone Zn-Cu Deposit

The Bur deposit (Fig. GS-8-4) occurs at or near the contact between interlayered garnetiferous and biotite greywacke-siltstone and argillite (Fig. GS-8-5). Graphite-pyrite layers in the argillite represent a geophysically and lithologically distinctive marker unit. The graphitic beds have a maximum of 20% pyrite and 3 to 5% sphalerite. Sections of the argillite have muscovite-rich layers with disseminated chalcopyrite. Locally, a calc-silicate mineral assemblage of grossular, diopside and calcite is associated with the mineralization and is also observed in outcrop south of the McLeod Road Thrust Fault (Fig. GS-8-3). The intrusion on the northwest shore of "Bur" Lake is a composite foliated intrusion with rafts of epiclastic sedimentary rocks. The intrusive phases are texturally uniform and unaltered, except for late joints and fractures that are rusty weathered and locally altered to a quartz-epidote-potassium feldspar assemblage.

Mineralization and Alteration

The Bur Zone deposit is characterized by a disseminated to solid zinc-rich sulphide assemblage with 1 to 95% sphalerite, 1 to 10% chalcopyrite, trace to 3% galena, trace to 2% arsenopyrite and trace to 5% pyrite. Sphalerite and chalcopyrite are predominantly fine grained, whereas galena and arsenopyrite occur as medium- to coarse-grained blebs, laminae and discrete subhedral to euhedral crystals. The ore contains 15 to 20%, 0.5 to 1 cm "chert balls" consisting of silicified wall-rock and late quartz vein fragments. This texture is interpreted to have resulted from late tectonic overprinting of the deposit.

The deposit appears to be distal with areally restricted visible alteration. Fine grained, siliceous beds interlayered with the mineralization are interpreted to represent silicified greywacke and siltstone. Within 10 to 15 m of the mineralization the host rocks contain very fine grained, disseminated iron sulphides and possible sphalerite. Thin laminae and irregularly shaped white quartz veins appear within 20 m of the deposit and may be accompanied by thin wisps and/or grains of arsenopyrite. An alteration pipe or conduit to the deposit was not observed in drill core.

CONCLUSIONS

The Bur Zone Zn-Cu and Kobar Zn-Pb-Ag deposits are examples of epiclastic sedimentary rock hosted massive sulphide type mineralization. The environment of deposition for these deposits is different from that of presently and past producing base metal deposits in the Snow Lake mining camp and, as such, demonstrates the need for

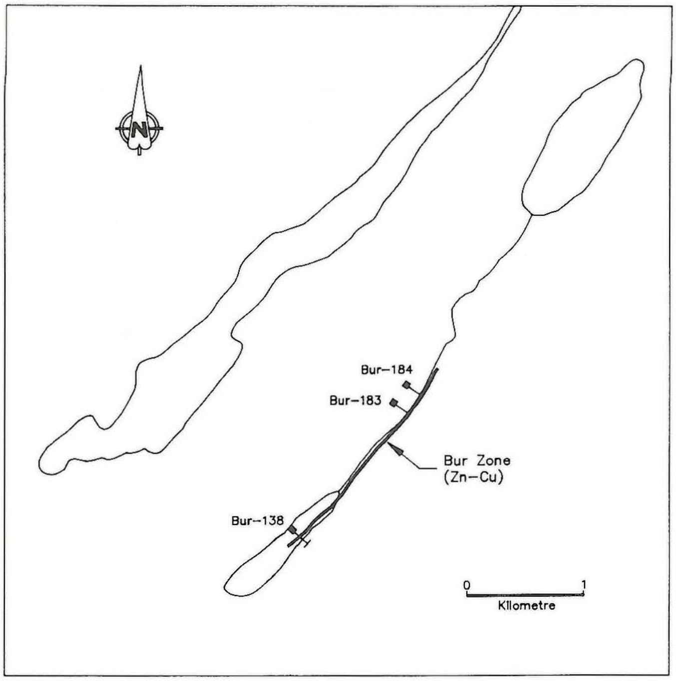

Figure GS-8-4: *Location map for the Bur Zone Zn-Cu massive sulphide type deposit and the drill holes logged and sampled for this study.*

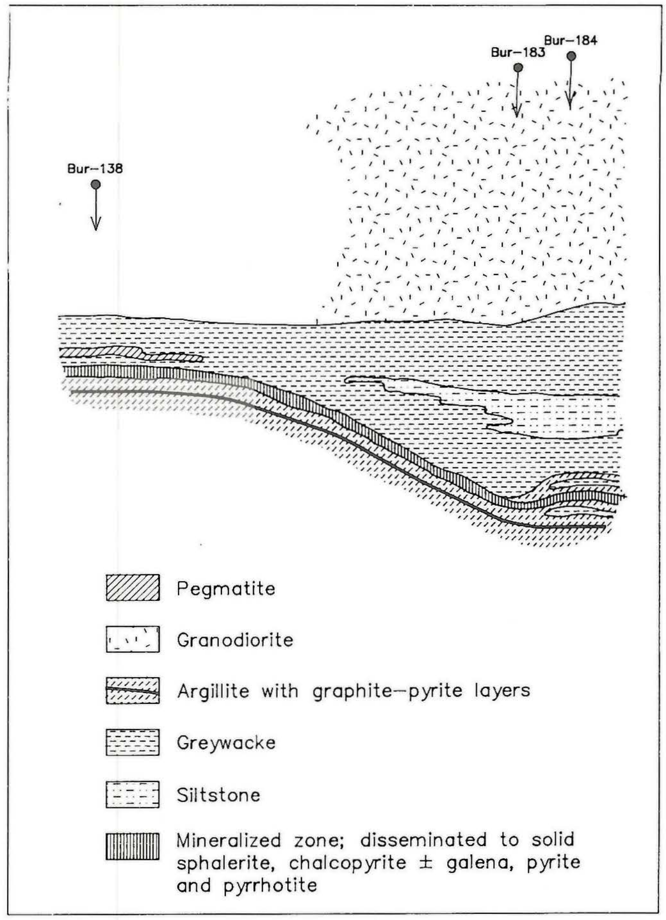

Figure GS-8-5: *Generalized cross section through the Bur Zone Zn-Cu massive sulphide type deposit. Section looks northwest.*

the inclusion of this type of depositional environment in any base metal exploration program. Of particular relevance to mineral exploration in this area is the northeast extension of the Bur Zone and Kobar deposit host rocks and the occurrence of multiple ground EM conductors in these and similar rocks (cf. Fig. 19; Bailes, 1975).

The occurrence of calc-silicate and epiclastic rocks in drill core and outcrop on both the north and south sides of the McLeod Road Thrust Fault is problematic. The long curvilinear swamp, which separates the predominantly rhyolitic rocks to the north from the epiclastic rocks to the south, may not represent the topographic expression of a thrust fault. Alternatively, the calc-silicate zones may represent zones of metamorphosed carbonate alteration along a splay or subsidiary fault to the McLeod Road Thrust Fault.

ACKNOWLEDGEMENTS

Jerry Kitzler, Hudson Bay Exploration and Development Ltd. (Snow Lake) is thanked for access to Bur Zone drill core as well as for discussions regarding the deposit and its depositional environment.

Table GS-8-1
Summary of ICP-AAS analysis of nine representative samples collected from trenches and dumps at the Kobar Zn-Pb-Ag deposit

Sample	Cu (ppm)	Ni (ppm)	Pb (%)	Zn (ppm)	Au (g/t)	Ag (g/t)
00621	928	nd	4.81	10.98 (%)	tr.	250.3
00622	0.10 (%)	62	6.00	14.45 (%)	tr.	302.0
00623	315	49	0.48	906	tr.	23.3
00624	0.10 (%)	nd	8.00	16.7 (%)	tr.	384.7
00625	419	65	2.03	17.5 (%)	tr.	92.9
01414	0.10 (%)	46	6.80	14.15 (%)	0.7	325.7
01423	60	110	0.11	133	tr.	6.0
01424	327	111	1.25	27	tr.	52.8
01425	71	12	0.97	436	tr.	48.3

nd - not determined

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GS-9 TILL GEOCHEMISTRY OF THE SNOW LAKE-FILE LAKE AREA (NTS 63K/16, 63J/13)

by G. Gobert* and E. Nielsen

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.

INTRODUCTION

Regional till sampling was resumed in the Snow Lake area to expand on the sampling that was started in 1990 as part of the EXTECH program (Gobert, 1990). The regional sampling covers parts of 63K/16 and 63J/13 and completes the sampling that will be reported through the EXTECH program.

In addition to the 108 sites sampled in 1990, 159 till samples from 145 locations were collected along with 142 humus samples during the past summer (Fig. GS-9-1). The till samples averaged 7 kg of predominantly unoxidized "C" horizon material collected from hand-dug holes. The humus samples averaged 0.5 kg each.

SURFICIAL GEOLOGY

Four and possibly five glacial advances are recorded by striae trending 270°, 210°, 190° and two separate advances toward 160°. Fabric analyses indicates the most commonly occurring till in the area is related to the 210° trending striae (C. Kaszycki, pers. comm., 1991). The till is generally noncalcareous except for minor occurrences of calcareous till that outcrop primarily northwest of Wekusko Lake. The calcareous till was derived from lower Paleozoic bedrock outcropping east and north of Ponton and transported into the Wekusko Lake area by late glacial ice flowing towards 270°.

*Geological Survey of Canada

ANALYSIS

Geochemical analysis of the <2 micron and the <63 micron fractions will be undertaken using the procedures employed for the 1990 samples.

Petrographic examination and black lighting will be undertaken on the heavy mineral fractions of all the samples.

The humus samples will be prepared and analysed by the methods outlined by Ferreira and Fedikow (1990).

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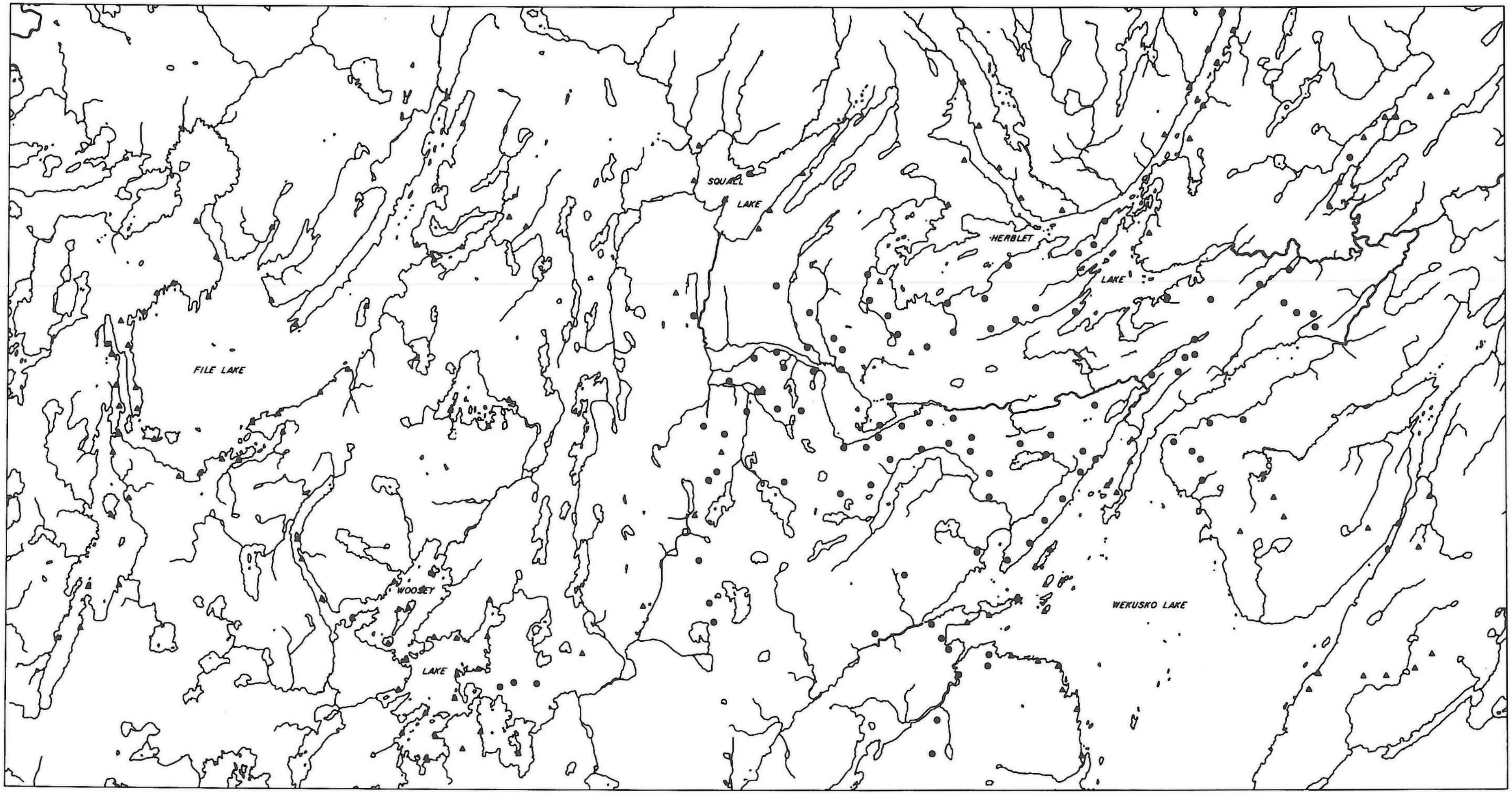

● 1990 Sites ▲ 1991 Sites

Figure GS-9-1: *Till sample sites in the Snow Lake-File Lake area. (• 1990 Sites, ▲ 1991 Sites)*

GS-10 GEOLOGY OF THE ENGLISH BROOK AREA, SOUTHEASTERN MANITOBA (NTS 62P/1)

by W. Weber

Weber, W., 1991: Geology of the English Brook area, southeastern Manitoba (NTS 62P/1); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities 1991, p. 49-52.

INTRODUCTION

Fieldwork in the English Brook area was continued this year (*c.f.* Weber, 1990). Traverses were undertaken to: obtain better control on unit contacts, collect structural data related to the deformation history of the area (specifically relative movements along faults, etc.), obtain a better understanding of the geology of the English Lake magmatic complex, and to assess the mineral potential of the area.

GENERAL GEOLOGY

Supracrustal Rocks

The supracrustal rocks of the English Brook area are in general similar to those of the Rice Lake Group in the Bissett area (Weber, 1990). Similarities with defined formations of the Rice Lake Group are discussed under the respective rock units.

METAVOLCANIC ROCKS

The metavolcanic rocks (V, Fig. GS-10-1) comprise mainly massive and pillowed metabasalt intruded by synvolcanic(?) medium to coarse grained gabbro. Intense shearing has obliterated pillow structures on most outcrops and these features would not be identifiable were it not for the excellent exposures resulting from the 1989 forest fires.

Felsic pyroclastic flows occur locally, but lack of exposed contacts with the mafic volcanic rocks do not give any indications as of their respective age (or stratigraphic) relationships.

An unique rock unit occurs east of the English Brook campsite. Where sheared, the unit has a pseudo-fragmental texture consisting of plagioclase-rich 'fragments" in an amphibole-garnet "matrix". The corresponding unsheared rock is a massive mafic flow or fine grained gabbro that has undergone hydrothermal alteration, preferentially along a fracture set. These altered fractures correspond to the amphibole-garnet "matrix" in the sheared rocks. This type of alteration indicates the possibility for volcanogenic massive sulphide deposits; however, no sulphides were encountered.

METASEDIMENTARY ROCKS

The metasedimentary rocks (S, Fig. GS-10-1) consist of interlayered lithic greywacke and mudstone-argillite. Lithologically the succession is similar to the Edmunds Lake Formation south of Long Lake (*c.f.* Weber, 1971), except it is compositionally more uniform and thicker bedded. Iron formation or conglomerate, typical for the Edmunds Formation south of Long Lake, were not observed and quartz-rich beds are very rare. In the centre of the metasedimentary belt (Fig. GS-10-1), where deformation is minimal (see Weber, 1990), the original sedimentary features of the succession are best preserved. It is thick-bedded, with greywacke beds 1 to 8 m (generally 3-5 m) thick and mudstone beds 0.5 to 1 m (rarely up to 2 m) thick. Near the (sheared) contacts with the metavolcanics and the tonalite, the succession is highly transposed, the beds are much thinner, with 10 cm beds of greywacke, and even thinner argillite beds. Primary depositional structures include poorly graded beds. A lack of soft sediment

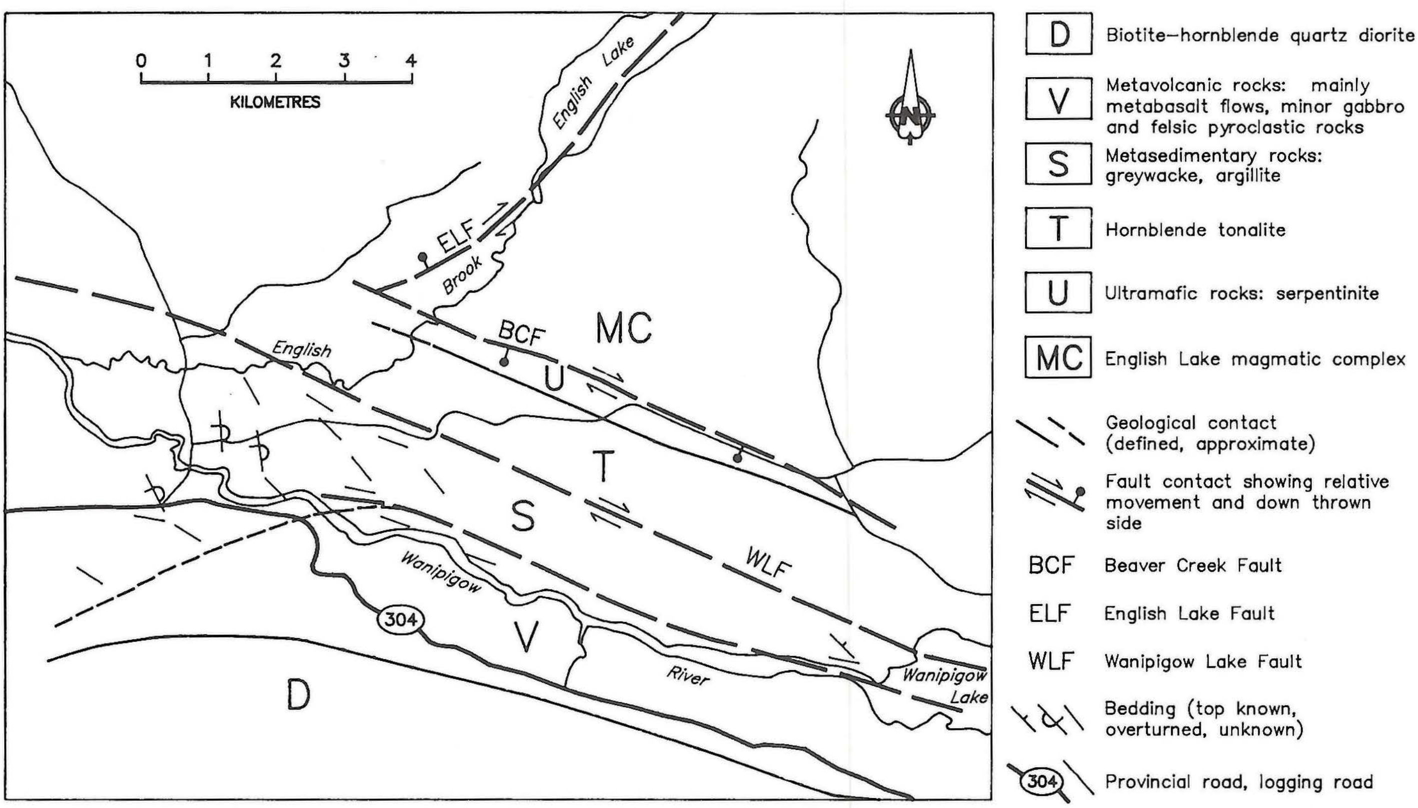

Figure GS-10-1: General geology of the English Brook area.

deformation structures may suggest that the sequence was deposited at the bottom, rather than on the flanks of a basin. The absence of any transitional facies between the sedimentary belt and the metavolcanic rocks to the south (such as chemical sediments or coarse epiclastic volcanogenic deposits), and the fact that the contact between the two above units is highly sheared, suggests a fault contact.

The contact with the tonalite (T, Fig. GS-10-1) to the north is also a fault. It is characterized (where exposed), by a 100 to 200 m wide zone of intense cataclasis and mylonitization. The fault is part of the Wanipigow Lake fault (WLF, Fig. GS-10-1), that extends from Lake Winnipeg to the east past the Manitoba/Ontario border, and resulted in approximately 20 km dextral displacement in the Wallace Lake area (Manitoba Mineral Resources, 1979).

TONALITE

The tonalite (T, Fig. GS-10-1) is coarse grained and texturally and compositionally relatively homogeneous, but contains several east-trending, fine grained, 5 to 20 m gabbroic sills. These sills seem to be restricted to the tonalite. In one small outcrop near the Beaver Creek road the tonalite is in sharp (untectonized) contact with an ultramafic rock (unit U). Russell (1949) and Ermanovics (1981) indicate that this tonalite extends west to the east shore of Lake Winnipeg, where a U-Pb zircon age of 2999 ± 10 Ma was determined (Ermanovics, 1981). This suggests that it is part of the pre-greenstone crust that makes up much of the terrain north of the Rice Lake greenstone belt (*c.f.* Turek and Weber, GS-11, this volume).

ULTRAMAFIC ROCKS

The ultramafic rocks (U, Fig. GS-10-1) form isolated knobs in a (up to 600 m wide) topographic low between tonalite (T) and the English River magmatic complex (MC, Fig. GS-10-1). The ultramafic rocks are serpentinites, locally with textures suggesting original olivine cumulates. East of the map area, the belt of ultramafic rocks changes into isolated serpentinite lenses along a fault zone within tonalitic rocks (Scoates, 1971). To the west, the serpentinites extend to the east shore of Lake Winnipeg and from there, in a northwesterly direction, below the lake. These ultramafic rocks probably are associated with a fundamental, crustal scale, regional fault that may be related to a discontinuity in the lower crust, indicated by refraction surveys (Hajnal, 1971) north of the Rice Lake greenstone belt.

ENGLISH LAKE MAGMATIC COMPLEX

The English Lake magmatic complex (Weber, 1990) is in fault contact with the belt of ultramafic rocks along the Beaver Creek fault (Fig. GS-10-1). The complex consists mainly of amphibolites to metapyroxenites, tonalites and retrogressed enderbites, intruded by anorthosites, hornblendites (metapyroxenites), pegmatites and diabase. The present interpretation is as follows: The oldest rocks are amphibolites and metapyroxenites of unknown origin. There are no lithologies, such as banded iron formation, which would suggest that the protolith included supracrustal rocks. The amphibolites were intruded by tonalites and/or enderbites that formed large scale *lits par lits* injections (Fig. GS-10-2) and plutonic masses. During, or following, the intrusion of these granitoids the region underwent granulite facies metamorphism (Fig. GS-10-3) leading to the formation of mobilizates or partial melts of tonalitic to anorthositic to leucogabbroic composition and hydrous ultramafic restites in the amphibolites (Fig. GS-10-4), and enderbitic mobilizates in the tonalites/enderbites. Following release of hydrostatic pressure (due to uplift or upthrust, into higher crustal levels with lower metamorphic conditions), the granitoid mobilizates pooled and were able to intrude into the surrounding rocks brecciating the amphibolite and enderbite (Fig. GS-10-5). The ultramafic restite also behaved intrusively, probably because it was very hydrous. This process produced spectacular igneous breccias, particularly in the centre of the map area (Weber and Young, 1991).

Subsequently, dykes of fine grained felsite, leucotonalite and pegmatites were intruded, generally in an east west direction. These were followed by intrusion of diabase dykes with a northerly orientation.

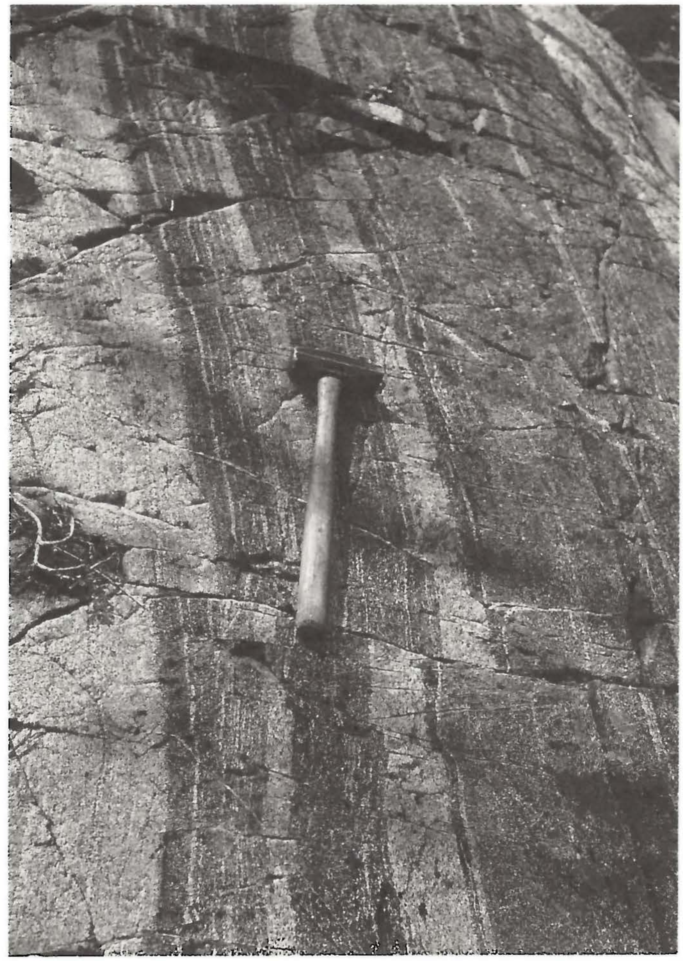

Figure GS-10-2: Lits par lits injections of tonalite into amphibolite.

The last event entailed brittle deformation along east to northeast trending shear and fault zones, largely with dextral displacement. The major faults are the Beaver Creek fault (BCF) and the English Lake fault (ELF) (Fig. GS-10-1). In addition, there are many subparallel, subsidiary faults or shear zones, e.g. the one 300 m north of BCF (Weber and Young, 1991). Quartz veins commonly occur within or adjacent to both, the minor and major fault and shear zones. They strike at an angle of 30°-60° oblique to these zones, are up to 2 m wide and up to 100 m long. The Lotus gold deposit is situated along one of these veins which formed in low pressure zones or fractures as a result of differential drag during dextral displacement.

ECONOMIC GEOLOGY

Hydrothermal alteration in mafic metavolcanic rocks indicates a potential for volcanogenic massive sulphide deposits.

Quartz veins, formed near and within east- and-northeast trending shear and fault zones, commonly carry minor sulphides and some have an associated silicified alteration zone up to 1 m wide. The Lotus deposit carries gold. Most, but not all veins were prospected.

Young and Theyer (1990) describe minor sulphide mineralization in mafic and ultramafic rocks. Locally in the old amphibolite-pyroxenite faint layering may be interpreted as igneous . Analyses are required to assess the platinum potential of these zones. Good igneous layering is developed in some of the younger anorthosites (Fig. GS-10-6), but no sulphide mineralization was observed. If the rocks older than anorthosites have undergone granulite facies metamorphism, it could be argued, that most sulphides and precious metals in the amphibolites-metapyroxenites would have been remobilized and expelled.

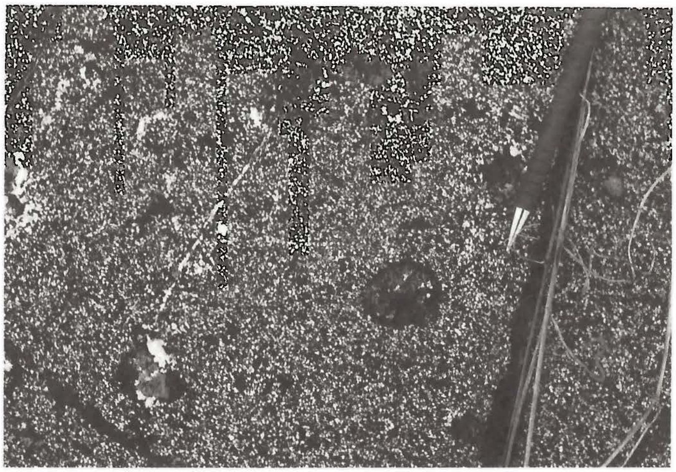

Figure GS-10-3: Garnet-amphibole pseudomorph after hypersthene in amphibolite.

Figure GS-10-4: Mobilizate of anorthositic and hornblendic composition (derived from in situ metamorphic differentiation of amphibolite).

One pegmatite in the northern part of the map area was found to be texturally and mineralogically zoned with a 30 cm zone containing garnet. This suggests some potential for rare element enriched pegmatites.

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Figure GS-10-5: *Injected anorthosite melt, forming intrusive breccia.*

Figure GS-10-6: *Igneous layering in anorthositic gabbro.*

GS-11 NEW U-PB ZIRCON AGES FROM THE RICE LAKE AREA: EVIDENCE FOR 3 GA CRUST

by A. Turek* and W. Weber

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, Minerals Division, Report of Activities, 1991, p. 53-55.

results OF u-pb zircon analyses

Out of six rock units sampled for U-Pb geochronology studies in 1989 two yielded zircons suitable for analyses.

One is a tonalite boulder (02-89-9), from a conglomerate of the Conley Formation (McRitchie, 1971; Weber, 1989), collected from the north shore of Wallace Lake (Fig. GS-11-1). It yielded an age of 3010±13 Ma (Table GS-11-1, Fig. GS-11-2). This supports earlier suggestions (Weber, 1988), that: (a) this formation consists of detritus of crust that is significantly older (2.9-3.0 Ga) than the ca. 2.73 Ga Rice Lake greenstone belt, and, (b) this older crust lies north of the Rice Lake greenstone belt (Turek *et al.*, 1989). However, further work is required to prove that the Conley Formation is part of the Mesoarchean 2.9-3.4 Ga rock association recognized in NW Ontario (Ontario Geological Survey, 1991; Thurston *et al.*, 1987).

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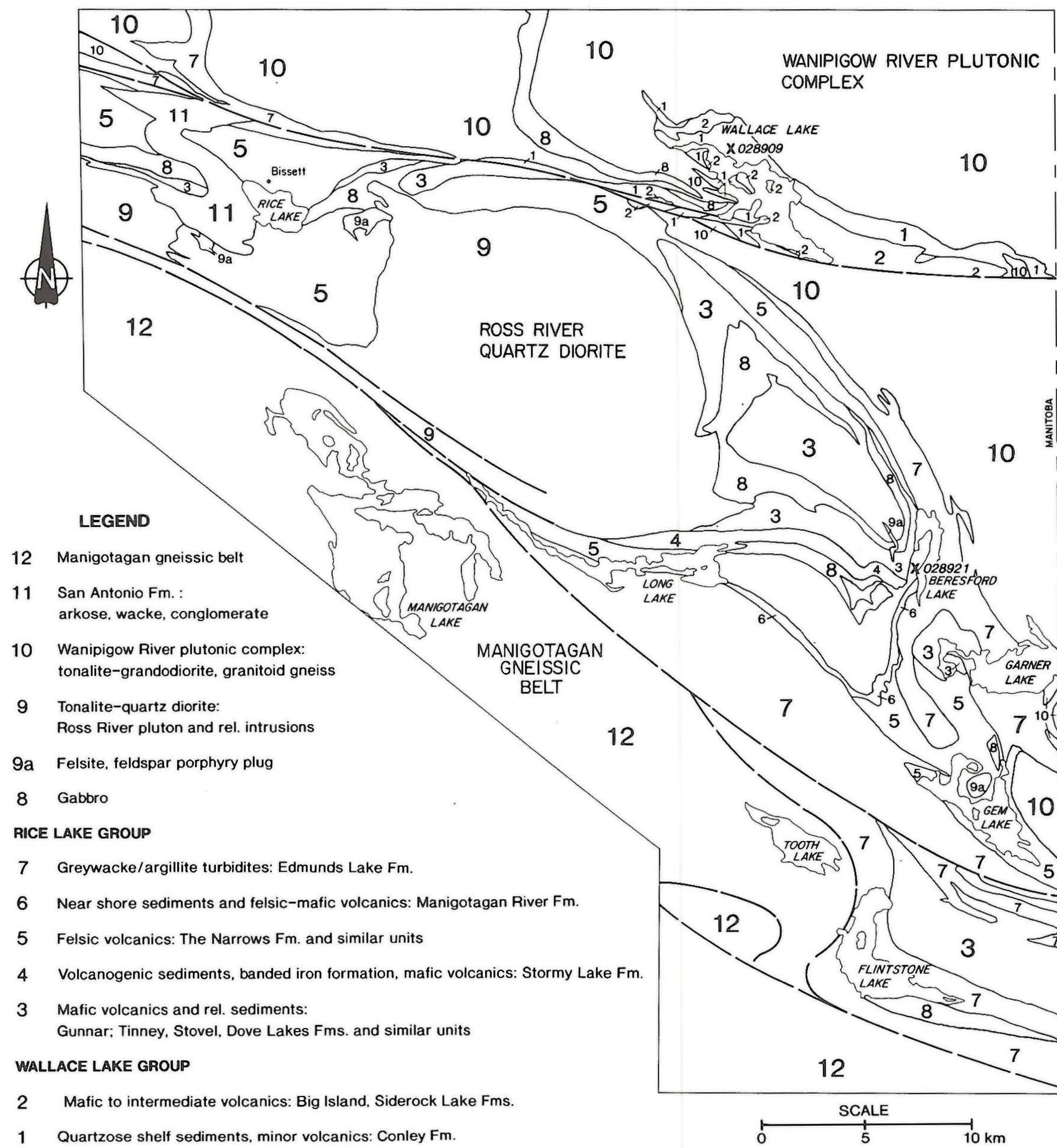

Figure GS-11-1: Generalized geology of the Rice Lake greenstone belt and sample locations of the dated units discussed in text.

