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Geology of the Kississing-Batty Lakes Area: Interim Report

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

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Winnipeg, 1992

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ACKNOWLEDGEMENTS

We thank Edgar Froese for his guidance to the geology of the Kississing - Batty Lakes area at the start of the project, his continued interest during the mapping, and his comments on the manuscript. We are indebted to D. Seneshen, G.D. Trembath, B. Miller and P. Elias for their help in mapping, and to all other assistants who worked with us in the field. The comments of W. Weber, K. Ferreira, D. Baldwin and G. Ostry allowed us to improve the original manuscript. Paul Lenton provided expert guidance and developmental skills to begin the process of computer analysis of structural data. The digitizing of maps to accompany the report is the result of ongoing developmental work being carried out at the University of New Brunswick by Paul Williams of the Department of Geology along with the staff of the GIS Laboratory. The maps were plotted in colour at the Geological Survey of Canada with funding through the Canada - Manitoba Partnership Agreement on Mineral Development. These maps are a preliminary product of the Shield - Margin Project operated within NATMAP, Canada's national mapping program.

INTRODUCTION

The Kississing Lake - Batty Lake area lies in the internal (Reindeer) zone of Trans-Hudson Orogen. It covers 2 500 km^2 on the south flank of the Kisseynew gneiss belt, and the most northern margin of the Flin Flon volcanic belt (Fig. 1). The investigation of this area helps to provide structural and stratigraphic control for base- and precious-metal deposits. The work establishes a new stratigraphic subdivision of the gneisses that distinguishes those of sedimentary and volcanic origin from orthogneisses derived by metamorphism of predominantly intrusive rocks. It traces the recognizable volcanic rocks of the Amisk Group north across the metamorphic boundary between the Flin Flon and Kisseynew belts into large structural outliers in which the coarse grained gneisses are interpreted to have a significant volcanic component.

The focus of this report is a preliminary stratigraphic and structural interpretation of the project area and a consideration of the economic geology arising from this analysis. Unit descriptions, which constitute the bulk of the report, are based, in part, on earlier published preliminary reports (Schledewitz, 1985, 1987, 1988; Schledewitz and Trembath, 1986; Zwanzig, 1983, 1984, 1985, 1988; Zwanzig and Lenton, 1987) and on preliminary petrographic observations. Modal estimates of granitic rocks are based on preliminary counts of 200 to 500 points (depending on grain size and uniformity)

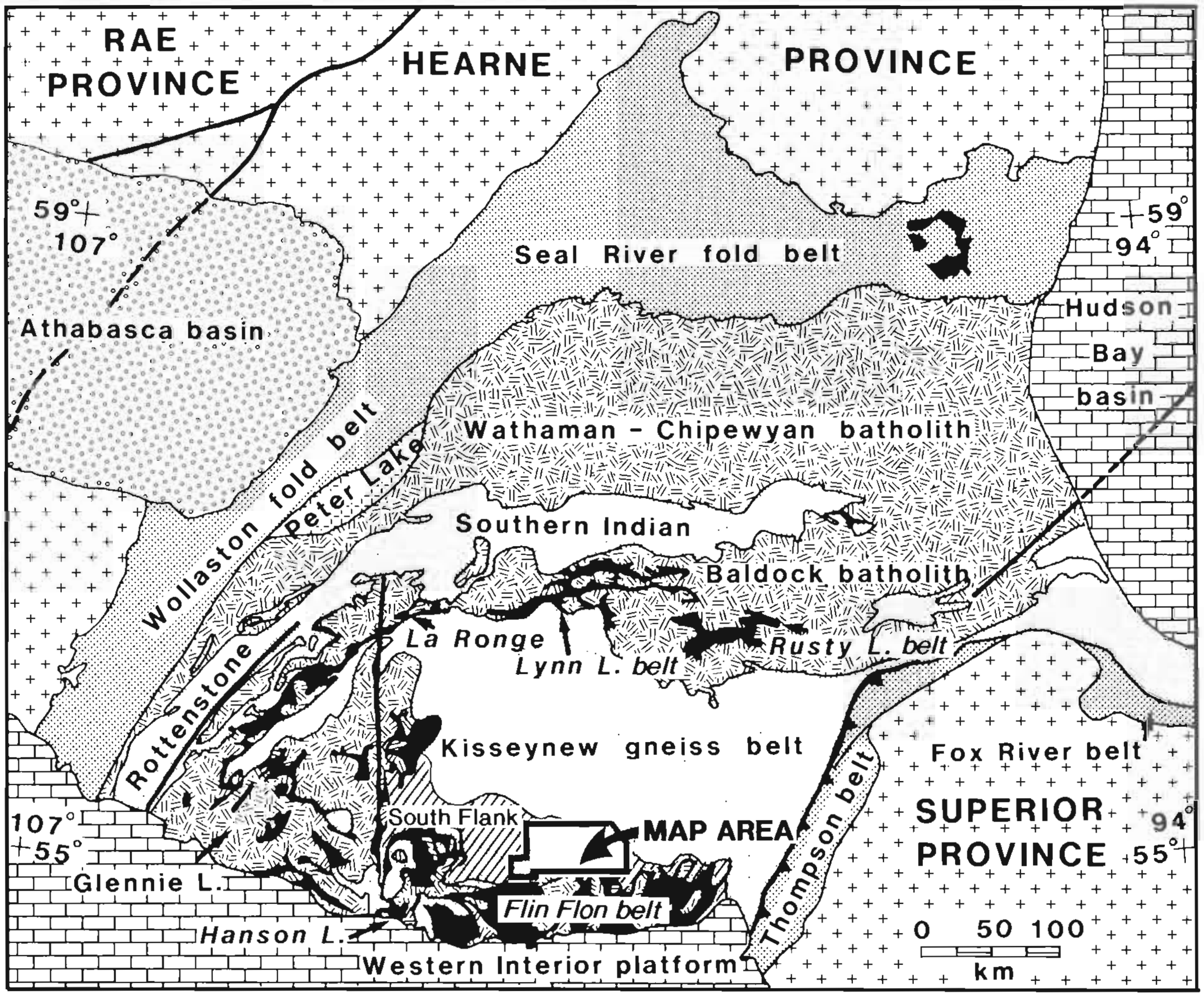


Fig. 1: Tectonic setting of the Kississing - Batty lakes area, showing lithostructural belts in Trans-Hudson Orogen, adjoining structural provinces and location of the map area on the south flank of the Kisseynew gneiss belt.

done on sawed slabs etched and stained for quartz, plagioclase and potassium feldspar. Structural analysis, which is the second major component of the report, was carried out with reference to three major lithotectonic domains that occur in the area. The geometry of major folds and intermediate scale fabrics are described for selected subareas that represent the variety of structural styles in all of the major domains. This involves structure sections and computer plotted equal area stereograms of subfabrics . The analysis was aided by a dBASE system of field data entry and retrieval developed by P.G. Lenton. The economic considerations focus on the gold occurrence in the southern part of the area and on base metal occurrences at Kississing Lake.

The area between latitudes 55°00' and 55°15' from Duval Lake to Limestone Point Lake (64N/2, 64N/3 and parts of 64N/1, 64N/4), and south of 55°00' in parts of 64K/13 and 64N/14 were mapped on 1:15 840 scale airphotographs and compiled at 1:50 000 scale on Maps OF92-2-1 and OF92-2-2 (in pocket). The compilation is based on previous preliminary maps and supersedes Maps

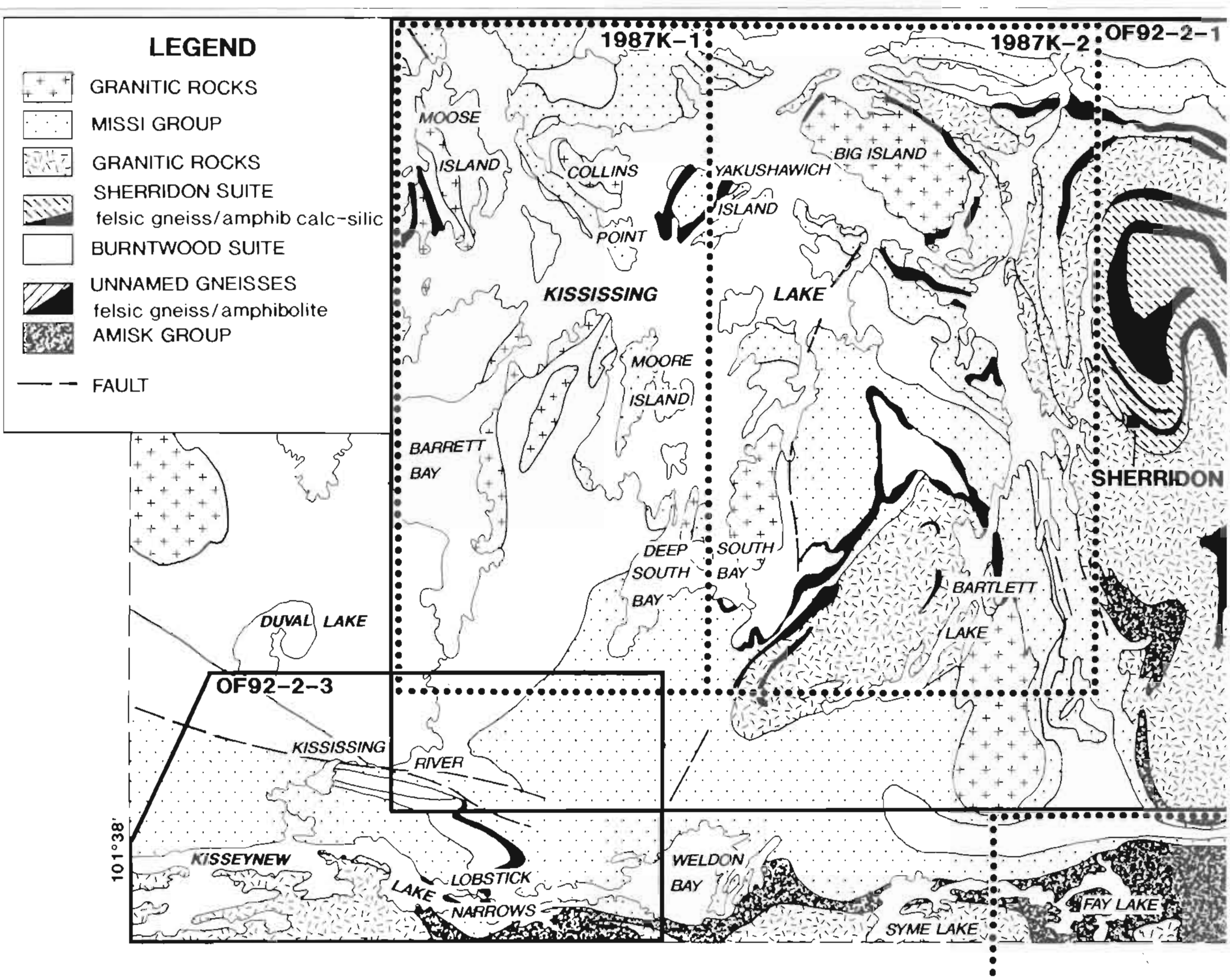
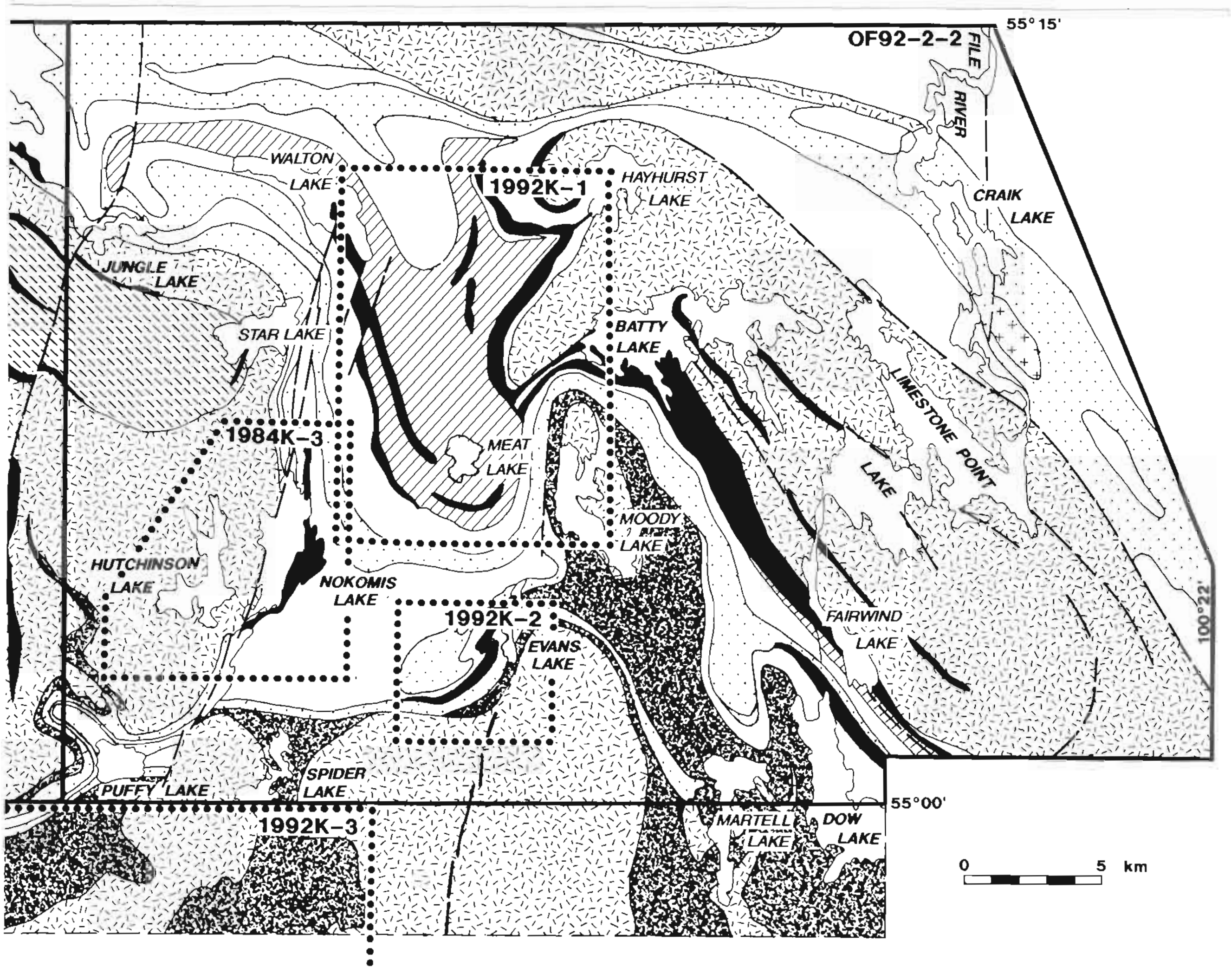


Fig. 2: Simplified geology of the Kississing - Batty lakes area and location of enclosed and available maps: OF92-2-1 and OF92-2-2, heavy outline (1:50 000 colour maps in cover); OF92-2-3, heavy outline (1:20 000 map in cover); 1987K-1, 2 and 1984K-3, dotted outline (1:20 000 preliminary maps, not enclosed).