Table GS-11-1
Analytical Results and Calculated Ages

Sample No.		Sample Detail: Magnetism (a)	Tyler mesh grain size	Weight (mg)	Concentration (ppm): U	Pb	Atomic ratios: (b) $^{204}Pb/^{206}Pb$	(c) $^{208}Pb/^{206}Pb$	(c) $^{207}Pb/^{206}Pb$	(d) $^{207}Pb/^{235}Pb$	(d) $^{206}Pb/^{238}Pb$	Model Ages (Ma): $^{206}Pb/^{238}Pb$	$^{207}Pb/^{235}Pb$	$^{207}Pb/^{206}Pb$	Concordia Ages (Ma): Upper intercepts	Lower intercepts	Remarks[a]
TONALITE BOULDER																	
89-9	A	NM3³-MO°	-100+200	2.3	146	83	0.000166	0.11589	0.21733	14.7256	0.4958	2596	2798	2947			
	B	NMO° Ab, Hp	-100+200	1.2	149	90	0.000123	0.12020	0.22035	15.9780	0.5293	2739	2876	2973	3010±13	>63±138	Model 1; P=48%
	C	NMO° Ab	-100+200	0.7	204	123	0.000153	0.11784	0.21968	15.7360	0.5237	2715	2861	2965			
	D	NM3° -MO	-200+325	1.4	89	51	0.000376	0.13159	0.22004	14.7450	0.4959	2596	2799	2948			
PORPHYRY																	
89-21	A	NMO° Hp	-100+200	2.8	141	81	0.000177	0.13558	0.19052	13.1261	0.5053	2637	2689	2728			
	B	NM2° -MO° Hp	-200+325	1.9	153	89	0.000954	0.18069	0.19964	12.5532	0.4840	2545	2647	2726	2732.8±6.2	232±182	Model 1; P=67%
	C	NMO°	-200+325	0.9	226	129	0.000303	0.15463	0.19200	12.8879	0.4963	2598	2672	2728			
	D	NM2° -MO°	-100+200	0.9	203	123	0.002234	0.22129	0.21478	12.3838	0.4784	2520	2634	2723			

(a) Relative magnetic susceptibility of zircons is reported as M(magnetic) and NM(nonmagnetic) at the indicated inclination of the Frantz searator using maximum current of 2A.
(b) Measured ratio.
(c) Blank corrected.
(d) Blank and nonradiogenic Pb corrected.

NOTES: Decay constants used: I $^{238}U = 1.55125 \times 10^{-10}$ year^{-1} and I $^{235}U = 9.8485 \times 10^{-10}$ year^{-1} (Steiger and Jäger 1977).
Error terms of Concordia ages are 20.
[a] is probability of fit as defined by Ludwig (1990).

The second rock unit (02-89-21) is a feldspar-quartz porphyry from west of Beresford Lake. It is part of an older set of dykes that is widespread in the Rice Lake area, particularly near the tonalite plutons, such us the Ross River pluton (unit 9, Fig. GS-11-1). The sampled porphyry gave an age of 2732.8±6.2 Ma (Table GS-11-1, Fig. GS-11-3). A sample from the same set of dykes from the Gunnar mine area yielded an age of 2731±12.6 Ma (Turek *et al.*, 1989). This set of dykes intruded prior to the oldest recognizable deformation period (Brommecker *et al.*, 1989). A younger set of quartz-feldspar porphyries intruded during this deformation period. This younger set of dykes is closely associated in age with the gold mineralization in the Beresford Lake area (Brommecker *et al.*, 1989). Unfortunately a sample collected from this unit did not yield any zircons suitable for dating. An age would have placed an accurate lower limit for the gold mineralization in that area.

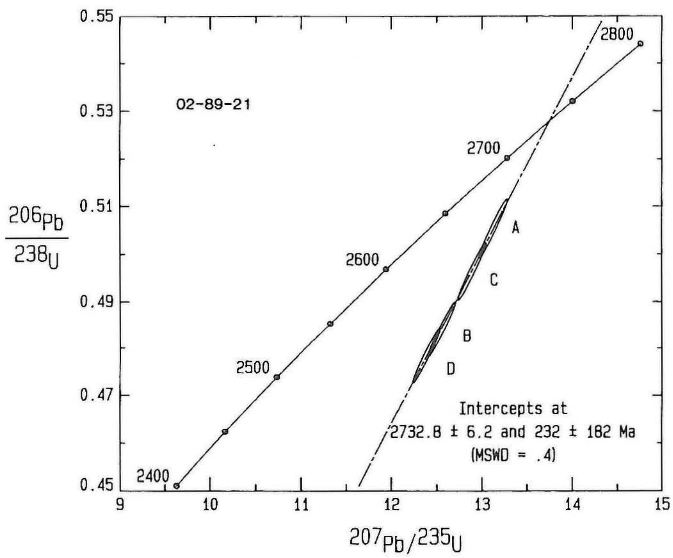

Figure GS-11-2: Concordia diagram for metatonalite boulder (02-89-9), north shore of Wallace Lake.

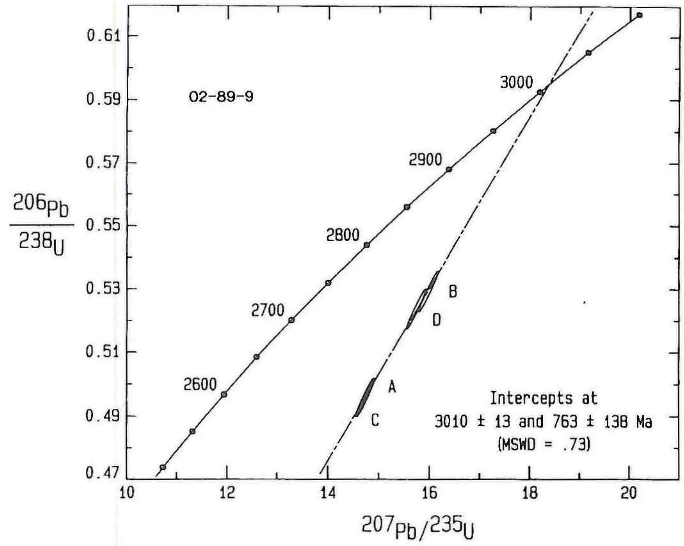

Figure GS-11-3: Concordia diagram for feldspar-quartz porphyry (02-89-21), near Beresford Lake.

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GS-12 CROSS LAKE SUPRACRUSTAL INVESTIGATIONS (PART OF NTS AREA 63J/9)

by M.T. Corkery

Corkery, M.T., 1991: Cross Lake supracrustal investigations (Part of NTS area 63J/9); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991. p. 56-57.

A two week field program completed 1:20 000 scale geological mapping of the west end of Cross Lake (part of NTS 63J/9SE and 63J/9NE) at a scale of 1:20 000. Manitoba Hydro is constructing a weir on the Nelson River to restrict flow from Cross Lake. This will return the lake level to historic values by the fall of 1991. Mapping was scheduled to gather maximum geologic data prior to the expected 1.5 to 1.8 m rise in lake level.

This years mapping further delineated previously defined geologic units (Corkery, 1983, 1985, 1990; Corkery and Lenton, 1984, 1989; Corkery *et al.*, 1988; and Corkery and Cameron, 1987). Table GS-12-1 outlines the major lithologies and geological events in the Cross Lake area.

Table GS-12-1
Order of Geological Events
(Cross Lake area)

15) Late brittle deformation manifested by fault breccia, pseudotachylite and erratic foliation developed in some Molson dykes
14) Intrusion of Molson dyke swarm; most abundant in the major NE shear zones. (1883 Ma)[3]
13) Periodic reactivation of shear zones accompanied by minor folding
12) Main Kenoran orogenic event: intrusion of granite plugs (2653 Ma) and pegmatites (largely controlled by the major shear zones) during the waning stages. (2658 - 2637 Ma)[1]
11) Intrusion of small gabbro dykes and plugs.

Intrusive contact

10) Initiation of high potassium basalt volcanism contemporaneous with fluvial to marine sedimentation.
9) Deposition of Cross Lake group alluvial and fluvial conglomerate and sandstone.

Unconformity

8) Regional metamorphism and deformation, granite plutonism (2719 Ma) and folding concomitant with activation of major linear shear zones. Spans the period of deposition of Cross Lake Group. (2713 - 2695 Ma)[1]
7) Intrusion of hornblende porphyritic gabbro dykes.

Intrusive contact

6) Deformation and metamorphism: produced northeast trending migmatites that overprinted east-west D_1 foliation. Contemporaneous with, to post deposition of, Gunpoint Group. (*circa* 2738 Ma)[2]
5) Deposition of the predominantly continental Gunpoint Group fragmental rhyodacite and alluvial, fluvial and marine sediments.

Unconformity

4) Pipestone Lake group incorporated into a cratonic land mass during a period of cratonization concomitant with Whiskey Jack Complex intrusions, (2734 Ma)

Oceanic Association

3) Deposition of Pipestone Lake Group basalts and subordinate sediments. Intrusion of anorthosite-gabbro complex with deposition of associated feldspar porphyritic basalts. (2760 Ma)

Old Cratonic Masses

2) Deformation and metamorphism: produced strong foliation (currently east-west) in Clearwater Bay Complex.
1) Formation of cratonic masses of Molson Lake Domain and Pikwitonei Domain on the south and north flanks of the supracrustal belt. (2839 Ma)

[1] Krogh *et al.*, 1985
[2] Mezger *et al.*, 1990
[3] Heaman *et al.*, 1986

Distribution of major rock types indicates a large shallow northeast-plunging synclinal structure in the west end of the Cross Lake supracrustal belt. Remnants of the Pipestone Lake Group are restricted to the south and north flanks of the belt, in contact with granitic rocks of the Molson Lake Domain and the Pikwitonei Domain. Rare occurrences of Gunpoint Group are in contact with Pipestone Lake Group. The Cross Lake Group forms the center of the belt. Basal conglomerates and coarse clastic fluvial deposits are abundant on the south and north shores of the lake with various crossbedded sandstones forming the core of the large scale structure.

Shallowly plunging small and large scale folds, axial planar to the dominant 050° to 060° foliation, fold both the supracrustal sequence and the granitic gneisses on the south side of the belt. These folds postdate an earlier folding event and bedding plane parallel brittle faults.

Primary structures and sequences are not as well preserved in the west end of the Cross Lake belt as they are to the east. Deformation, represented by two periods of folding and numerous shear zones, obliterates primary relationships of the three groups. However, major units and subunits are recognizable, and although attenuated, could be followed for considerable distances across the map area (Preliminary map 1991K-1). Cross Lake Group is in contact with both Pipestone Lake Group and Gunpoint Group in several locations. The typical garnetite regolith at the base of the Cross Lake Group occurs in several of these locations, however, deformation has transposed all primary features into orientations parallel to the structural fabric direction. This, combined with the high degree of recrystallization, does not allow recognition of the unconformable relationships documented elsewhere in the Cross Lake belt.

The metamorphic grade and degree of recrystallization is generally higher in the west than further east. This recrystallization is especially noticeable in conglomerates. In outcrop, clast boundaries for several clast types can not be distinguished with certainty. However, major layering characteristics such as unsorted framework conglomerate beds and interbedded conglomerate-sandstone fluvial deposits can be distinguished. Remnants of primary structures such as cross bedding, graded bedding, pillow selvages, pillow breccias and gabbroic textures are preserved. These are highly discontinuous and rarely of any value other than recognition of the original lithologies.

Primary characteristics are further disrupted by 3 to 10% granitic intrusions. These consist of several ages of injected pegmatite, granite, granodiorite and tonalite dykes and sills. In many exposures post intrusive deformation produces a *lit par lit* paragneiss. In addition, 1 to 5% pegmatitic mobilizate may be present.

On the south shore of an island, west of where the Minago River enters Cross Lake, several gossan zones occur within altered basalt (Preliminary map 1991K-1). A previously reported alteration zone consisting of a zone of silicified Pipestone Lake Group basalt and associated gossans on the east end of Metis Island (Preliminary map 1987N-2) was traced intermittently along the north shore to reefs at the west end of the island where a further zone of intense alteration and related sulphide mineralization occurs.

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GS-13 MINERAL DEPOSIT INVESTIGATIONS IN THE GODS LAKE AREA (NTS 53L/9, 53L/10, 53L/16)

by P. Theyer

Theyer, P., 1991: 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.

INTRODUCTION

Studies of mineral deposits in the Gods Lake map area (NTS 53L/9, 53L/10, 53L/16) were undertaken as the first step for an evaluation of the mineral potential in the northern Superior Province of Manitoba. Investigations were concentrated on the geology of Elk Island, Jowsey Island and surrounding areas, in an effort to determine the origin of the Gods Lake and the Jowsey Island gold deposits. Geological studies on Elk Island included a thorough investigation of the shoreline complemented with traverses across the island. Glacial debris covers much of the southern and southeastern shore of Elk Island and hinders a thorough investigation of that shoreline. Geological mapping was conducted at a scale of 1:5000.

PREVIOUS WORK

The area was mapped initially by Bruce (1919) and Wright (1925, 1931 and 1932). Wright subdivided the supracrustal rocks into a lower, mainly volcanic sequence (the Hayes River Group) that is overlain unconformably by sedimentary rocks (Oxford Group). This subdivision has been adopted by later workers. The Gods Lake area was subsequently mapped by Dix (1951) and Barry (1961).

Southard (1977) compiled a summary of known mineral occurrences in the area based on exploration results condensed from cancelled assessment files of the Mineral Resources Division and on the results of the Greenstones Project. This project included mapping of several greenstone belts in the Superior Province of northeastern Manitoba at 1:31 680 scale and resulted in a report with ten 1:50 000 scale maps depicting the geology, geophysics and geochronology of several greenstone belts (Gilbert, 1985). Theyer (1984) described the lithology of the host rocks to the Gods Lake Gold Mine. Richardson and Ostry (1987) provided an overview of gold deposits in Manitoba.

MINERAL DEPOSITS AND OCCURRENCES

Gods Lake Gold Mine

The Gods Lake Gold Mine began production in 1935. Access to the ore was through the 276 m No. 1 shaft. The 572 m No. 2 exploration shaft did not provide additional ore reserves. The mine produced 490 866 tonnes of ore before suspension of operations in 1943. The gold-bearing rock was interpreted to be stratabound since it was mined from a layer of volcanogenic detrital and chemical sediments at the contact between a gabbro sill and basalt.

Geology and mineralization

Geological studies of the mineralization are difficult since outcrops in the vicinity of both the No. 1 and No. 2 shafts are covered with muck and debris, the shafts are capped, and geological records are sparse.

The mineral-bearing layer is exposed in outcrop on the shoreline between the two shafts and west of the No. 1 shaft. These exposures were investigated, mapped and sampled with a rock saw (Fig. GS-13-1). Rocks in the mineralized layer consist of intensely sheared and folded wacke, silicic wacke, and black to purplish slate. These rocks have been intruded by quartz-feldspar porphyry lenses that remained relatively undeformed. Sericitization, chloritization, carbonatization, and silicification affect the rocks to varying degrees. Sulphides are restricted to accumulations of pyrite and pyrrhotite in lenses up to several cm long.

Jowsey Island Gold Mines

Gold was discovered on Jowsey Island by R.J. Jowsey, A. MacDonald and R. Howie in 1932.

This occurrence was developed in 1934 by the sinking of a 70 m deep shaft and drifting on two levels. Two mineralized zones were encountered on the 30 m level and one on the 61 m level.

Geology and mineralization

The host rocks of the Jowsey Island gold mine are described as two parallel, grey to black quartz veins in a quartz-feldspar porphyry dyke. The Jowsey A quartz vein is at least 96 m long and has an average width of 1.36 m, whereas the Akers quartz vein is 1672 m long and up to 3 m wide (Mineral Inventory Card 53L/9NW Au1).

Jowsey Island (Preliminary Map 1991G-1) is underlain by largely undeformed pillowed mafic volcanic rocks that are interlayered with flow breccia, and pillow breccia, and intruded by quartz-feldspar porphyry dykes. The western part of the island is underlain by granite.

Most outcrops in the vicinity of the shaft of the Jowsey Island gold mine are covered by mine muck. In the immediate vicinity of the Jowsey Island shaft there is a west-striking (280°) shear zone, that ranges in thickness from centimetres to 20 m and characterizes much of the northeastern end of Jowsey Island (Fig. GS-13-2).

Along the length of the shear zone there is a quartz-feldspar porphyry dyke that ranges in thickness from a few centimetres in the east, to 16 m in the vicinity of the shaft. Locally, especially at its eastern end, the quartz-feldspar porphyry dyke branches, anastomoses, and pinches and swells over short distances.

The shear zone is a complex set of narrow subparallel shears, and many are the loci of alteration that includes simple chloritization and weak carbonatization, minor sericitization, and pervasive silicification. Maximum silicification of the mafic flow rocks produces a fine grained to aphanitic light grey to beige, massive to foliated felsic rock characterized by a beige smoothly weathered surface that is mottled with off-white spots; this rock is difficult to distinguish from a felsic tuff. The average thickness of the silicified shears shows a marked increase in a westerly direction ranging from centimetre thick silica veinlets exposed on the easternmost peninsula of Jowsey Island (Fig. GS-13-2) to metres thick, discrete silica dykes, lenses and several metres thick zones of gradually increasing, pervasive silicification of sheared pillowed flows in the vicinity of the shaft.

Sulphide mineralization, comprising trace to 5% pyrite and very subordinate amounts of pyrrhotite, is concentrated in the altered rocks of the shear zone. There is no evidence of a correlation between the amount of sulphide mineralization and the position within the shear zone.

Summary and conclusions

Elk and Jowsey islands are underlain by a suite of mafic volcanic and volcanic-derived rocks, characterized by a network of shear zones and intruded by quartz-feldspar porphyries. These shears are characterized by zones of foliated and altered rocks, several tens of metres wide that are readily recognizable on the ground and on air photos (Preliminary Map 1991G-1). Since many of these shear zones proved to be mineralized with sulphides and gold (Jowsey Island Gold deposit, Elk Island Gold deposit, Smelter gold occurrence), it is suggested that they could be worthwhile exploration targets.

In addition, there is a zone of intense and widespread pyritization in a bay near the western tip of Elk Island south of Jowsey Island (Preliminary Map 1991G-1). This mineralization is thought to be unique in the area since; a) there is no discernible tectonic control, and b) sulphide mineralization occurs in normally barren rocks such as quartz-feldspar porphyry and pyroxenitic gabbro.

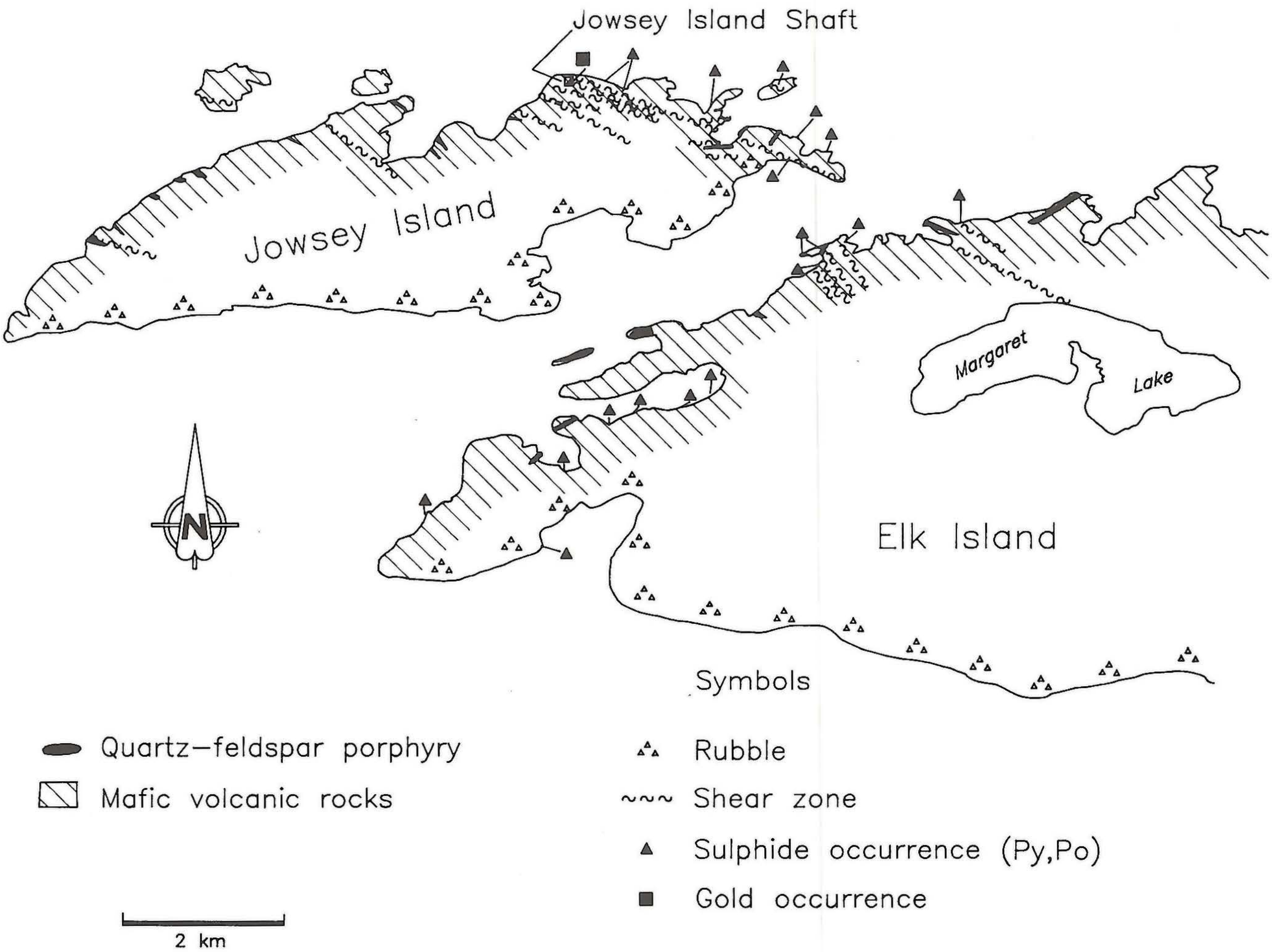

Figure GS-13-1: Geological sketch map of the Jowsey Island gold occurrence and of the gold-hosting structure.

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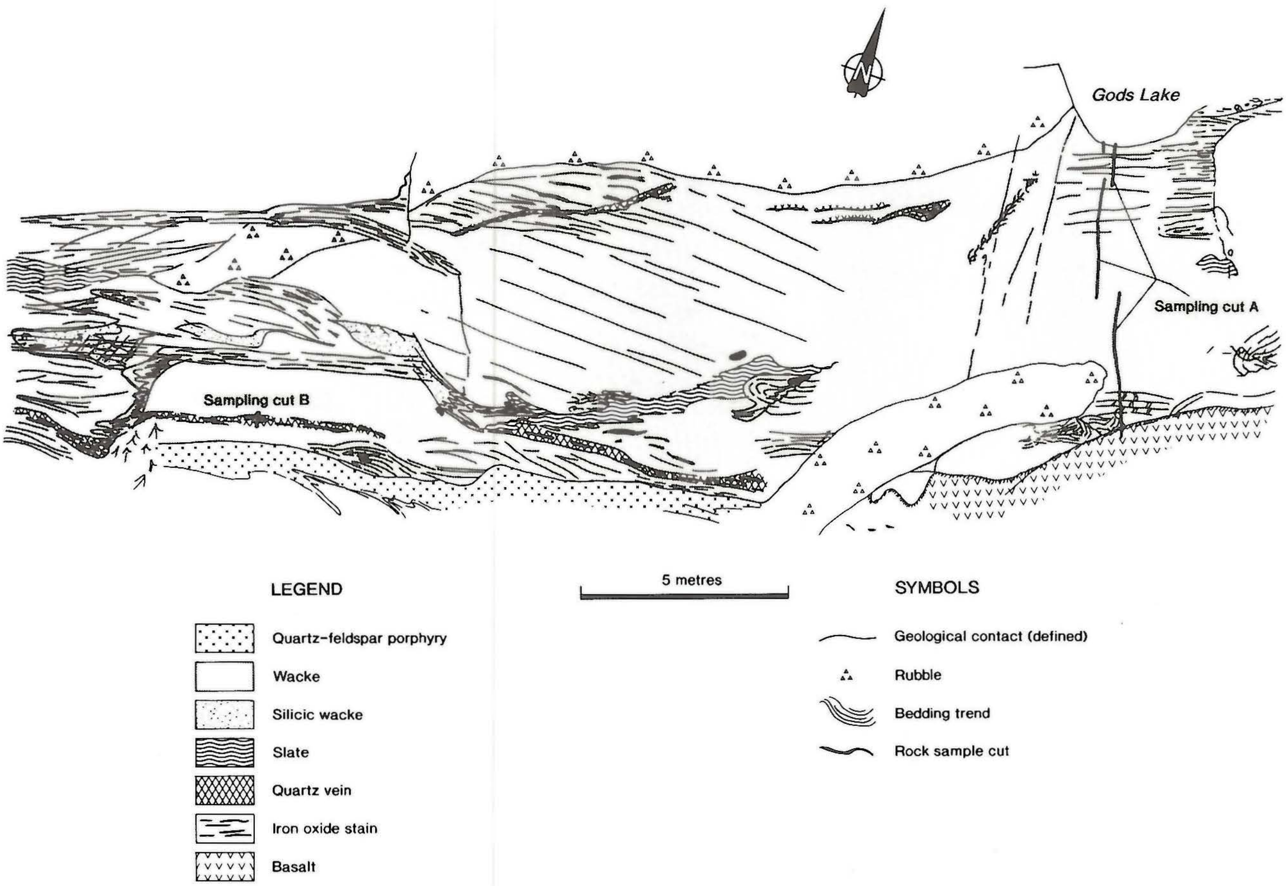

Figure GS-13-2: *Detailed outcrop map of the lithologic unit that hosts the Gods Lake gold deposit. For location of this figure, see Preliminary Map 1991G-1.*

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GS-14 STRATIGRAPHIC MAPPING (NTS 63F, 63K) AND CORE HOLE PROGRAM 1991

by R.K. Bezys

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INTRODUCTION

Geological activities were carried out on four separate projects in 1991. They include: 1) continued drilling of the Winnipegosis Formation reef at the Bluff (Dawson Bay, Lake Winnipegosis); 2) regional Silurian and Ordovician mapping in The Pas - Cranberry Portage area; 3) continued drilling in the Silurian outcrop belt north of Grand Rapids; and 4) compilation for the Western Canada Sedimentary Basin atlas project. A total of 1118.3 m in 16 core holes were drilled. Additional stratigraphic studies were undertaken on core drilled in the Interlake area for high calcium limestone (Gunter GS-18, this volume) and high purity dolomite (Bamburak GS-17, this volume). Results of all drilling are shown in Figure GS-14-1 and Table GS-14-1.

THE BLUFF

Drilling continued on the Bluff (Dawson Bay, Lake Winnipegosis) (holes M-1-91, M-2-91, and M-2A-91, Fig. GS-14-2) to delineate the extent of the Devonian Winnipegosis Formation reef complex. The reef is represented by a highly fossiliferous, stromatoporoid-rich limestone and appears to be flanked by an interior lagoon facies characterized by sparsely fossiliferous limestone with poor horizontal bedding. Drilling in 1990 determined the presence of the overlying Dawson Bay Formation (Lower Member) and Second Red Beds to the south and southwest of the reef. Results of the 1991 drill program further defined the extent of the reef structure. Core hole M-1-91 (abandoned at 48.1 m due to sand) revealed a reefal sequence very similar to M-5-88. Core hole M-2-91 contained a transitional breccia sequence overlying the Winnipegosis Formation which represents the brecciated equivalent of the Prairie Evaporite located in the subsurface of southwestern Manitoba. Core hole M-2A-91 was abandoned after intersecting 6.1 m of overburden. Research on the Winnipegosis Formation in this area by D. Kent and J. Minto (University of Regina), continues.

63F AND 63K REGIONAL PALEOZOIC MAPPING

Regional geologic mapping in NTS map sheets 63F and 63K was carried out as a follow-up to mapping done by McCabe (1984; 1985; 1986) (Fig. GS-14-3). All Paleozoic shoreline outcrop on Athapapuskow Lake was mapped. Type geologic sections at Cormorant Hill, Rocky Lake and Namew Lake were also visited and measured to permit better correlation of Silurian and Ordovician units into the subsurface of the Williston Basin. Some outcrops were examined in NTS 63F on Clearwater Lake. Most of the work on this map sheet consisted of logging Paleozoic drill core from mineral exploration drill programs.

Athapapuskow Lake

Baillie (1951), who previously mapped part of Athapapuskow Lake, considered all bedrock exposures as Red River Formation except one outcrop on the southeast shore that was mapped as Winnipeg Formation sand. However, during a visit to this location this summer, only a garnetiferous, quartzose beach sand was found. The remainder of the outcrops on Athapapuskow Lake consist of lithologically similar Red River Formation dolomite. It is finely crystalline, dense, fossiliferous, slightly granular dolomite with pronounced variations in colour and bed thickness. Colours include pale mottled grey and buff, mottled buff and red-grey to red and yellow. Colour variations may be related to fractures and probably reflect recent intense oxidation and reduction. Correlation between outcrops is handicapped by the lack of marker beds within the Red River Formation.

Very high exposures of Red River Formation dolomite occur at the West Arm of the lake and at Limestone Narrows (up to 14 m thick) (Fig. GS-14-4). Although none of the dolomite outcrops had exposed contacts with the Precambrian, there were Precambrian outcrops in close proximity at lake level. It appears that large, slumped blocks of Red River strata may have separated at this contact at the sandy, argillaceous and weathered erosional surface. From isopach studies and stratigraphic drilling in the area, the Winnipeg Formation is not present, and thus could not have acted as a zone of weakness.

Red River Formation exposures also occur to the east and north along Provincial Highways 39 and 392 respectively. The Red River Formation exposed on highway 392 comprises two outliers on small Precambrian topographic highs. Precambrian outcrops surround the outliers, but are not in contact with them. There is no evidence of slumping of the Red River strata and no outcrops of Winnipeg Formation sand or shale. Rounded boulders and cobbles of buff yellow to brown, consolidated to slightly friable sandstone occur in the area surrounding the outliers, but not *in situ*. The Winnipeg Formation is probably thin or absent in the area along the present northeastern limit of Paleozoic strata. Future stratigraphic drilling on these outliers could determine the presence of Winnipeg Formation strata.

Cormorant Hill

The contact between the Ordovician and Silurian strata is located in the upper part of the Stonewall Formation. Based on stratigraphic investigations in the subsurface of the Williston Basin and in the Manitoba outcrop belt, Brindle (1960) suggested that the boundary occurs at the argillaceous T-marker near the middle of the Stonewall Formation. In the northern area of the Manitoba outcrop belt, the Upper Stonewall Formation is conglomeratic, suggesting the conglomerate is a depositional unit in contrast to sections to the south where conglomerate beds are rare or absent. This suggests a more complete sequence of the Stonewall Formation to the south, and therefore a thicker sequence.

Outcrops of the Stonewall Formation are rare in the northern outcrop belt and sections with the T-marker are more rare. Therefore, a roadcut section located south of the village of Cormorant (Tp. 60, Rge. 22; Fig. GS-14-3) has become invaluable in determining the precise location of the Ordovician/Silurian boundary in Manitoba. The roadcut is through a large bedrock hill that is essentially an outlier of the Stonewall Formation. Approximately 6 m of section is exposed (Fig. GS-14-5, Table GS-14-2).

McCabe (1986; 1988) sampled the Cormorant Hill roadcut and adjacent core hole M-9-86 for conodont analysis. Results from the Geological Survey of Canada are now available (Nowlan, 1989) and indicates the Ordovician/Silurian boundary in this section occurs between 3.2 and 5.0 m (Unit 3a and 4). In core hole M-9-86, the boundary may occur between 4.75 and 5.34 m, which corresponds to the T-marker. At the roadcut section, there appears to be a slight disconformity between units 3a and 4, but the faunal data place the period boundary higher up (towards the top of unit 3a). In core hole M-9-86, the conodont fauna are not diagnostic in the interval 4.75-5.34 m (T-marker) and this appears to place the boundary lower in the core hole than in the roadcut section. Further work will continue on the roadcut section to precisely locate the boundary. A detailed sampling program will be carried out on both the roadcut section and the core hole, and the samples resubmitted for conodont analysis.

At the extreme south end of the Cormorant Hill outlier, a new quarry exposes dolomite beds from the Lower Stonewall Formation. The quarry section is approximately 6 m thick and appears to correlate with the Williams Member of the Stonewall Formation. A red argillaceous marker bed is present near the top of the section (lower T-marker?) and the remainder of the sequence consists of slightly argillaceous, sublithographic to lithographic dolomite. A fossiliferous dolomite bed is present at the extreme top of the section. A prominent bed at the base of the section contains red skeletal halite molds (Fig. GS-14-6). The presence of skeletal halite and the lack of fossils suggest a

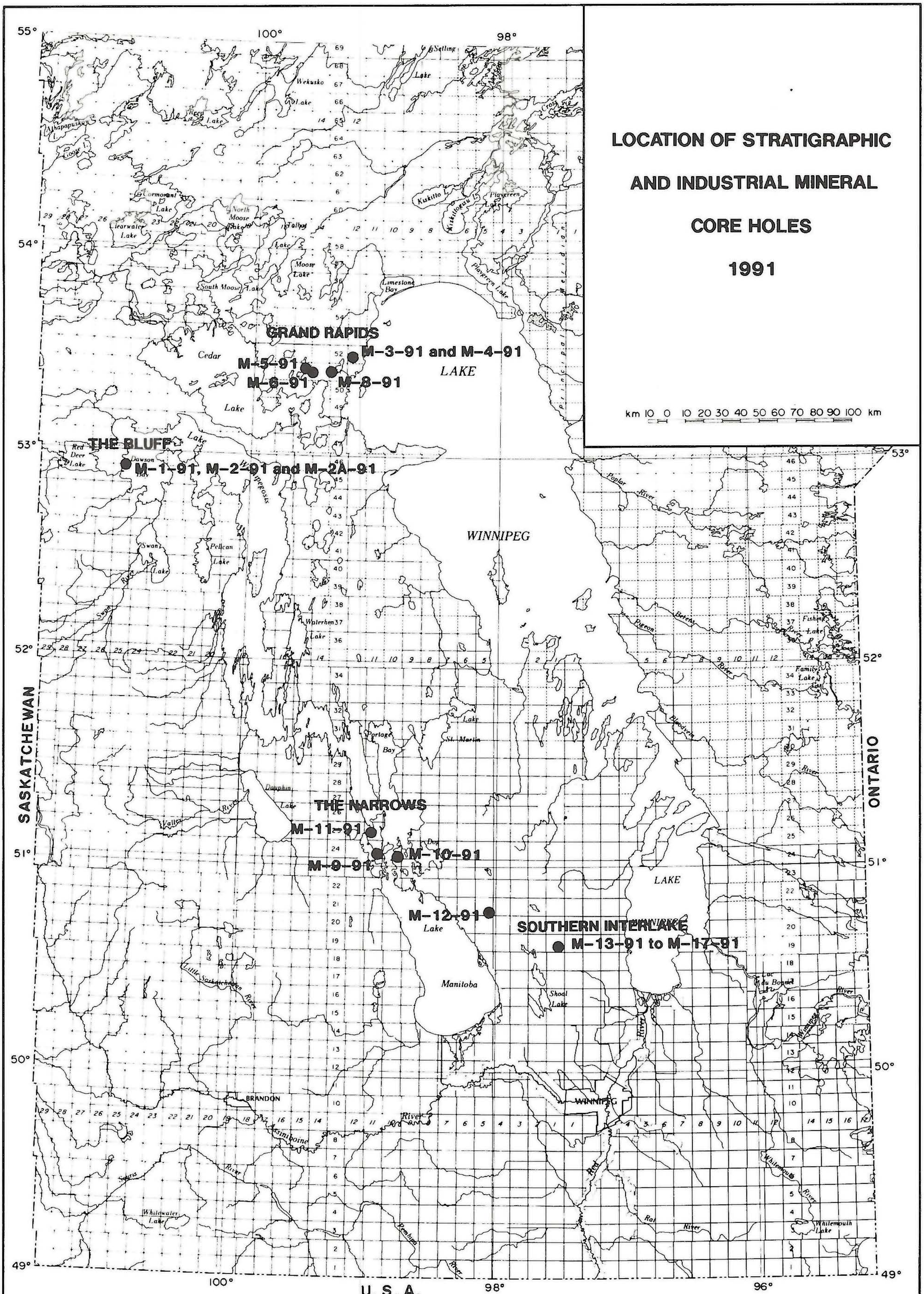

Figure GS-14-1: Location of 1991 stratigraphic and industrial mineral core holes in Manitoba. See Table GS-14-1 for coordinates and elevations.

Table GS-14-1
SUMMARY OF CORE HOLE DATA 1991

Hole No.	Location and Elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-1-91 The Bluff East	7-35-45-25W +249.9	DEVONIAN-Winnipegosis	0.0-35.5	Dolomite (minor limestone): light brown to tan; fine crystalline to minor sublithographic zones; very porous in places; fossiliferous with corals, brachiopods and crinoids.
			35.5-38.8	Limestone: buff brown; fossiliferous; porous; fine crystalline; reefal-like.
		Lower Winnipegosis	38.8-48.1	Dolomite: light tan; faintly laminated; ~5% porosity; minor breccia.
M-2-91 The Bluff West	7-35-45-25W +262.2	DEVONIAN-Winnipegosis	0.0-2.3	Large boulder fragment of Winnipegosis Fm dolomite-not in place?
		(Transitional Beds)	2.3-8.6	Argillaceous Dolomite: orange grey brown; high angle bedding (~25°); very irregular unit; slightly brecciated (=Prairie Evaporite).
		Upper Winnipegosis	8.6-56.8	Dolomite and Limestone (interbedded): light brown to grey; fossiliferous to reef-like; vuggy; indiscernible fossils; fine crystalline.
		Lower Winnipegosis	56.8-84.9	Limestone (minor dolomite): buff to grey; sublithographic; minor reefal-like beds at top; dense and uniform in other places.
		Ashern	84.9-87.3	Dolomitic Limestone to Dolomitic Shale: olive green to red; mottled; minor breccia.
M-2A-91 The Bluff Ridge	7-35-45-25W +263.0	Overburden	0.0-6.1	Overburden (abandoned).
M-3-91 Sturgeon Gill Road	13-7-52-12W +266.7	SILURIAN-Moose Lake	0.0-8.9	Dolomite: brown buff; dense; very fine crystalline; slightly fossiliferous; minor sand and breccia zone.
		(U_1-marker)	8.9-9.1	Argillaceous Dolomite: sandy conglomerate/breccia.
		Fisher Branch	9.1-21.0	Dolomite: brown to light brown; fine crystalline; slightly fossiliferous to stromatolitic; minor porosity; *Virgiana* at 20.7 m.
		Stonewall	21.0-24.6	Dolomite: light brown; fine crystalline; minor breccia; slightly fossiliferous.
		(T-marker)	24.6-24.8	Argillaceous Dolomite: olive grey; sandy with minor breccia.
		ORDOVICIAN-Lower Stonewall	24.8-33.4	Dolomite: buff brown; fine crystalline; indistinctly mottled.
			33.4-34.8	Argillaceous Dolomite: (lower T-marker?): grey; slightly burrow mottled.
			34.8-41.4	Dolomite: grey to buff yellow; very fine crystalline to sublithographic; slightly fossiliferous; 5-8% porosity; slightly brecciated.
			41.4-42.6	Argillaceous Dolomite: dark grey to grey; faintly laminated.
			42.6-44.0	Dolomite: brown; irregular bedding and laminations; minor brecciation; fine crystalline.
		(Williams Member)	44.0-46.6	Dolomite: brown to grey; indistinctly mottled; fine to medium crystalline; argillaceous in places; massive to finely laminated.
		Stony Mountain (Gunton)	46.6-55.4	Dolomite: light brown; indistinctly nodular; 5-8% porosity; minor bituminous partings; fine crystalline; minor burrowing.
		(Penitentiary)	55.4-72.4	Dolomite: brown; slightly argillaceous; slightly fossiliferous - indiscernible; scattered hardground surfaces; 5% porosity; fine crystalline.
		Red River (Fort Garry)	72.4-83.6	Dolomite: olive brown to grey; mottled to dense; slightly argillaceous in places; 5-8% porosity; scattered breccias; minor burrowing; minor

				laminations; very fine to fine crystalline.
M-4-91	13-7-52-12W	SILURIAN-Moose Lake	0.0-8.9	(See description in M-3-91)
Sturgeon Gill West	+259.1	(U_1-marker)	8.9-9.1	
(re-drill of M-3-91)		Fisher Branch	9.1-20.9	
		Upper Stonewall	20.9-24.6	
		(T-marker)	24.6-25.0	
		ORDOVICIAN-Lower Stonewall	25.0-41.3	
		(Williams Member)	41.3-42.7	
		Stony Mountain	42.7-55.2	
		(Gunton)		
		(Penitentiary)	55.2-73.1	
		Red River (Fort Garry)	73.1-86.8	Dolomite: dark grey; slightly argillaceous; massive; slightly mottled to burrow mottled; finely laminated; minor breccia zones; fine crystalline.
		Lower Red River	86.8-131.7	Dolomite: light brown to brown; good mottling; very burrow mottled in places; Tyndall Stone-like; fine fossiliferous material; fine crystalline.
		Winnipeg	131.7-137.8	Argillaceous Sandstone: dark brown to black; olive-green clay intervals; mottled with burrows; quartzose-well rounded; fine to medium grained; minor pyrite.
M-5-91	14-23-51-15W	SILURIAN-Cedar Lake	0.0-1.9	Dolomite: buff yellow; porous; fine to medium crystalline; slightly fossiliferous.
Cook's Cave South	+274.3			
		East Arm	1.9-20.5	Dolomite: brown to buff; ranges from sublithographic to porous; very fine to fine crystalline; scattered floating sand grains; reefal in places; scattered argillaceous marker beds.
		Atikameg	20.5-25.6	Dolomite: brown to buff; vuggy; reefal-like; fine to medium crystalline.
		Moose Lake	25.6-34.1	Dolomite: light brown; very fine to fine crystalline; massive to dense; minor brecciated intervals; scattered floating sand grains.
		(U_1-marker)	34.1-34.4	Argillaceous Dolomite: sandy conglomerate/breccia; light brown-grey.
		Fisher Branch	34.4-45.3	Dolomite: light brown to tan; fossiliferous with *Virgiana* at the base; irregularly mottled; medium crystalline.
		Stonewall	45.3-50.9	Dolomite: brown to grey; massive to laminated; slightly argillaceous; minor breccia; fine to medium crystalline.
		(T-marker)	50.9-51.5	Argillaceous Dolomite: dark grey to grey.
		ORDOVICIAN-Lower Stonewall	51.5-53.9	Dolomite: brown to grey; fine crystalline; faint mottling and banding.
M-6-91	15-18-51-14W	SILURIAN-Cedar Lake	0-2.0	Dolomite: tan to brown; fine crystalline; faintly laminated; rare fossiliferous material (questionable pick).
Cook's Cave	+266.7			
Southeast		East Arm	2.0-20.2	Dolomite: brown to buff; very fine to fine crystalline; sublithographic; rare stromatolitic beds; minor breccia.
		Atikameg	20.2-25.2	Dolomite: buff yellow; vuggy; reefal-like; 10% porosity; very fine to fine crystalline.
		Moose Lake	25.2-30.6	Dolomite: tan; irregularly laminated to mottled; sublithographic to porous; scattered floating sand grains; scattered fossils.
		(U_1-marker)	30.6-30.9	Argillaceous Dolomite: fine breccia conglomerate.
		Fisher Branch	30.9-39.5	Dolomite: tan; vuggy; 5-8% porosity; fossiliferous with good Virgiana specimens at base; mottled; fine crystalline.
		Stonewall	39.5-43.0	Dolomite: grey to brown; fine crystalline; slightly argillaceous at top; minor breccia and laminations.
		(T-marker)	43.0-45.0	Argillaceous Dolomite: dark grey to green; very mottled; irregularly coloured.

		ORDOVICIAN-Stonewall	45.0-57.8	Dolomite: tan to brown; massive; fine crystalline; fossiliferous; slightly mottled; 5-10% porosity; some argillaceous interbeds; scattered breccia beds with floating sand grains.
		(Williams Member)	57.8-61.2	Argillaceous Dolomite: green grey to grey; very finely laminated; some mottling; very fine to fine crystalline; minor breccia.
		Stony Mountain (Gunton)	61.2-75.8	Dolomite: brown; nodular; fine crystalline.
		(Penitentiary)	75.8-93.5	Dolomite: brown; slightly nodular; fine to medium crystalline; rare chert; minor fossil material; irregular mottling; 5-8% porosity; minor hard ground surfaces at the base.
		Red River (Fort Garry)	93.5-108.9	Dolomite: tan, brown to grey; fine crystalline to sublithographic; some argillaceous intervals; scattered breccia zones; fine laminations in places; scattered vugs.
		Lower Red River	108.9-152.0	Dolomite: brown; mottled to burrow mottled; fine crystalline; scattered chert; scattered fossiliferous material.
			152.0-152.2	Sandy Dolomite: grey to black brown; mottled; scattered pyrite.
		Winnipeg	152.2-154.5	Sandy Siltstone: grey to green-grey; argillaceous at top, sandier at base; burrow mottled; quartzose; fine grained.
			154.5-161.8	Sandstone: light grey to white; very friable and porous; subrounded quartz grains; coarse grained at base to fine at top.
		PRECAMBRIAN-Weathered	161.8-162.6	Granodiorite: medium crystalline; biotitic; highly kaolinized.
		Unweathered	162.6-163.7	Granodiorite: grey to blue grey; very coarse to coarse crystalline.
M-8-91 (M-2-89 reaming)	12-19-51-13W +274.3	ORDOVICIAN-Winnipeg	145.0-145.3	Silty Claystone: green grey; fine grained; minor chert and dolomite (maybe infill?).
			145.3-157.2	Sandstone: slightly argillaceous; brown; finely laminated; fine to medium grained; quartzose.
		PRECAMBRIAN-Weathered	157.2-158.0	Kaolinized and seriticized granitoid, green grey in colour.
		Unweathered	158.0-161.3	Granite to Granodiorite: grey to red; slightly gneissic to weakly foliated; very coarse grained; minor sulphide mineralization; biotitic.
M-9-91 West of Narrows Quarry	9-2-24-11W +253.0	DEVONIAN-Dawson Bay (Lower Member)	0.0-20.0	Dolomitic Limestone: brown with red staining; very fine crystalline to sublithographic; minor burrow mottling; slightly fossiliferous.
			20.0-26.5	Calcitic Dolomite: brown; very fine to fine grained; massive.
		(Second Red Beds)	26.5-32.3	Argillaceous Calcitic Dolomite: red to green; some intervals are very calcitic; very fine grained; brecciated towards the base.
		Winnipegosis (Transitional Beds)	32.3-36.9	Argillaceous Calcitic Dolomite: olive green to brown; brecciated (=Prairie Evaporite).
			36.9-63.0	Calcitic Dolomite: brown to tan; very fine to fine crystalline; massive; scattered fossiliferous material; minor crypto-algal laminations; slightly argillaceous in places; transitional lower contact.
		Elm Point	63.0-78.4	Limestone: dark brown to tan; fine to medium crystalline; fossiliferous; stylolitic; ~5% porosity.
		Ashern	78.4-80.3	Argillaceous Dolomite: olive green to red; medium to coarse grained; brecciated.
M-10-91 East of Narrows	9-14-24-10W +250.9	DEVONIAN-Dawson Bay (Lower Member)	0.0-14.3	Dolomitic Limestone: grey; very fine to fine crystalline-sublithographic; minor breccia.
		(Second Red Beds)	14.3-19.4	Argillaceous Dolomite: dark red; very fine to fine grained.
		Winnipegosis (Transitional Beds)	19.4-20.6	Dolomitic Clay to Siltstone: red to grey; massive to brecciated (=Prairie Evaporite).
			20.6-21.0	Argillaceous Calcitic Dolomite: brown to tan; finely laminated to crenulated; some argillaceous partings; very fine grained.

			21.0-30.8	Dolomitic Limestone(transitional to Elm Point?): brown; slightly argillaceous; very laminated in places; minor mottling; variable porosity 5-10%.
		Elm Point	30.8-50.5	Limestone: brown to tan; mottled; fossiliferous; fine to medium crystalline; porosity up to 10%.
			50.5-50.9	Dolomitic Limestone: brown; vuggy; 5-10% porosity; minor pyrite mineralization; granular texture.
		Ashern	50.9-53.8	Argillaceous Dolomite: red to blue grey; mottled and brecciated.
M-11-91 Reykjavik	9-16-25-11W +254.5	DEVONIAN-Dawson Bay (Lower Member)	0.0-17.0	Limestone: grey to brown; very fine to fine crystalline; scattered dolomitic intervals; scattered stylolites; some fossiliferous material; dense and massive.
		(Second Red Beds)	17.0-22.2	Argillaceous Dolomite: brown buff to red; slightly brecciated; massive.
		Winnipegosis (Transitional Beds)	22.2-25.8	Dolomitic Breccia: red green to brown; completely brecciated; very clayey and sandy (=Prairie Evaporite).
			25.8-32.2	Calcitic Dolomite: brown grey to buff; slightly argillaceous; very finely laminated; fine crystalline; dense; porosity <5%.
			32.2-65.9	Calcitic Dolomite: brown; mottled; moldic porosity (5-10%); fossiliferous; near absence of stylolites; massive; fine crystalline (similar to Elm Point Formation but not calcareous).
		Ashern	65.9-69.0	Argillaceous Dolomite: grey to green to red; brecciated at top; clayey; very fine to fine grained.
M-12-91 Deerhorn Quarry	9-3-21-5W +263.7	SILURIAN-Cedar Lake	0.0-9.8	Reefal Dolomite: buff yellow; fossiliferous; 5-10% porosity.
			9.8-43.9	Dolomite: tan brown with red and green staining; slightly fossiliferous; scattered red and green infill; fine crystalline.
		East Arm	43.9-60.4	Dolomite: tan to brown; slightly stromatolitic; some fossiliferous material; fine crystalline.
		(V-marker)	60.4-61.5	Argillaceous Dolomite: red to green; silty; scattered spheroidal imprints (3-8 mm in diameter).
		Moose Lake	61.5-80.0	Dolomite: light tan to white; very fine to fine crystalline; massive; variable porosity (1-10%); slightly nodular; slightly stromatolitic; U_2-marker? present at 65.9-66.1 m.
		(U_1-marker)	80.0-80.2	Argillaceous Dolomite: purple red; slightly sandy with spheroid imprints.
		Fisher Branch	80.2-91.7	Dolomite: light brown; fine crystalline; fossiliferous; porcelaneous; *Virgiana* at base.
		Stonewall	91.7-92.0	Dolomite: grey; fine crystalline; containing spheroid imprints.
		(T-marker)	92.0-93.1	Argillaceous Dolomite: red to green; some sand lenses; laminated; containing small spheroid imprints.
		ORDOVICIAN-Lower Stonewall	93.1-96.6	Dolomite: tan to white; very fine crystalline to sublithographic; slightly fossiliferous; porcelaneous.
M-13-91 Narcisse	2-10-19-1W +275.8	SILURIAN-Fisher Branch	0.0-13.0	Dolomite: buff yellow; fine to medium crystalline; fossiliferous with coral debris and *Virgiana*.
		Stonewall	13.0-13.5	Dolomite: buff yellow brown; irregularly laminated; conglomeratic; containing spheroidal imprints.
		(T-marker)	13.5-14.5	Argillaceous Dolomite: red; slightly arenaceous; containing spheroidal imprints.
		ORDOVICIAN-Lower Stonewall	14.5-16.0	Dolomite: olive green; very fine crystalline; sublithographic.

M-14-91 Narcisse	3-10-19-1W +275.5	SILURIAN-Fisher Branch	0.5-12.3	Dolomite: light brown; fine to medium crystalline; massive to dense; fossiliferous (coral debris and *Virgiana*); slightly oolitic in places; minor breccia and conglomerate beds.
		Stonewall	12.3-12.8	Dolomite: grey to buff yellow; slightly argillaceous; conglomeratic; dense; <5% porosity.
		(T-marker)	12.8-13.9	Argillaceous Dolomite: red with spheroidal imprints.
		ORDOVICIAN-Lower Stonewall	13.9-15.9	Dolomite: porcelaneous; massive; dense, sublithographic.
M-15-91 Narcisse	4-10-19-1W +275.5	SILURIAN-Fisher Branch	0.3-13.2	Dolomite: light brown; wackestone; fossiliferous; 5-10% porosity; possibly some *Virgiana* fossils-especially at the base.
		Stonewall	13.2-15.9	Dolomite: buff tan; slightly sublithographic.
M-16-91 Narcisse	5-10-19-1W +275.2	SILURIAN-Fisher Branch	1.2-11.9	Dolomite: light brown to buff; slightly fossiliferous and conglomeratic; *Virgiana* present at 8.0 m.
		Stonewall	11.9-13.6	Dolomite: buff yellow to tan; finely laminated; sublithographic.
		(T-marker)	13.6-14.4	Argillaceous Dolomite: red with spheroidal imprints.
M-17-91 Narcisse	12-10-19-1W +275.2	SILURIAN-Fisher Branch	0.0-13.1	Dolomite: tan brown; fossiliferous; vuggy; 5-10% porosity; difficult to place lower contact to upper Stonewall.
		Stonewall (T-marker)	13.1-14.6	Argillaceous Dolomite: red with spheroidal imprints.

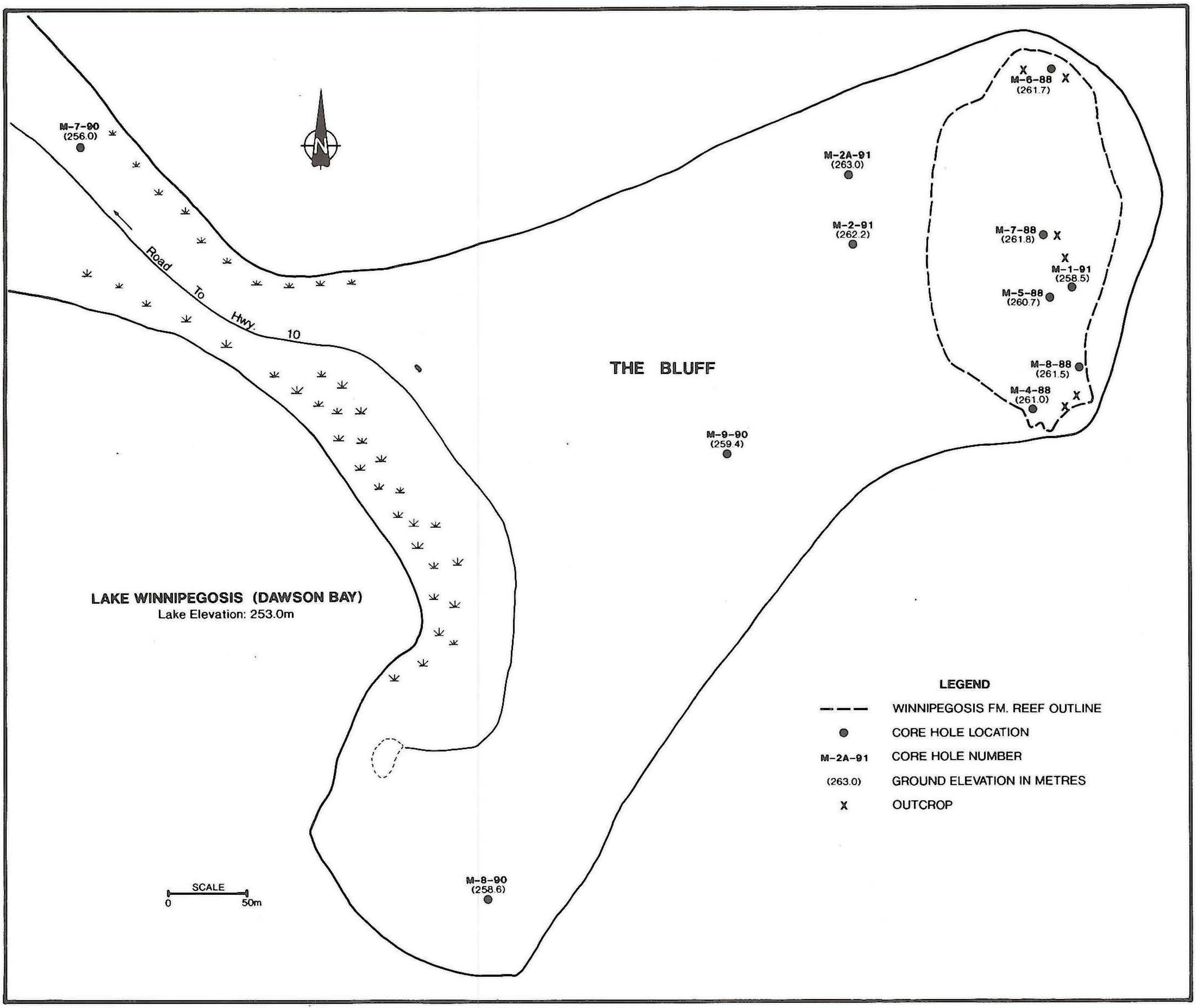

Figure GS-14-2: Location of stratigraphic core holes drilled on The Bluff and corresponding outcrop exposures.

brine-rich to an evaporite-rich environment of deposition. These horizons may correlate to similar horizons deeper in the subsurface of the Williston Basin which contain anhydrites (such as the Lower Stonewall Anhydrite).

Namew Lake

On Sturgeon Point (Namew Lake), an 8 to 12 m section exposes the contact where the Stony Mountain Formation overlies the argillaceous and recessive beds of the Fort Garry Member (Red River Formation). Kupsch (1952) first measured the section in detail, but placed the entire section in the Stony Mountain Formation. Since that time, McCabe and Bannatyne (1970) have discovered a new member (the Fort Garry) in the Red River Formation as a result of stratigraphic studies conducted in the southern Interlake area. Although McCabe (pers. comm.) had not visited the Namew Lake section, correlation of this section to the Rocky Lake section (which McCabe had visited) allowed him to place the argillaceous, recessive beds of the Namew Lake section into the Fort Garry Member. Kupsch could not have known that these argillaceous beds belonged to the Red River Formation.

The Fort Garry Member, at the Namew Lake section, consists of interbedded argillaceous dolomites, dolomitic shales and breccia beds. Colours range from red grey to red green. Some beds appear to be highly disturbed which may represent solution collapse features and may correlate to anhydrite beds in the subsurface. Correlation of the section to adjacent stratigraphic holes and mineral exploration holes will be carried out in conjunction with correlations to the subsurface in Saskatchewan.

GRAND RAPIDS

Three stratigraphic core holes were drilled north of the Grand Rapids area to establish an east-west transect for groundwater studies. Two of the core holes penetrated the Precambrian (M-2-89 and M-6-91); M-5-91 was abandoned at 53.9 m due to drilling problems. In 1991 core hole M-2-89 was reamed out and deepened to widen the hole for down-hole geophysical and groundwater tools. Testing of the holes will commence in late 1991 in collaboration with the Water Resources Branch (Natural Resources).