1988K-1 and -2. More detail is shown in some areas at 1:20 000 scale on OF92-2-3 (in pocket) and Preliminary Maps 1984K-3, 1987K-1, 1987K-2, 1992K-1 and 1992K-2 (Fig. 2).

Certain magnetiferous units were traced locally with the help of aeromagnetic total field and vertical gradient maps (Manitoba Mines and Natural Resources, 1954; Manitoba Energy and Mines and Geological Survey of Canada, 1983a, 1983b; Geological Survey of Canada, 1987a, 1987b). Considerable revision has been made to the earlier geological maps of Tanton (1941), Bateman and Harrison (1946), Kalliokoski (1952), Robertson (1953), Frarey (1961), Pollock (1964) and Kornik (1968). The most recent mapping conducted in the Sherridon area (Froese and Goetz, 1981) was not extensively revised; additional work was done by Tuckwell (1979), Gale (1980), and at Kisseynew Lake by Ashton (1989), Froese and Gall (1981) and McRitchie (1980, 1986). A coloured preliminary compilation map of NTS area 63N was published at 1:250 000 scale, in part, using data of the Kisseynew project (Manitoba Energy and Mines, 1988).



LITHOSTRATIGRAPHY

The south flank of the Kisseynew gneiss belt contains a variety of plutonic rocks and five assemblages of supracrustal rocks (Table 1), most of which are highly metamorphosed equivalents of units in the adjacent Flin Flon volcanic belt.

Table 1: Supracrustal Rocks

(1) Amisk Group: fine grained amphibolites and felsic gneisses derived from metavolcanic and metasedimentary rocks;

(2) Burntwood Suite: graphite-bearing garnet-biotite gneisses, migmatites and minor amphibolites that are equivalent to greywacke-mudstone turbidites (File Lake Formation), which Bailes (1980a) considered to be the upper part of the Amisk Group on the north margin of the Flin Flon belt;

(3) Unnamed gneisses: fine- to coarse-grained amphibolite and felsic gneisses, probably highly recrystallized equivalents to the Amisk Group;

(4) Sherridon Suite: predominantly quartz-rich rocks, a large part of which are also suspected to be equivalent to the Amisk Group;

(5) Missi Group: quartz-rich metasedimentary gneiss, and metavolcanic rocks interpreted to be equivalent to the metasandstones in the Flin Flon area (Bailes, 1980b; Ashton, 1989).

Volcanic rocks that have been clearly identified as Amisk Group are restricted to the south part of the Kississing - Batty lakes area. They are best exposed between Moody and Dow lakes. A smaller outlier of the Amisk Group is host to the gold mineralization at Puffy Lake. Much of the remaining area is underlain by the metasedimentary rocks of the Burntwood Suite and Missi Group. These rocks are particularly extensive at Kississing Lake and northeast of Limestone Point Lake. A basal metaconglomerate of the Missi Group is well exposed in the southeast part of the area. However, the felsic and mafic gneisses of the Sherridon Suite and unnamed unit, which have particular significance for exploration for massive copper sulphide deposits, outcrop extensively throughout the central part of the area from Sherridon to Batty Lake. (See maps, in pocket.) Unnamed felsic gneisses west of Batty Lake were poorly exposed and inaccessible at the time of mapping such that these important rocks were not well explored. The extensive forest fire in 1989 and building of logging roads have enabled a more detailed mapping project to be planned and conducted between 1992 and 1994 in the Walton Lake - Evans Lake area.

Stratigraphic relationships of some suites of predominantly supracrustal rocks can be established locally at the south margin of the Kisseynew belt and in adjacent parts of the Flin Flon belt, where primary structures are preserved. The Amisk Group forms the oldest strata. It is overlain by the Missi Group with angular unconformity. The Missi Group contains the youngest supracrustal rocks in the Kississing - Batty lakes area. Both groups extend across the boundary between the Flin Flon and Kisseynew belts. The other units are considered to be metamorphic suites rather than groups, because a stratigraphic facing generally cannot be recognized and the order of superposition is uncertain (North American Commission on Stratigraphic Nomenclature, 1983). These rocks of uncertain age comprise the Burntwood Suite, an unnamed unit (3) and the Sherridon Suite. They are provisionally interpreted to contain highly recrystallized equivalents of the Amisk Group and locally a significant volume of gneiss derived from intrusive rocks. Recognition of rocks equivalent to the Amisk Group in the Kisseynew belt is important in regional structural interpretation and mineral exploration: the Puffy Lake gold deposit is interpreted to be hosted by Amisk Group rocks, and massive Cu-Zn sulphide deposits occur in Sherridon Suite rocks.

The Burntwood Suite overlies the Amisk Group metavolcanic rocks north of Martell Lake where it is overlain, in turn, by the Missi Group. Bailes (1980a) has interpreted the metagreywacke (herein called the Burntwood Suite) as a turbidite basin deposit at the top of the Amisk Group, but in this report it is considered to be a separate metamorphic suite because the stratigraphic relationship between it and Amisk Group metavolcanic rocks is uncertain. On a regional scale the turbidites were deposited in a different environment and could be slightly younger than the dated volcanic rocks in the Amisk Group (Zwanzig, 1990). In many places Amisk Group volcanic rocks change abruptly to metagreywacke across a fold developed in the Missi Group, a relationship that suggests structural juxtaposition between the Amisk Group and Burntwood Suite.

The structure is very complex in the area such that all of the major units do not appear to occur in a continuous stratigraphic sequence. Different sequences of lithologic assemblages are interpreted to represent different fold nappes, each of which is dominated by one of three sequences (Table 2). The origin of these sequences has not been fully resolved. One explanation is that they represent depositional facies; (1) proximal to the Flin Flon volcanic belt, (2) a coeval basin-margin facies, and (3) deposits from the deeper part of a basin. These sequences have been structurally telescoped and their lithologic assemblages were juxtaposed during proposed phases of nappe development and southwest tectonic transport.

Table 2: Sequences of Lithologic Assemblage

VOLCANIC ARC (SEQUENCE 1)	BASIN/ARC MARGIN FACIES (SEQUENCE 2)	BASIN FACIES (SEQUENCE 3)
Missi Group Missi Group conglomerate	Missi Group (fine grained) ± Missi Group conglomerate	Missi Group (fine grained)
angular unconformity	*low-angle unconformity*	*disconformity (?)*
Pre-Missi granitic rocks Amisk Goup / Sherridon Suite / Unnamed gneisses (Amisk Group?)	± Unnamed amphibolite Burntwood Suite paragneiss	Burntwood Suite paragneiss

Structural analysis given in this report indicates that considerable tectonic transport took place between sequence 1 and the other sequences, possibly before the deposition of the Missi Group. U-Pb zircon ages determined from the volcanic rocks and from detrital grains are required to test the question whether the sediments of the Burntwood Suite were derived from active Amisk volcanoes or from an uplifted Amisk basement.

Little is known of the original stratigraphic thicknesses of the assemblages because of repetitions in folds and extreme attenuation during structural transport and later compression. Structure sections suggest that the present maximum structural thickness of the Amisk Group is in the order of 1.5 km, but in the Kississing - Batty lakes area much of the group occurs as thinner slices or roof pendants in plutons. The most common structural thickness of the Burntwood Suite is in the order of 0.5 km, but the wide distribution of the unit suggests a greater original thickness. The Missi Group is in the order of 1 km thick, but stretched pebbles suggest three to five times that thickness including structural repetitions.

AMISK GROUP

In the Kississing - Batty lakes area the Amisk Group comprises amphibolite and felsic gneisses derived from predominantly metavolcanic rocks, closely related metasedimentary rocks and early intrusions. The term "Amisk Group" has been retained only for these rocks where they are recognizable on the south margin of the Kississing - Batty lakes area (Fig. 2) and even there, high-level intrusions generally cannot be distinguished from flows. Northeast of Dow Lake these rocks are overlain by the Burntwood Suite, which, in turn, is overlain by the Missi Group.

Mappable units in the Amisk Group are summarized in the appendix. Basaltic and dacitic rocks with moderately developed foliation occur at Spider Lake; these may be largely intrusive. Fine grained, more strongly foliated amphibolite and minor felsic rocks extend west to Kisseynew Lake and east to Dow Lake. South of Moody Lake, Amisk Group rocks lie in a saddle structure between two granitic domes. Narrow belts of Amisk Group rocks mantle other domes. North and west of Puffy Lake, and north of Moody Lake such belts are more highly recrystallized extensions of the recognizable Amisk Group rocks. Amphibolite at Bess Lake is probably also Amisk Group, which is largely displaced by tonalite and granite south of the lake.

Undivided amphibolite, intermediate gneiss (1)

Various types of amphibolites distinguished by their mineral contents are mapped as unit 1 (undivided) where they are interlayered or poorly exposed. Layered quartz-plagioclase-hornblende-biotite±garnet gneiss is locally abundant within areas of amphibolite. This intermediate gneiss was probably derived from volcaniclastic rocks.

Amphibolite, metabasalt, metagabbro (1a)

A belt of Amisk Group rocks composed mainly of amphibolite (1a) is about 4 km wide and extends for 10 km from Dow Lake northwest to Moody Lake. Discontinuous belts, which are in the order of 1 km wide, extend west from Evans Lake to Bess Lake and southwest to Kisseynew Lake along the south margin of the map area.

Generally unit 1a in these belts consists of uniform dark green and weakly layered amphibolite with hornblende (0.2-3.0 mm) slightly in excess of plagioclase. Fine grained varieties were derived from aphyric and finely plagioclase-phyric metabasalts. Medium grained massive amphibolite is locally identified as sills, dykes or thick flows, but generally flows cannot be distinguished from high-level intrusions. Some layers of medium grained amphibolite contain garnet and represent altered and strongly recrystallized basaltic rocks. Thin layers and lenses rich in epidote or diopside that represent transposed alteration domains in basalt are common south of Moody Lake and locally at Puffy Lake, whereas uniform fine grained amphibolite is abundant at Spider Lake.

Amphibolite derived from pillow basalt (1b)

Metabasalt with deformed pillow selvages is locally preserved within the belts composed predominantly of unit 1a. Pillows are generally flattened beyond recognition. The attenuated selvages are either darker and slightly coarser grained than the rest of the amphibolite and contain garnet porphyroblasts (Fig. 3), or have white-weathering plagioclase-rich centres with dark hornblendic rims (Fig. 4). Both probably represent different types of alteration of the original pillow rinds accentuated by metamorphic mineral assemblages.

Felsic gneiss, metadacite (1c)

Thin units of grey felsic rocks are locally intercalated with amphibolite. Some layers, interpreted to be dacite, contain 2 mm phenocrysts of plagioclase and (polygonized) quartz, elongate hornblende-biotite aggregates (derived from mafic phenocrysts) in a groundmass of 0.05 mm long grains of quartz, feldspar and biotite. Other layers contain <25% combined hornblende and biotite and 10 mm long mafic aggregates. Small felsic fragments <4 cm long are present locally. Strongly foliated felsic rocks in the northeast may include metasedimentary rocks. Small porphyroblasts of garnet and magnetite, and retrograde chlorite and calcite occur in several places. This unit is prominent at Spider Lake and for 10 km northeast to Evans Lake.

Felsic gneiss, metarhyolite (1d)

Pale grey- to buff-weathering fine grained Amisk Group felsic rock, interpreted to be metarhyolite, occurs within the belts of amphibolite south and west of Puffy Lake. The rock forms 50 cm to several metres wide isolated units, probably dykes. The rock contains fine grained (0.1-0.3 mm)

Fig. 3: *Deformed metabasalt (1b) with hornblende-rich pillow selvages (thin dark layers), Moody Lake.*

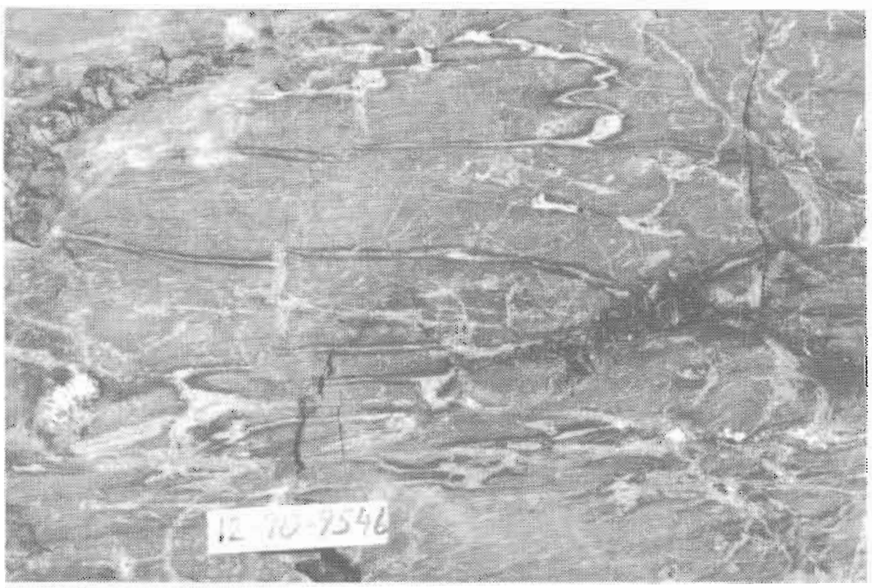


Fig. 4: *Metabasalt (1b) with zoned deformed pillow selvages (white plagioclase-rich bands with black hornblende-rich margins on the pillows), Puffy Lake area. Tape is 10 cm.*

quartz, plagioclase, microcline, biotite, muscovite and locally poikiloblastic garnet (<5 mm) with rims of quartz and plagioclase.

A suite of pink to buff-weathering, quartz-rich metasedimentary rocks and possible metarhyolite tuff forms a narrow, partial mantle on the pre-Missi granitic dome (9) northeast of Puffy Lake. Xenoliths of felsic gneiss (1d) up to several metres long occur on the margins of tonalite to granodiorite gneiss (6b) west of the abandoned mine. These rocks are probably high-grade metamorphic equivalents of the Amisk Group. They are intruded by the pre-Missi granite and unconformably overlain by the basal Missi conglomerate (Zwanzig, 1984; Hunt and Zwanzig, 1990). Some xenoliths have a fragmental texture and may be rhyolite breccia.

Biotite gneiss ± garnet, magnetite, amphibole (1e)

Uniform, medium grey, felsic biotite gneiss is exposed in a belt <1 km wide on the east shore of Dow Lake where it extends for a strike length of 20 km in a large, northwest-trending, S-shaped fold. Local layering is defined by biotite concentrations interpreted to be relict sedimentary bedding. The gneiss commonly contains magnetite and scattered small grains of garnet. Amphibole is a variable constituent of the rock in the west limb of the fold and in several metre wide occurrences elsewhere, such as on Evans Lake and north of Dutka Lake. A more feldspathic variety of 1e occurs southwest of Hutchinson Lake and a biotite-rich variety derived from metagreywacke injected by fine-grained pre-Missi granitic dykes occurs south of Evans Lake. Along the southwest shore of Bess Lake, layers of buff biotite gneiss, 1 to 10 cm thick, are intercalated with garnetiferous amphibolite (3a). The layers contain feldspar (50-55%), quartz (25%), biotite (15%), hornblende (5-10%), magnetite (0-2%) and red garnet (0-2%).

The unit is mapped as part of the Amisk Group because some biotite gneiss is conformably underlain and overlain by amphibolite that is recognized as unit 1.

BURNTWOOD SUITE

The Burntwood Suite (Burntwood River Metamorphic Suite of Gilbert *et al.*, 1980; Lenton, 1981) outcrops throughout most of the Kississing - Batty lakes area, generally north of the well preserved Amisk Group rocks. The Burntwood Suite is the oldest lithological assemblage in most parts of the Kisseynew belt (Zwanzig, 1990a). Its distribution is controlled by early isoclinal folds that have an individual strike length of limbs up to 40 km. On the south flank much of these rocks were mapped as Nokomis Group by Robertson (1953). Subsequent work showed that they are equivalent to low-grade metaturbidites, which were designated as the File Lake Formation, the uppermost unit in the Amisk Group on the north margin of the Flin Flon belt (Bailes, 1980b). In the Wildnest Lake area of Saskatchewan and in the adjacent Florence Lake area in Manitoba, identical rocks to the Burntwood Suite are mapped as Amisk Group metasedimentary rocks and are considered to be interlayered with volcanic rocks (Ashton *et al.*, 1987; Ashton, 1989).

In this report the Burntwood Suite is defined as quartzofeldspathic biotite ± garnet, cordierite, sillimanite, graphite gneiss of sedimentary origin. It forms a regionally extensive succession over 500 m thick. In these rocks primary sedimentary structures have been largely obliterated. The rocks rarely contain amphibole, and have little interlayered amphibolite, but may be underlain or overlain by amphibolite. Lithologic divisions of the Burntwood Suite are based on varying occurrence of certain minerals and structures depending on; (i) metamorphic grade, (ii) metasomatic effects, (iii) degree of migmatization, and (iv) primary variations in composition. (See below for detail, and appendix for summary.) Where a subdivision has not been made the rocks are mapped as unit 2 (undivided).

Garnet-biotite gneiss, metagreywacke (2a)

Typical metagreywacke occurs as fine grained garnet-biotite gneiss that is generally graphitic. It is exposed in the south half of the Kississing - Batty lakes region in large irregularly shaped areas because of extensive folding and generally shallow dips. Outcrops are low and weather grey to brown. Fresh surfaces are dark grey; some broken weathered surfaces are brownish yellow; cleavage surfaces commonly have a maroon-red-weathering cast. At rare localities remnants of graded bedding are preserved as changes in the size and concentration of biotite and garnet. White-weathering veins of quartz ± plagioclase constitute less than 10% of most outcrops of unit 2a.

Biotite constitutes 15 to 30% of the rock; garnets make up <20% and are generally subhedral and *ca.* 2 mm; quartz and plagioclase make up the remainder. Sillimanite and cordierite occur in the mudstone component. Minor phases include graphite, iron sulphide, apatite, tourmaline and sphene. At Lobstick Narrows and west of Puffy Lake Mine, quartz-sillimanite knots *(faserkiesel)* are locally abundant near the top of the unit. In numerous localities retrograde chlorite and muscovite overgrow some biotite and garnet.

Biotite gneiss, metagreywacke (2b)

Garnet-free metagreywacke is interlayered with, and grades into, 2a in the most southerly part of the Kississing - Batty lakes area. Part of the unit is a psammite with abundant quartz and feldspar, and 10 to 20% biotite. Another variety contains dark brown biotite derived from garnet, apparently by potassium metasomatism. Cores of garnet rimmed with retrograde biotite are locally preserved. The texture suggests that this variety of 2b was derived from 2a. The end product of this process was mapped as 2e (below). A rusty-weathering pyritic variety of 2b occurs in a zone, 200 to 300 metres wide, along the north side of Big Island of Kississing Lake and extends discontinuously to the east to Three Finger Lake. The pyritic rock contains irregular shaped lenses of hornblende-biotite-graphite gneiss (3g). The contact between 2b and 3g is gradational.

Metatexite, greywacke derived (2c)

Greywacke derived migmatite occupies complexly shaped belts with a structural thickness <1 km in the north half of the Kississing - Batty lakes area and thicker northeast of Craik Lake. The rock comprises fine- to medium-grained, grey-weathering layers of 2a or 2b intercalated with white-weathering *lits* of plagioclase-quartz ± garnet or rare microcline. The paleosome is characterized by abundant biotite and 2 to 3 mm mauve garnet porphyroblasts, locally with sillimanite and cordierite (Fig. 5). The best preserved rocks have repetitive layering (3-25 cm) defined by reverse metamorphic grading; their protolith is recognized as graded greywacke-mudstone beds. The leucosome makes up 30 to 60% of the rock. It forms up to several centimetre thick veins and patches, and up to several metre thick pegmatitic sheets that are generally parallel to relict bedding. The veins are synkinematic and exhibit folds and boudins; some veins cut early-folded bedding and some pegmatite cuts early veins.

Diatexite, greywacke derived (2d)

A narrow southeasterly trending unit of diatexite, 0.5 to 5 km wide and about 12 km long, lies immediately south of Big Island on Kississing Lake. Unit 2d also occurs in the Adamson Lake dome in the south half of the map area. The diatexite is a nebulosic biotite granodiorite to tonalite with highly variable biotite concentrations and scattered inclusions of metatexite (2c). The biotite ranges from 5 to 12%, but 15 to 20% in wispy, irregularly distributed graphitic and variably garnetiferous schlieren. This rock type is characteristically medium- to coarse-grained.

The principal minerals of the diatexite are reddish brown biotite (5-20%), plagioclase (40-45%) and quartz (25-30%). Perthitic microcline megacrysts range from 0 to 15%. Muscovite is present as fine grains (1%) and chlorite is present in trace amounts. The rock has a mortar texture with fine grains of plagioclase, quartz, myrmekite, biotite, muscovite and trace chlorite curved around lenticular and elongate grains of feldspar and quartz. This fabric formed after peak metamorphic conditions. Muscovite crystallized in necking zones of extended feldspar grains, chlorite grew on biotite and myrmekite partly replaced plagioclase.

Muscovite-biotite gneiss, metagreywacke (2e)

A distinctive garnet-free, schistose variety of metagreywacke intruded by muscovite-bearing pegmatite and granite occurs in the southern part of the Kississing - Batty lakes area, in discontinuous east-trending units intercalated with units 2a and 2b over a strike length of 50 km and a width <2km. The principal outcrop areas are; (i) along the Kississing River, (ii) south of Dumbell Lake, and (iii) from South Nokomis Lake to Evans Lake. Contacts with 2a and 2b are gradational and there is a spatial association with abundant sills of leucogranite (10 and 10a).

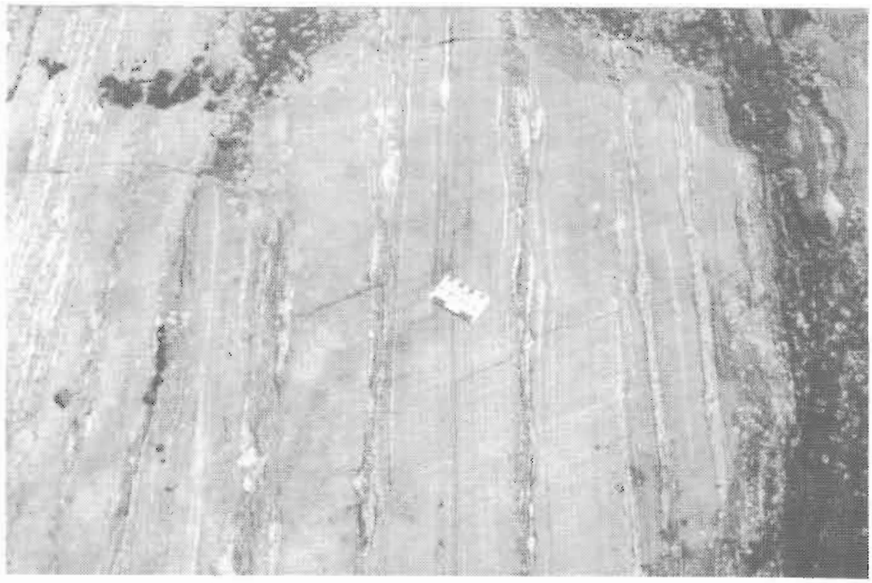


Fig. 5: *Burntwood Suite greywacke-derived migmatitic garnet-biotite gneiss (unit 2c), north of Craik Lake, showing leucosome as white lenses, and 4 to 20 cm layering (shades of grey) produced by variations in biotite-garnet contents.*

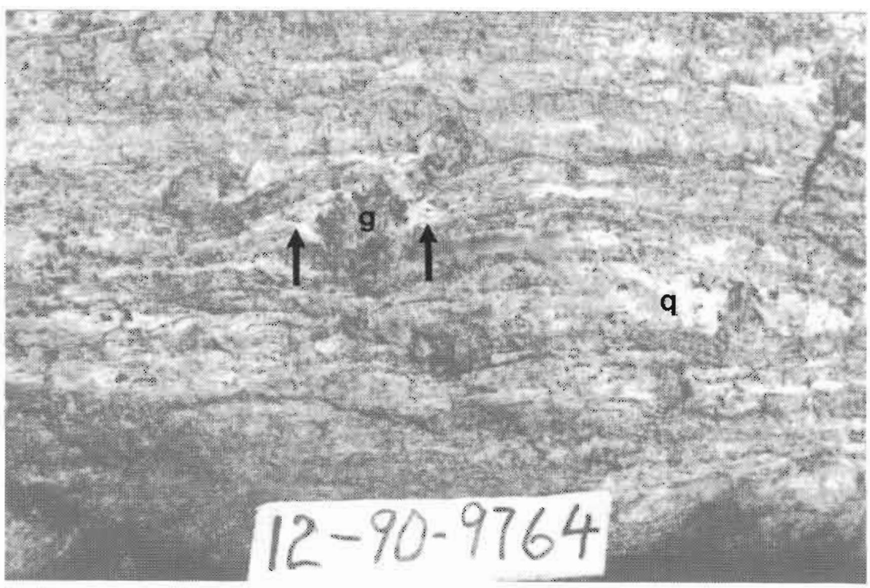


Fig. 6: *Garnet-biotite gneiss (unit 3h) with abundant quartz-rich mobilizate (q) and asymmetric quartz-plagioclase pressure shadows (arrows) on garnet porphyroblasts (g). Tape is 10 cm long.*

Unit 2e commonly contains <10% retrograde muscovite porphyroblasts and over 15% biotite. Muscovite overgrows strongly aligned biotite that has some nearly colourless margins. Veins of quartz-rich neosome were generally boudinaged during late-stage deformation. The mineralogy of this unit appears to be the result of potassium metasomatism caused by the associated intrusions.

Garnet-biotite gneiss ± staurolite-sillimanite (2f)

Well layered greywacke-mudstone derived gneiss that contains staurolite porphyroblasts and fibrolitic sillimanite occurs south of Duval Lake, north of the Kississing River in a west-trending belt that is up to 3 km wide and extends into Saskatchewan. Unit 2f is interlayered with and grades into 2a. Scattered occurrences of 2f composed of pelitic layers in 2a occur south of the Kississing River. The staurolite forms subhedral prismatic grains (<15%) <10 mm long . Many grains have a sieve texture of straight inclusion trails, commonly oblique to the groundmass schistosity that is partly curved around them. In the high-strain zone along the Kississing River staurolite has pressure shadows of quartz and plagioclase. The staurolite co-exists with 2 mm subhedral garnets (<20%) and generally with 5 mm bundles of fibrolitic sillimanite, present in minor amounts. The groundmass comprises 20 to 30% well aligned biotite and fine grained quartz and plagioclase with accessory graphite, tourmaline and sphene.

UNNAMED GNEISSES (Amisk Group, in Part)

Unnamed mafic and felsic gneisses outcrop up to 40 km north of the recognizable Amisk Group volcanic rocks but are probably high-grade metamorphic equivalents of the Amisk Group: they generally lie stratigraphically beneath the Burntwood Suite. They are distinguished from the Amisk Group by coarser grain size, better developed gneissic layering and absence of any primary structures or hint of a protolith on outcrop surfaces affected by growth of lichen and moss.

One assemblage of unnamed gneisses is dominated by amphibolite and outcrops in a belt that is *ca.* 1 km wide, extending from Batty Lake for 20 km southeast to the File River, south of Fairwind Lake. West of Batty Lake the outcrop area of unnamed gneisses is dominated by felsic rocks and widens to 10 km in the gently dipping core of a synform centred on Meat Lake. A 0.5 km wide arm of this belt extends along the northeast shore of Walton Lake and for 5 km farther west. Much of the felsic rock in the area west of Batty Lake was mapped as Sherridon Group by Robertson (1953), and resembles quartz-garnet gneiss (4b) or quartz-garnet-sillimaite-biotite gneiss (4i). However, it contains more biotite and sillimanite, and has therefor been excluded from the Sherridon Suite and mapped as unit 3h. Nevertheless, work in progress after the 1989 forest fire indicates that volcanic features are locally present and that much of the felsic rock indeed may be equivalent to the Sherridon Suite.

Medium grained amphibolites of unit 3 also occur as screens within foliated granitic bodies and as discontinuous, but locally thick, mantles around them. In particular, the Adamson Lake and Big Island domes have partial mantles of unit 3 amphibolite. Screens of unit 3 amphibolite are especially continuous and abundant in the Batty Lake dome, between Batty Lake and Tower Lake. Highly strained injection complexes of orthogneiss and partly digested amphibolite screens form *straight gneisses* in this area.

Other units of amphibolite occur between the Burntwood Suite and the Missi Group. The amphibolite, and locally an intercalated, intermediate gneiss (3d), have an uncertain age, but may compose the upper part of the Burntwood Suite because they generally underlie the Missi Group basal conglomerate. These units, and the large screens and partial mantles of amphibolite around granitic rocks, generally have a strike length in the order of 5 or 10 km and are *ca.* 250 m wide. At some localities, a few metres of unit 3 amphibolite occur within the Burntwood Suite metagreywacke.

Some of these rocks are metagabbro, others are highly recrystallized basalt and some are identified as silicate iron formation.