Figure GS-14-7 is a cross section of the core holes utilized in this east-west transect. Datum for the cross section was hung on the

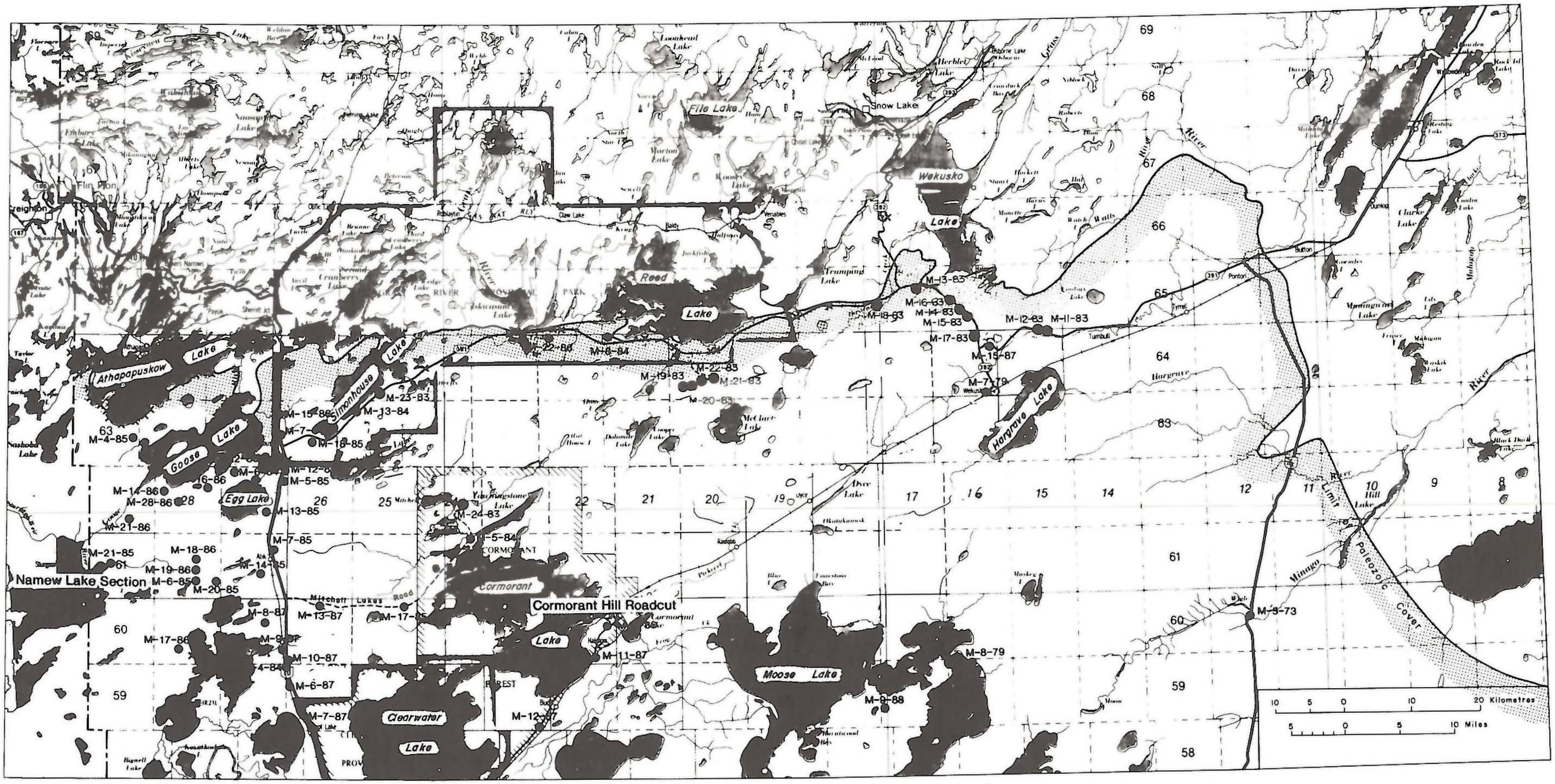

Figure GS-14-3: *Map of the northern Paleozoic edge of outcrop. Station locations from 1991 mapping are approximately indicated by (x) and previous stratigraphic core hole drilling are indicated by (•). The stippled edge is the limit of Paleozoic cover.*

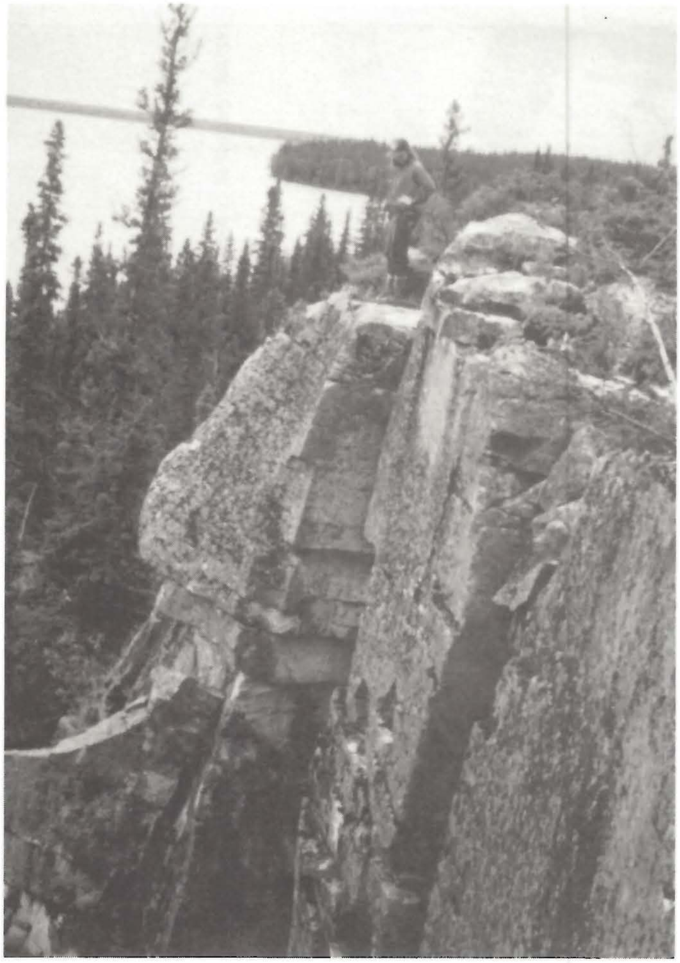

Figure GS-14-4: *An approximate 14 m high section of Red River Formation dolomite, West Arm, Athapapuskow Lake.*

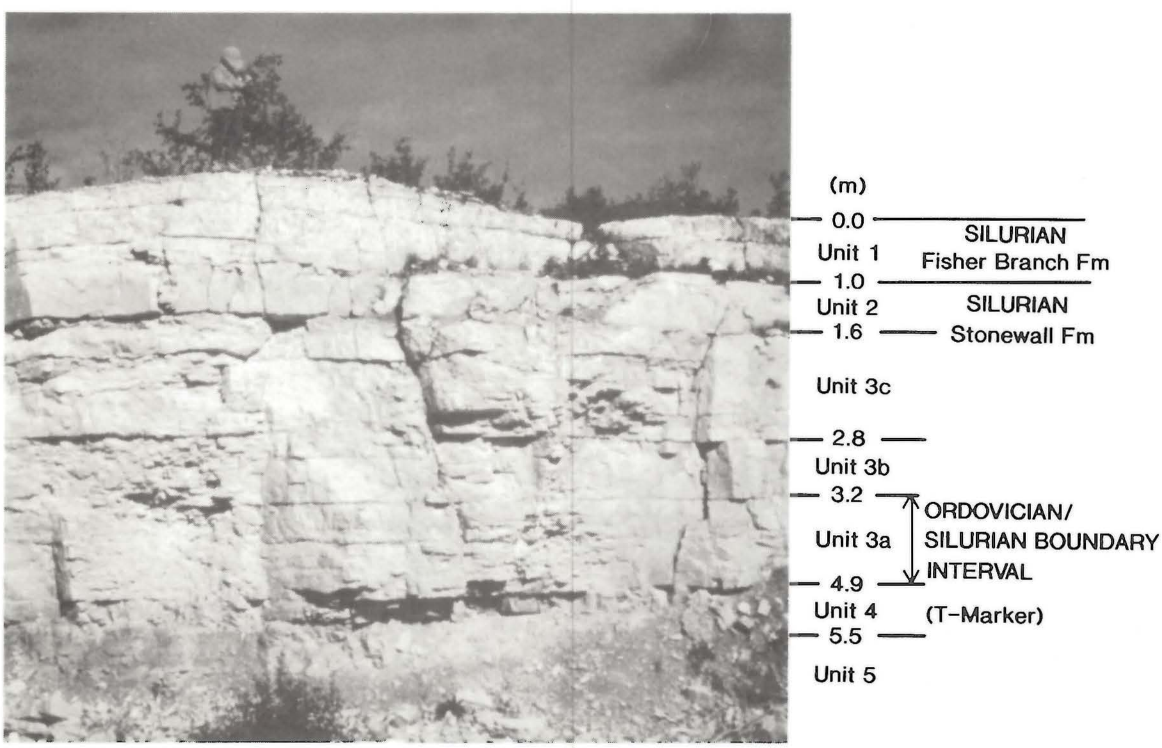

Figure GS-14-5: *Unit subdivisions of the Cormorant Hill roadcut indicating the Ordovician/Silurian boundary interval. See Table GS-14-2 for detailed descriptions.*

Table GS-14-2
Summary of Unit Descriptions of the Cormorant Hill Roadcut

UNIT 1: Silurian Interlake Group (Fisher Branch Fm)
Thickness range: 1.0-1.6 m
Dolomite: light brown, tan, buff and orange; fine to medium crystalline; thin to thick bedding; scattered pinpoint porosity (up to 20%); vuggy (3-5 cm in diameter); irregularly nodular; minor fossiliferous material - no evidence of *Virgiana*; sharp lower contact.

UNIT 2: Silurian Stonewall Formation
Thickness range: 0.75-1.2 m
Dolomite: (becomes argillaceous at south end of roadcut) light grey to green grey; fine crystalline; very thin to medium bedded; some interbedded shale beds - very flaggy texture; some beds are conglomeratic to brecciated (clasts size: 1-10 mm - most are somewhat rounded); sharp lower contact.

UNIT 3c: Silurian Stonewall Formation
Thickness range: 0.4-0.5 m
Dolomite: light brown, tan to buff; very fine crystalline to sublithographic; thin to medium bedded; irregular bedding contacts; gradational lower contact.

UNIT 3b: Silurian Stonewall Formation
Thickness range: 0.5-0.6 m
Conglomeratic dolomite: blue grey to tan brown; predominantly clast-supported in a matrix of fine dolomite fragments; clast size ranges from <1 mm to 4 cm in diameter; very well indurated; rare foreign clasts; slightly argillaceous bed at lower contact (<1 cm thick); sharp lower contact.

UNIT 3a: Silurian/Ordovician Stonewall Formation
Thickness range: 0.4-1.0 m
Dolomite: (very similar to UNIT 3C) light brown tan to buff; fine crystalline; fine to medium bedded - irregular contacts; <3-4% porosity (pinpoint and vuggy); slightly nodular bedding.

UNIT 2: Silurian/Ordovician Stonewall Formation (T-marker)
Thickness range: 0.6-1.3 m
Argillaceous dolomite: red to green; very thin bedded to laminated; interbeds of argillaceous clay-rich beds and dolomite beds; no evidence of brecciated or conglomeratic beds; large concretions present (0.5 x 0.75 m in diameter), very fine crystalline to sublithographic dolomite, purple red in colour; beds in contact to these concretions are at 45°; sharp lower contact.

UNIT 1: Ordovician Stonewall Formation
Thickness range: >1.0 m (covered)
Dolomite (slightly argillaceous): dark brown to tan; fine crystalline to sublithographic; thin to medium bedded; only exposed on north end of roadcut; predominantly rubble covered; negligible porosity; becoming somewhat oxidized in contact with T-marker (red in colour).

argillaceous T-marker of the Stonewall Formation. The stratigraphic correlations appear to conform to regional trends, aside from minor exceptions. The Atikameg Formation, in M-6-91, appears to be stratigraphically lower than in adjacent holes M-5-91 and M-2-89. The top interval in M-6-91 was relogged and the Atikameg Formation appears to occur at the indicated interval. It is possible that solutioning below the Atikameg Formation interval (i.e. in the Moose Lake Formation) has down dropped the entire sequence and produced large sinkholes at surface. This interpretation is strongly supported by the presence of large diameter sinkholes in the vicinity of core holes M-5-91 and M-6-91.

Uncertainties in correlation can occur in the lower Interlake Group, due to the cyclical repetition in lithology and apparent omission of some marker beds. In this cross section, the U_1-marker (base of Moose Lake Formation) is not identified in M-3-89, although it is present in the other core holes. The U_2-marker (base of East Arm Formation) and V-marker (middle to top of East Arm Formation) were not identified in any of the core holes.

The Williams Member (Lower Stonewall Formation) is stratigraphically conformable in the cross section until core hole M-4-91 where it appears to pinch-out. It is difficult to determine if this is a real feature or if it is due to an erroneous core pick. Continuing correlations with mineral exploration holes to the west and into Saskatchewan, will determine the existence of additional irregularities within the Lower Paleozoic sequence.

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 in Edmonton, with contributions by federal and provincial agencies, academia, and the private sector. In 1989-90, a systematic check of all atlas well picks from Manitoba was done, with some of this data being incorporated into the ongoing development of basin-wide cross sections for the Lower Paleozoic. Additional work in 1991 includes: a Hudson Bay Basin cross section; a nomenclature chart incorporating Manitoba outcrop terminology and present subsurface usage; and, a subsurface map of evaporite distribution. Final edits on the accompanying text for the Lower Paleozoic chapter, as well as the Jurassic chapter, were carried out with help from H.R. McCabe. Release of the atlas is scheduled for late 1991.

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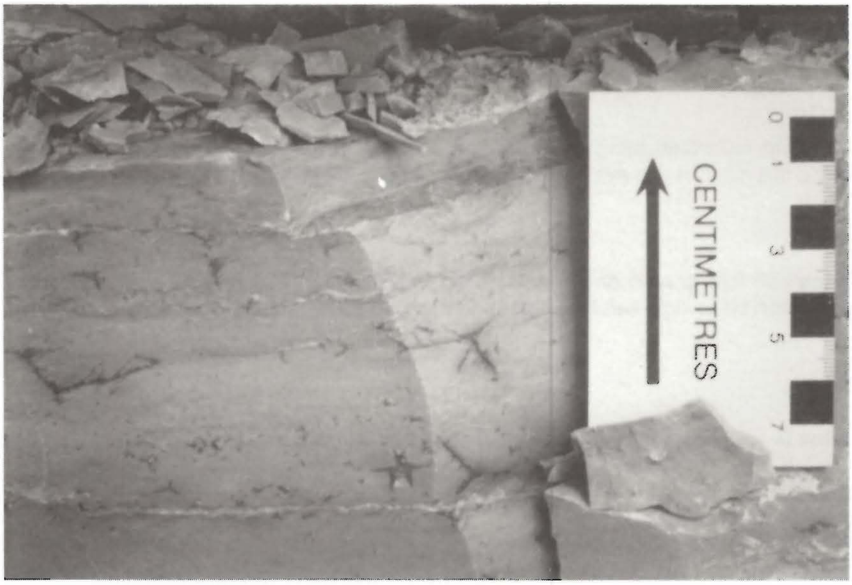

Figure GS-14-6: Red, skeletal halite molds in sublithographic dolomite from Cormorant Hill (Williams Member, Lower Stonewall Formation).

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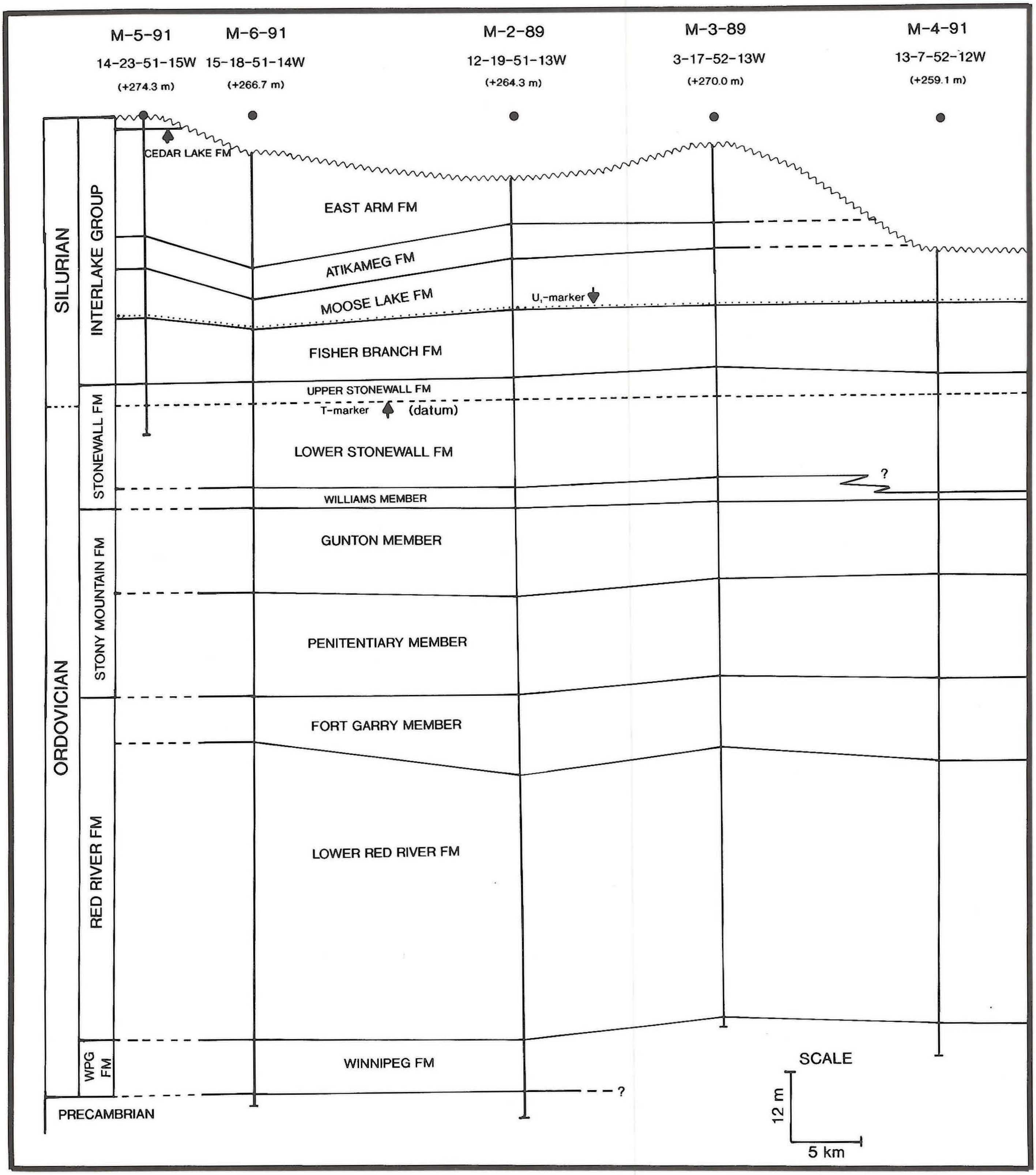

Figure GS-14-7: *West to east cross section of Paleozoic units north of Grand Rapids. Locations are indicated by township and range, and ground elevations are indicated by (+274.3 m).*

GS-15 MANITOBA OIL AND GAS WELL INFORMATION SYSTEM (MOGWIS)

by G.G. Conley

Conley, G.G., 1991: Manitoba oil and gas well information system (MOGWIS); **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 74-76.

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. It is designed to replace a hybrid record keeping system in which some records are maintained in paper format and others in a number of small computer databases. Typically, general well data, production data, and engineering data is maintained by the Petroleum Branch. Phanerozoic core storage data is maintained by Geological Services Branch. Stratigraphic data is maintained by both branches.

The Manitoba Oil and Gas Well Information System will incorporate all existing paper and computer databases into one centralized integrated system. Once it is fully operational, in a multi-user networked environment, it will be used to record the daily well transactions of Petroleum and Geological Services. MOGWIS will provide rapid access to all well records both for internal users and external clients and represents a major step in the automation of technical information services of Petroleum and Geological Services. Computerization of the Phanerozoic core storage has already resulted in a dramatic reduction of time required to retrieve core. Geographic Information System capabilities will enhance stratigraphic and petroleum related map production and products. MOGWIS, in combination with GIS, will allow demonstration of new tools and techniques to clients, to assist them in the exploration and development of the mineral resource and oil and natural gas potential of Manitoba. Security provisions will limit access to sensitive or confidential data.

INPUTS

The Manitoba Oil and Gas Well Information System consists of 36 primary tables or groups of well data. Each primary group may have one or more additional tables to record detail information. All tables are linked by a Unique Well Identifier (UWI) consisting of location information. Table GS-15-1 contains a listing of the proposed tables.

Table GS-15-1
Proposed MOGWIS database tables

Table		Name	Description
1		WELL_HDR	Well header information.
2		WELL_LICENSE	Information about the licensing of a well.
3		WELL_RIGHTS	Well mineral rights.
4		WELL_DLS_NTS	Breakdown of dls and nts system used for performance reasons.
5		WELL_LOCATIONS	Legal descriptions of well for areas in USA.
6		WELL_INDICATORS	Counts of sub records (non-normalized).
7		WELL_M_B	Well metes and bounds for raw survey locations.
8		WELL_DRILL_SHOW	Record of petroleum show information found during drilling.
9		WELL_INTEREST	Well ownership information (interest information by partner).
10		WELL_DIR_SURVY_HDR	Directional survey header.
10	A	WELL_DIR_SURVY_PTS	Directional survey points.
11		WELL_COUNTS	Counts of sub records (normalized).
12		WELL_VELOCITY	Well velocity information.
13		WELL_TOUR_OCC	Record any (typically abnormal) occurrence during a tour while drilling.
14		WELL_EVENT	Store any event associated with a well.
15		WELL_PROD_ZONE_HDR	Header for historical production and injection data.
15	A	WELL_PROD_HIST	Well production history by month.
16		WELL_PROD_ZONE_PAY	Pay of producing zones in well.
17		WELL_TOPS	Well tops interpretations from one or more source.
18		WELL_STATUS	Historical status information by date.
19		WELL_INIT_POTENT	Initial potential data.
20		WELL_CEMENT	Cement data.
21		WELL_PLUGBACK	Plugback and abandonment data.
22		WELL_POROUS_INTRVL	Contains information about any porous interval.
23		WELL_INIT_PROD	Initial production test information.
23	A	WELL_INIT_PROD_REC	Actual amounts of fluids recovered during the specified production test.
23	B	WELL_INIT_PROD_MAT	Rates of recovery for the specified production test.
24		WELL_COMPLETIONS	Completion information.

25		WELL_CASING	Casing details.
26		WELL_SHOWS	Any show information for the well.
27		WELL_REMARKS	Any remark or comments about the well.
28		WELL_DST_HDR	Drill Stem Tests Header - information that applies to the whole test.
28	A	WELL_DST_VO	DST Valve Open Period.
28	A1	WELL_DST_VO_REC	Actual amounts of fluids recovered during specified valve open period.
28	A2	WELL_DST_VO_MAT	Rates of recovery for the specified valve open period.
28	A3	WELL_DST_VO_ANAL	Records analysis performed on a fluid for a Drill Stem Test.
29		WELL_LOG_RUN_HDR	Well log run header.
29	A	WELL_LOG_RESIST	Details of the mud and water resistivity information.
29	B	WELL_LOG_CURVE_HDR	Well log curve header.
29	B1	WELL_LOG_DIGITS	Well log digits.
30		WELL_CORE_HDR	Core analysis header.
30	A	WELL_CORE_METHOD	Methods used during core analysis.
30	B	WELL_CORE_SAMPLE	Details about the specific sample of the core being analyzed.
30	B1	WELL_CORE_LINE	Specific details of the core analysis.
30	C	WELL_CORE_DESC	Any remark, comment or description about the core.
31		WELL_PRESS_HDR	Header table for Absolute Open Flow and Bottom Hole Pressure.
31	A	WELL_PRESS_BHP	Details of the Bottom Hole Pressure Survey.
31	B	WELL_PRESS_AOF	Details of the Absolute Open Flow Test.
31	A1	WELL_PRESS_REMARKS	Remarks about pressure surveys that do not fit into specific areas.
32		WELL_GAS_ANAL_HDR	Gas analysis header.
32	A	WELL_GAS_ANAL_DETL	Gas analysis detail information.
33		WELL_CRD_ANAL_HDR	Crude oil header and analysis information.
33	A	WELL_CRD_VISCOSITY	Crude oil viscosity.
34		WELL_WTR_ANAL_HDR	Water analysis header.
34	A	WELL_WTR_ANAL_DETL	Water analysis detail information.
35		WELL_SIEVE_HDR	Sieve analysis header.
35	A	WELL_SIEVE_SCREEN	Sieve analysis detail.
36		POOL_GAS_ANAL_HDR	Gas analysis on a field and pool basis.
36	A	POOL_GAS_ANAL_DETL	Gas analysis detail on a field and pool basis.

OUTPUTS

The Manitoba Oil and Gas Well Information System will be used to generate a wide variety of reports for both internal and client use. The system will also provide data extracts to be used in the generation of maps.

Reports will typically include the Weekly Well Activity Report, Well Card, Index of Core and Sample Storage, Lower Paleozoic Formation Tops, Drill Stem Tests and Oil and Gas Shows, Formation Water Analyses, and custom reports for clients.

Maps will typically include Stratigraphic Maps (various scales, isopach and structure contour), Stratigraphic Cross-sections, Depth to Bedrock Maps, Well Location maps, Field/Pool Location Maps, etc.

IMPLEMENTATION TIMETABLE

The committee responsible for the development of the Manitoba Oil and Gas Well Information System have identified five phases of the project and the projected timetable for implementation of each of the phases:

Year		Activity
1990	I.	PLANNING: define role and scope of project (completed).
	II.	DESIGN: define database structure and content, data entry screens, and report forms (in progress).
	III.	IMPLEMENTATION: develop menus, forms and reports in Oracle (in progress).
1991	IV.	DATA VERIFICATION: verify existing digital data, verify interpretive data (tops) and begin entry and updating of current data (in progress).
1992	V.	FULL OPERATION: move the database on-line in a multi-user networked environment to record daily transactions.
1993	VI.	FUTURE DEVELOPMENT: complete the mapping component of the Manitoba Oil and Gas Well Information System by the addition of a Geographic Information System (GIS).

Current Status of the Project

The schema that has been adopted (with some modifications) is a relational schema developed by a consortium consisting of Gulf Canada Resources, Applied Terravision Systems, Digitech Information Services, and Finder Graphic Systems. The schema was recently published by Rhynes (1990) and is available to the general public. At that time, 20 companies were using the schema and several major workstation software vendors had acquired it.

At present the system is in the design and implementation phases (Phase II and III). In the design phase, the committee is examining the schema in detail, identifying priorities for table development, and within tables, identifying fields to be kept, deleted or added.

In the implementation phase, the tables have been created and existing databases (Petroleum, Geological Services and Digitech Information Services) have been merged into the appropriate tables. Menus, data entry and query forms, and reports are currently being developed. Petroleum has requested that the first application to be developed be the Weekly Well Report, to ensure that current levels of service will be guaranteed. The second application will focus on the Well Information Card. Additional segments will be developed according to needs and priorities.

The MOGWIS database application is being developed and tested in a single user version of Oracle database software by G.ˇConley (Geological Services).

Phanerozoic core storage data is being maintained by D.ˇBerk (Geological Services) in dBase IV files. In addition, dBase IV programs have been written for recording storage locations of stratigraphic and exploration core.

The data verification phase (Phase IV) has two components: a)ˇverification of interpretative data (formation tops - C.ˇMartinuk (Petroleum) and R.ˇBezys (Geological Services)); and, b)ˇverification of hard data records. The hard data records for 1400 wells (license number 3000 to 4400) were verified and updated by a student hired by the Petroleum Branch this past summer.

Implementation

Once the verification process nears completion and the Weekly Well Report and Well Information Card applications are functional, the next step is to move the MOGWIS database into full daily operation in a multi-user networked system. The target date is 1992.

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 small 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.

Future Developments

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).

A Geographic Information System would allow selective extraction of data from the database and provide visual display of the data as a 2 or 3 dimensional map. Similarly, one could query the database by pointing to a well or wells on the screen map and view the associated data in a table. The extracted data could be used individually or in combination with other data to produce a large variety of maps. The database component will provide rapid and efficient access to the data collected. The Geographic Information System will allow demonstration of new tools and techniques to clients to assist them in exploring and developing the mineral resource and oil and natural gas potential of Manitoba.

A GIS would permit shortening the cycle in Phanerozoic map production by allowing the computer to do the data retrieval and the majority of the contouring. Mapping capabilities could also be extended to other areas of interest such as field/pool studies, definition of subsurface structures and traps, oil density/maturity/migration studies, mapping of core geochemistry, site management, environmental and site planning in relation to spillage from well-heads, pumps, tanks and pipelines, etc.

Maps produced on a GIS could be made available to clients as paper maps or in digital form for use in CAD or client GIS systems.

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GS-16 DIMENSION STONE INVESTIGATIONS IN SOUTHEASTERN MANITOBA

by J.D. Bamburak and B.E. Schmidtke

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.

INTRODUCTION

During the 1984-1989 Canada-Manitoba Mineral Development Agreement, the dimension stone potential of intrusions in southeast Manitoba was evaluated and specific outcrops that have the potential to be quarried for dimension stone were identified by Leathers (1985); Schmidtke (1986); Schmidtke and Gage (1987); and Schmidtke (in prep.).

Prior to the current field season, nine areas in southeast Manitoba had been identified as requiring further investigation. These areas were reconnoitered by detailed examination of air photographs in order to evaluate their potential as sources of building stone. Outcrops with widely spaced fractures commonly appear as either flat, bald surfaces usually with low relief and no discernible patterns of vegetation growth, or as large ridges of high relief with ledges that appear as fine dark lines that parallel the long axis of the ridge. Outcrops that have closely spaced fractures usually have abundant vegetation growth that follows linear patterns (Schmidtke, in press).

Five of the outcrops areas were withdrawn from further investigation on the basis of a detailed examination of aerial photographs. These areas are shown on Figure GS-16-1 as:

1. Maskwa Lake batholith, from the junction of PR314 and 315 north to Cat Lake;
2. Inconnu granite, from Shoe Lake west along the Maskwa Lake road;
3. Marijane Lake batholith, south of PR315 to Ontario border;
4. Lac du Bonnet batholith, north of PR313 and east of PR315; and
5. Pointe du Bois tonalite, north of Pointe du Bois and along Winnipeg River.

Four outcrop areas that were determined from the air photography study to be potential sources of building stone are indicated on Figure GS-16-1. These areas were selected for field examination to confirm fracture orientations and frequencies and the colour, texture, mineralogy and homogeneity of the rocks.

MEDITATION LAKE

Hornblende granodiorite, quartz diorite, porphyritic pink to red granodiorite and monzogranite were mapped (Fig. GS-16-2) by Janes (1978) in the vicinity of Meditation Lake. An outcrop, south of the lake, identified as a potential source of building stone by Schmidtke (1987) is presently under lease to Canital Explorations Inc. for test quarrying. This outcrop appears on aerial photographs as a flat surface with little vegetation growth. Outcrops of similar rock north and west of Meditation Lake were recommended for ground follow-up on the basis of a helicopter reconnaissance by G.H. Gale (pers. comm., 1990).

Site M1

Homogeneous brown porphyritic quartz monzonite, texturally similar to that in the proposed Canital quarry site, outcrops 500 m north of Meditation Lake (Fig. GS-16-2). The portion of the outcrop that was mapped in detail is shown in Figure GS-16-3. Site M1 has more quartz veins than the Canital site. Subvertical fractures are randomly spaced and only several parallel fractures were noted. The outcrop has four ledges that range in height from 1 to 3 m. Xenoliths were not noted at this site. This site is a potential source of the same dimension stone as that being developed at the south end of Meditation Lake.

Site M2

The rock at site M2 (Fig. GS-16-2) is an homogeneous pink-red porphyritic granite that is texturally similar to the rocks at the proposed Canital quarry site and site M1. However, pegmatite veins and lenses are abundant. Fractures in this rock strike north and are spaced 0.5 to 5.0 m apart (Fig. GS-16-4). The outcrop has three ledges that range in height from 1 to 3 m. Xenoliths were not noted at this site. This site is a marginal source of dimension stone due to the pegmatites and the closely spaced vertical and horizontal fractures.

BIRD LAKE

Three sites in the Bird Lake area that appear as high, massive ridges on aerial photographs were investigated (Fig. GS-16-5). The outcrops in this area were mapped as the Great Falls quartz diorite by Janes (1978).

At site B1, hornblende-biotite gneiss, foliated granodiorite, quartz monzonite and pegmatite are exposed in steep-sided, north-trending ridges. Locally large sericitic and mafic inclusions occur in the granitic rocks and white quartz veins are common.

The country rock at site B2 is similar to that at B1, and the surface expression is also the same. Plant growth is abundant with tall spruce and pine growth located in vertical fractures, less than 1 m apart.

At site B3, east of Tulabi Falls, massive, pink, coarse grained granite to quartz monzonite is the most abundant rock type (Leathers, 1985). Pegmatite veins and lenses are abundant, but the rock contains fractures and fewer mafic inclusions than that at sites B1 and B2. Horizontal fractures are spaced less than 0.5 m apart.

These sites are not considered to be potential sources of dimension stone, because they contain pegmatites and rock inclusions, and the fractures are closely spaced.

LAC DU BONNET BATHOLITH

Site L1 (Fig. GS-16-6) south of Pinawa Bay, and east of Lee River, was chosen for investigation because widely spaced fractures were indicated on aerial photographs. The outcrop was mapped as the Lac du Bonnet monzogranite pluton by Janes (1978).

At this site, pink and grey granite with an inhomogeneous texture contains mafic inclusions and abundant pegmatite. These properties make this site an unlikely source of dimension stone.

GREAT FALLS BATHOLITH

A reconnaissance survey was undertaken to investigate grey granodiorite within grey gneiss and pink microcline granite-quartz monzonite as indicated on Map 1969F-5 (McRitchie, 1969). On aerial photographs the rocks appear to have widely spaced fractures. The area is situated north and west of Lac du Bonnet along PTH 11, PR304 and the Maple Creek Road (Fig. GS-16-1).

Foliated granodiorite with mafic gneiss inclusions and pink pegmatite occur in intensely fractured outcrops and in road quarries along PR304. Epidote is abundant in hairline fractures in a quarry located just west of and 0.1 km south of a bridge crossing a small creek on PR304, 9 km north of the Brightstone Sand Hills.

This area appears to have a very low potential as a source of dimension stone due to the highly fractured nature of the outcrops and the presence of epidote.