Undivided amphibolite (3)

Poorly exposed and little explored areas northwest and southeast of Fairwind Lake, underlain by mainly medium grained amphibolite, are mapped as unit 3 (undivided).

Diopside-bearing amphibolite (3a)

A belt of predominantly layered amphibolite that contains diopside (0-50%) and minor calcite, and calc-silicate gneiss extends 10 km from Batty Lake to Fairwind Lake where it is 300 m wide; other belts, 2 to 3 km long and *ca.* 200 m wide occur west of Batty Lake and around the Adamson Lake dome. Unit 3a is interlayered with 3b to 3e. Layers are 2 to 3 cm thick and weather pale grey-green and black on a ribbed surface. They comprise alternating plagioclase-diopside-rich layers and hornblende-rich layers. The rock is locally streaked with ochre carbonate segregations. Green- and pink-weathering calc-silicate layers contain abundant epidote; some varieties contain abundant scapolite, sphene and magnetite, or clino- and ortho-amphibole. Pyrrhotite, pyrite and traces of chalcopyrite occur locally. The unit was probably derived from carbonatized or epidotized basalt, as well as mafic volcaniclastic rocks.

A dark grey-green, massive to mottled variety of 3a is the major component in the amphibolite capping the Burntwood Suite paragneisses at Lobstick Narrows, Nokomis Lake and Evans Lake. It is exposed in belts <10 km long and up to several hundred metres wide. The massive rock is medium grained and contains acicular amphibole and a few per cent diopside with minor calcite. It was apparently derived from gabbro, but there is also altered basalt. The mottled rock is coarser grained and contains <50% diopside in metamorphosed alteration domains. The rocks typically lie in the footwall- and hanging wall-blocks of the intermediate mottled gneiss (3d) that contains the gold occurrences at Nokomis and Evans lakes.

Uniform amphibolite (3b)

Medium grained hornblende-plagioclase amphibolite is generally uniform, massive to foliated, and was derived largely from fine grained intrusions and flows. At Batty Lake it is locally interlayered with 3a on a scale of centimetres and metres. In some other areas it contains garnetiferous or diopside-bearing layers. In one variety, tabular amphibole (<8 mm) occurs in a medium- to fine-grained matrix. Thin veins of plagioclase-quartz, and local weak layering are secondary features.

Garnetiferous amphibolite (3c)

Garnetiferous amphibolite forms a major component in several belts of unit 3. The rock is characterized by 1 to 3 mm garnet porphyroblasts (generally 5 to 15%) in medium- to fine-grained hornblende and plagioclase. It weathers dark grey-green, is locally rusty, and is interlayered with 3a and 3b on a scale of millimetres and metres.

Up to 5 km long belts of 3c interlayered with 3a occur between Kississing Lake and Bartlett Lake. This amphibolite is characteristically fine- to medium-grained and has *lit par lit* layering. The *lits* are white plagioclase and quartz. Where present in the amphibolite in the vicinity of Kisseynew Lake, garnet has a white corona of plagioclase and quartz. Olive green lenses that contain diopside, plagioclase, hornblende and carbonate occur locally.

Farther east, between Walton and Fairwind lakes, less mobilized, weakly layered garnet-bearing amphibolite and massive varieties occur locally, generally associated with 3a and 3b.

A distinctive, rusty-weathering, commonly pyrite-magnetite-bearing variety of 3c occurs at Nokomis Lake and Evans Lake, where it forms a layer (<1 m) in the stratigraphic footwall of 3d. The rock has <30% garnet and accessory magnetite, sphene and apatite. A less pyritic variety, layered from a few millimetres to centimetres occurs at a similar stratigraphic position near Lobstick Narrows, Puffy Lake and Star Lake. Gruenerite is reported in these rocks (Norman, personal communication, 1992). They are interpreted to be silicate iron formation.

Intermediate gneiss (3d)

Cream- and grey-weathering intermediate gneiss occurs in the general vicinity of Batty Lake where it forms several 2.5 to 5 km long and <250 m wide belts. The rock is weakly layered and commonly interlayered with amphibolite. It contains abundant plagioclase with varying amounts of quartz and hornblende; calc-silicate minerals or garnet are locally present.

A grey mottled variety of intermediate to felsic gneiss that occurs at Nokomis Lake and Evans Lake is <10 m thick and has a strike length of 4 to 6 km. It contains hornblende, magnetite, calcite and garnet. The rock features stratiform pyrrhotite (generally <5%), pyrite, arsenopyrite and gold (in trace amounts and, at Nokomis Lake, in the order of 10 g/t). Some systematic variations of iron oxide, carbonate and sulphides among layers are consistent with a sedimentary origin for the rock, but patchy textures, the presence of albite and an amphibole-rich stockwork suggest that the variations in mineralogy are due to alteration.

Felsic gneiss, protoquartzite (3e)

A discontinuously exposed unit of felsic gneisses, interpreted to be derived from sedimentary and felsic volcanic rocks, extends from Walton Lake southeast to Fairwind Lake. The unit weathers white to brown, rarely pink, and is weakly layered. A very fine grained siliceous variety is most common. The plagioclase content is variable, biotite and potassium feldspar are low, and muscovite, garnet, pyrite, magnetite or graphite are minor.

The largest outcrop area of the unit is at Walton Lake where it is over 1 km wide. It has not been traced to its full extent because of poor access, but work in progress suggest that it can be traced into felsic volcanic rocks to the south. These include breccia and porphyry (Zwanzig, 1992). At Batty lake the rock forms belts, less than 100 m wide and *ca.* 1 km long. West of Fairwind Lake 3e is a medium grained protoquartzite.

Rusty biotite-plagioclase-quartz gneiss (3f)

This rock type is characterized by a high quartz content (<75%); the rest is plagioclase with 1 to 5% pyrrhotite and trace amounts of chalcopyrite disseminated in layers 1 to 5 cm thick. The rock occurs in discontinuous, 1 to 2 m thick layers intercalated with gneisses that contain; (i) sillimanite-cordierite-biotite-plagioclase-quartz, (ii) tourmaline-biotite-plagioclase-quartz, and (iii) carbonate. Rock types 2 and 3 contain <60% quartz.

This assemblage has very limited exposure, but it is significant because of its association with massive sulphide mineralization in the areas of Collins Point, the east side of Yakushavich Island, along the southeast side of Big Island, and at the Ideal showing 4 km to the south of the southeast corner of Big Island.

Garnet-hornblende-biotite-graphite gneiss (3g)

This variably rusty-weathering, graphitic gneiss has been identified at several localities in the north half of the Kississing Lake area, where it is persistently associated with sulphide mineralization. The unit forms angular, step-shaped outcrop ridges controlled by biotite parting planes spaced 20 cm to 2 m apart. The rock comprise fine grained quartz (15-25%) and plagioclase (55-65%), red almandine garnet (1-2%), biotite (10-15%), hornblende and/or cummingtonite (3-8%), graphite (<1%) and trace pyrite. This rock type is similar and may be equivalent to the garnet-biotite gneiss (4g), which outcrops in the central part of the Sherridon structure.

The unit is interlayered with 3f near Collins Point; it occurs as layers in 2b in a narrow zone that extends from the north side of Big Island east to Three Finger Lake. It also occurs in areas of sulphide-bearing amphibolites such as at the southeast end of Big Island and 4 km farther south at the Ideal showing.

Garnet-biotite±cordierite±sillimanite gneiss (3h)

A 4 by 12 km area north of Meat Lake, and a 0.5 by 8 km area northwest of Walton Lake are underlain by coarsely garnetiferous gneiss. The rock weathers grey to brown and locally contains abundant, discontinuous quartz veins. Garnet porphyroblasts, which are generally <10 mm in diameter (locally < 30 mm), constitute 10 to 20% of the rock. The average biotite content is 15% (locally < 30%). In numerous places the rock contains cordierite and fibrous sillimanite, locally with hercynite and rarely anthophyllite. The remaining minerals are fine- to medium-grained quartz and plagioclase. Crystals of clear blue cordierite occur locally, but in many places the mineral is altered and milky grey. Quartz rims and pressure shadows surround the large garnets, and quartz occurs as abundant inclusion within them. Magnetite or pyrite occur locally and graphite was observed at one locality. Gossan layers, 10 cm to 2 m thick are widely scattered throughout the unit.

The unit was deformed into a highly planar tectonite, and subsequently folded such that a protolith generally cannot be recognized. Biotite is commonly concentrated in trails that are curved around large porphyroblasts. Quartz veins are boudinaged and garnet has asymmetric quartz-plagioclase pressure shadows (Fig. 6). Widespread late-stage deformation has led to partial retrogression of biotite-garnet-cordierite-plagioclase to assemblages with white mica and chlorite.

Unit 3h was mapped as part of the Sherridon Group by Robertson (1953) and may be a premetamorphic alteration product of Fe-Mg metasomatism (possibly with a volcanic and intrusive protolith). Several occurrences of anthophyllite-cordierite (*eg.* northwest of Walton Lake) support this interpretation. However, unlike the Sherridon gneisses, in numerous places the unit contains more biotite, more sillimanite and generally less amphibole. It is locally well layered at *ca.* 20 cm in a variety interpreted to be metapelite and probably associated with the Burntwood Suite, but more work is in progress to assign an origin and a stratigraphic position to 3h.

SHERRIDON SUITE

The Sherridon Suite (Sherridon Group of Bateman and Harrison, 1946; Robertson, 1953) comprises coarse grained "siliceous, pelitic and calc-silicate gneisses interlayered with amphibolite" that outcrop in the Sherridon - Star Lake area (Froese and Goetz, 1981). Large areas previously mapped as Sherridon Group farther east have been re-assigned to other units, but narrow belts of highly garnetiferous and anthophyllite-bearing rocks at the margin of the gneissic granitic bodies, and in other felsic gneisses, are included with the Sherridon Suite in this report. Structural analysis (below) indicates that the Sherridon Suite is not a simple stratigraphic sequence: it is interpreted to be a tectonic assemblage that has both supracrustal and plutonic components. In many places the Sherridon Suite contains coarse grained ferromagnesian porphyroblasts, suggesting that these rocks have been exposed to premetamorphic hydrothermal alteration. Generally the rocks lack primary structures and origin is uncertain (Zwanzig and Lenton, 1987). They were considered to be metasedimentary rocks by Bateman and Harrison (1946), Robertson (1953) and Froese and Goetz (1981). However, Ashton and Froese (1988) suggested that the Sherridon Suite may be metavolcanic rocks equivalent to the Amisk Group. This interpretation is preferred here, but a significant proportion of the gneisses is probably of intrusive origin.

The gneisses in the Sherridon - Star Lake area were not remapped in detail. Their subdivision by Froese and Goetz (1981) is summarized in an appendix. Reconnaissance traverses south of Jungle Lake indicate that the main unit of quartz-rich gneiss has a variable content of mafic minerals that define large and small domains that originated from premetamorphic Fe-Mg alteration. Those rocks with a higher colour index generally contain large conspicuous garnet porphyroblasts, and can be separated as a (4b); they have not been mapped in detail. Cordierite-anthophyllite-bearing alteration rocks were mapped as 4f. The wide distribution of these units and their association with massive sulphide mineralization are evidence that the Sherridon Suite has undergone extensive hydrothermal alteration.

Quartz-rich gneiss (4a)

Unit 4a constitutes over 50% of the Sherridon Suite in the 4 by 15 km structure in the Sherridon - Star Lake area. Typical quartz-rich gneiss, as examined southwest of Star Lake, forms uniform light grey-weathering outcrops. On average it contains 45% plagioclase, 40% quartz and 15% mafic and accessory minerals. Quartz forms irregularly shaped or flattened polycrystalline lenses up to 20 mm long. Locally quartz has been mobilized into discontinuous ribs with plagioclase-rich margins to form a coarse gneissosity. Potassium feldspar is present only in some varieties of 4a. Mafic minerals occur in irregularly shaped aggregates up to 10 mm long. They comprise biotite and dark green and pale amphibole that are partly altered to chlorite, calcite and muscovite. Biotite aggregates are generally elongate and wispy. Where present, garnet occurs as porphyroblasts (<15 mm) and is sieve textured, skeletal or cut by quartz-filled tension gashes. Apatite, sphene and magnetite are common and sillimanite is rare.

The nature of the protolith of unit 4a is uncertain: layering of segregated quartz and plagioclase appears to be the result of ductile strain and high-temperature recrystallization that has obliterated primary textures. Coarse patches with a massive interlocking texture may be migmatitic neosome. Some textures are tentatively interpreted to be a remnant from originally coarse- to medium-grained intrusive rocks. Varieties of 4a with a low colour index and a fine grained granoblastic texture may be felsic volcanic rocks. One layer, south of Jungle Lake, has quartz eyes that are similar to phenocrysts in metarhyolite. Poorly defined quartz eyes elsewhere may be constituents of high-level intrusive rocks. The presence of garnet in these rocks can be attributed to premetamorphic Mg-Fe metasomatism with removal of alkalis, also a characteristic of 4b. The variable but generally high quartz content (27-60%) may be a result of silicification.

Quartz-garnet gneiss (4b)

Garnet-rich varieties of the quartz-rich gneiss occur as metre long lenses and layers up to several kilometres long within the Sherridon structure, and at the margin of the Batty Lake complex. The rocks grade into units 4a, 4c and 6a, and are interpreted to be products of Fe-Mg metasomatism. In several places 4b contains well defined Mg-rich alteration rocks with cordierite ± anthophyllite, or it grades into 4f. The centre of some domains contains scattered iron sulphide and is more mafic than the margin. Locally these domains are discordant to the regional foliation.

Unit 4b contains <20% mafic minerals; 5 to 30% of these are garnet porphyroblasts, which have an irregular size and distribution; locally they are <30 mm (Fig. 7). Amphibole occurs generally as dark green stubby grains that are probably hornblende, and rarely as pale acicular grains of tremolite-actinolite or anthophyllite. The light coloured minerals comprise quartz and lesser plagioclase, much of which is uniformly distributed, but in some areas these minerals are concentrated in patches or gneissic laminae.

Amphibolite and intermediate gneiss (4c)

Amphibolite forms several continuous layers between Sherridon and Park Lake where it has been mapped and described by Froese and Goetz (1981). Unit 4c is similar to 3a and 3b, but it is distinguished from these units because it is interlayered with 4a and 4b. An intermediate variety of 4c (not shown separately on the map) was interpreted to be fragmental volcanic rock (Froese and Goetz, 1981). The presence of calcite, cummingtonite and anthophyllite reported by these authors suggests carbonate and Fe-Mg metasomatic alteration that predated the regional metamorphism.

Calc-silicate rock (4d)

Layers of calc-silicate rock with a thickness of tens of centimetres to metres are especially prominent on the contact of the Sherridon Suite with 6b. The rock has a variable mineral content (Froese and Goetz, 1981); an assemblage at Star Lake contains plagioclase-microcline-quartz-calcite-scapolite-biotite-sphene-apatite and abundant diopside (replacing amphibole). Adjacent rocks are rich in epidote.