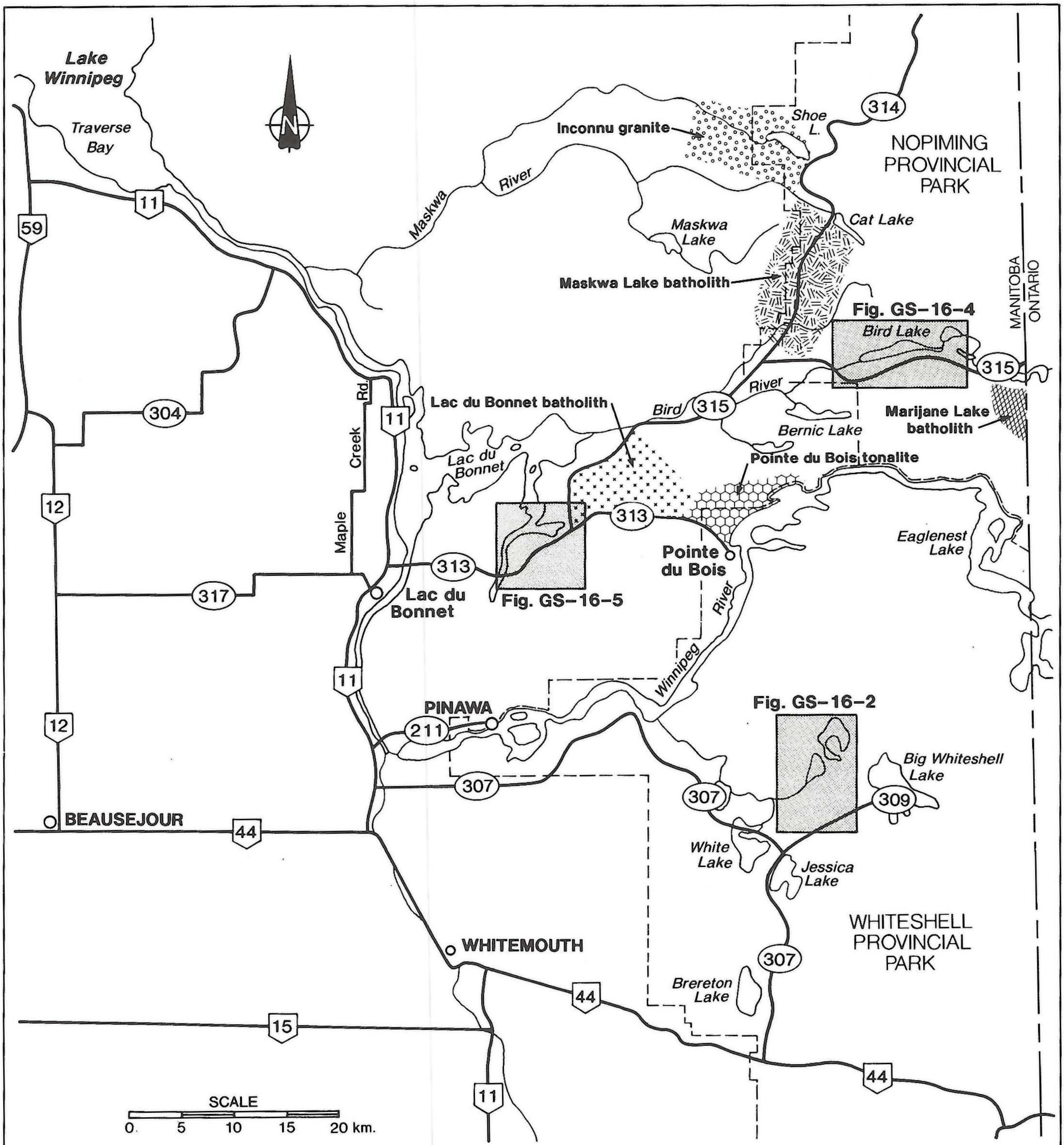

Figure GS-16-1: Index map of outcrop areas in southeastern Manitoba.

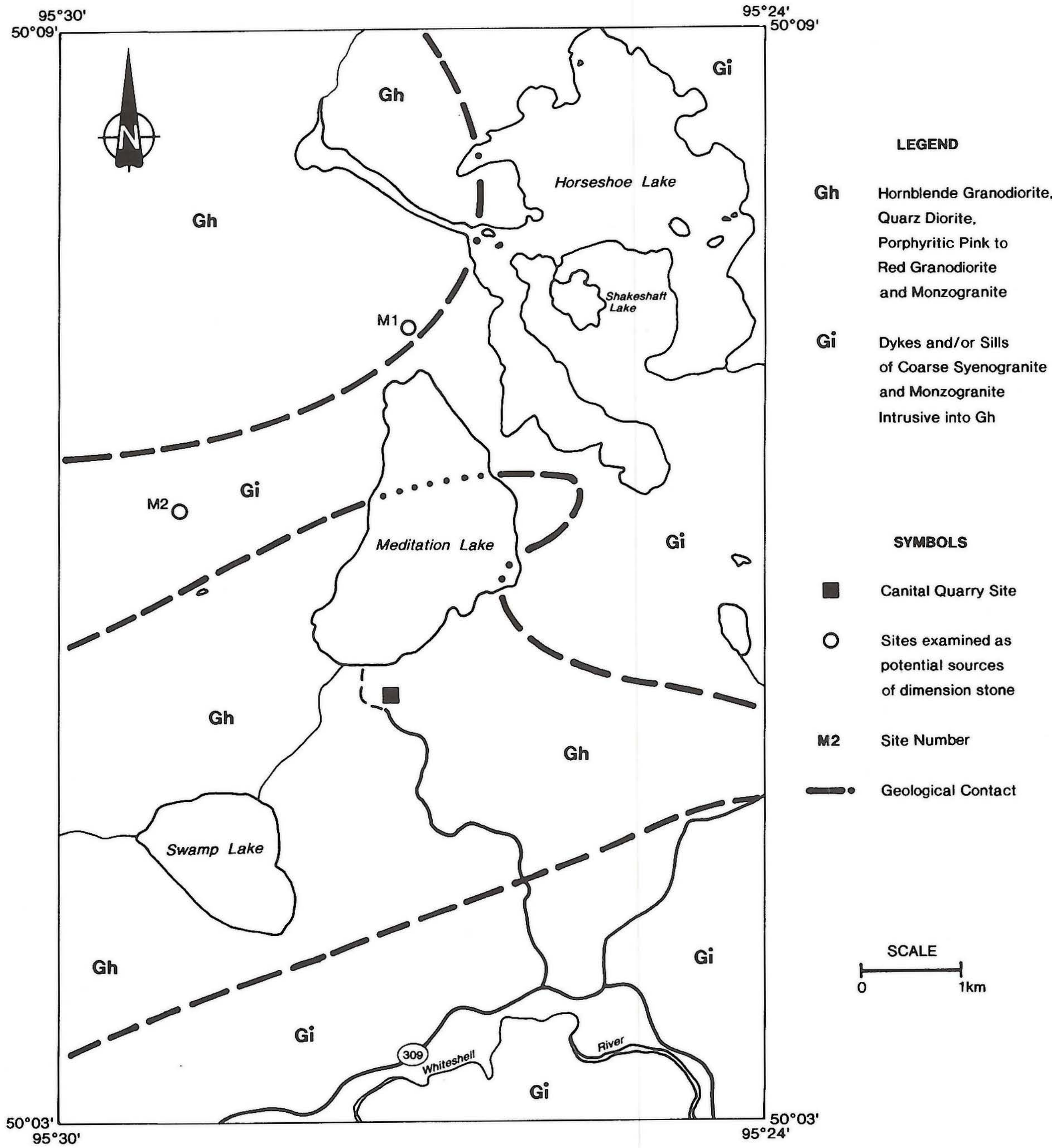

Figure GS-16-2: *Location of sites in Meditation Lake area.*

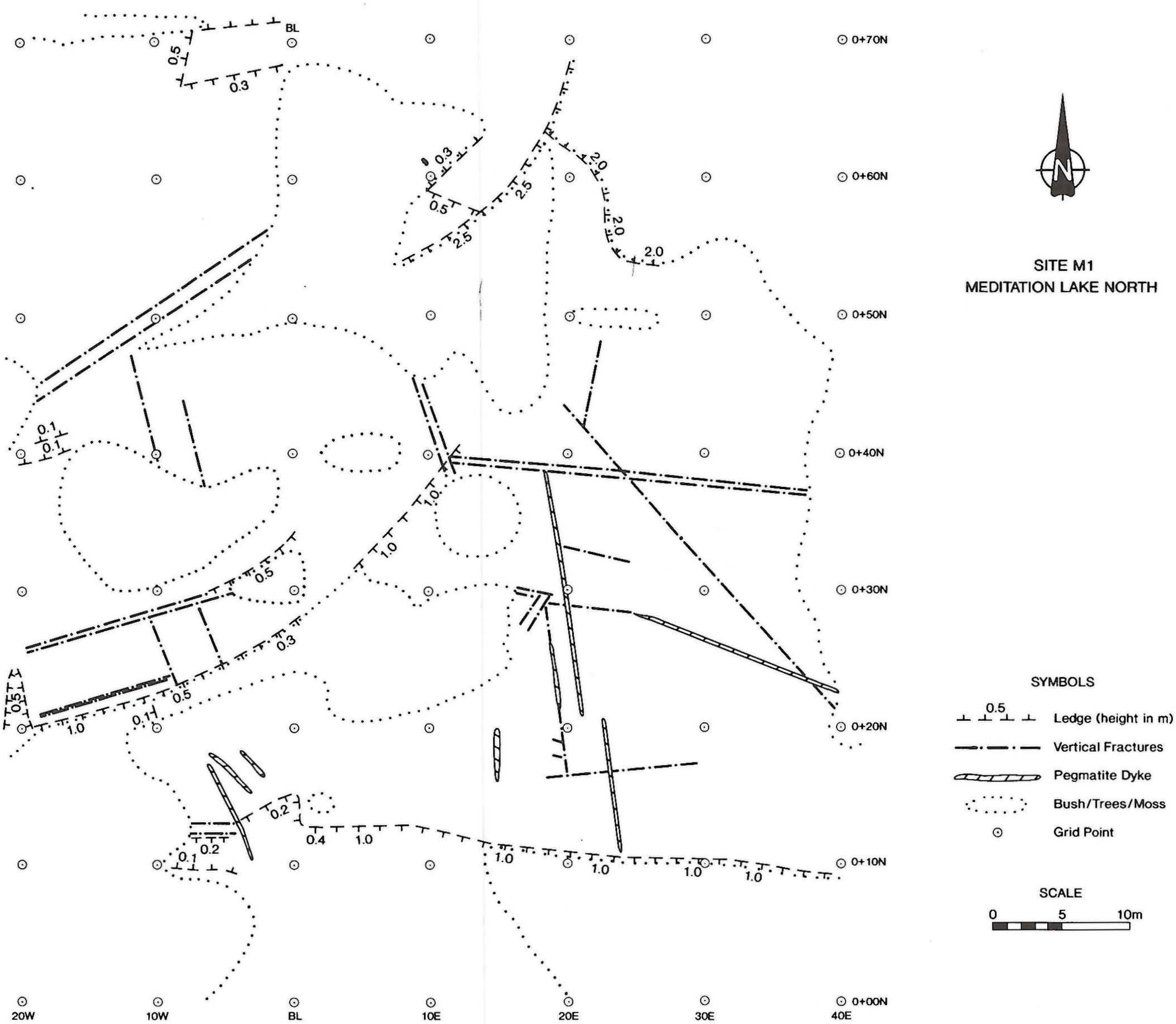

Figure GS-16-3: Joint diagram of Site M1, Meditation Lake.

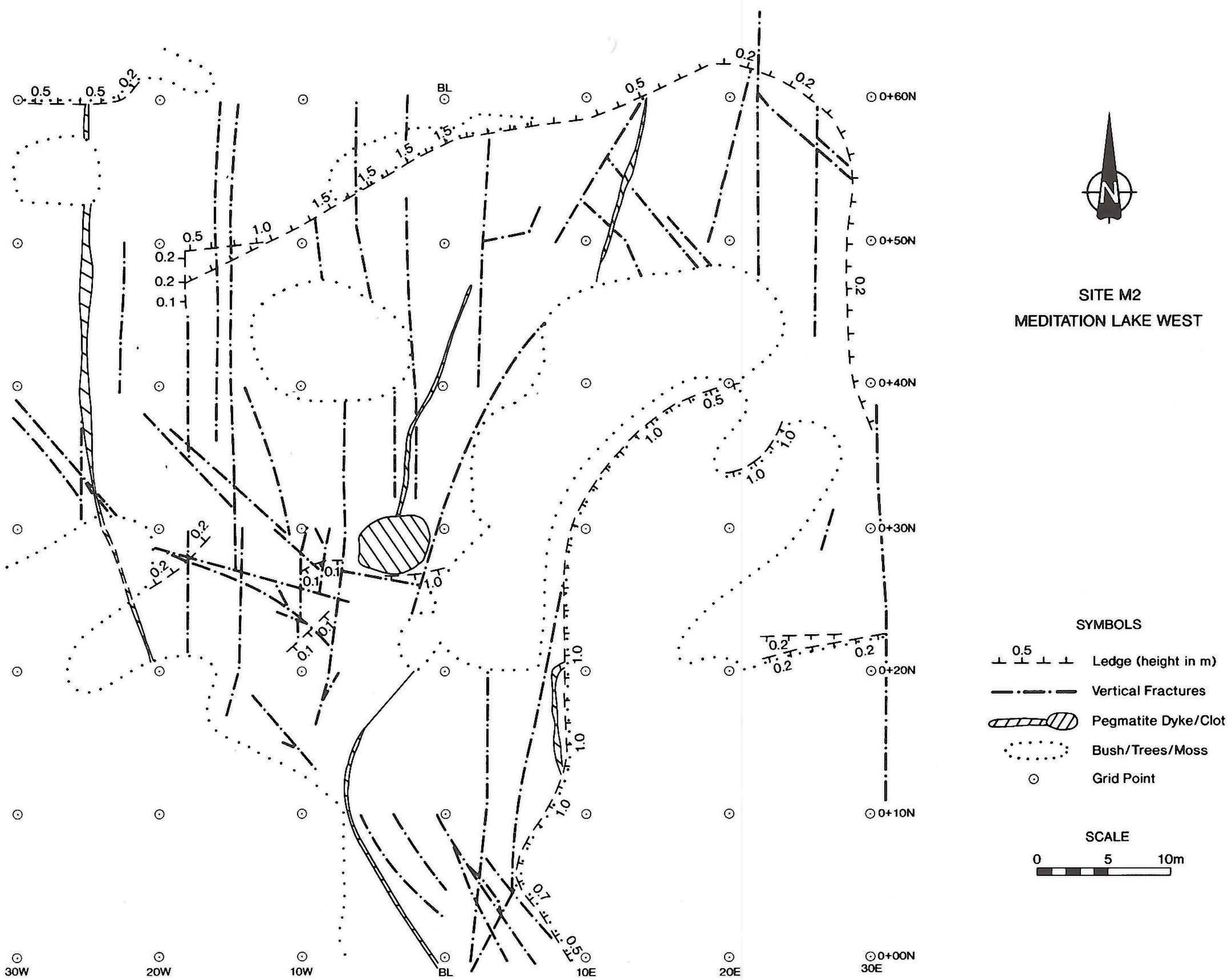

Figure GS-16-4: Joint diagram of Site M2, Meditation Lake.

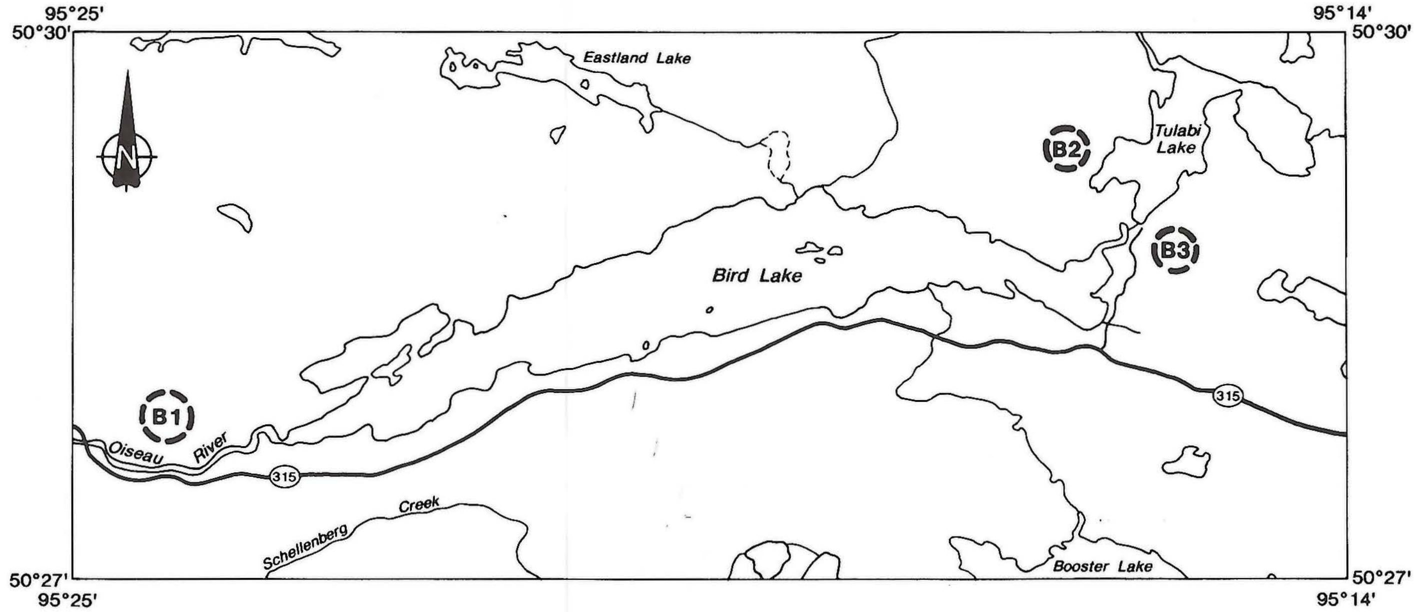

Figure GS-16-5: *Sites investigated in Bird Lake area.*

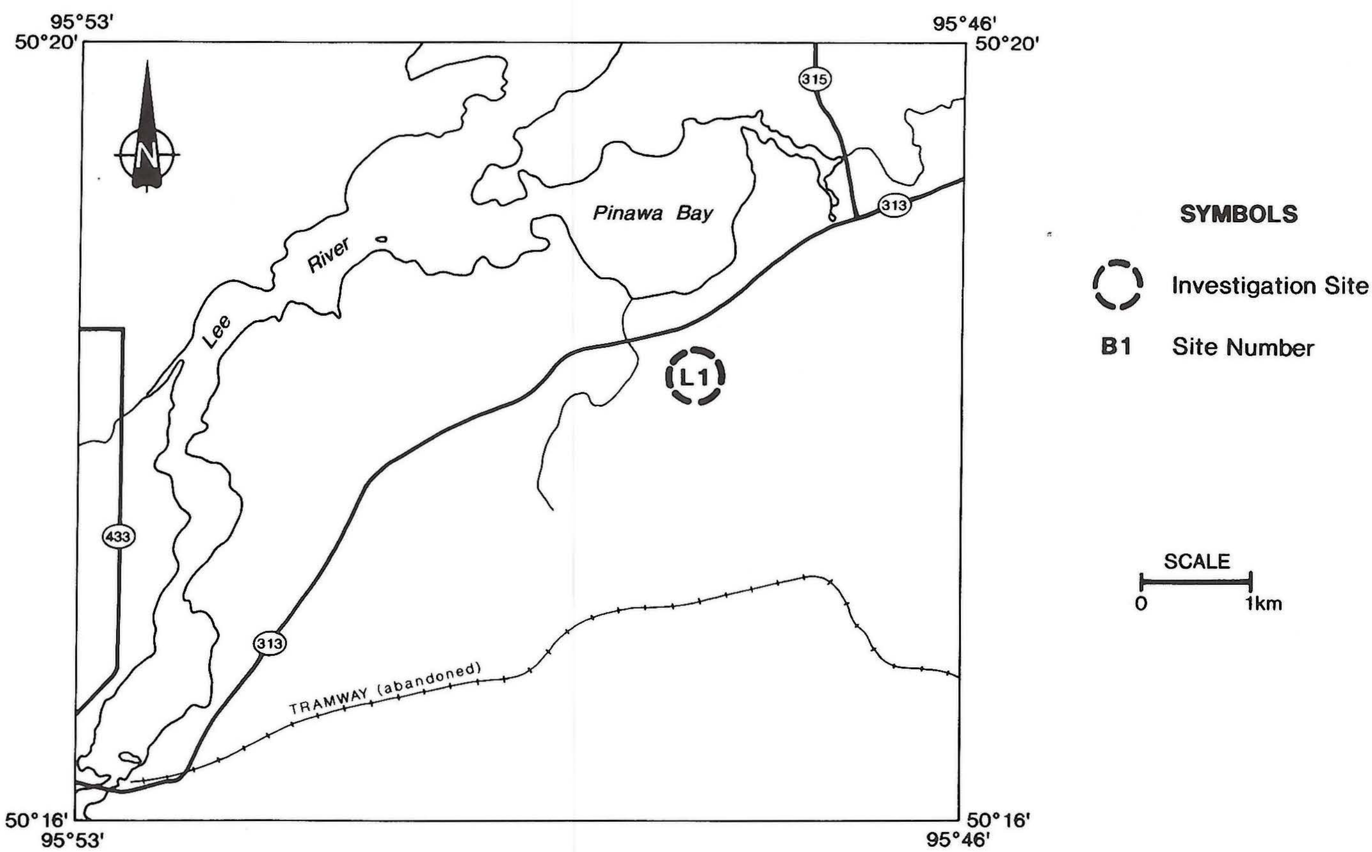

Figure GS-16-6: *Site investigated in Lac du Bonnet area.*

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GS-17 HIGH-CALCIUM LIMESTONE INVESTIGATIONS: EAST SIDE OF LAKE MANITOBA, SOUTH OF THE NARROWS (NTS 62I, 62O)

by J.D. Bamburak

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, Minerals Division, Report of Activities, 1991, p. 84-88.

INTRODUCTION

High-calcium limestone is defined as a carbonate rock with a minimum of 95% combined $CaCO_3$ and $MgCO_3$, and a maximum of 5% $MgCO_3$. However, for production of portland cement the requirement is for less than 3% $MgCO_3$, 1.3% SiO_2 and 3.7% $Al2O_3$. To date, high-calcium limestone produced in Manitoba has been obtained from Devonian beds in the Elm Point, Dawson Bay and Souris River formations (Bannatyne, 1975).

Inland Cement Ltd. produces cement, at its Tuxedo plant in Winnipeg, from limestone quarried by Lafarge Canada Inc. (formerly, Canada Cement Lafarge Ltd.) at Steep Rock, 240 km to the northwest (Fig. GS-17-1). Continental Lime Ltd. produces high-calcium and high-magnesia lime at its Faulkner quarry near Steep Rock for the construction industry, steel processing, the pulp and paper industry, and for municipal water softeners. High-calcium limestone from several quarries has also been used to produce crushed stone for road construction and grit for poultry feed south of Steep Rock.

High-calcium limestone deposits in Manitoba were documented by Bannatyne (1975). These Devonian-aged deposits have been recently investigated west of The Narrows, Lake Manitoba, and as far south as Dog Lake, 36 km southeast of Steep Rock (Gunter 1989, 1990 and GS-18, this volume). The high-calcium limestone potential of the Devonian Elm Point Formation was evaluated in a Bachelor's thesis by Rehill (1991).

The objectives of the present study were: 1) to locate sources of high-calcium limestone closer to Winnipeg, which would have a transportation cost advantage over presently producing quarries in the Steep Rock area; and 2) to identify localities within the study area that have a low potential as sources of high-calcium limestone, but would be more suitable for other uses, such as aggregate.

The area of investigation extends from east of The Narrows to south of Dog Lake (Fig. GS-17-1). Outcrops in the study area were examined and sampled during a four week period. Quarries were measured and suspected high-calcium limestone sections were channel sampled for chemical analysis. One hole was drilled east of The Narrows to fill-in missing stratigraphic data and to provide samples for analysis.

STRATIGRAPHY

Within the study area, Devonian strata unconformably overlie Silurian dolomitic beds. These sediments comprise the Ashern, Elm Point, Winnipegosis and lower Dawson Bay formations (Fig. GS-17-2).

The Ashern Formation is a brick-red to greyish-orange argillaceous dolomite with buff joint surfaces; it paraconformably underlies the Elm Point and Winnipegosis formations. The Elm Point Formation, a light grey to brown mottled limestone, is a facies equivalent of the Lower Member of the Winnipegosis Formation, a light to medium brown, faintly mottled, porous, bedded dolomite that has been interpreted as platform beds by Norris *et al.* (1982). "An arbitrary lower limit of 25% calcium carbonate (limestone) is used to differentiate the Elm Point Formation from the Lower Member of the Winnipegosis Formation." (Norris *et al.*, 1982, p. 17). The conformably overlying Upper Member is a light-yellowish to grey, vuggy, thin bedded to massive dolomite (interpreted as a biohermal reef/inter-reef facies). At the top of the Winnipegosis Formation, there are "Transitional Beds" that consist primarily of limestone-shale breccias and angular to contorted fragments of light buff, clean, relatively coarsely crystalline limestone in a grey clay-shale matrix; these sediments have been reported from drill holes (Norris *et al.*, 1982), but have not been observed in outcrop in the study area.

The lower beds of the Dawson Bay Formation are draped directly over the Winnipegosis Formation (Fig. GS-17-2). The Prairie Evaporite Formation, which is present in the subsurface to the west, has been removed by salt solution in the outcrop belt. The lower Dawson Bay Formations comprise the Second Red Member (also referred to as Member A or Mafeking Member) and the conformably overlying Lower Member (sometimes called Member B). The Second Red Bed Member, which does not outcrop in the study area, consists of red to greenish grey, noncalcareous and fissile shale with a hackly fracture and is gradational upward to argillaceous dolomitic limestone. The Lower Member consists of a lower portion of dolomite and calcareous dolomite and upper beds of light- to medium-brown, very fine grained to dense, micritic, fossiliferous limestone with bright red and orange stain (Norris *et al.*, 1982). The Middle and Upper members of the Dawson Bay Formation occur west of the study area.

OBSERVATIONS

Within the area investigated high-calcium limestone is present only in the Elm Point and the Dawson Bay formations.

The position of the lower contact of the Elm Point Formation with the underlying Ashern Formation, as shown on Map ER85-1-1 (Bannatyne, 1988), was verified by outcrop examination. The "upper" contact, which is a gradational facies boundary (Norris *et al.*, 1982, p. 17) could not be confirmed. The accurate positioning of this contact will require the results of chemical analyses on samples collected this summer, and possibly, future field work.

The contact of the Dawson Bay Formation shown on Map ER85-1-1 (Bannatyne, 1988) could be confirmed only in The Narrows area. A "pavement" outcrop (Bannatyne, 1975) on a small peninsula in the southwest corner of Dog Lake was not found.

Outcrops of all formations in the study area are concentrated within four east- trending belts - Oak Point, Lily Bay, Overton and The Narrows East (Fig. GS-17-3). The Elm Point Formation is present at surface in the first three belts and the Dawson Bay Formation in The Narrows East belt.

Oak Point belt

The Oak Point belt is 80 km from Winnipeg and was the first to be quarried.

The Elm Point Formation was quarried, prior to 1923, for crushed stone and lime production 4 km north of Oak Point. The stone in the quarry is a magnesium limestone with an average of 7.49% $MgCO_3$ reported between surface and 3.4 m depth and an average of 6.52% $MgCO_3$ between 4.6 and 7.6 m depth in drill hole FRED 69-1 (Bannatyne 1975). These results would indicate that it is unsuitable for cement production. However, exploration permits were issued in 1986 and converted to quarry leases in 1991 by Lafarge Canada Inc. (a cement producer) on quarter sections that lie immediately north, west and south of the old quarry.

Lily Bay belt

High-calcium limestone for cement has been produced only from the Lily Bay belt, 120 km northwest of Winnipeg.

Canada Cement Lafarge Ltd. operated the "Lily Bay West" quarry, located 0.6 km west of the former village of Lily Bay, from 1971 to 1974 and developed it to a width of 91 m, a length of 122 m and a depth of 9 m. An annual production rate of 136 000 tonnes had been proposed; however, the basal beds (0.9 m from bottom) were reported as being "high in $MgCO_3$" in nearby drill holes. In 1975 the last crushed stone, for use in cement production, was removed from a stockpile (Mineral Inventory Card No. 932). Samples were collected for chemical analysis to confirm the $MgCO_3$ values.

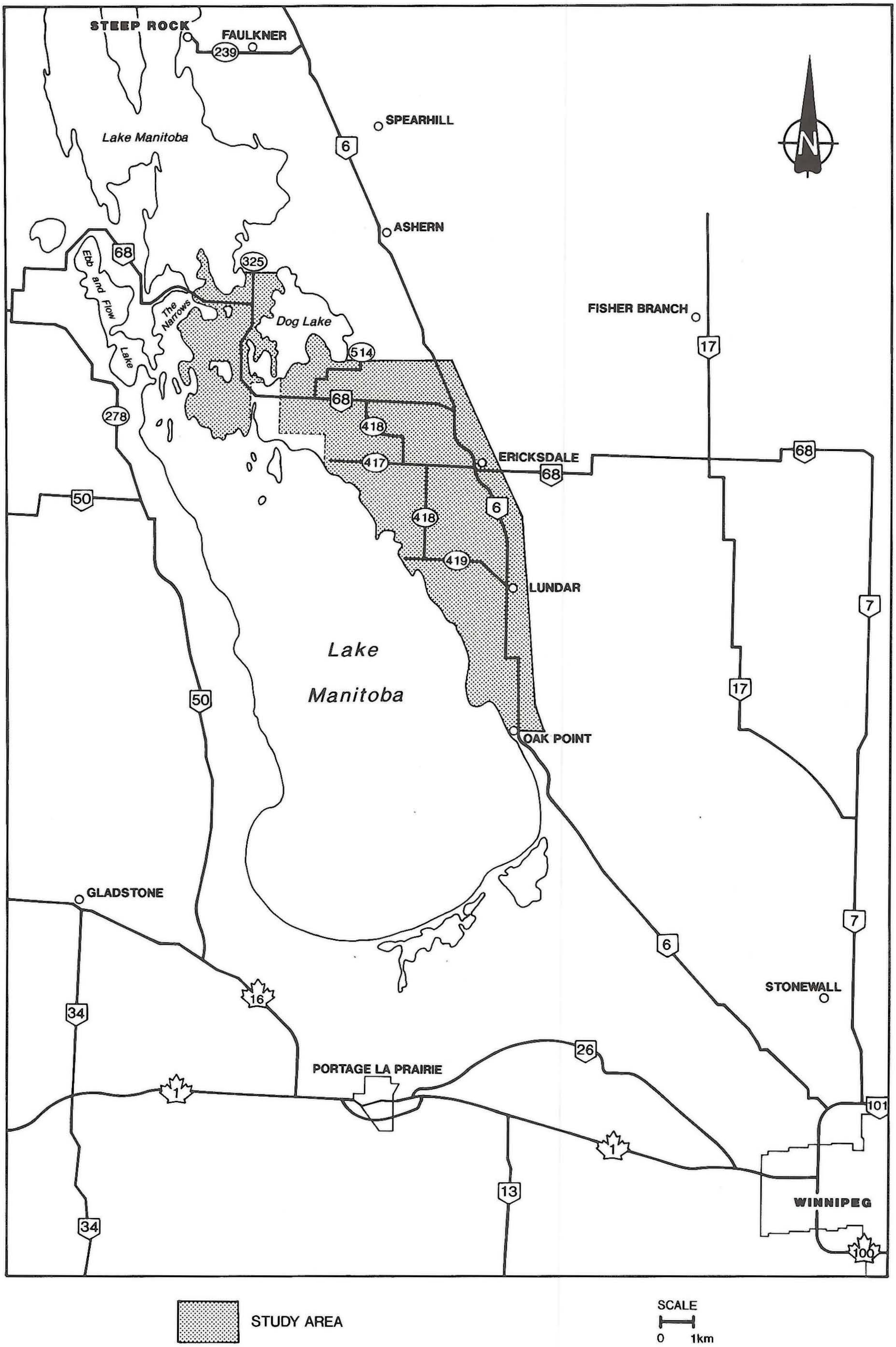

Figure GS-17-1: Location map for The Narrows East study area.