Calcareous gneiss and marble (4e)

Impure marble, which surrounds the core of the Sherridon structure is "mineralogically similar to calc-silicate rocks" (4d in this report), "except that it has a higher content of calcite" (Froese and Goetz, 1981). The presence of chrome-bearing grossularite in this unit argues against a metamorphic origin from impure limestone as suggested by Robertson (1953). "Calc-silicate rock and impure marble...could readily be interpreted as products of carbonatization of volcanic rocks" (Ashton and Froese, 1988).

Cordierite-anthophyllite rock (4f)

Coarse grained rocks, generally with garnet-cordierite-anthophyllite ± sillimanite, occur as discontinuous layers 1 to 20 m thick in 4a and 4b, locally in unit 3, and adjacent to 6a. Textures range from massive porphyroblastic, in a 20 m layer at Star Lake, to highly schistose in thinner metre layers associated with high ductile strain and faulting at Limestone Point Lake. The rocks have been interpreted as hydrothermal alteration products of a variety of rock types (Froese and Goetz, 1981;

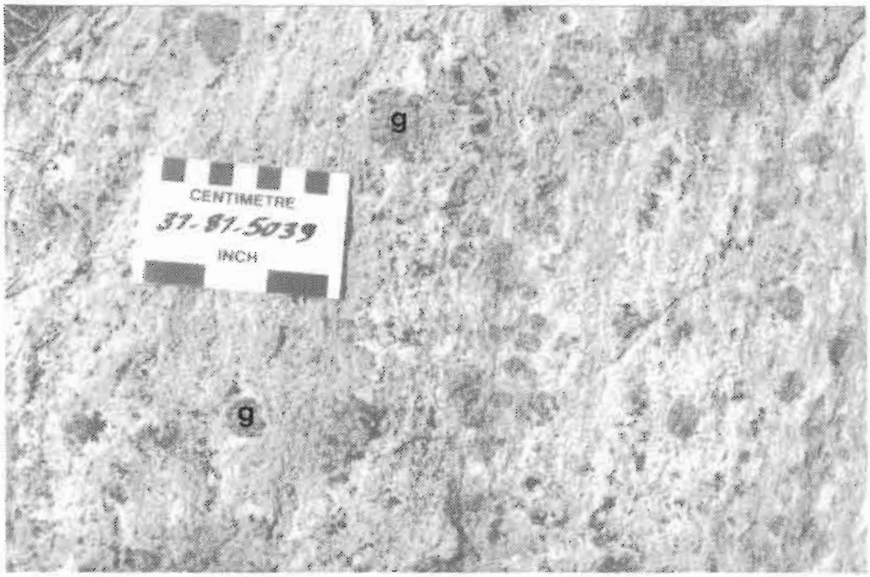


Fig. 7: *Quartz-rich garnet gneiss of the Sherridon Suite (unit 4b, protolith uncertain), showing affects of hydrothermal alteration as abundant garnet porphyroblasts (g), Batty Lake.*

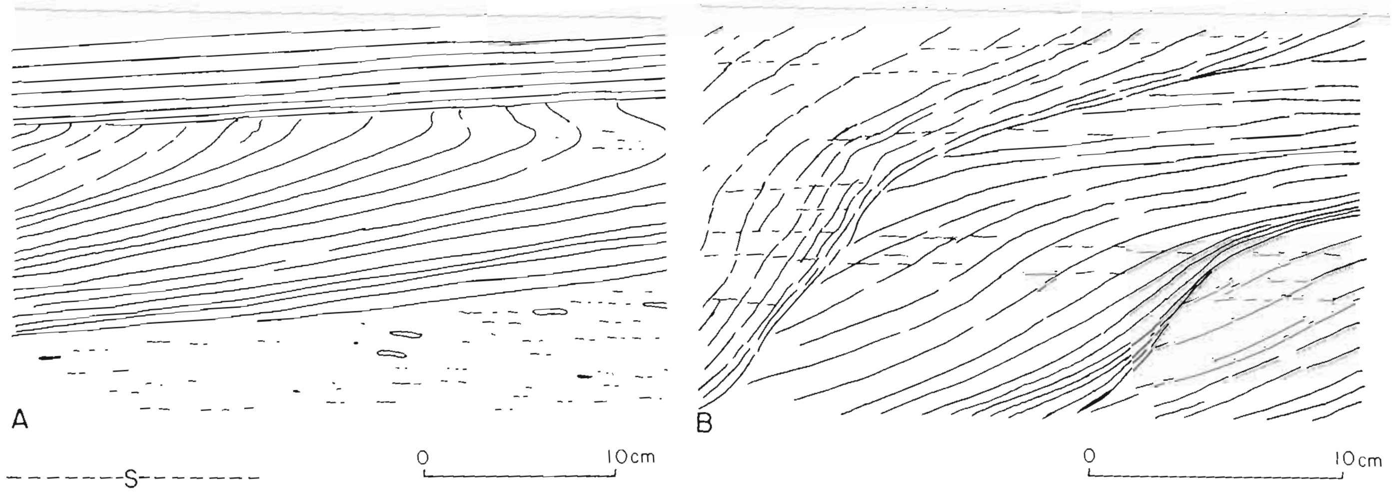


Fig. 8: *Deformed crossbedding in the Missi Group (5b), Lobstick Narrows area, as it appears in **A.** the limb of a major fold where bottom sets are subparallel to schistosity (S); **B.** the hinge area where foresets are closer to S.*

Zwanzig and Lenton, 1987; Leroux, 1989). They are associated with sulphide-bearing gossan layers and with Cu-Zn massive sulphide deposits near Sherridon.

Garnet-biotite gneiss (4g)

Much of the core of the Sherridon structure is composed of uniform grey garnet-biotite gneiss with small amounts of hornblende. The unit is described by Froese and Goetz (1981) who interpreted it as a metasedimentary rock. Froese indicates (written communication, 1992) that these rocks are graphitic and equivalent to the Burntwood Suite. Further study is warranted.

Massive amphibolite (4h)

Fine- to medium-grained massive amphibolite is indistinguishable from unit 3b but is confined to the Sherridon Suite, forming mappable layers within 4a, 4b and 4d. Its uniform composition suggests an igneous protolith.

Quartz-rich garnet-sillimanite-biotite±cordierite gneiss (4i)

This rusty-weathering quartz-rich rock was examined along the east shore of Singsing Lake about 8 km north of Sherridon. The unit was mapped as a pelitic schist (unit 4, Froese and Goetz, 1981) and is interpreted to lie along a lithologic zone with sulphide deposits. Unit 4i is a coarse grained gneiss composed of layers of a dark grey siliceous rock that contains quartz (60%), biotite (12%), 2 to 3 mm garnet (8%), 4 mm long bundles of sillimanite (10%), cordierite (5%), plagioclase (5%), disseminated pyrite and graphite. Other layers are rusty- to white-weathering siliceous granitoid rock that contains quartz (60%) with a mixture of sericite and chlorite after plagioclase (10%), sillimanite (8%), biotite (8%), chlorite after cordierite (7%), and pyrite (1%). The biotite appears pinkish brown in hand sample and in thin section (plane polarized light).

Rather than representing a pelitic sedimentary unit as suggested by Froese and Goetz (1981) 4i may have originated as alteration.

MISSI GROUP

An assemblage of predominantly quartzofeldspathic gneisses (Missi Group in this report) outcrops on the south flank of the Kisseynew belt. This assemblage typically comprises magnetite-bearing quartz-feldspar-biotite±hornblende gneisses derived from sandstone, and mesocratic gneisses, amphibolite and felsic gneiss derived from sedimentary and volcanic rocks. Much of the Kississing Lake area is underlain by these rocks, and they occur in the Batty Lake map sheet in five overturned synclines that form belts of quartzofeldspathic gneiss up to 50 km long and 250 to 1000 m wide.

The main belts of quartzofeldspathic gneisses were previously mapped as the Sherridon Group (Robertson, 1953; Kornik, 1968). This terminology was retained in the early stages of our mapping (Zwanzig, 1984). However, the gneisses are clearly distinguishable from the coarser grained, less magnetiferous and generally garnet-bearing gneisses at Sherridon, such that they were called Missi Metamorphic Suite as a working term (Schledewitz, 1987; Zwanzig and Lenton, 1987). Our completed mapping has shown that these gneisses are equivalent to the low-grade metasandstones and conglomerate of the Missi Group, which unconformably overlie the Amisk Group in the Flin Flon metavolcanic belt. This equivalency is supported by cross bedded and pebbly layers preserved locally in the high-grade rocks, features that are typical of the Missi Group, which has been interpreted to be an alluvial deposit (Mukherjee, 1974; Bailes and Syme, 1989). The equivalency is also supported by about 150 km of discontinuous exposure of the basal unconformity in the Kississing - Batty lakes area, commonly with a conglomerate unit overlying high-grade Amisk Group rocks and intrusions into the Amisk Group. Moreover, the assemblage of quartzofeldspathic gneisses (high-grade Missi Group) is intercalated with amphibolite and fine grained felsic rocks that are high-grade equivalents of Missi Group metabasalt, meta-andesite and metarhyolite, exposed at Wekusko Lake (Gordon and Gall, 1982; Gordon and Lemkow, 1987). The equivalency between the gneisses and the low-grade Missi Group was also established by Bailes (1980b, 1985) and Ashton and Wheatley (1986) for the File Lake, Saw Lake and Kisseynew - Wildnest areas in Manitoba and

Saskatchewan.

The major unconformity at the base of the Missi Group described in the Flin Flon belt (Bailes and Syme, 1989) is now also documented in the Kisseynew belt. In different parts of the Kississing - Batty lakes area, a basal conglomerate is in contact with Amisk Group rocks, the Burntwood Suite, amphibolite of uncertain age and various types of granitic rocks. Previously, a structural contact relationship could not be ruled out because the basal contact is locally sheared or structurally inverted (Zwanzig, 1984, 1988). Recently, pre-Missi U-Pb zircon ages of granitic gneisses near Puffy Lake Mine firmly established the unconformity at the base of the Missi Group (Hunt and Zwanzig, 1990). An angular unconformity occurs in sequence 1, on the volcanic-arc assemblage. For example, east of the Puffy Lake Mine and southwest of Evans Lake the unconformity cuts across intrusive contacts between pre-Missi granitic rocks and the Amisk Group. North of Spider Lake the basal conglomerate overlies Amisk Group amphibolite with <30% garnet at the contact. This unusual rock is interpreted to be a metaregolith. However, there is only a low-angle unconformity on the basin-margin assemblage (in sequence 2). On the other hand, the Burntwood and Missi gneisses are structurally concordant, conglomerate is absent and there is no indication of an unconformity or a fault on the turbidite-basin assemblage (in sequence 3). A conformable stratigraphic relationship has not been established with any certainty (Table 2).

A coherent stratigraphic succession has been delineated in the Missi Group in the Kisseynew belt only locally along the south margin of the Kississing - Batty lakes area. This succession starts with a thin unit of amphibole-bearing metaconglomerate (5h) at the base. The conglomerate becomes more felsic upward and grades into quartzofeldspathic metasandstone (5b) that locally contains meta-arkose (5c), felsic volcanic gneiss (5e) and amphibolite (5g). In some areas 5b grades upwards into hornblende gneiss (5a) representing more mafic metasedimentary rock. Elsewhere stratigraphic details and relationships are less certain but detailed mapping in the Lobstick Narrows - Cleunion Lake area by Norman (personal communication, 1992) indicates a distinctive local succession. On a regional scale stratigraphic details in the Missi Group vary between adjacent major folds. Fine grained quartzofeldspathic biotite gneiss (5b) is abundant in the northeast, and hornblendic gneiss (5a) is locally abundant on Kississing Lake. Metavolcanic rocks (parts of 5e and 5g), and metaconglomerates (5f and 5h), become increasingly important components in successive synclines towards the south, and are rare in the north; these variations are interpreted to be lateral sedimentary and volcanic facies changes.

Quartz-feldspar-hornblende-biotite gneiss (5a)

In the Kississing Lake area this mesocratic rock is variably layered from 1 cm to more than 1 m. Hornblende content characteristically increases as quartz and biotite contents decrease. Hornblende-microcline granite locally occurs as sills and *lits*. The unit is generally interlayered with more quartz-rich units (5b and 5c) or a calc-silicate-bearing varicoloured quartzofeldspathic unit (5d). Unit 5a is discontinuous and the terminations appear to be irregular in shape. This structure may be the result of deformation and/or sedimentary facies changes.

Based on thin-section and stained-slab examination, unit 5a contains hornblende (10-25%), biotite (5-15%), quartz (20-25%) and plagioclase (35-65%). In areas with a more granitic appearance, microcline, epidote and sphene are major constituents, and biotite is either absent or present as ragged and embayed flakes intergrown with epidote. The hornblende in these areas is generally bright green and can be highly poikiloblastic. Thin-section observations suggest biotite and plagioclase are an unstable mineral assemblage and react to form epidote, microcline and hornblende with varied amounts of sphene and calcium carbonate.

East of Cleunion Lake 5a is weakly layered, dark grey, brown or green, fine grained and possibly derived from mudstone. More typical medium grained gneiss with 5 mm long hornblende porphyroblasts is a minor unit in this area. Locally at Puffy Lake and Nokomis Lake fine grained unit 5a gradationally overlies 5b, in some places grading upward into amphibolite (5g).

Unit 5a also contains quartz diorite to gabbro sills (7), and mafic to intermediate gneiss interpreted as volcanic rocks (5g). From the east side of Big Island on Kississing Lake westward to an area north of Collins Point, 5a is in contact with mesocratic gneiss (7a), which is generally distinguishable by its lower quartz content and higher hornblende content. However, growth of epidote and microcline in 7a locally produces a mineral content similar to 5a. Poor exposure and the presence of granitic rocks obscure the contact relationship between 5a and 7a.

Quartz-rich paragneiss (5b)

Grey and pale pink quartzofeldspathic gneisses that are derived from lithic or arkosic sandstones predominate in the Missi Group. Their appearance varies from one area to another. North of Kisseynew Lake and northeast to Thunderhill Lake the rocks weather pale grey and are medium- to coarse-grained; some are massive, but others are characterized by biotite laminae that are presumably derived from bedding-plane partings. Small, widely scattered pebbles and rare beds of conglomerate are locally present. In the logged area between Lobstick Narrows and the Kississing River, crossbedding is locally preserved; it appears to be tabular crossbedding, but is generally deformed (Fig. 8). The set height is <80 cm (possibly 250 cm undeformed).

The grey gneiss north of Kisseynew Lake contains a high proportion of quartz, a smaller amount of plagioclase, less than 15% biotite, and minor magnetite. Either muscovite or epidote and calcite are generally present. Epidote is abundant in pale green lenses and in rare layers of calc-silicate rock that is interpreted to represent layers with carbonate cement. Small porphyroblasts of potassium feldspar, garnet or quartz-sillimanite knots *(faserkiesel)* occur locally.

In the area from 1.5 km north of Weldon Bay to Deep South Bay, 5b is commonly medium- to fine-grained and interlayered with 5c and 5d. This variety of sandstone derived gneiss weathers grey to pale pink. It contains similar amounts of quartz and plagioclase; potassium feldspar and magnetite or specular hematite are generally present. Some layers contain calcite, epidote and locally green amphibole; other layers contain small late-metamorphic muscovite porphyroblasts. At the northeast end of Piat Lake, 5b contains <30% quartz-sillimanite knots (faserkiesel) where it is interlayered with conglomerate (5f).

In the north half of the project area 5b generally comprises grey-weathering paleosome and pink-weathering granitic *lits*. In numerous places the metasandstone paleosome is well layered, light and dark grey, with increased biotite contents that define relict bedding and selvages on veins (Fig. 9). Green hornblende (<15%) is unevenly distributed at local and regional scales. In the northeast part of the map area, the unit is buff, and contains <20% biotite. Magnetite is abundant in certain layers interpreted to be beds with a high concentration of heavy minerals, disseminated or in placers.

The leucosome occurs mainly in well defined, several centimetres thick, leucogranitic veins, parallel to layering. Veins have a granitic or pegmatitic texture; they are generally boudinaged or folded. In many places at Kississing Lake the leucosome contains 2 to 3% poikiloblastic hornblende and low percentages of biotite.

Meta-arkose (5c)

Pale grey to pink and buff-weathering quartz-rich gneiss occurs as interbeds in 5b and as thin units that locally grade into felsic gneiss (5e). The rock contains less than 10% biotite, generally with potassium feldspar and magnetite. Variable amounts of muscovite and hematite occur along the south margin of the Kississing - Batty lakes area. In the vicinity of Cleunion Lake the rock is generally fine grained and has thin, faint layering. Near Puffy Lake it is medium- to coarse-grained and schistose; this variety of rock shows more distinct signs of anatexis farther to the south than do all other rocks. The neosome comprises patches, veins and sheets of pink pegmatitic granite.

Varicoloured paragneiss (5d)

Quartz-rich beds like those in units 5b and 5c form a component of interlayered pink, grey and green-weathering gneiss that contains, in addition, hornblende and/or epidote in green layers and abundant biotite in dark gray layers. The varicoloured unit was apparently derived from a rhythmic succession of fine grained sandstone with carbonate-bearing beds and argillaceous siltstone. Fine grained grey hornblende-biotite gneiss with conspicuous green calc-silicate interlayers occurs north of Cleunion Lake. Transitions, interpreted as sedimentary facies changes, occur between 5b, 5c and 5d.

Fig. 9: Strongly layered and folded Missi Group (5b) with relict bedding (dark layers across the centre) and selvages on the granitic veins (dark margins on lighter vein, eg. arrow). Tape is 10 cm.

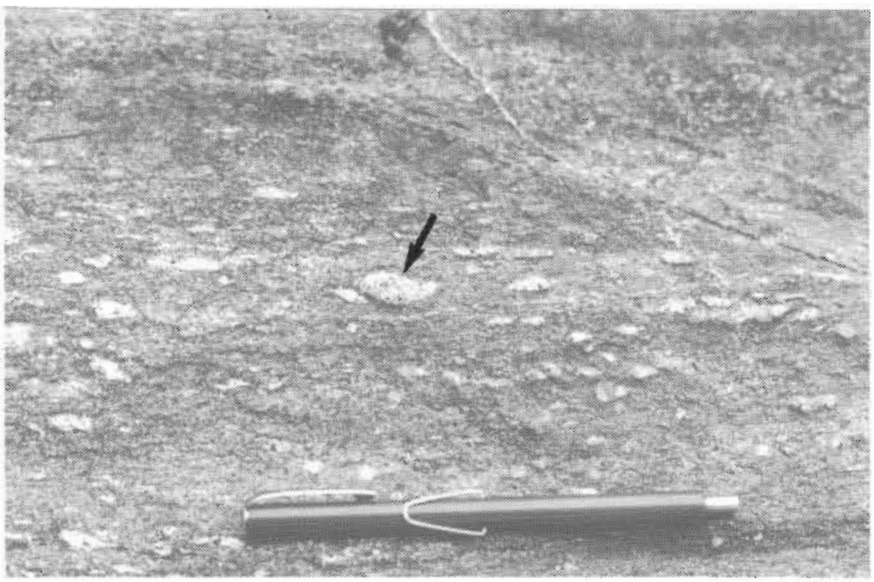


Fig. 10: Amygdaloidal zone in deformed basaltic flow (5g), Missi Group, Evans Lake. Largest amygdales (arrow) are 2 cm long.

Pink felsic gneiss, felsic volcanic rocks (5e)

Pink felsic gneiss occur in the southwest part of the Kississing - Batty lakes area in bodies generally <5 km long and hundreds of metres wide; a body at Lobstick Narrows is over 15 km long. Thin units of this gneiss extend east to Puffy Lake. Similar rocks occur locally farther east and north of Limestone Creek.

Unit 5e weathers pink and is brick red to buff on the fresh surface. It has a positive signature on aeromagnetic maps (references are given in the introduction). It has a uniform leucogranitic composition, but varies somewhat in structure and texture. A fragmental structure is very locally preserved and there are scattered relicts of small quartz and feldspar phenocrysts (*ca.* 1 mm), but generally faint layering is the only structure that may be interpreted to be primary. Part of the unit is very fine grained (0.1 to 0.3 mm in the south). A groundmass of granoblastic quartz, microcline and altered plagioclase is locally overgrown with 1 mm porphyroblasts of muscovite. Granitic leucosome is present in some areas. Thin, nearly white-weathering laminae and lenses are commonly recrystallized to 1 to 2 mm grains of mainly quartz and plagioclase alternating with layers that contain microcline. Magnetite porphyroblasts, traces of biotite, epidote, tourmaline, hematite and apatite are present. Traces amounts of fluorite have been identified in one locality and are probably present in others. Trace amounts of fine grained red garnet are locally present.

The structure, texture and uniform mineral content of unit 5e provides information about its protoliths. The unit is interpreted to have been derived from igneous rocks: rhyolite, felsic tuff, reworked tuff and probably subvolcanic intrusions. Thin quartz lenses, which occur south of the Cleunion Lake, for example, may be attenuated metamorphic relicts of silicified pumice fragments. These and the relicts of fragmental structure and porphyritic texture in a very fine grained groundmass suggest an overwhelmingly volcanic origin. Some rocks in 5e are associated with heterolithologic felsic breccia, conglomerate and pink to buff-weathering metasedimentary rocks (5h, 5b and 5c). The best preserved section containing 5e northeast of Lobstick Narrows also contains rhyolite-rich conglomerate (5f) and crossbedded meta-arkose. These relationships are consistent with an interpretation that one or more subaerial felsic volcanic centres surrounded by reworked pyroclastic detritus existed in an alluvial environment of deposition in the vicinity of Cleunion or Thunderhill lakes.

Unit 5e is tentatively correlated with volcanic rocks in the Missi Group at Wekusko Lake (Chickadee Lake rhyolite of Gordon and Lemkow, 1987) and pink granoblastic (volcanic derived) gneiss, unit 26a of Bailes (1980b) at File Lake. A U-Pb zircon age of 1826 +11/-4 from Piat Lake is consistent with the age of Chickadee Lake rhyolite (Hunt and Schledewitz, 1992).

Metaconglomerate and metasandstone (5f)

Metaconglomerate with a felsic matrix and abundant quartz or felsic clasts, generally interlayered with quartz-rich gneiss (metasandstone), occur along the southwest margin of the Kississing - Batty lakes area. The rocks occur in lenses, several centimetres to several hundred metres thick and <5 km long, that occupy various stratigraphic levels within the Missi Group in association with units 5b, 5c and 5e. They are interpreted to be part of a proximal clastic facies association that provides data about provenance and depositional environment of the Missi Group in the Kisseynew belt.

Individual lenses contain different proportions of conglomerate and have clasts with variable compositions. Northwest of Lobstick Narrows a 300 m thick (deformed) section of crossbedded, locally pebbly metasandstone contains subordinate intercalations of clast-supported metaconglomerate. The conglomerate beds (on average 30 cm thick, deformed) appear to be tabular. The clasts are poorly sorted; cobbles (<15 cm) are rounded, whereas pebbles are rounded to angular, a feature found in streams with high gradients or in flash floods. The clasts comprise fine grained metasedimentary rocks, felsic volcanic rocks and quartz, and lesser amphibolite, iron formation and granodiorite.

Northeast of Lobstick Narrows almost 200 m of boulder conglomerate underlie a mixed sedimentary and volcanic section of the Missi Group. The clasts are highly deformed, but their angularity and lack of sorting is locally recognizable. They consist almost entirely of rhyolite or possibly, very fine grained granite.

In the vicinity of Cleunion Lake lenses of metaconglomerate are associated with felsic gneiss (metarhyolite, 5e) and, in one locality, grade into fragmental rhyolite (5e). The matrix and local interbeds comprise grey, pink and green metasandstone, possible metatuff and minor calc-silicate rock. Clasts are flattened; some are folded and many are nearly obliterated to form a patchy textured gneiss. Recognizable clasts are commonly 1 to 2 cm long, or are unsorted and range from granules to cobbles; most are angular. The clasts comprise fine grained pink to buff felsic gneiss (metarhyolite) and accessory vein-quartz, muscovite schist and metasandstone. Cobbles of feldspar porphyry are locally abundant south of Cleunion Lake. Northeast of the lake an epidote-bearing conglomerate contains abundant quartz pebbles.

In the vicinity of Piat Lake lenses of conglomerate are interlayered with a variety of 5b rich in faserkiesel, and a variety of 5b derived from pebbly metasandstone. The conglomerate is predominantly clast supported; the clasts are flattened and folded. Clast types comprise very fine grained granular quartz with dull grey massive hematite , vein quartz, fine grained cream granite and muscovite schist. The conglomerate matrix and metasandstone interbeds locally contain epidote-rich lenses, which lie oblique to the foliation and may represent segments of a primary layering.

Conglomerate occurs as inclusions in granodiorite (9) at three localities along the southwest shore of Gwillam Lake, and is exceptionally well preserved at one of these places. The conglomerate contains clasts (1-20 cm) of amphibolite and metadiorite, as well as the clast types observed at Piat Lake.

Near Puffy Lake interbeds of felsic metaconglomerate and scattered pebbles occur in quartz-rich buff gneiss (5c, meta-arkose), at the top of the basal conglomerate and in 5b (metasandstone). The clasts include pink and buff fine grained felsic gneiss and rare calc-silicate rock, but quartz pebbles are locally most abundant.

Only two small occurrences of conglomerate were recognized in the gneissic to migmatitic rocks mapped as part of the Missi Group in the Kississing Lake area. These are in the high strain zone that extends from Big Island to Bess Lake. At the southeast end of Big Island and immediately west of Bess Lake, there are thin discontinuous lenses that contain 20 to 30% highly flattened clasts of vein quartz, very fine grained magnetite-bearing quartz, scattered metadiorite and aplite clasts. The conglomerate lenses are interlayered with the biotite- and hornblende-bearing Missi Group quartzofeldspathic rocks (5b and 5a). The apparent absence of conglomerate elsewhere in the vicinity may indicate a primary sedimentary facies change (northward fining over the region) or, alternately that high strain and metamorphism have masked their presence.

These conglomerate lenses provide information about the provenance and depositional environment of the Missi Group in the Kisseynew belt. They suggest a provenance from an orogenic hinterland in which predominantly felsic volcanic, and sedimentary and fine grained granitic intrusive rocks were exposed. Part of the source terrain was similar to 5e, possibly eroded during active continental volcanism. The association of rounded cobbles and angular pebbles is typical for high-energy fluvial/alluvial environments.

Amphibolite, volcanic and intrusive rocks (5g)

Units of amphibolite that occur in the Missi Group have been identified from Lobstick Narrows east to Dow Lake, and north to Walton Lake. These rocks have diverse textures and mineral proportions. Fine grained amphibolite with subequal amounts of hornblende and plagioclase with accessory magnetite are most common. A coarsely plagioclase-phyric variety is also widespread over the Kississing - Batty lakes area. Quarzt-biotite-bearing amphibolite occurs locally and grades into unit 5a. These amphibolites are distinguished from the amphibolites of units 1, 3 and 4 by (i) the common presence of magnetite, (ii) absence of garnet, (iii) local abundance of amygdales (<30%), at some localities over 10 mm long, (vi) their common occurrence in thin layers (20 cm to 3 m) within the Missi Group metasedimentary rocks (and clearly part of that group), and (v) the continuity of these layers over several kilometers.

The origin of many of these rocks is uncertain. Fine grained uniform amphibolite is interpreted to be metabasalt; units with highly amygdaloidal zones are interpreted to be derived from subaerially erupted flows. Mafic to intermediate metaporphyries probably include flows, tuffs and dykes. Fine grained hornblende-biotite-rich paragneiss (5a) is spatially associated with amphibolites of 5g. This type of metasedimentary rock may be tuffaceous or eroded from the mafic volcanic rocks.

Moderately well preserved mafic flows are common throughout the area. They are well exposed on the north tip of the island in Evans Lake where one finely porphyritic flow is 150 cm thick; others are only 20 cm because of thinning during deformation. Epidosite marks the flow contacts and zoned, feldspar-filled amygdales characterize the upper third of the flows; quartz amygdales make up 30% of the flow top (Fig. 10). Amygdale abundance and size (<20 mm), and a general lack of pillow structure are consistent with subaerial deposition.

The porphyritic varieties generally form thin layers interbedded with metasandstones (5a and 5b). Some contacts are gradational and suggest local reworking of tuffs. Other porphyritic layers are amygdaloidal and are interpreted as flows. Phenocrysts consist of plagioclase grains (<20 mm), commonly replaced by mineral aggregates, and hornblende replacing mafic grains. The plagioclase-phyric variety is most common and acts as a widespread marker unit that identifies 5g. One variety has plagioclase glommerocrysts (20 mm), locally with swallow-tail morphology. Similar rocks occur in the Missi Group at Wekusko Lake, on the east end of the Flin Flon belt (Gordon, pers. com.)

A thick layer (<300 m) of highly deformed amphibolite, interpreted as mafic volcanic rocks and gabbro, occurs along the Kississing River. It is mostly fault bounded but locally contains interlayered Missi Group metasandstones (5a and 5b) at the margins. These rocks are generally porphyritic. Layering represented by abrupt variations in phenocryst contents, a fine grained matrix and fine grained aphyric interlayers suggest an extrusive origin.