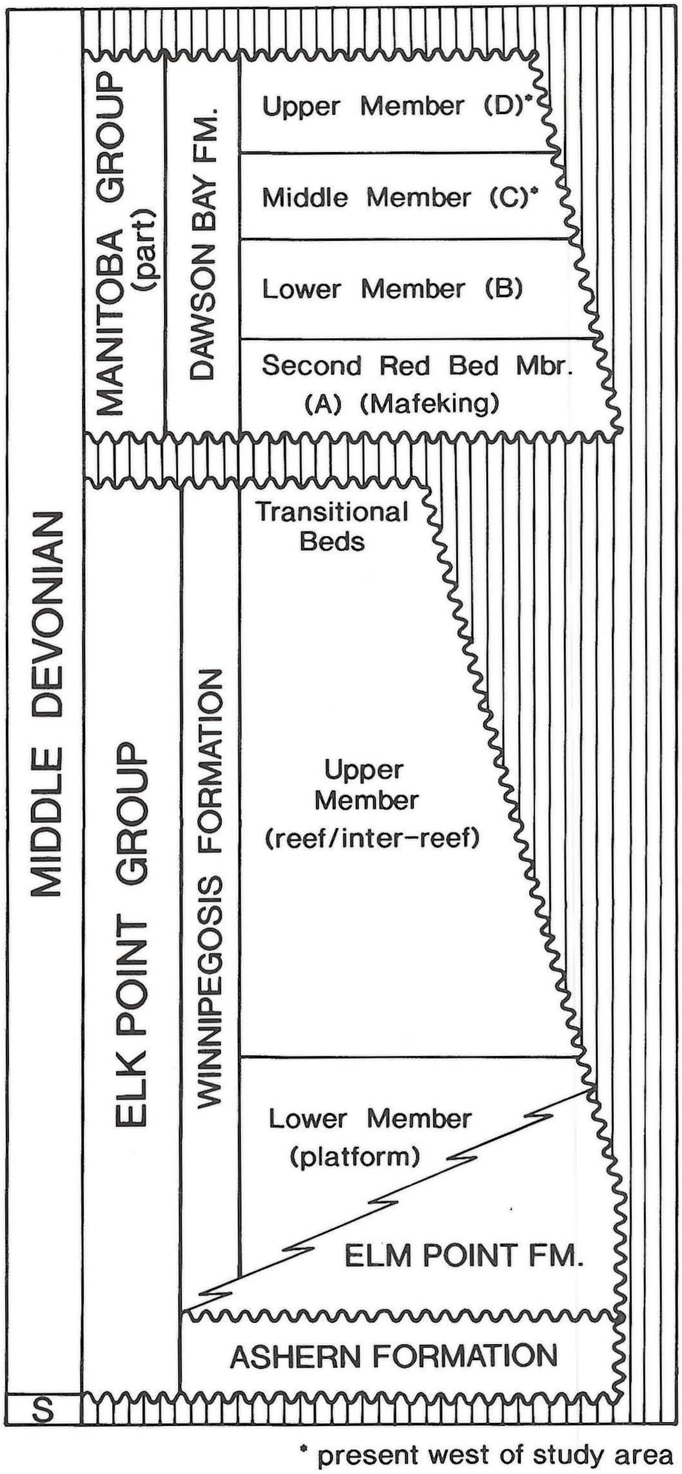

Figure GS-17-2: Formational nomenclature in the study area.

A quarry, 4 km north of Lily Bay, produced crushed stone for highway construction in 1970. Values of $MgCO_3$ ranging from 5.67% to 10.46% were reported by Bannatyne (1975); consequently stone from this quarry should be unsuitable for production of high-calcium limestone. Channel samples were taken this year for analysis in order to provide additional data.

In the past ten years, two other quarries have been developed, in the Lily Bay area, for production of crushed stone. One site is immediately north of the former village of Lily Bay ("Lily Bay Central") and the other is 3 km northwest of the village. Visual observation indicates that the stone is not suitable for production of high-calcium limestone; but channel samples were collected to confirm this interpretation. The Ashern-Elm Point contact is exposed at the base of the "Lily Bay Central" quarry, confirming its presence below overburden to the east (see Figure GS-17-3).

Bannatyne (1975) stated that "Considerable exploration has been done by cement companies interested in the potential of this area as a source of high-calcium limestone." Analyses of drill cores from these exploration programs, and holes drilled by the Department, have indicated that magnesia contents are variable, with highest values obtained near the top, middle or bottom of holes drilled at almost the same elevation and short distances apart. In spite of these inconsistent results, most of the 31 km^2 area outlined by Bannatyne (1975) has been leased by Lafarge Canada Inc.

Overton belt

In this belt, south of Dog Lake and 150 km northwest of Winnipeg, two crushed stone quarries are now dormant. Representative sections were described and sampled, but it can be determined visually that dolomitization has proceeded to a point that makes stone from these quarries unsuitable for production of cement. In the "Dog Lake" quarry mottled dolomitized Elm Point Formation underlies vuggy reefal dolomite of the Winnipegosis Formation. The gradational facies boundary between these formations could only be found at this location, in the subsurface.

The Narrows East belt

High-calcium limestone occurs in the upper beds of the Lower Member of the Dawson Bay Formation in The Narrows East belt, 190 km northwest of Winnipeg. This belt appears to have a high potential as a source of cement grade high-calcium limestone, but the beds may be too thin for economic production.

An average of 94.26% $CaCO_3$ and 1.18% $MgCO_3$ over an interval of 2.7 m from surface was obtained from drill hole M-9-69 on a topographic high in NW8-13-24-10W (Bannatyne, 1975). To determine the lateral extent of these beds and their thicknesses, Hole M-10-91 (see Bezys; GS-14, this volume) was drilled into the flank of the topographic high. Core from holes M-9-69, M-10-91 and M-2-76 (also drilled on the same beds) will be sampled and analyzed for major element contents.

In 1974, an estimated 2 700 tonnes of crushed stone were removed from the "Lake Manitoba" quarry, located in the centre of the topographic high, to be used for riprap on a dam across Skunk Bay. This was the only quarry, within the study area, developed in the upper beds of the Lower Member of the Dawson Bay Formation; but a vertical section could not be measured because the quarry surface was levelled (Mineral Inventory Card No. 935) and it is now used as an airstrip.

Outcrops of the Dawson Bay Formation that occur west of Skunk Bay were also sampled for analysis.

CONCLUSIONS

The Elm Point Formation and the upper beds of the Lower Member of the Dawson Bay Formation are potential sources of high-calcium limestone. Localities of inferior grade material that would be suitable for aggregate production, etc. can be defined.

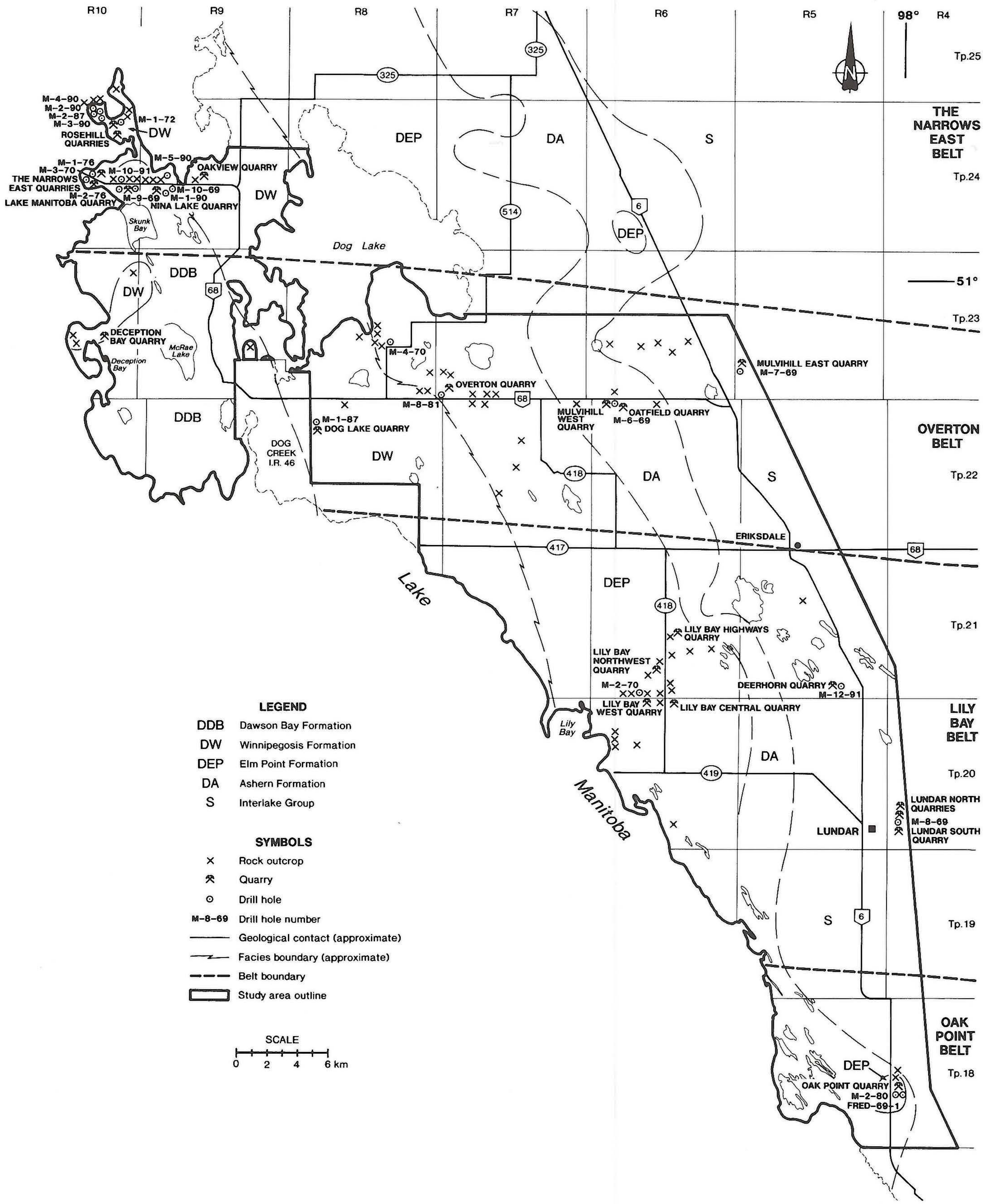

Figure GS-17-3: General geology of The Narrows East area (after Bannatyne, 1988, Map ER85-1-1) and east-trending outcrop belts.

ACKNOWLEDGEMENTS

Assistance in the field was ably and enthusiastically rendered by Lestor Dabeck. The author also wishes to thank Richard Gunter and Ruth Bezys for their informative comments and suggestions on stratigraphy, dolomitization and karst development.

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GS-18 HIGH-CALCIUM LIMESTONE (NTS 62O WEST HALF)

by R. Gunter

Gunter, R., 1991: High-calcium limestone (NTS 62O west half); in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 89-93.

INTRODUCTION

This study was initiated to quantify occurrences of high-calcium limestone in both The Narrows and Winnipegosis - Crane River areas (Fig. GS-18-1). Figure GS-18-2 and Figure GS-18-3 show the distribution of the Devonian units, above the Ashern Formation in NTS 62O.

The Devonian stratigraphy in Manitoba was first described by Baillie (1950) and NTS 62O area was included in a survey of the province's high-calcium limestone resources (Bannatyne, 1975). Norris *et al.* (1982) constructed cross sections of both the Narrows and Winnipegosis - Crane River areas that describe the Winnipegosis Formation as reefs and assign the Dawson Bay and Souris River Formations to the reef capping or inter-reef position. No new chemical analyses of the Dawson Bay or Souris River Formations were published in their memoir.

From the base upward, the formations exposed in the west half of NTS 62O are: Winnipegosis Formation; Dawson Bay Formation; Souris River Formation; and, minor amounts of the Cretaceous Swan River Formation. Outcrop morphology in the Narrows and the Winnipegosis - Crane River areas is very similar to that of the Dawson Bay area (Norris *et al.*, 1982; Gunter 1989).

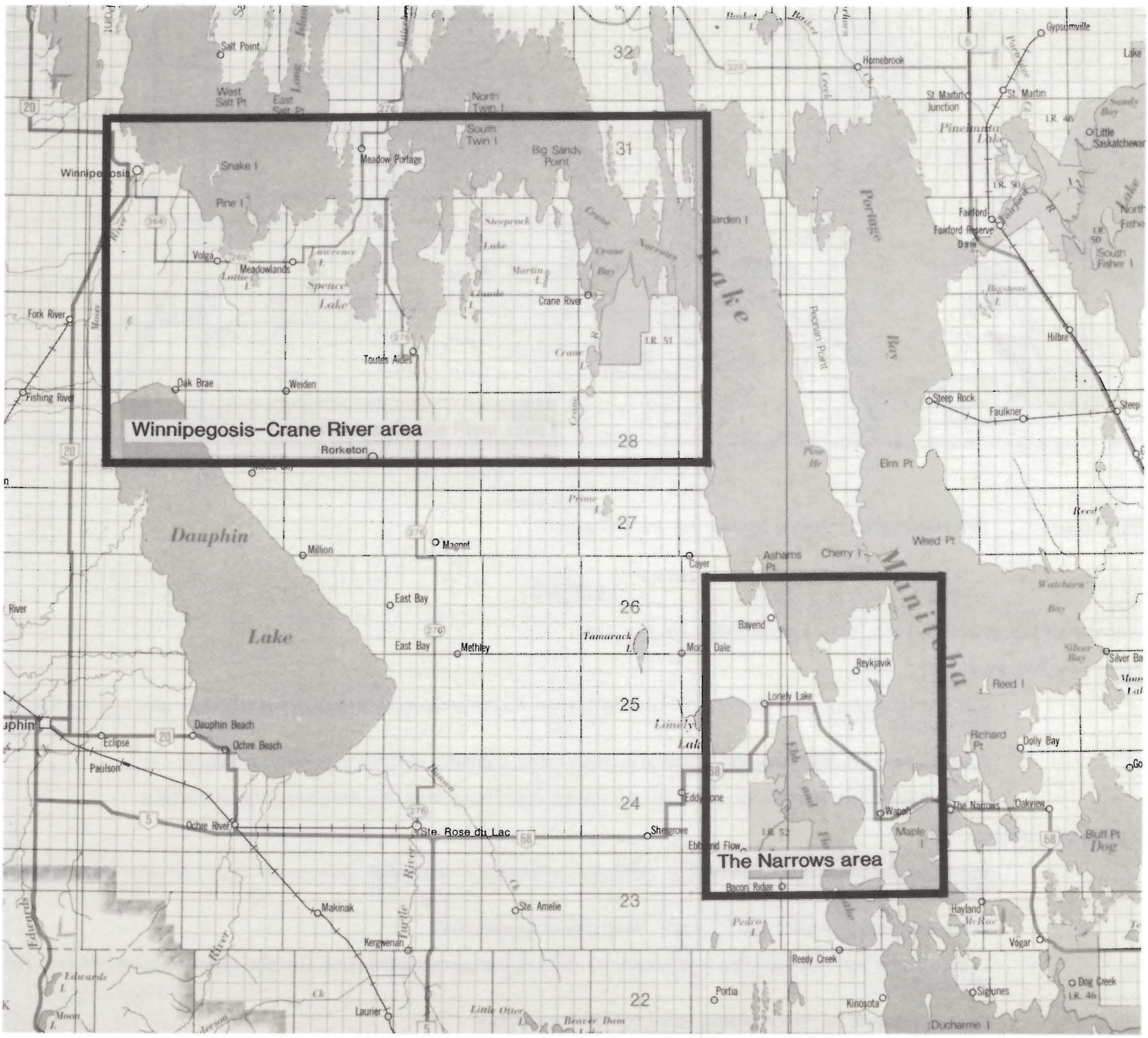

Figure GS-18-1: Location map of high-calcium limestone areas NTS 62O (west half).

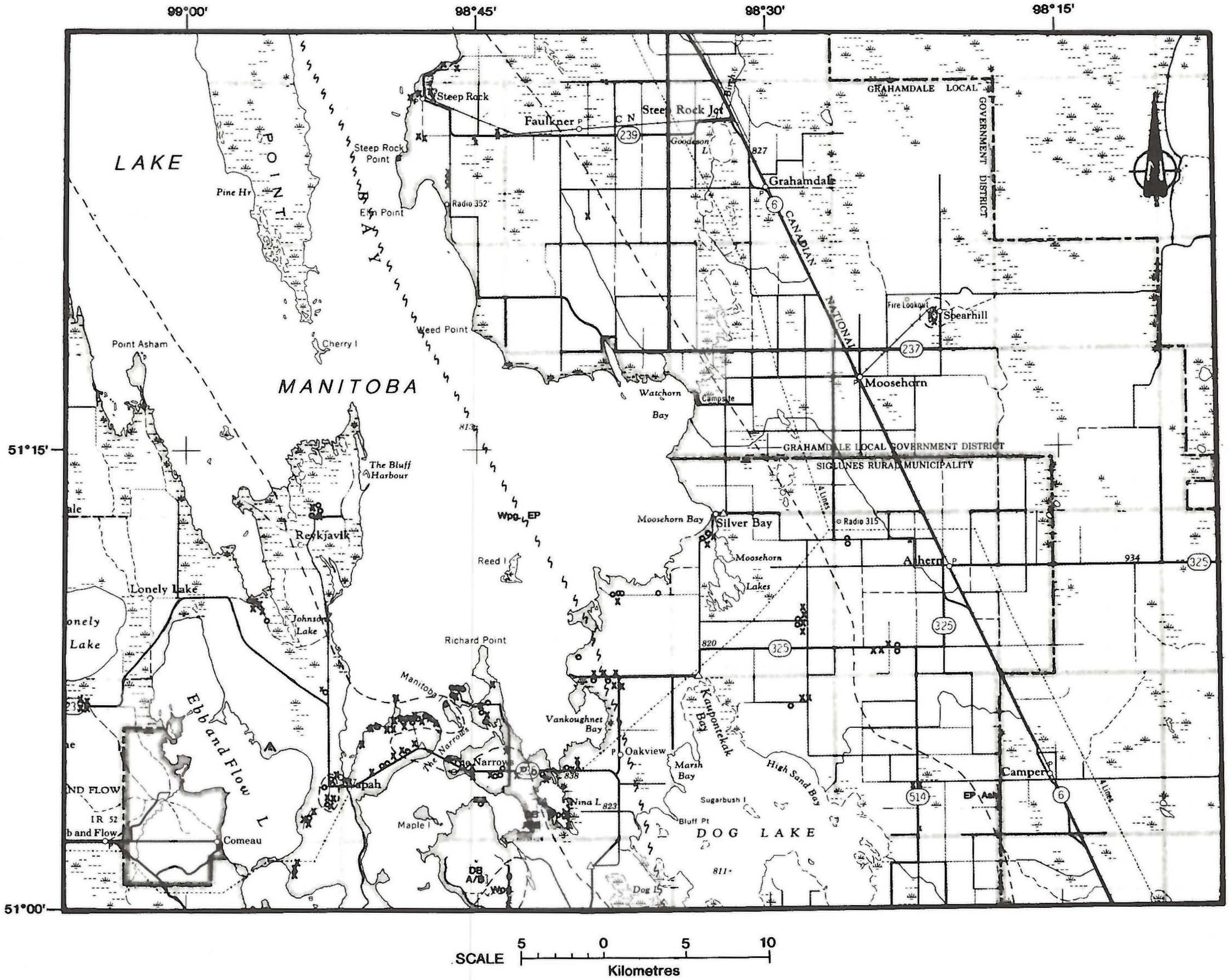

Figure GS-18-2: *Devonian Formations within The Narrows area, NTS 62O.*

LEGEND

Unconformity (Devonian units truncated by Jurassic and Cretaceous strata)

Souris River Formation:

Upper Member (Sagemace Member): White to light brown, micritic and pelletal limestone, typically developed near the town of Winnipegosis

Lower Member (Pt. Wilkins Member): Orange to cream brown, crystalline, dolomite to dolomitic limestone

First Red Beds: Red and greenish-grey calcareous and noncalcareous shale, limestone and dolomite interbeds

Dawson Bay Formation:

Upper Member (D): Fragmental limestone commonly containing stromatoporoids and some corals and yellowish brown saccharoidal dolomite

Middle Member (C): Argillaceous limestone, bluish-grey calcareous shale

Lower Member (B): Yellowish-grey, fossiliferous, thin-bedded, biofragmental limestone. Red staining on fractures occurs in The Narrows area

Second Red Beds (A): Red to greenish-grey, non-calcareous shale

Unconformity (Prairie Evaporite in the subsurface of southwestern Manitoba)

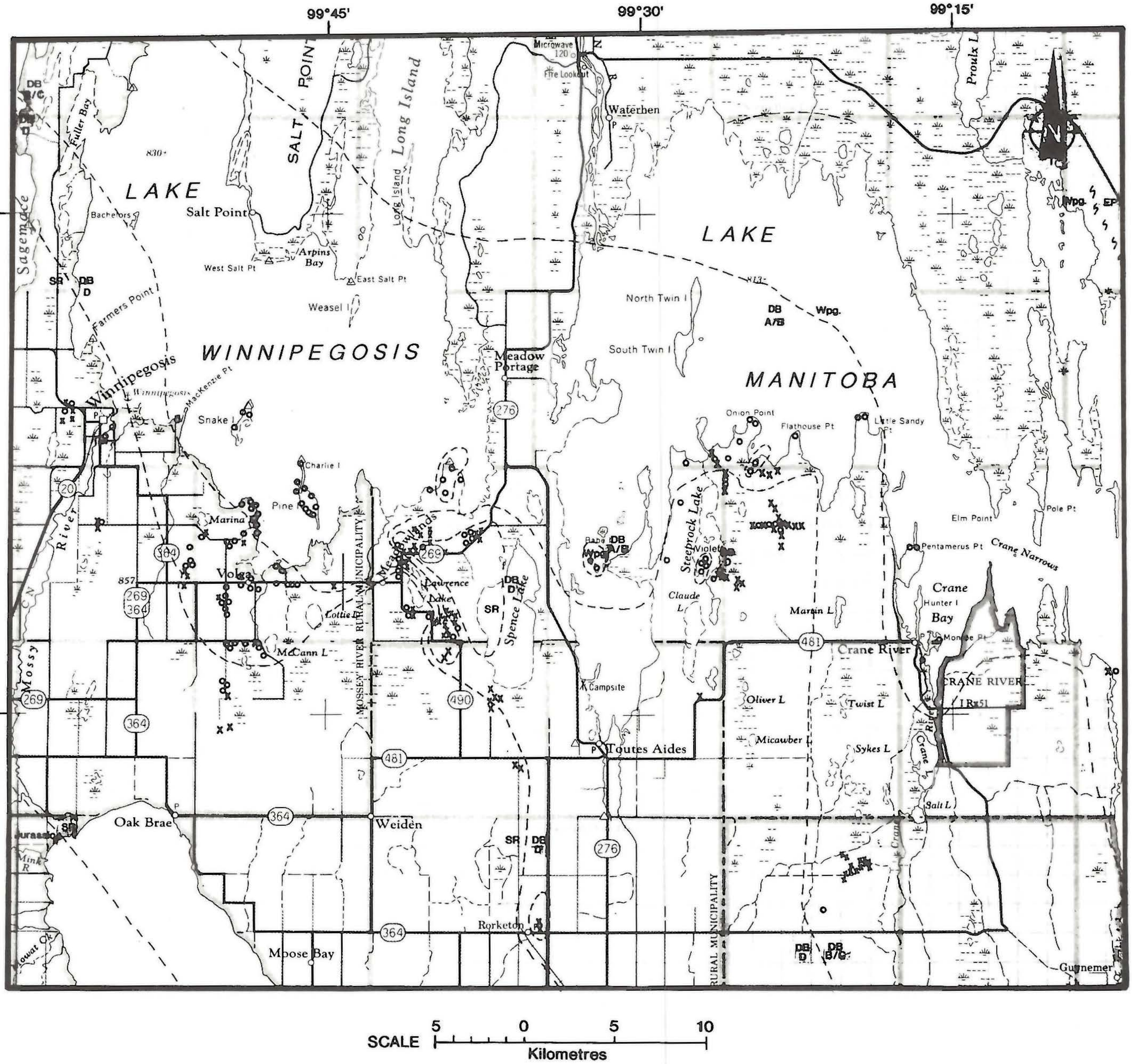

Figure GS-18-3: Devonian formations within the Winnipegosis-Crane River area, NTS 62O.

Winnipegosis Formation: Light-yellowish to grey, vuggy, dolomite, locally containing numerous fossils, massive to thick bedded, reefal; occurs as small pinnacle reefs

Elm Point Formation: Light grey to brown, mottled, limestone. It is defined as a limestone equivalent to dolomite in the lower Winnipegosis Formation

Information source: Norris *et al.* (1982) and Bannatyne (1975)

Symbols

x	1991 station
o	Station from Norris *et al.* (1982) and Bannatyne (1975)
^	1991 station-rubble
—	Geological contact, assumed
^^^	Geological contact, facies change

THE NARROWS AREA

The Narrows area is 60 km by 30 km. This report covers the west half, west of Lake Manitoba Narrows, (Fig. GS-18-2). The stratigraphic section exposed in the outcrop area is listed below.

Dawson Bay Formation (Lower Member) "B" beds;

Limestone, light-to medium-brown, fine grained to sublithographic, locally very fossiliferous, bright red staining on fracture planes and as a 1 to 2 mm thick layer surrounding fossil moulds, locally abundant secondary calcite.

Dawson Bay Formation (Second Red Bed Member) "A" beds;

Red calcareous shale, bright red argillaceous limestone is present at the top of the Winnipegosis Formation in an outcrop west of The Narrows, that may be correlatable with the "A" beds.

Transitional Beds;

Dolomite and limestone, fine-to coarsely-laminated, white to light yellow.

Winnipegosis Formation;

Dolomite, white to light yellow colour, medium-to fine-grained, crystalline, cavernous porosity with abundant fossil moulds of brachiopods, no secondary calcite or saccharoidal porosity, minor iron oxide coating fractures. Locally, very fine grained porcellaneous interbeds occur between fossil-rich buildups.

The area between the Narrows and the Winnipegosis-Crane River areas is a 38.2 km gap with no identified outcrops. The eastern half of this gap is very swampy and the western half is agricultural land with little or no relief.

THE WINNIPEGOSIS AREA

The Winnipegosis-Crane River area is approximately 62 km x 27 km, on the south shore of Lake Winnipegosis and the north end of Lake Manitoba, (Fig. GS-18-3). The stratigraphic section exposed in this area is listed below.

Souris River Formation;

There are two outcrop areas of the Souris River Formation; west and south of Winnipegosis and between Lawrence Lake and Spence Lake, west of Toutes Aides. The upper beds are a fine-to very fine-grained, high-calcium limestone that has been quarried northwest of Winnipegosis. The lower beds are dolomitic. They range from partly dolomitic in the quarry northwest of Spence Lake to a yellow-brown, fine-to medium-grained crystalline dolomite in the area south and southeast of Winnipegosis, and south of Spence Lake. Souris River Formation beds are not found in the Toutes Aides-Crane River area.

First Red Beds (Souris River "A" beds);

The First Red Beds occur as thin intervals of limestone, dolomite and calcareous shale. The beds are exposed in outcrop only in a quarry northwest of Spence Lake. There are few markers in the First Red Beds so correlation between the quarry and the intersection of the First Red Beds in the numerous drill holes in the Winnipegosis area is difficult. Many unrecovered intervals are noted in diamond drill cores within the First Red Beds. Assuming the Spence Lake quarry is typical of the First Red Beds the brecciated and cavernous nature of the rock in this quarry would explain the missing core.

Dawson Bay Formation (Upper Member) "D" beds;

In the Winnipegosis area "D" beds outcrop in two areas; south and east of the town of Winnipegosis, and east of Toutes Aides, south of Onion Point and Flathouse Point. The "D" beds within the map sheet have two distinct lithologies. The high-calcium limestone unit in these beds has a *coral-stromatoporoid* fauna that is distinct from the *Atrypid* fauna of the "B" beds. The presence of the stromatoporoids gives the outcrop surface a rough bouldery texture unlike the flat pavement outcrops of the "B" beds.

The dolomitic portion of the "D" beds is a yellow-orange crystalline dolomite with vugs and fractures filled with secondary calcite. Where both lithologies occur in the same outcrop, the dolomite is secondary and has a sharp contact with the high-calcium limestone.

The "D" beds have been intersected by several drill holes in the Winnipegosis area. These drill core intersections will be sampled to determine the calcium carbonate content of the beds. Several circular features, noted on air photos of an area east of Steeprock Lake were investigated and found to be shallow subcrops of Dawson Bay Formation "D" beds that have little or no topographic expression and are covered with grass and scrub.

Dawson Bay Formation (Middle Member) "C" beds;

These beds outcrop at one location on Hwy 269 west of Meadowlands. Norris *et al.* (1982) describe these as "interbedded argillaceous limestone and bluish-green calcareous shale". They do not appear to have any potential for high-calcium limestone.

Dawson Bay Formation (Lower Member) "B" beds;

The "B" beds occur as domal to flat lying pavement outcrops that have an even surface. The brachiopod *Atrypa* is always present and locally abundant. Red mottling that characterizes the "B" beds in The Narrows area is not present in the northern part of the "B" bed outcrops. An area of Dawson Bay Formation "B" beds, 20 km east of Rorketon, has several outcrops with the distinctive red mottling that is similar to the "B" beds from The Narrows area. Dolomitization is rare in the "B" beds and saccharoidal dolomite, similar to the dolomite in the "D" beds, is not encountered.

Other Formations;

The Dawson Bay Formation "A" beds and the Winnipegosis Formation were not examined in detail in the Winnipegosis area as neither represent a potential source for high-calcium limestone.

An outcrop of the Jurassic Reston Formation limestone and calcareous shale occurs south of St. Rose du Lac, and Cretaceous kaolinitic shale occurs within the Red River Brick and Tile quarry located just south of the map area. These Mesozoic rocks overlie Devonian carbonates in the southwestern quarter of the map area. This cover of younger rocks limits the occurrence of high-calcium limestone to areas east of St. Rose du Lac and the town of Winnipegosis.

CHANGES IN OUTCROP LOCATIONS

Mapping in this area revealed considerably more outcrop than was noted on the maps of Norris *et al.* (1982) and Bannatyne (1975). This allowed greater control on the definition of the reef and interreef beds and resulted in a much simpler outcrop pattern, (Fig. GS-18-2, GS-18-3).

New outcrops of Dawson Bay Formation "B" beds were described from a cut line on the east shore of Ebb and Flow Lake south of Wapah. The outcrop of Winnipegosis Formation, southwest of Reykjavik, was reclassified as Dawson Bay Formation "B" beds, based on partly dolomitized outcrops found north and south of the road. This interpretation has been confirmed by drill cores from the area. In the Winnipegosis area a chain of reef domes, cored by Dawson Bay Formation "B" and "D" beds, occurs between northwestern Spence Lake and the town of Rorketon. New outcrops were described northeast of Steeprock Lake and east of Crane River. Several areas of "thin overburden", outlined on the map of Norris *et al.* (1982), were investigated and no outcrop was found, so a similar designation was not adapted for this map, (Fig. GS-18-2, GS-18-3).

Outcrops in The Narrows area, west of Lake Manitoba, occur on the west and north slope of topographic highs. Thus, several topographic closures were investigated east and north of Ebb and Flow Lake to determine if there is any previously nondocumented outcrop. Areas of angular rubble of Dawson Bay "B" beds indicate that bedrock may be close to surface.

Two drill holes were completed in The Narrows area, west of Lake Manitoba, to test the high-calcium limestone potential of the Dawson Bay Formation "B" beds. These holes are located: M-9-91, south of Wapah, at lsd. 9 2-24-11W ; and M-11-91, south-west of Reykjavik, at lsd. 9 16-25-11W. The cores have been logged, (Bezys, GS-14, this volume), and will be sampled for chemical analysis. Surface samples from outcrops of Dawson Bay Formation "D" and "B" beds that are potential sources of high-calcium limestone will be analyzed.

The two diamond drill holes, plus newly documented outcrops of Dawson Bay Formation "D" and "B" beds have outlined significant resources of high-calcium limestone that are not presently under lease.

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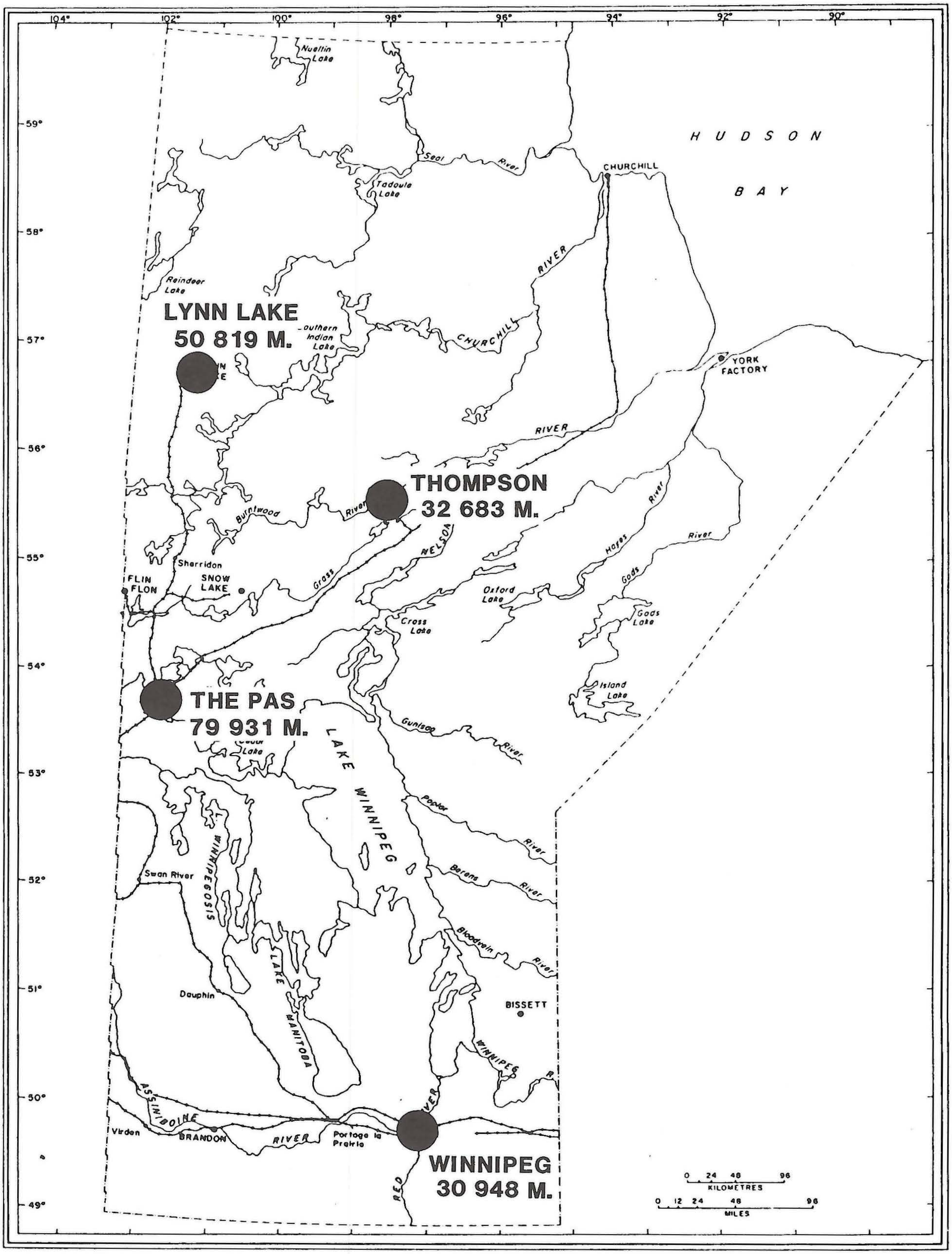

Figure GS-19-1: *Present core holdings in core libraries; the four libraries currently hold 194 381 metres of core.*

GS-19 MANITOBA'S PRECAMBRIAN DRILL CORE COLLECTION PROGRAM: AN UPDATE AND REVIEW

by D.E. Prouse

Prouse, D.E. 1991: Manitoba's Precambrian drill core collection program: an update and review: in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 94-95.

INTRODUCTION AND HISTORY

The Manitoba Minerals Division considered retrieved exploration drill core to be valuable data source that can be utilized by explorationists and researchers. For this reason the province has retrieved and stored Precambrian drill core since the early 1970's.

The core collection program was started in the early 1970's to assist exploration companies and prospectors working in the province. The construction of core sheds at The Pas (1972), Thompson (1973), and Lynn Lake (1974) provided storage space that allowed for a concerted effort towards core collection. The acquisition of storage space in 1980 for core from southeastern Manitoba meant that there was a core storage facility for drill core collected and donated from companies carrying out drill programs in the major greenstone belts in Manitoba.

Precambrian drill core collection has been the responsibility of various Energy and Mines personnel. From 1971 to 1977, it was the responsibility of the Resident Geologist in The Pas. When the Resident Geologist position was discontinued in 1977, core collection was administered by various Mines Branch employees, or core was delivered to core storage facilities by exploration companies. By the end of 1982, 88 600 metres of drill core had been collected. However, due to limited staff during the 1970's, much of this core was not properly inventoried nor was it stored in an organized manner.

In April, 1984, the Governments of Canada and Manitoba embarked on the Canada-Manitoba Mineral Development Agreement (MDA). Under the terms of this five year Agreement $24.7 million was allotted for activities that were key to strengthening Manitoba's mineral industry. During the term of the five year Agreement, $631,000 was spent on capital and operating costs of Manitoba's Precambrian Drill Core Libraries Program. This funding allowed for the expansion of all the northern core storage facilities as well as better documentation and organization of inventories. During MDA approximately 80 000 metres of core were collected and added to the system and about 58 000 metres of core were discarded.

Industry and public use of the core library program facilities and services increased during the early years of MDA; but markedly declined in fiscal years 1987-88 and 1988-89. This trend was reversed in the last two fiscal years as usage tripled and doubled respectively compared to fiscal year 1988-89. This renewed interest may be in part due to the 1989 release of the open file listing of holdings within Manitoba's drill core libraries.

1991 PROGRAM

Core inventory in The Pas library increased by 34 holes totalling 3716 metres. In Lynn Lake, 10 holes totalling 1191 metres were added to the inventory holdings. The Thompson and Winnipeg libraries received no new drill core in 1991. As of September 1, 1991, the provincial Precambrian core storage system had increased by 44 holes totalling 4907 metres of core (Fig. GS-19-1; Table GS-19-1).

Table GS-19-1
Drill Core Libraries Holdings

Library Location	Present Inventory	% Capacity Utilized
Lynn Lake	50 819 m	65
Thompson	32 683 m	55
The Pas	79 931 m	49

HOW TO USE MANITOBA'S CORE LIBRARIES

The four core libraries have well lit, heated inspection rooms, with benches and a core splitter. A rock saw for cutting core is available for use at The Pas library.

Department core libraries are not permanently manned, therefore enquiries and permission for access must be made to:

D. Prouse, Resident Geologist
Geological Services
Manitoba Energy and Mines
Provincial Building, Third and Ross Avenue
The Pas, Manitoba R9A 1M4
Phone: (204) 623-6411 ext. 251
OR
B. Esposito, Assessment Geologist
Mines Branch
Manitoba Energy and Mines
555-330 Graham Avenue
Winnipeg, Manitoba R3C 4E3
Phone: (204) 945-6535

Permission to access the Lynn Lake or Thompson libraries, for viewing only the nonconfidential core, must be granted by Mr. Prouse or Mr. Esposito who will make appropriate arrangements with local Government representatives on behalf of the user.

The representatives are:

Lynn Lake: Conservation Officer
Manitoba Department of Natural Resources
675 Halstead Avenue
Lynn Lake, Manitoba R0B 0W0
Phone: (204) 356-2413

Thompson: H. Schumacker
Manitoba Department of Labour
Workplace Safety and Support Services Division
Mines Inspection Branch
Provincial Building, 59 Elizabeth Drive
Thompson, Manitoba R8N 1X4
Phone: (204) 677-6819

In special cases where a user requires assistance in locating specific holdings, the Resident Geologist in The Pas will travel to Lynn Lake or Thompson to assist the user.

The master file of drill hole logs, collar locations and assays for non-confidential drill core holdings in the northern libraries is available for inspection at the Mines Branch office in The Pas. Information pertaining to non-confidential drill core stored in the Winnipeg library can be viewed at the Mines Branch office in Winnipeg.

Viewing, Storage and Sampling Policy

Access to confidential drill core is allowed only with written permission from the company that holds the respective property. This written permission must be presented to the Resident Geologist in The Pas, or the Assessment Geologist in Winnipeg, prior to inspection.

Core boxes placed in a library will be managed by drill core personnel. Library users will not be permitted to remove core from the library premises. Users wishing to examine drill core must be prepared to physically handle the core boxes and return them to the racks. Permission is required to sample core contained in the libraries.

Assay results and pulps from these samples must be forwarded to the Resident Geologist or Assessment Geologist if so requested. Quartering of previously sampled core will not be permitted.

ACKNOWLEDGEMENTS

The author wishes to extend thanks to the office staff in Winnipeg and The Pas for their assistance with the drill core program throughout the year.

GS-20 MANITOBA MINERAL INVENTORY

by P. Athayde

Athayde, P., 1991: Manitoba mineral inventory; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 96.

A total of 110 mineral inventory cards were either updated or compiled in 1990-1991.

For the Flin Flon area, 22 mineral inventory cards were updated and 8 mineral inventory cards were compiled that describe base metal occurrences in NTS areas 63K/9, 63K/10, 63K/14, 63K/15 and 63K/16. Over the last two years, 74 mineral inventory cards have been either updated or compiled for the general Flin Flon area.

An additional 80 mineral inventory cards that describe various mineral occurrence types in NTS areas 64C/10, 64C/11, 64C/12 (Lynn Lake area), 63I/5, 63I/12 (Cross Lake area) and 63J/13 (Wekusko Lake area) were updated during 1990-1991.

Between September 1990 and August 1991 approximately 70 clients used the Mineral Inventory and Corporation Files.

GS-21 GIS AND COMPUTER PROJECTS WITHIN MANITOBA ENERGY AND MINES

by P. Lenton and L. Chackowsky

Lenton, P. and Chackowsky, L., 1991: GIS and computer projects within Manitoba Energy and Mines; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 97.

In recent years Manitoba Energy and Mines has renewed its involvement in developing computerized systems for managing geological information. Previous involvement dating back to the late 1960's was unsuccessful, largely because needs exceeded available technology. With the advent of affordable computers, portable computers and developments in GIS and database software a new thrust toward automation has evolved. Current activities are concentrated in two areas; information management through the use of database systems, and information management and map development using GIS software.

Recording of geological field descriptions is now computerized using XBase relational database software. The system was developed within the Provincial Geological Survey, however use of this system will soon include the Mineral Deposits Section. The program records the total content of observations made on outcrop. The data is entered in the field using portable computers with digitized UTM coordinates appended later. Analytical databases (geochemistry and petrography) are added as they become available. The system, called GEODATA, is an open format database series currently comprising 7 databases. These databases record:

- location identification including UTM coordinates
- structural information
- complete field petrological description including extended written notes
- geochemical database
- petrographic analysis database
- photographic record file
- code translation database

All records in the various databases share a common unique identifier for the station location, so all information contains a geographic coordinate component. The structure of the system allows addition of further databases as needs arise. Databases specific to mineral deposit descriptions are currently under study to expand the information base. Extension of field data recording to include entry of graphic information, such as geological contacts, directly in the field camps is also under development. This is considered essential to the transition to a full scale GIS system.

This database system will be the core for a Provincial Geological GIS currently under study. Manitoba's involvement in the NATMAP Shield Margin Project (NASMAP) will involve development of a GIS based compilation of the entire Flin Flon - Snow Lake belt. During the current stages of development and design, existing PAMAP GIS software is being used to operate the Manitoba segment of the NASMAP. Study is underway to select a more powerful GIS platform to operate both the Manitoba segment of NASMAP and form the basis for a comprehensive Manitoba Geological Information System (MGIS). The current NASMAP GIS project involves the Elbow Lake area mapped by E.C. Syme during the 1990 and 1991 seasons. This is the first project for which the computerized full content database system was used from the start of the project. The databases currently contain 1973 rock descriptions and 1816 records of structural information for 1802 locations in the 1:20 000 scale Elbow Lake mapping program. The preliminary map for the Elbow Lake area (as produced in the field) was digitized using PAMAP GIS software. Structural trend overlays were automatically generated by merging GEODATA information with GIS files. This digital map was sent to Ottawa, along with data files of structural and text information, where the Geological Survey of Canada will produce a full colour preliminary geological map as a technology demonstration of NASMAP capabilities. Subset databases containing rock description information will be attached to the electronic map.

Outside of NASMAP, the PAMAP GIS is currently used to manage the claim map system within the Mining Recording office and to do spatial analysis studies using geochemical and geophysical information. Full colour and black and white thematic maps have been produced showing spatial distribution of geochemical data from various study areas. These are fundamental components of the planned MGIS.

The project that is currently the most advanced system for inclusion in a GIS is the Manitoba Oil and Gas Well Information System (MOGWIS; see GS-15, this volume). This is a comprehensive database system using an industry standard Oracle database schema. It manages information for all aspects of petroleum production for Manitoba, including geology, production, engineering and administration. Phanerozoic geology data from the Geological Survey is included in MOGWIS. It includes drill hole data from research holes as well as production holes and contains a library to manage all stored drill core in the Provincial Phanerozoic drill core library. The entire system was designed to be implemented under a GIS.

The computer based collection of geological information allows Energy and Mines to offer new products to the public. Release of open file reports in electronic form will be a major feature of the computerized systems. It started in the spring of 1991 with the preliminary publication of field data of the Athapapuskow Lake project by E.C. Syme. This data was released as a text file available on diskettes that contains approximately 5000 printed pages of field descriptions of 3500 locations. Included with the outcrop descriptions were over 100 whole rock geochemical analyses, preliminary geology maps, station location maps and a brief description of the general geology and descriptions for the data files. In future, field data will be released as relational databases with a view and query utility to allow interactive retrieval and manipulation of the data.

GS-22 KARST IN MANITOBA'S INTERLAKE: SINKHOLES AND SUBCUTANEOUS DRAINAGE

by W.D. McRitchie

McRitchie, W.D., 1991: Karst in Manitoba's interlake: sinkholes and subcutaneous drainage; in Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 98-103.

INTRODUCTION

Investigations of karst features in the Interlake region, continued in cooperation with members of the Speleological Society of Manitoba. Reconnaissance traverses were conducted in the Grand Rapids, and Mill Ridge regions. Attention focussed primarily on locating swallow holes in regional depressions, these being the principal input points to the subsurface drainage systems. Several new caves were discovered and mapped.

Groundwork in the Gypsumville area concluded definition of surface exposures of gypsum east of Gypsum Lake, and east of the Gypsumville north quarry (Fig. GS-22-1).

GRAND RAPIDS

Five, evenly spaced, stratigraphic drill holes were completed across the highland plateau between Sturgeon Gill and Kaministikwak Lakes, in the Buffalo Lake area (Bezys GS-14 this volume). Four BQ holes, are large enough to facilitate logging by down-the hole probes, and will eventually be used for installation of permanent, groundwater observation stations, in cooperation with the Water Resources Branch.

Ground traverses located swallow/drain holes in numerous 15 to 20 m deep internally drained regional depressions and collapse dolines 10 to 14 km west of Buffalo Lake (Fig. GS-22-2). Several of the bedrock-hosted swallow holes exhibit extensive solution features and

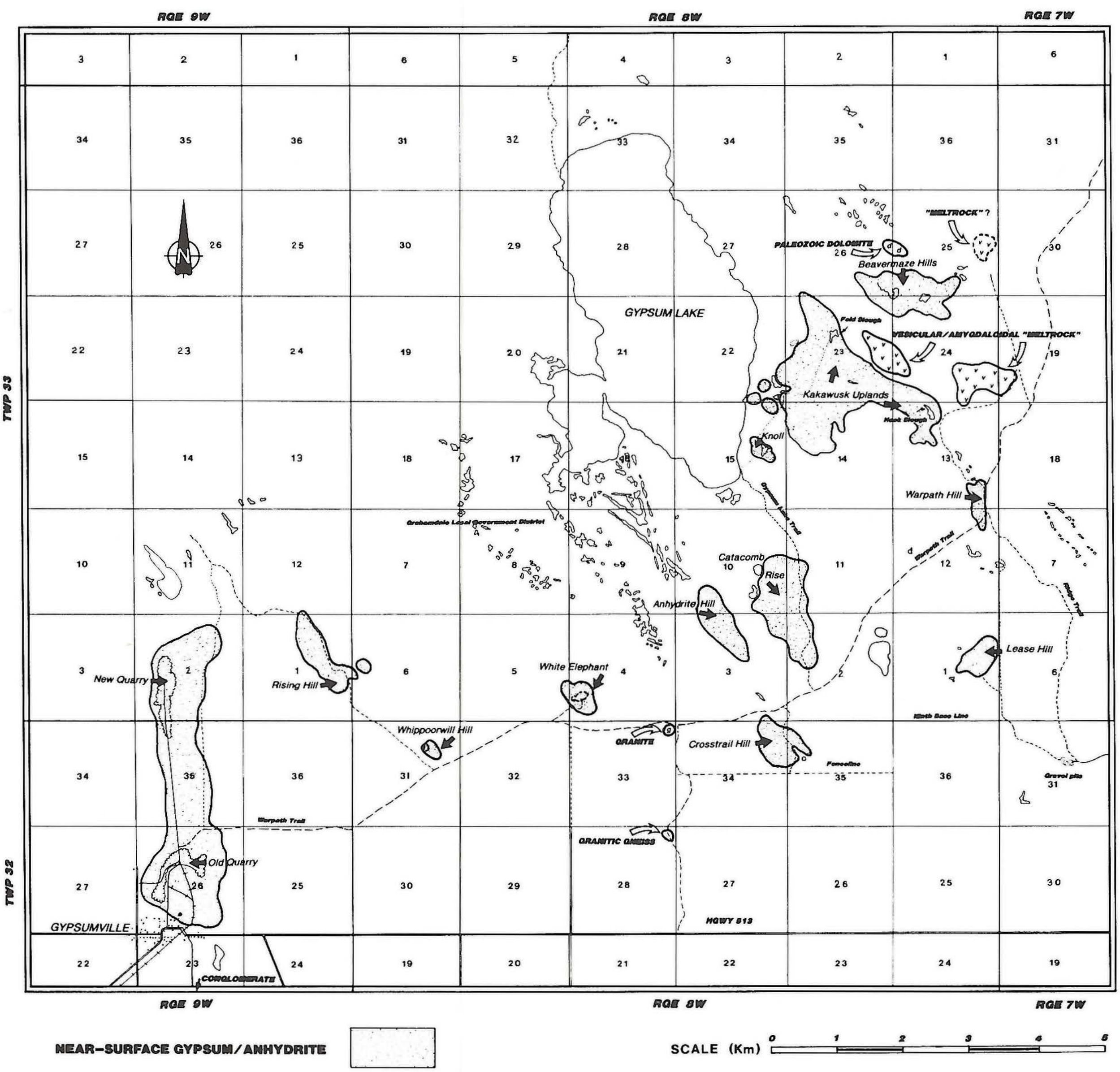

Figure GS-22-1: Near surface gypsum/anhydrite deposits, Gypsumville and Gypsum lake area, Manitoba.

Figure GS-22-2: *"Deep Basin". A possible karst gulf, or internally drained collapse doline, on the south spur off the Buffalo lake Road. This 20 m deep basin appears to intersect the local water table. It, and nearby deep sinks, all display periodic, and apparently synchronous fluctuations in water level up to 3 to 4 m, occasionally drying up altogether.*

indications of substantial recent water flows, suspected to be seasonal meltwater run-off. Examination of aerial photographs reveals a coincident flooding and drainage history for many of the spatially associated regional depressions. This may reflect a seasonal synchronicity in point drainage, or regional buffering by a shared water table. In this case, some depressions may represent karst-gulfs.

Several (5) new caves were located, one (Iguana Crypt; total length 50 m) contains the best examples of speleothems yet encountered in the province (Fig. GS-22-3).

GYPSUMVILLE

Ground traverses north of Gypsumville delineated the extent of gypsum exposures near Rising Hill (Fig. GS-22-4), and refined the extent of gypsum bedrock in the Gypsum Lake east region (Fig. GS-22-1). Aerial photography, taken post leaf and immediately after the first snowfall, provided optimal conditions for interpreting the distribution of sinkholes in the region (Fig. GS-22-5), and making a preliminary analysis of sinkhole densities. Nevertheless it was only possible to define the major sinks in areas of polygonal karst, and actual concentrations must be significantly higher than those defined from the air-photo interpretation (Fig. GS-22-6).

MILL RIDGE

Reconnaissance traverses were conducted west of the Idlewyld Road (northeast of Ashern), to explore this region of extensive carbonate exposures, pavement, and several 1 to 3 m high, west-facing scarps of East Arm dolomites. Several of the region's fens contain numerous swallow holes, many in beaded chains representing linear subcutaneous drainage systems. All fens were dry for most of the summer (June-October). Water movement appears to be restricted to early spring when melt-water ponds over ice plugs in the throats of the swallow holes, and then drains rapidly once the plugs melt. These event-specific flows are substantial enough to scour the thin clay (commonly less than one metre thick), covering the floor of the depressions, around the immediate apron of the drainholes. This process commonly exposes dolomite bedrock pavement in the floor of the sedge and clump willow-lined fens. One sink was excavated, revealing a 1 m diameter, horizontal, shallow, circular, phreatic, solution passage lying beneath the floor of the fen. Fens with well developed sinks are concentrated on the northwest and southeast flanks of the main 250 km^2 bedrock ridge (Fig. GS-22-7). Drainage directions are to the northwest in "Plantation", "Bee" and "Silverweed" fens, to the north in "Vanishing Creek" fen, and to the south in "Maw" and "Breezy" fens.

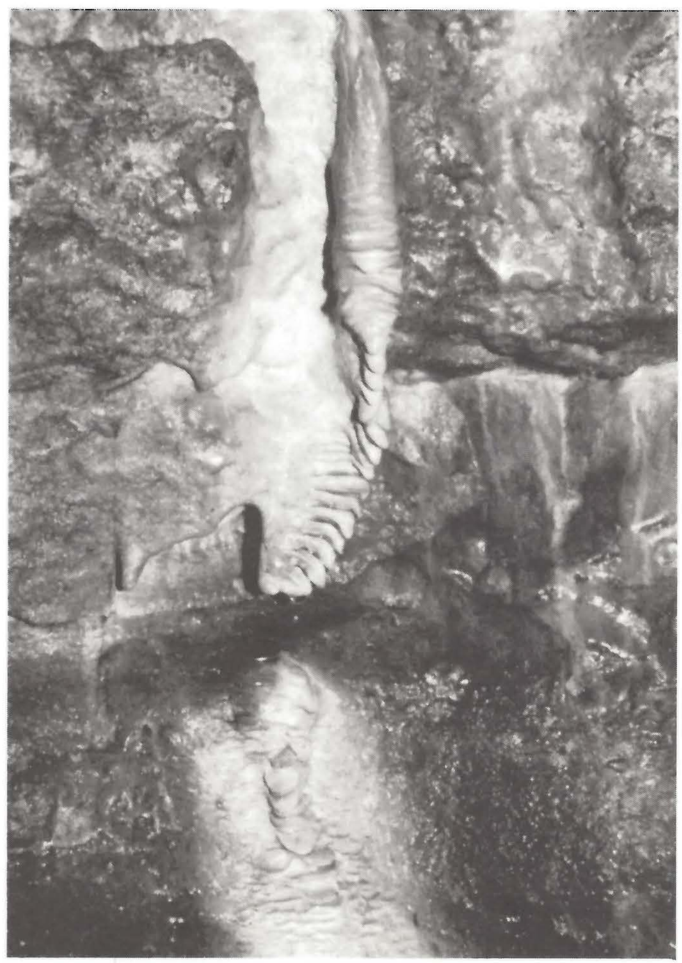

Figure GS-22-3: *Iguana Crypt, Grand Rapids Uplands; Multi-tongued odontolithic drapery coalescing near ceiling into smooth secondary flowstone column.*

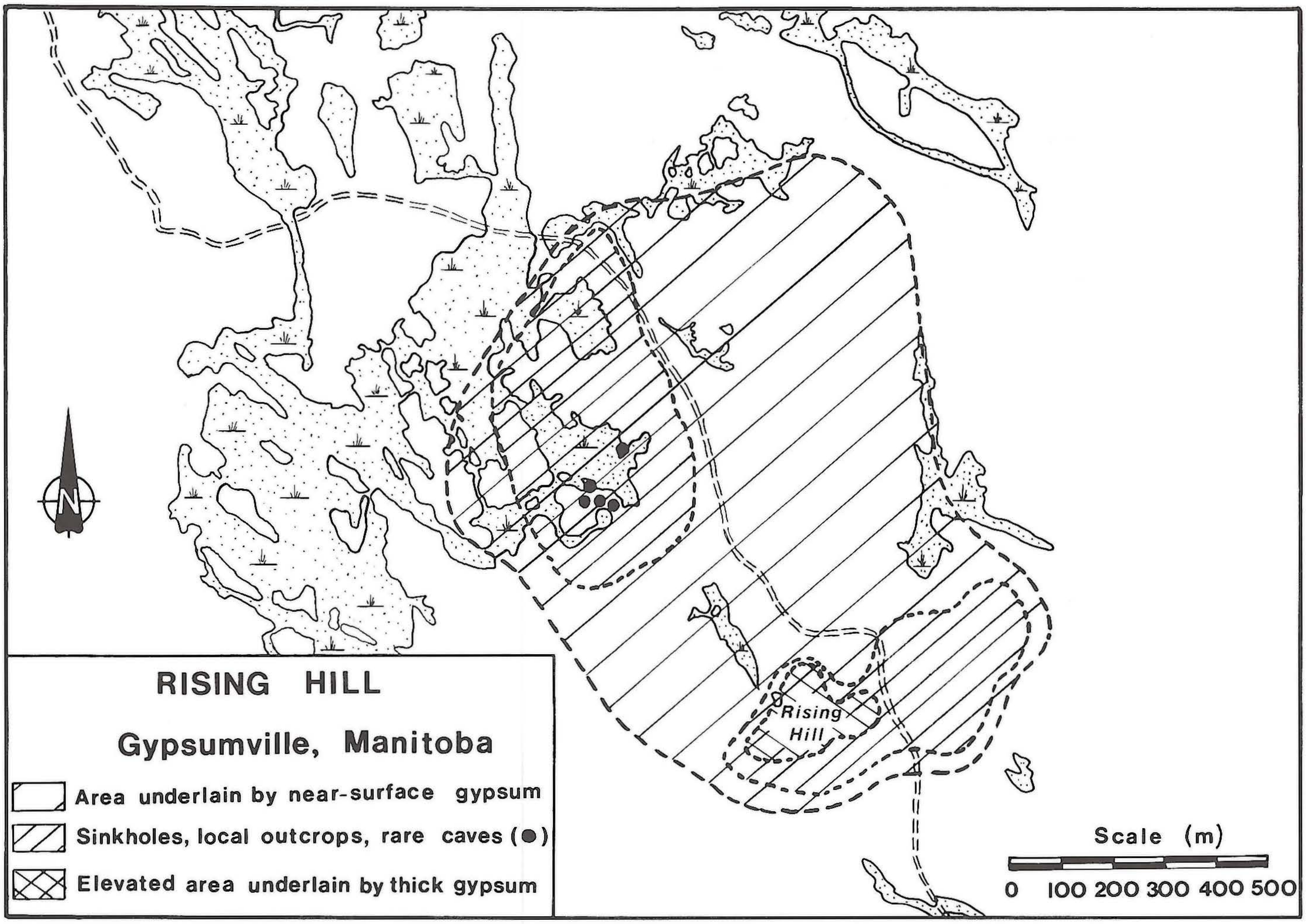

Figure GS-22-4: Rising Hill, Gypsumville, Manitoba.

The above observations suggest that the most active post-glacial solutioning will have taken place in areas where thin clay and till aprons focussed local run-off into specific drain points. The drain/swallow holes developed because the clay veneers were thin enough to be breached by collapse of the solution cavities in the underlying carbonates. By way of contrast, percolation of meteoric waters in areas dominated by bedrock pavement would be highly dispersed, and in areas of thick till would result in the water either being ponded, or channeled into surface drainage networks, never reaching the bedrock below.

Accordingly, access points to significant subsurface drainage systems should, in the recharge areas, be best developed in the swallow holes showing evidence of recent seasonal and storm-related active drainage.

Compilation continues on the Atlas of Caves in Manitoba's Interlake with release of this publication scheduled for early 1992.

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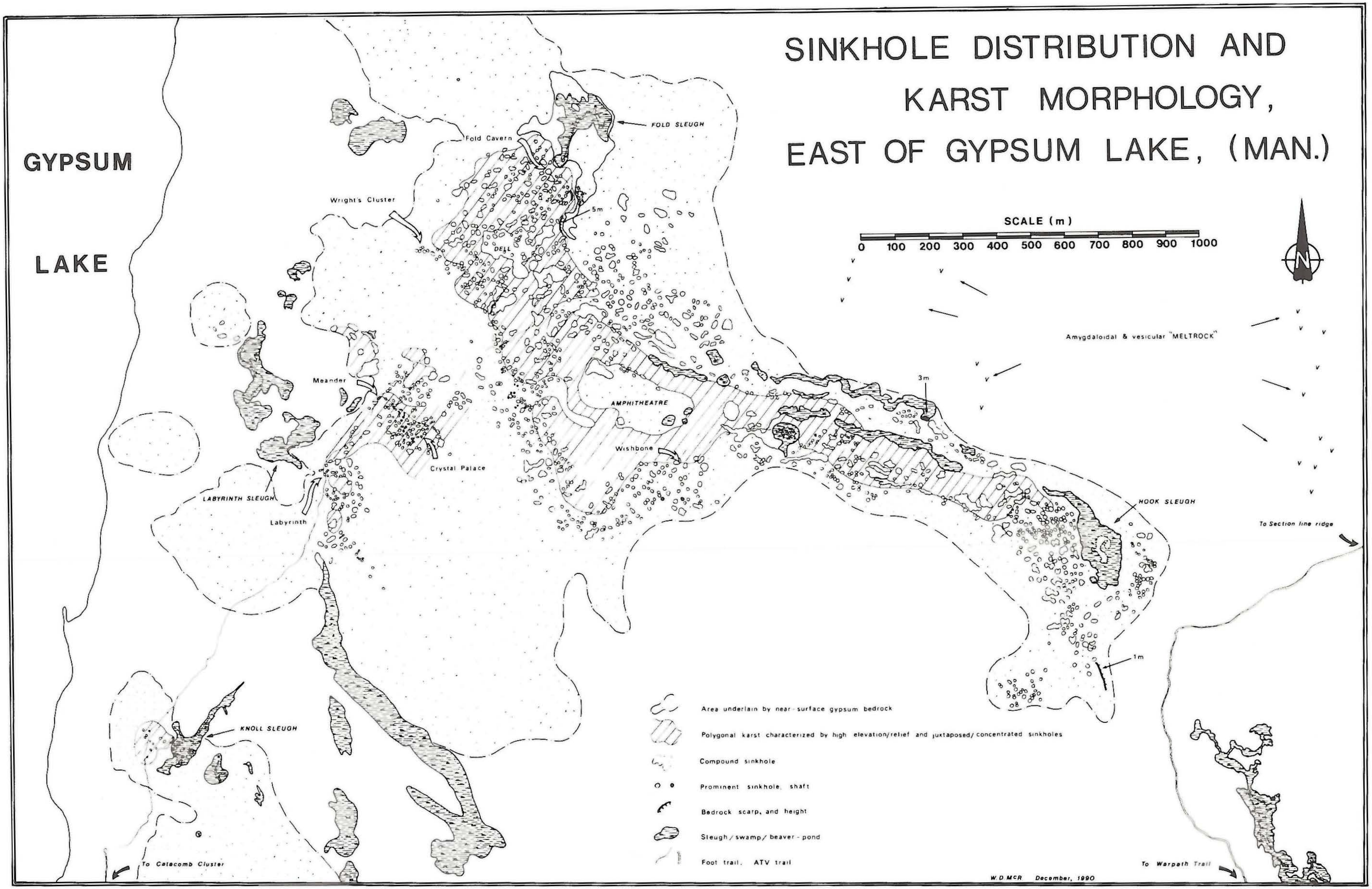

Figure GS-22-5: Gypsum Lake east, sinkhole distribution and karst morphology, east of Gypsum Lake, Manitoba.