Basal metaconglomerate, ribbon gneiss (5h)

A unit of metaconglomerate occurs at the unconformable base of the Missi Group along the south flank of the Kisseynew belt. It is exposed discontinuously from Lobstick Narrows for 50 km east to Martell Lake and is locally well preserved as far north as Jungle Lake. Ribbon gneiss derived from the conglomerate extends north along the east shore of Nokomis Lake. The unit is generally 3 to 10 m thick (at least 10 to 40 m prior to deformation); locally it is 20 m thick.

The conglomerate has a dark green or grey amphibole-bearing groundmass that is compositionally graded from intermediate, at the base of the unit, to felsic at the top. The groundmass is interpreted to represent clasts that were obliterated during recrystallization and an originally fine grained matrix.

Clasts are well preserved only locally (Fig. 11). Generally they are highly flattened and elongated, folded or obscured by recrystallization. At South Nokomis Lake dimension ratios attributed to deformation of the clasts are about 1:4:16. Farther north, 5h is a banded black, pink and grey gneiss in which most clasts have been reduced to a thickness of 2 or 3 mm and may be over a metre long. Where they are least deformed, clasts are angular to well rounded and <30 cm long. Recognizable clast types generally include fine grained, buff, pink and pale grey metarhyolite and metasandstone, mafic and calc-silicate rocks, and quartz. Clasts of pre-Missi intrusive rocks are not common, even directly above the unconformity; rarely do they include the underlying granitic rock, and Burntwood Suite clasts have not been recognized. However, mafic clasts are locally abundant where the conglomerate overlies Amisk Group amphibolite. Pale pink clasts, which in many places are diagnostic of the basal conglomerate, resemble part of 1e, which underlies the conglomerate and is intruded by the pre-Missi granite gneiss (9).

Several beds of feldspathic quartzite are locally interlayered with the basal conglomerate. Some of these contain quartz granules several millimetres in size. South of Puffy Lake Mine a bed that contains scattered, well rounded quartz pebbles directly overlies the unconformity.

Unit 5h overlies numerous rock types at the unconformity. Near Puffy, Spider, Moody and Martell lakes, it overlies Amisk Group amphibolite (1a). Between Spider and Evans Lakes it overlies tonalite (6). West of the abandoned Puffy Lake Mine and east of Jungle Lake, it overlies tonalitic gneiss (6b). East of the mine and near the west shore of South Nokomis Lake, the conglomerate overlies granitic gneiss (9). The overturned unconformity near the mine (Fig. 12) oversteps the intrusive contact between units 1 and 9. Northwest of Nokomis Lake ribbon gneiss at the base of the Missi Group overlies granodiorite gneiss (6c). North of Spider Lake the conglomerate overlies a thin

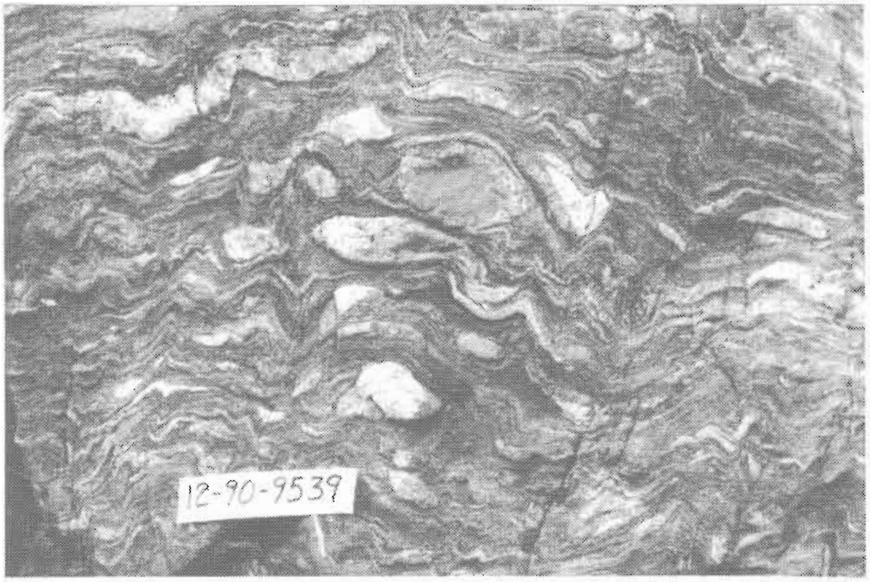


Fig. 11: Missi Group basal metaconglomerate (5h) with pebbles stretched during D_2-D_3 and refolded during D_4, Puffy Lake area. Tape is 10 cm long.

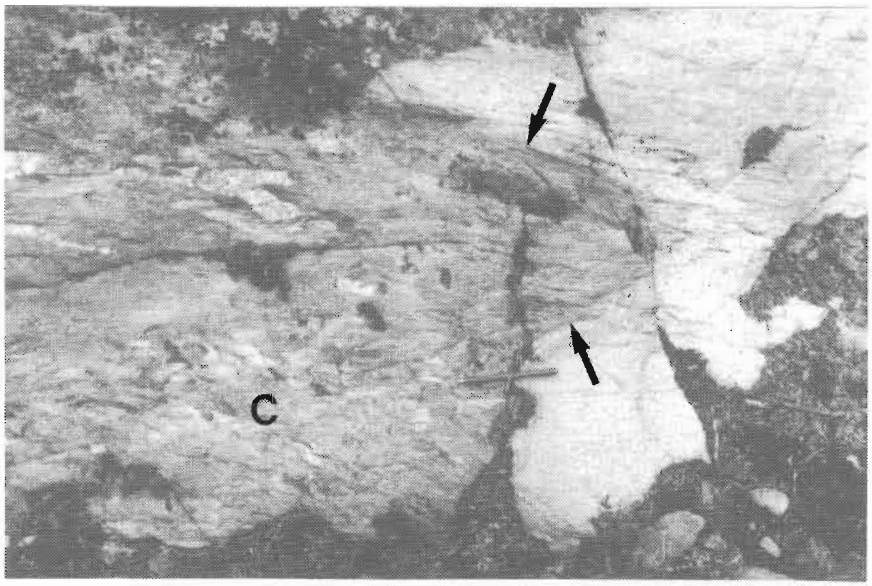


Fig. 12: The unconformity (arrows) between conglomerate (C) and pre-Missi granite was overturned and folded during D_3. Arrows are 8 cm long.

layer of garnet-rich amphibolite, interpreted to be a metaregolith at the top of Amisk Group metabasalt. Farther east the conglomerate cuts down into tonalite. About 350 m north of this contact, on the north limb of a syncline developed in the Missi Group rocks, the same conglomerate directly overlies the Burntwood Suite metagreywacke or the amphibolite (3) as it does near Puffy Lake Mine. North of Lobstick Narrows, near the south shore of Nokomis Lake and at Evans Lake it generally overlies thin amphibolite (3).

The conglomerate provides evidence for an extensive erosional interval before the deposition of the Missi Group. Provenance was from an orogenic hinterland of predominantly sedimentary and volcanic rocks, probably dominated by the Amisk Group. Deep-seated intrusions were locally exposed. Deposition on the margin of an alluvial plane is suggested by (i) the presence of heavy mineral placers in the associated metasandstones, (ii) the uniform composition and thickness of the conglomerate in sequences 1 and 2, and (iii) the absence of conglomerate in sequence 3. The Burntwood Suite may have underlain much of the alluvial plane, where it did not contribute significantly to the detritus in the Missi Group.

INTRUSIVE ROCKS

Plutonic rocks on the south flank of the Kisseynew belt range from ultramafic to leucogranitic. Many of these rocks have lost their massive intrusive texture, but display deformational structures from pre-tectonic, granoblastic or gneissic to late-tectonic, massive to foliated. The early intrusions are overturned domes and large complexes of plutons that underlie over 30% of the Kississing - Batty lakes area. Smaller masses of younger leucotonalite to leucogranite are most abundant in the north and probably represent syntectonic, anatectic melt fractions. In this report each unit represents many intrusions that generally have a unique composition and texture. These units are further grouped, primarily, by composition, and listed below from oldest to youngest where possible:

(6, 6a, 6b, 6c, 6d)	tonalitic to granodioritic;
(7, 7a, 7b)	intermediate;
(8, 8a, 8b)	mafic to ultramafic; and
(9, 9a, 10, 10a, 11)	granitic to granodioritic.

Each group has a wide range of ages, including pre- and post-Missi intrusions. There is an overall decrease in potassic and pegmatitic varieties with age, but no comprehensive chronological order has been established. Some intrusions of units 6, 6a, 6b, 6c and 9 are unconformably overlain by the Missi Group; these rocks are pre- to early-tectonic. An intrusion of 6b northwest of Puffy Lake has an U-Pb zircon age of 1892 +66/ -25 Ma (Hunt and Zwanzig, 1990). This age corresponds (within error limits) to the 1890 +8/ -9 Ma age of granodiorite gneiss in the Herblet Lake dome similar to 6c (Gordon *et al.*, 1990). Apparently, some areas of 6b, 6c and their enclaves of Amisk Group amphibolite and felsic gneiss appear to be the oldest rocks in the Kisseynew belt. An intrusion of unit 9 north of Puffy Lake, unconformably overlain by the Missi Group, has an U-Pb zircon age of 1873 $\pm$4 Ma (Hunt and Zwanzig, 1990). An intermediate phase of plagioclase porphyry (6d) is also pre-Missi but a felsic phase that intruded the Burntwood Suite south of Duval Lake is interpreted as syn-Missi from U-Pb analyses (Ashton *et al.*, 1992).

Units 7 and 8 have an unknown age, whereas many bodies of units 9 to 11 intrude the Missi Group. Units 10, 10a and 11 are syn- to late-tectonic. Rocks of 10a are correlated with granite, unit 12 of Baldwin *et al.* (1979) that yielded an age of 1816 +23/ -12 Ma from a sill in the Burntwood Suite northeast of the Kississing - Batty lakes area (Gordon *et al.*, 1990). This age is similar to 1814 +17/ -11 Ma obtained from granodiorite, less than 10 Ma older than monazite recrystallization ages and thus interpreted as the age of peak metamorphism (Gordon *et al.*, 1990). The full range of intrusive ages on the south flank of the Kisseynew belt can be established only by more U-Pb geochronology.

A systematic transition exists within the early-tectonic intrusions from moderately foliated bodies (6) in the south-central part of the Kississing - Batty lakes area, to orthogneisses (6a, 6b, 6c, 9) in the centre, and coarsely recrystallized meta-igneous rocks (6b, 6c) on the north side. The orthogneisses are characterized by medium- to fine-grained granoblastic texture, well developed foliation and linear fabric as evidence of intense ductile deformation. Part of the orthogneisses were originally mapped as metasedimentary rocks of the Sherridon Group (Robertson, 1953; Kornik, 1968). Some of these rocks have a supracrustal origin, but as a result of mapping during the current project most of units 6a to 6c have been interpreted as highly metamorphosed or migmatized intrusive rocks equivalent to the less deformed plutons on the south-central part of the Kississing - Batty lakes area that is part of the Flin Flon volcanic belt. However, the origin of part of the orthogneiss assemblage is an unresolved problem that is being addressed with further mapping.

Most intrusive rocks in the Kississing - Batty lakes area occur in overturned, elongate (<30 km) domal structures. These complexes are composed of up to six homogeneous phases of quartzofeldspathic orthogneiss. Most complexes also contain large screens of supracrustal rocks. The complexes are shown and labeled (**A**) to (**K**) in Fig. 13. They are listed from west to east, and their geology is summarized in Table 3.

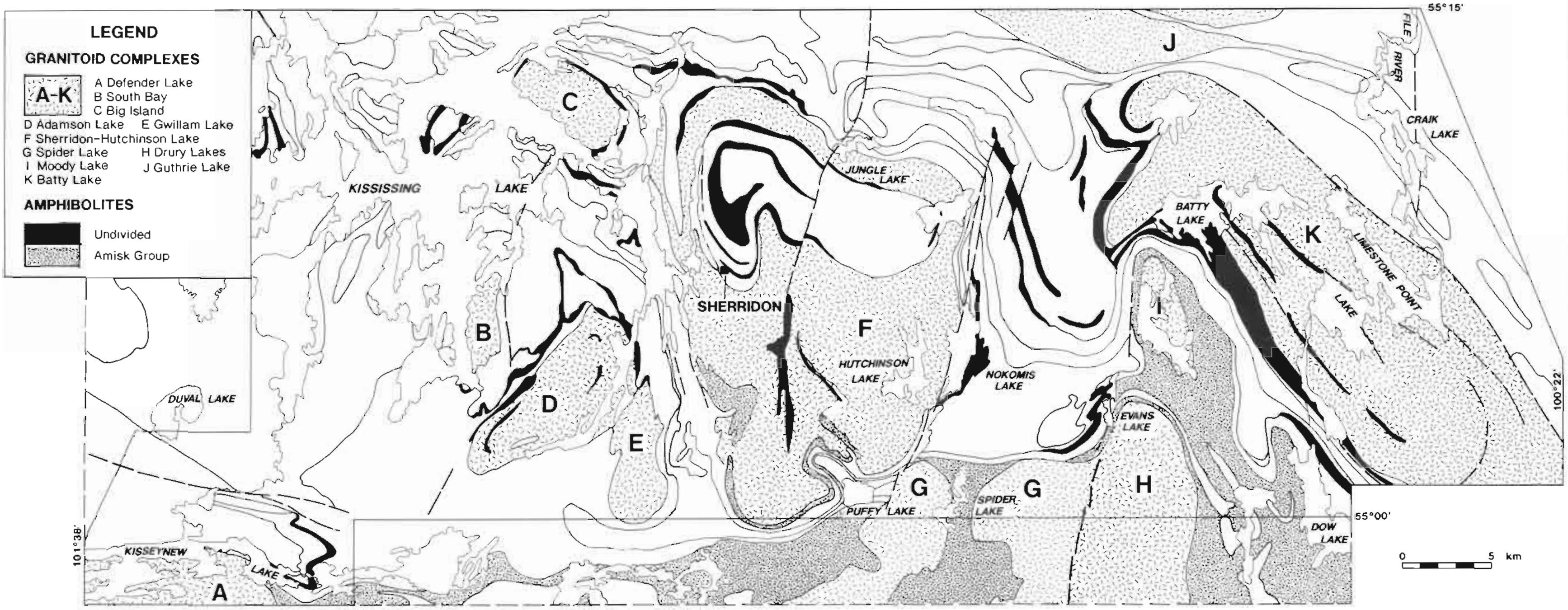


Fig. 13: Major granitic complexes in the Kississing - Batty lakes area, also showing distribution of amphibolites, and geological contacts within paragneisses (unpatterned).