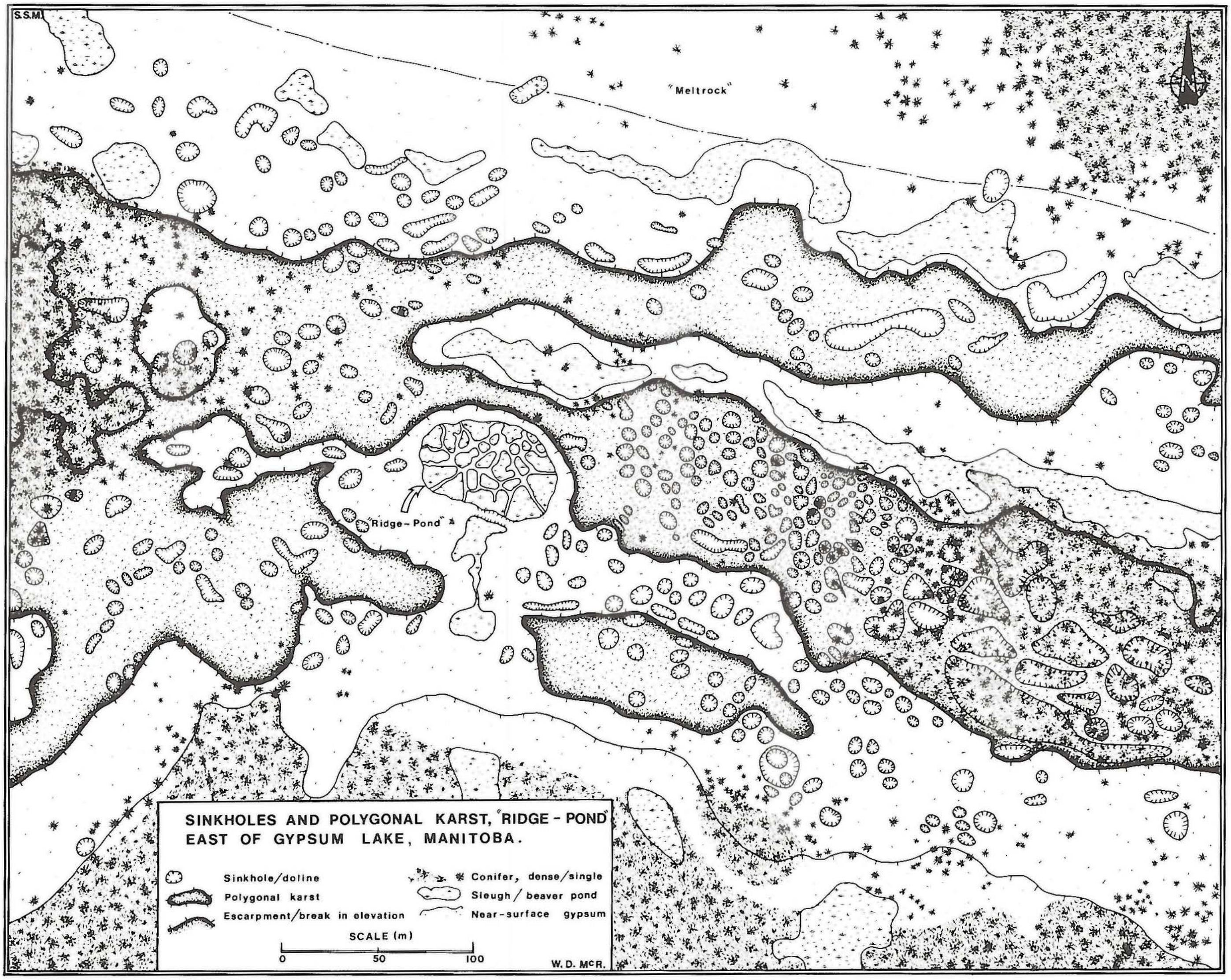

Figure GS-22-6: Sinkholes and polygonal karst, Ridge-pond (Gypsum Lake East).

Swallow holes in the Mill Ridge region.

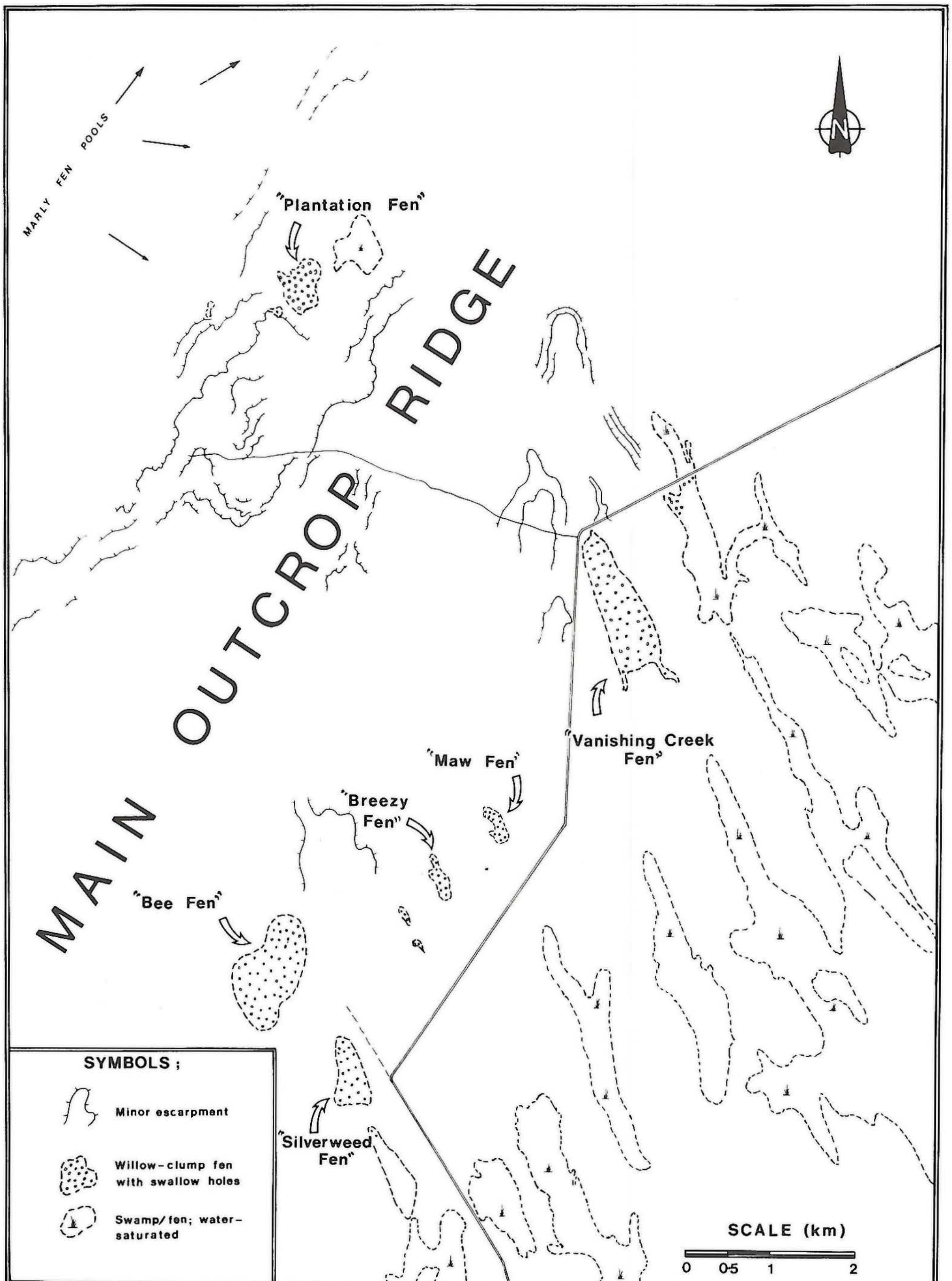

Figure GS-22-7: Mill Ridge Area. Outcrop area and principal fens (modified from Bannatyne, 1988).

GS-23 LITHOPROBE ACTIVITIES IN MANITOBA, 1991

by W. Weber

Weber, W., 1991: Lithoprobe activities in Manitoba, 1991; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991, p. 104.

The Trans-Hudson Orogen Transect (THOT) is the first of three new transects constituting Phase III of LITHOPROBE. The Trans-Hudson Orogen is a 500 km collisional belt that includes a broad zone of Early Proterozoic oceanic rocks (the Reindeer zone in southeastern part of the Churchill province) sandwiched between Archean continental blocks, the Superior province to the southeast in Manitoba, and the Hearne-Rae provinces (northwestern part of the Churchill province) to the northwest in Saskatchewan. The objective of the transect is to understand the tectonic development of this zone and the processes involved in its evolution by determining the crustal architecture and other geophysical, geological, structural and geochemical characteristics of its four lithotectonic segments.

Specific objectives are:

- to determine the subsurface extension of the margin of the bounding Archean cratons;
- to delineate the 3 dimensional geometry of major faults and shear zones within and at the margins of the various domains;
- to test the hypothesis that large nappe/thrust sheets occur in the Reindeer zone:
- to relate the northwest dipping subduction zone convergence to the deep crustal structure of the collision zone;
- to relate the North American Central Plains electro-conductive anomaly to the lithotectonic segments.

Up to date scientific information from research by the Manitoba, Saskatchewan and federal Geological Surveys, universities and industry presented at a symposium during the 1987 GAC-MAC Annual Meeting was used for the development of the transect program and was released in early 1991 as GAC Special Paper 37 (Lewry, J.F. and Stauffer M.R.P, *eds.*, The early Proterozoic Trans-Hudson Orogen of North America).

The THOT scientific program consists of;

1. Seismic reflection surveys along one major and two additional corridors. In addition to these regional surveys which are designed to map the crust down to 50 km, high resolution reflection seismic surveys will be undertaken in mining areas with additional funds from industry and provincial government to map the structure in the upper 10 km of the crust in more detail.
2. Seismic refraction surveys along nine profiles
3. High resolution gravity and magnetic surveys along the reflection survey lines.
4. Electromagnetic studies (magnetotelluric and high resolution EM methods) along reflection survey lines.
5. Paleomagnetic and other geophysical studies.
6. Various geological studies, including structural-kinematic, geochemistry-isotope, geochronology and petrology studies.

The transect program is to run from 1990 to 1995 with a total budget of ca. \$7.5 Mi, most of which (ca. \$ 4 Mi) will go towards acquisition, processing and evaluation of the reflection seismic data

Fieldwork on the Trans-Hudson transect was started in Manitoba in July with a VIBROSEIS reflection seismic survey. undertaken by ENERTEC of Calgary. Twenty (20) km of High Resolution lines were completed in Thompson across the Thompson belt to obtain detailed shallow crustal information of the Thompson mines area. This part of the operation was funded by INCO; results of the survey will remain confidential for 2 years. Forty (40) km of Regional Surveys was completed in the same area, but further west into the Churchill Province. An other line across the eastern part of the Churchill-Superior boundary zone was undertaken further south, from Jenpeg to Setting Lake and from Clarke Lake to Highway 6 (95.5 km). The regional survey continued on Highway 6 and 39, from Dunlop to Simonhouse, across the Thompson belt and the Flin Flon belt (191 km), on Highway 392 to Snow Lake (32.7 km) and then on Highway 10 from Simonhouse to Flin Flon (75 km). A line across the Flin Flon belt into the Kisseynew gneiss belt was done along the road from Highway 10 to Sherridon, and from there along a recently built logging road towards the Churchill River (109.7 km). Preliminary results indicate that the survey was successful, i.e. several good reflectors were mapped. A workshop will take place in the Spring of 1992 to present the results of the survey and other ongoing LITHOPROBE projects.

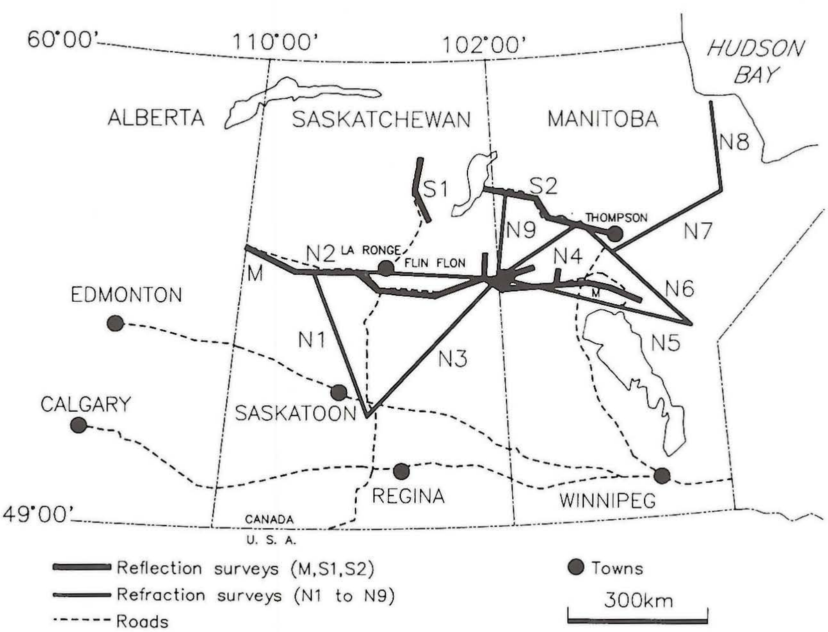

Figure GS-23-1: Map showing proposed seismic survey lines of Lithoprobe Trans-Hudson Orogen Transect (THOT).

GS-24 A VEGETATION GEOCHEMICAL SURVEY IN THE VICINITY OF THE TANCO PEGMATITE, BERNIC LAKE AREA, SOUTHEASTERN MANITOBA (52L/6)

by M.A.F. Fedikow and C.E. Dunn[1]

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.

INTRODUCTION

The vegetation geochemical orientation survey undertaken at the Tanco Ta-Li-Cs deposit in 1990 (Fedikow *et al.*, 1990) was expanded this year. A multi-species vegetation sampling program was undertaken over a 3 day period in August this summer. Approximately 100 samples including twigs, inner bark, outer bark, and trunk wood were collected from jack pine, black spruce, alder and, tamarack at 34 stations along three grid lines. Previous rock geochemical surveys by the Tantalum Corporation of Canada Ltd. had defined a multi-sample Li, Rb and Cs anomaly in this area. The vegetation samples were collected from areas of abundant outcrop and also from low swampy ground in an attempt to reproduce the rock geochemical anomaly. Unlike the general area of the vegetation geochemical orientation survey, this summer's survey area is considered to be free of contamination from mine development. A few additional vegetation samples were collected from the immediate area of the mine tailings and from areas sampled in March, 1989 to examine the flux of trace element concentrations in the vegetation from winter to late summer.

[1]Exploration Geochemistry Subdivision, Mineral Resources Division, Geological Survey of Canada, Ottawa.

RESULTS

Currently, vegetation samples are being ashed in the laboratories of the Geological Survey of Canada (Ottawa) and accordingly, analyses are unavailable. Information will be released as it becomes available.

ACKNOWLEDGEMENTS

We acknowledge the cooperation of the Tantalum Corporation of Canada for access to Tanco properties and company maps. In particular we acknowledge the cooperation of Peter Vanstone, Dave Alderman and Scott Anderson. Scott Anderson is also thanked for his assistance during the sampling program this summer.

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GSC-1 THE RUTTAN CU-ZN DEPOSIT AND DEPOSITIONAL ENVIRONMENT: AN UPDATE

by D.E. Ames*

Ames, D.E., 1991: The Ruttan Cu-Zn deposit and depositional environment: an update; **in** Manitoba Energy and Mines, Minerals Division, Report of Activities, 1991. p. 106-107.

INTRODUCTION

Field work by the Geological Survey of Canada (GSC) continued in the Rusty Lake belt as part of the Exploration Science and Technology Initiative (EXTECH). This multidisciplinary program is one of several by the GSC on major base metal deposits and camps including Kidd Creek, Sullivan, Snow Lake, Manitouwadge, Ansil and Bathurst. The second full field season of 1:5 000 geological mapping by the author and J.S. Scoates encompassed the supracrustal sequence southeast of the mine and north of the previous years' mapping to the Vol Fault (Ames *et al.*, 1990). During the previous three field seasons specific levels in the mine were sampled for stratigraphic and alteration studies. One important objective of this years field work was to determine the relationship between the stratigraphy northeast of the mine and the mine sequence. The 1:5 000 map with accompanying descriptive notes will be placed on open file release this spring by the Geological Survey of Canada (Ames, in prep.). Results from the 1991 field season are summarized here.

NORTHEAST OF THE MINE

This summers' field work established the continuity of a sequence of mineralized felsic pyroclastic rocks 5 to 10 m wide, containing pyrrhotite, pyrite and chalcopyrite, 2 km northeast of the open pit (see Fig. GSC-3-1, GSC-3-2 in Ames *et al.*, 1990). This felsic tuff is discontinuous over a strike length of greater than 1 km and is locally continuous for a maximum of 500 m. The felsic tuff lies between an amygdaloidal, feldspar phyric andesite in the footwall and a well-bedded hanging wall sequence of volcanogenic mafic wacke and breccia. Elsewhere, the footwall and hanging wall rocks are in contact. Because the same stratigraphic sequence occurs in drill core form the footwall to the mine, the strata northeast of the mine are considered correlative with those in the mine sequence. Locating the mineralized felsic tuff along this vital horizon, as previously defined by Ames *et al.* (1990) greatly increases the exploration potential for the area.

The microcline alteration zone first described in Ames *et al.* (1990, 1991) has now been delimited. This zone, the felsic tuff and the surrounding strata were mapped at 1:250 scale and a detailed lithogeochemical sampling program was undertaken. Microcline alteration occurs in two bulbous zones, 120 x 70 m and 100 x 50 m, linked by a narrow zone 10 m wide that collectively form a zone over 400 m long. The detailed Airborne Gamma Ray Spectrometer Survey of the Ruttan Area distinguishes these two occurrences as subtle "bulls -eyes" on the potassium map (Hetu, 1990).

Within the microcline alteration a new gold occurrence was discovered. Visible gold (Au:Ag = 4:1) was identified in a solid sulphide vein of arsenopyrite and scorodite ($FeAsO_4.2H_2O$). The sulphide vein cuts the microcline-bearing vein system. A detailed till geochemical study by Nielsen (1986) outlined an anomalous area of gold and arsenic south of the Vol Fault. Nielsen postulated that this anomaly was due to the erosion of sulphide occurrences along that fault. His anomaly corresponds directly with the new gold occurrence, the extension of the mine horizon, and the mineralized felsic tuff to the northeast (see Fig. GSC-3-1, GSC-3-2 in Ames *et al.*, 1990).

REE, major and trace element composition of 1990 samples indicate that the protolith of the microcline zone is rhyolite. Xenotime (YPO4) identified by SEM in the microcline zone may provide a U/Pb age. The mineralized felsic tuff is compositionally equivalent to rhyolite and the feldspar-pyroxene phyric basalt is andesitic (see Fig. GSC-3-1 in Ames *et al.*, 1990).

Mapping this summer extended the subdivision of the mafic volcanic sequence. Mafic units now include massive and sparsely pillowed aphyric basalt, hornblende phyric basalt, both massive and breccia units and feldspar phyric basalt. Facies changes occur consistently within units. From northeast to southwest basalts change from massive to breccia units, the andesite varies from pillowed to massive to lapilli tuff units with reversely-graded to normally-graded beds. In the hanging wall mafic wacke and breccia, the sequence also fines towards the southwest. Dioritic and gabbroic bodies and sills were emplaced in the basaltic sequence. The basaltic sequence and mafic intrusions are cut at their western limit by granodiorite of the Brehaut Lake Intrusion. The latter intrusion contains angular inclusions of the supracrustal rocks, dominantly basalt.

MINE SITE

A thin microcline-sericite altered felsic tuff unit was identified 700 m east-northeast of the headframe and on the east edge of the open pit. The mineralized felsic tuff 2 km to the northeast also contains local patches of microcline. Between the felsic tuff localities are tailings or till and bog deposits. A till geochemical study by the Geological Survey of Canada is in progress in this area .

Within the mine, a series of footwall "mine quartzite" units were sampled for follow-up REE, major and trace element geochemical work to help define the mine sequence and to compare with the felsic volcanic deposits 700 m and 2 to 3 km northeast of the mine, and the mine rhyolite defined by Speakman *et al.* (1982). Geochemistry of these felsic deposits will also facilitate comparison with the subaerial rhyolite sequence (Baldwin, 1987) in the adjacent Karsakuwigamak block.

Alteration mapping and sampling was continued to determine the distribution and nature of the hitherto undescribed assemblages. From a cursory viewpoint, the alteration in the immediate Ruttan mine area seems typical of many massive sulphide deposits metamorphosed to middle amphibolite grade, such as Winston Lake (Severin *et al.*, 1990) and Geco (Manitouwadge) (Williams *et al.*, 1990). At Ruttan, however, there is an extreme diversity of alteration assemblages; gahnite-sericite, biotite-staurolite-garnet-andalusite Ò sillimanite, chlorite-cordierite, anthophyllite-cordierite, anhydrite and apophyllite. The latter two exist as open-space vug infillings but anhydrite is also intergrown with the ore. The spectacular alteration assemblages at Ruttan were mapped and sampled through drill core and mine exposures over the last two and a half field seasons; concomitant petrologic and geochemical studies are in progress.

The presence of microcline alteration in the footwall is unique to the Ruttan massive sulphide deposit compared to known base metal deposits in the Early Proterozoic rocks of Canada. However, microcline alteration occurs in the footwall to the Archean Selbaie gold-base metal deposit, Quebec (Larson and Hutchinson, 1991; Faure *et al.*, 1990) and base metal deposits in the Early Proterozoic Bergslagen district, Sweden (Hedstrom *et al.*, 1989). Both Selbaie and the Bergslagen deposits occur in felsic volcanic rocks deposited in shallow water to subaerial rhyolite sequences.

The Ruttan deposit and associated strata have been folded into a series of Z-shaped minor folds. The map pattern reflects the folding (see Fig. GSC-3-1 in Ames *et al.*, 1990). Within the map area the vergence between bedding and the penetrative foliation is consistent. The minor folds, orebodies and lineations plunge approximately 65° to the southeast. The strata top and dip to the southeast and the synclinal fold closure is towards the east. The strain is much more intense in the orebodies and the footwall sequence than in the hanging wall rocks. The chalcopyrite-chlorite-talc stringer zones are transposed parallel to the massive ore.

*Geological Survey of Canada

A sinistral oblique slip shear zone northeast of the mine, strikes 050° and dips 80° SE . Towards the Vol Fault and the contact with the Brehaut Lake granodiorite a secondary shear foliation is well developed in broad zones within the basaltic sequences. This penetrative fabric (S_2) has a mean attitude of 053°/77° SE, N=33. At the mine site, the North Wall Shear (Speakman *et al.*, 1982) is a high angle reverse fault with south side up as indicated by the flexure of foliation in the shear zone on the west-northwest side of the open pit. The sense of movement described in Ames *et al.* (1990) was from a shear zone on the 800 level and was thought then to be the North Wall Shear underground; clearly it is not. A series of additional splay faults have been described in Speakman *et al.*, (1982). Within the mine, lineations are well developed, the orebodies and enveloping alteration zones have been folded and sheared. Preliminary investigations underground indicate that the minor folds are also Z-shaped with a trend and plunge parallel to that of the orebodies at 130°/60°SE. This correlates with the minor folds east and northeast of the mine in the hanging wall sedimentary rocks, the stretching direction of amygdales in the footwall andesite and basalt and the overall map-scale pattern.

SOUTHWEST OF THE MINE

The supracrustal sequence south of the mine is a southwest tapering wedge with a maximum apparent thickness (map view) of 300 m that pinches out at the southern limit of Ruttan Lake. This sequence is bounded by xenolithic phases of the Brehaut Lake granodiorite to the west and diorite of the Corner Lake Intrusion to the east. The strata, shear zones and a well developed penetrative fabric are all parallel at 030°/75°SE. Intrusion breccia zones of the Brehaut Lake granodiorite are strained, and felsic dykes are strongly boudinaged. Aspect ratios of fragments (length:width) vary between 30:1 to 3:1 with the intensity of deformation stronger where the supracrustal rocks are 25 to 200 m wide, to the south.

The stratigraphic assemblage is dominated by variably altered felsic rocks of unknown origin and contains a sequence of breccia with felsic fragments to the east. The altered felsic rocks and breccia have similarities to the volcanically derived felsic pebble conglomerate stratigraphically high in the hanging wall of the Ruttan deposit (see Fig. GSC-3-1 in Ames *et al.*, 1990) or they may represent a new sequence of felsic volcanic rocks. The footwall volcaniclastic rock reported by Speakman *et al.*, (1982) and Baldwin, (1988) southwest of the mine consists of, from west to east, a sequence of highly strained mafic basaltic rocks, variably altered felsic rocks and bedded silicified mafic metasedimentary rocks. They were intruded by a slightly discordant feldspar porphyry and various phases of diorite and granodiorite. The feldspar porphyry east-northeast and southwest of the deposit, previously termed "footwall volcaniclastic" are both locally discordant to stratigraphy.

Understanding the structure, regional stratigraphy, mine stratigraphy, physical volcanology and the alteration system are key for the recognition of other Ruttan-type ore environments in this area and elsewhere.

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LIST OF GEOLOGICAL STAFF AND AREAS OF CURRENT INVOLVEMENT

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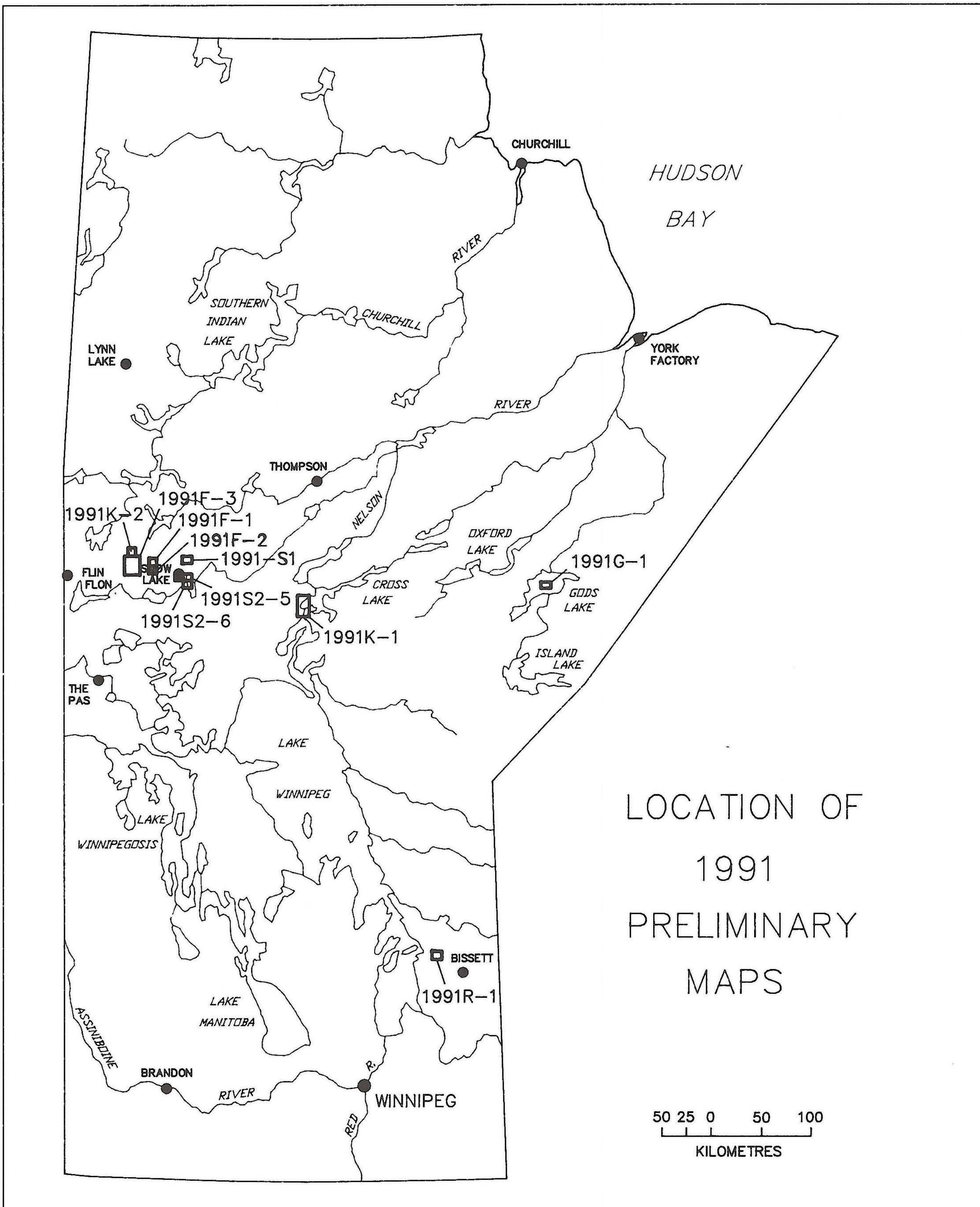
	H.P. Gilbert	Tartan Lake
	P.G. Lenton	Cross Lake, Data Management and Analysis
	Dr. J.J. Macek	Thompson
	D.C.P. Schledewitz	Kississing Lake
	E.C. Syme	Flin Flon, Athapapuskow Lake, Elbow Lake
	Dr. H.V. Zwanzig	Churchill Province, Kisseynew belt
Mineralogist	C.R. McGregor	Mineralogy, Sub-Phanerozoic Precambrian
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
	L. Norquay	North Star Lake
Resident Geologist (The Pas)	D.E. Prouse	Exploration activity, drill core programr
Resident Geologist (Flin Flon)	Vacant	Flin Flon - Snow Lake region
Industrial Minerals Geologists	W.R. Gunter	Northern Manitoba
	B.E. Schmidtke	Southern Manitoba
	J. Bamburak	Manitoba Inventory
	P. Athayde	Mineral Inventory Assistant
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	Southern Manitoba

PRELIMINARY MAPS 1991

GEOLOGICAL SERVICES BRANCH

		Scale
1991F-1	North Star Lake area (Part of NTS 63K/15NE) by L.I. Norquay, D.E. Prouse, M. Bieri and G.H. Gale (Supersedes 1990-F2)	1:10 000
1991F-2	North Star Lake area (Part of NTS 63K/15SE) by L.I. Norquay, D.E. Prouse, M. Bieri and G.H. Gale (Supersedes 1990-F2)	1:10 000
1991F-3	Elbow Lake (Part of 63K/15W) by E.C. Syme and J.B. Whalen	1:20 000
1991G-1	Elk Island and Jowsey Island (Part of NTS 53L/9) by P. Theyer	1:10 000
1991K-1	West Cross Lake (Parts of NTS 63J/9SE and 63J/9NE) by M.T. Corkery and H.D.M. Cameron (Supersedes 1990K-1)	1:20 000
1991K-2	Webb Lake (NTS 63K/15) by D.C.P. Schledewitz (Supersedes 1990-K2)	1:20 000
1991R-1	English Brook (NTS 62P/1) by W. Weber and J. Young	1:20 000
1991S-1	Geology and Alteration at the Wim Deposit (Part of NTS 63N/1) by M.A.F. Fedikow	1:5 000
1991S-2	Anderson Lake (South) (Parts of NTS 63K/16SE and 63J/13SW) by A.H. Bailes and A.G. Galley (Supersedes 1990-S2)	1:5 000
1991S-3	Anderson Lake (North) (Parts of NTS 63K/16SE and 63J/13SW) by A.H. Bailes and A.G. Galley (Supersedes 1990-S2)	1:5 000
1991S-4	Stall Lake (South) (Part of NTS 63J/13SW) by A.H. Bailes and A.G. Galley	1:5 000
1991S-5	Stall Lake (North) (Part of NTS 63J/13SW) by A.H. Bailes and A.G. Galley	1:5 000
1991S-6	Wekusko Lake (Northeast) (Part of NTS 63J/13SW) by A.H. Bailes, A.G. Galley and R. Hicks	1:20 000


HUDSON
BAY
CHURCHILL
RIVER
CHURCHILL
SOUTHERN
INDIAN
LAKE
LYNN
LAKE
YORK
FACTORY
RIVER
THOMPSON
NELSON
1991F-3
1991K-2
1991F-1
1991F-2
1991-S1
FLIN
FLON
SNOW
LAKE
1991S2-5
1991S2-6
1991K-1
CROSS
LAKE
OXFORD
LAKE
1991G-1
GODS
LAKE
ISLAND
LAKE
THE
PAS
LAKE
WINNIPEG
LAKE
WINNIPEGOSIS
BISSETT
1991R-1
LAKE
MANITOBA
ASSINIBOINE
BRANDON
RIVER
R.
RED
WINNIPEG
LOCATION OF
1991
PRELIMINARY
MAPS
50 25 0 50 100
KILOMETRES