Table 3: Granitic Complexes

(A) *Defender Lake dome* is a large east-trending complex at Kisseynew Lake (only partly covered during recent mapping). It contains a core of 6a and a mantle of crescent-shaped bodies of 6a and 6c. The north margin of the complex is strongly foliated, banded gneiss, which is structurally overlain by Amisk Group amphibolite; this is overlain, in turn, by the Missi Group. The core gneiss is heterogeneous, and possibly contains a considerable volume of felsic supracrustal rocks derived from the Amisk Group (Ashton, 1989).

(B) *South Bay dome* is a smaller, elongate, northerly trending body of foliated tonalite (6b) that lies along the east shore of South Bay of Kississing Lake. It has a discontinuous mantle of mesocratic gneiss (7a) at the northwest and east margins. These rocks are intruded into the Burntwood Suite.

(C) *Big Island dome* is a northwesterly trending structure comprising monzogranite to granodiorite (9). The structure is overturned to the southwest with the southeast end of the dome plunging to the east, whereas the northwest end of the dome has a northerly plunge.

(D) *Adamson Lake complex* is a suite of foliated and gneissic intrusive rocks that vary from tonalitic and granodioritic gneiss to monzogranite (6b, 6c and 9). The complex is exposed in an elongate dome that has a northeasterly trend with the northwest limb of the structure overturned to the northwest. Quartz-diorite to metagabbro (7, 7a and 8) lie along the southeast margin of the complex. Discontinuous zones of supracrustal gneisses and diatexite occur throughout it.

(E) *Gwillam Lake dome* comprises foliated monzogranite to granodiorite (9) exposed in a northerly trending, east-dipping flattened lens. The structure has a shallow to intermediate plunge.

(F) *Sherridon - Hutchinson Lake complex* extends from Archie Lake 23 km north to Contact Lake and is interpreted to be a multiple dome (or large sheath fold) of granitic bodies and a core of Sherridon Suite gneisses. The west half of the Sherridon Suite core-structure is intruded by and mantled with metagabbro (8). Pre-Missi tonalitic to granitic gneisses (6b, 6c and 9) occur in the south half of the Sherridon - Hutchinson Lake complex. Arcuate intrusions on the margins of the complex are progressively more strongly foliated and more potassium-rich outward. Amisk Group rocks mantle the granitic rocks in the south, and screen the contacts between intrusive phases. The south, east and north sides of the complex are unconformably overlain by the Missi Group; the Missi Group rocks on the west side are too sheared for the unconformity to be recognizable.

(G) *Spider Lake area* encompasses the northern parts of two large masses of tonalite (6) that lie in the Flin Flon volcanic belt on the south border of the Kississing - Batty lakes area. These are the well preserved intrusive rocks (with primary igneous textures). They are intruded into the Amisk Group; the pluton east of Spider Lake is unconformably overlain by the Missi Group along part of the north contact.

(H) *Drury Lakes dome* comprises uniform, buff-weathering tonalite (6b), and younger pink granodiorite (6c), prevalent along the margin of the dome where it intrudes the Amisk Group. The Drury Lakes dome is elongate and foliated on a northerly trend. It is separated from more massive tonalite to the west by the northern extension of the Elbow Lake shear zone.

(I) *Moody Lake dome* has supracrustal rocks (1), hornblendite and melagabbro (8a) in the centre, granodioritic rocks (6b and 6c) in the north and a shell of highly foliated, muscovite-sillimanite-bearing orthogneiss (6c) in the south. Metagabbro (8) lies on the outside of the dome on the east and west. The orthogneiss that fringes the dome on the south appears to have an intrusive contact with the Missi Group.

(J) Guthrie Lake complex is a narrow west-northwest-trending body of foliated and partly remobilized granodiorite (6b) in the northeast part of the map area.

(K) Batty Lake complex extends from Hayhurst Lake 27 km southeast to Geekie Lake. It contains mainly quartz-rich tonalitic orthogneiss (6a), but narrow belts and screens of amphibolite (3a to 3d) are abundant between Batty Lake and Fairwind Lake, and screens of Burntwood Suite occur south of Geekie Lake. The complex is strongly foliated and its margin is a zone with discontinuous slices of various rock types including augen gneiss, felsic gneiss (3e) sulphide-bearing gossan and cordierite-anthophyllite rock (4f).

TONALITIC AND GRANODIORITIC ROCKS

Tonalite (6)

Weakly foliated metatonalite, in which the primary igneous texture is largely preserved, is restricted to the Spider Lake area. The tonalite occurs in two large bodies, one on each side of Spider Lake, and as dykes southeast of Puffy Lake. The tonalite intrudes the Amisk Group; the eastern intrusion is unconformably overlain by the Missi Group; no contacts with the Burntwood Suite are exposed.

The rock is characterized by medium grained subporphyritic texture. The grain size is generally 3 to 8 mm, with <10 mm subhedral plagioclase grains in a seriate porphyritic varieties. Some plagioclase grains display relics of oscillatory zoning. Preliminary modal estimates average 30% quartz, 58% plagioclase, and 12% combined biotite and hornblende but some samples contain more mafic minerals.

Quartz-rich tonalitic orthogneiss (6a)

A high quartz content (commonly 30 to 50%), and presence of local garnet, well developed foliation, lineation and younger granitic veins distinguish 6a from 6. The rock composes the main phases of the Defender Lake dome (A in Fig. 13) and the Batty Lake complex (K in Fig. 13). These bodies have sheared contacts with supracrustal rocks, and their age is uncertain. They include narrow belts of Burntwood Suite metagreywacke interpreted to be xenolithic screens. They also include amphibolite that is most likely part of the Amisk Group. Generally uniform texture and composition indicate an intrusive origin for much of the unit, but the high quartz content is unusual for an igneous rock. Silicified tonalite is a likely protolith, but the presence of abundant supracrustal rocks in parts of 6a cannot be ruled out. The common presence of garnet (generally <5%) may be a result of alkali loss during the formation of neosomal veins and patches. Where the migmatitic neosome is clearly defined it locally contains euhedral garnet porphyroblasts (<15%). Large areas of similar rocks on peninsulas in the west part of Kisseynew Lake have been mapped as felsic volcanic rocks by Ashton (1989). Intensively altered orthogneiss is shown as 4b or 4f.

At Kisseynew Lake, in the Defender Lake dome, quartz-rich orthogneiss has several compositional and textural varieties tentatively interpreted as different intrusive phases. Some rocks are thinly layered and contain intercalations and inclusions of amphibolite, biotite-hornblende gneiss and biotite gneiss. The core of the dome comprises fine- and medium-grained gneiss with inequigranular texture. It has, on average, 40% quartz, 45% plagioclase, small amounts of potassium feldspar and 12% mafic minerals, locally with garnet, epidote, sphene and muscovite. A partial shell within the dome contains slightly less quartz and <20% biotite.

In the Batty Lake complex the main phase of 6a is a medium grained, quartz-rich tonalitic gneiss that weathers light grey, beige or pink. Small elongate inclusions and large narrow screens of amphibolite are common in parts of the unit. Much of the rock has a uniform gneissic texture interpreted to be a high-strain fabric that was largely annealed. Shear zones are recrystallized. Formation of veins and neosome was restricted to certain areas, probably for lack of water. A typical mode is 40% quartz, 50% plagioclase and 10% mafic minerals, but the quartz content is variable. Green hornblende predominates over biotite, but locally biotite is the only mafic mineral present.

Garnet is common, ranging in size from 0.5 to 10 mm (average 1 mm). The magnetite content is variable. Anthophyllite occurs instead of hornblende in some altered rocks. Quartz commonly forms thin polygonized lenticular aggregates (< 20 mm long) in the plane of gneissosity. The larger grains have a well developed mortar texture that is generally annealed to form stringers of small (0.1 mm) grains along their margin. Plagioclase is part of an interlocking granoblastic texture. Mafic minerals occur as elongate trains that help define the gneissosity (Fig. 14). The trains are interpreted to be the product of larger, magmatic grains that have recrystallized during high strain amphibolite facies conditions. The textures are consistent with an intrusive origin of 6a.

Tonalitic to granodioritic gneiss (6b)

Strongly foliated to gneissic varieties of metatonalite and granodiorite with consistent quartz content (30-35%) occupy large domed intrusions and metamorphosed igneous complexes throughout the Kississing - Batty lakes area. These rocks have a variable grain size and texture, but each variety is restricted to a given area. These varieties clearly represent different intrusions or intrusive phases with a limited range of compositions. Some phases are unconformably overlain by the Missi Group and others may contain Missi Group inclusions.

The main phase of the Drury Lakes dome (H in Fig. 13) weathers buff and is medium grained (2-5 mm). An average modal estimate is 33% quartz, 58% plagioclase, 9% biotite and variable amounts of potassium feldspar, epidote, amphibole and magnetite. Biotite and epidote form elongate mafic aggregates. Quartz grains are polygonized, some annealed, others highly strained. The rock is moderately foliated; it has a well developed mortar texture that represents a transition between primary (igneous) and secondary (granoblastic).

The tonalitic to granodioritic phase of the Moody Lake dome (I in Fig. 13) is strongly foliated and locally garnetiferous. Potassium feldspar defines a weak gneissic layering, apparently due to partial remobilization of the rock. Quartz and plagioclase form irregular to lensoid grains <7 mm long. A typical mode is 29% quartz, 55% plagioclase, 6% potassium feldspar and 9% mafic minerals.

The most strongly foliated tonalite gneiss occurs in the folded sheet that intrudes Amisk Group amphibolite east of Martell Lake. This rock features flaser texture of flattened aggregates of quartz and thin foliae of mafic minerals <20 mm long.

The Sherridon - Hutchinson Lake complex (F in Fig. 13) contains several varieties of grey-weathering, foliated to gneissic tonalite, all mapped as 6b. They form a thick mantle surrounding the Sherridon Suite (4a to 4i). The rocks are predominantly medium grained (2-5 mm). The average mode is 30% quartz, 57% plagioclase, 3% potassium feldspar and 10% biotite plus hornblende. Between Molly Lake and Hutchinson Lake the unit has a fine grained (1-2 mm) core. The phase at Hutchinson Lake is similar to 6b in the Drury Lakes dome but has more highly aligned biotite and more highly strained amoeboid quartz grains. A partial mantle southeast of Hutchinson Lake contains more interstitial grains of potassium feldspar and is weakly layered. Northwest of Star Lake, and between Bess Lake and Puffy Lake Mine, 6b contains equal amounts of hornblende and biotite (*ca.* 6% each) intergrown with epidote where mortar texture is prominent. The rock is slightly more mafic than at Hutchinson Lake. Along the west side of the Sherridon - Hutchinson Lake complex 6b contains prominent dioritic and amphibolitic inclusion trains.

The intrusions southwest of Guthrie Lake (J in Fig. 13) comprise beige to grey-weathering biotite tonalite to granodiorite. The rock has an average of 26% quartz, 56% plagioclase 12% biotite, <6% potassium feldspar, variable amounts of hornblende and traces of magnetite. The rock is well foliated on the south margin, but elsewhere early mortar texture appears to be largely annealed. The rock has regained (or preserved) homogeneous medium grained granitic texture with subhedral plagioclase grains and interstitial potassium feldspar. Inclusions of supracrustal rocks (2c and 5b) are common near the south margin of the intrusion.

In the Kississing Lake area the average composition of 6b exposed in the South Bay and Adamson domes (B and D in Fig. 13) is 30% quartz, 40% plagioclase, 20% potassium feldspar and 10% biotite plus hornblende.

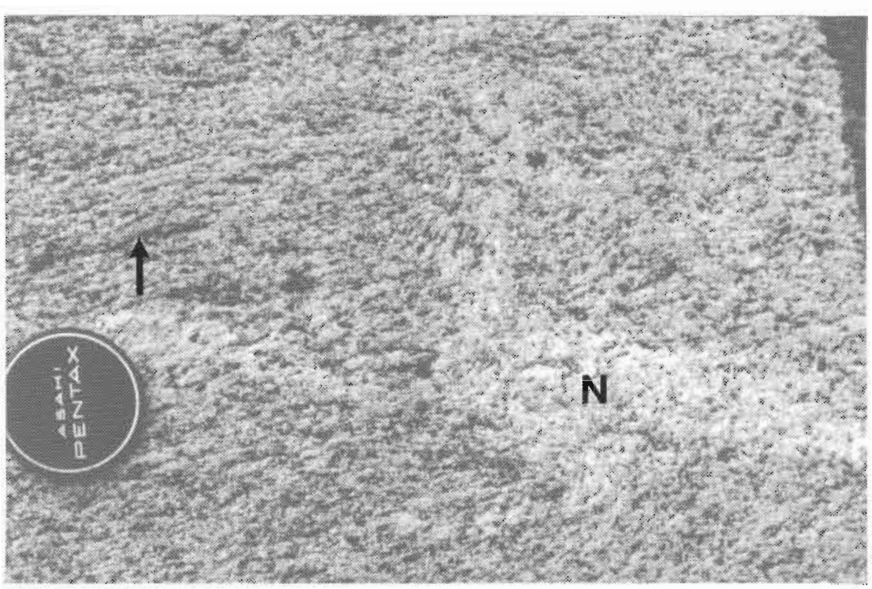


Fig. 14: Tonalitic orthogneiss (6a) with elongate trains of mafic minerals (eg. arrow) forming gneissosity in paleosome, and lighter areas of neosome (N), Defender Lake complex. Lense cap is 5 cm.

Granodioritic to granitic gneiss (6c)

The outer margin and parts of the interior of the Drury Lakes dome (L in Fig. 13) comprise pink-weathering, foliated and lineated granodiorite to monzogranite and locally tonalite. Quartz and feldspar are polygonized; composite grains are 1 to 5 mm long. An average mode is granodioritic with 34% quartz, 43% plagioclase, 12% potassium feldspar and 3% biotite, but the composition varies considerably.

The granitic phase of the Moody Lake dome (I in Fig. 13) comprises pink and pale grey-weathering strongly foliated and polygonized gneiss locally cut by younger granite veins. Locally the rock contains small garnets, and highly flattened sillimanite bundles overgrown with retrograde muscovite. A typical mode is 32% quartz, 32% plagioclase, 28% potassium feldspar and 8% biotite. A medium grey variety with a higher biotite content may be a supracrustal component of 6c.

A narrow belt of strongly foliated hornblende granodiorite gneiss south and east of Hutchinson Lake is a distinctive mesocratic variety of 6c. The composite polygonized grains are over 5 mm long and less than 1 mm thick. They comprise quartz (30%), plagioclase (30-40%), potassium feldspar (15%) and aligned biotite-hornblende aggregates (15-25%).

At Kisseynew Lake the northeast part of the Defender Lake dome comprises shells of orthogneiss that range in composition from tonalite to monzogranite. The rocks have a partly annealed mortar texture with quartz and plagioclase grains <3 mm long and localized amoeboid potassium feldspar megacrysts <8 mm long. Trains of mafic grains are aligned in the foliation and surround small felsic domains. They are aggregates of biotite or biotite-hornblende-epidote-sphene. The texture is interpreted as relict intrusive. An average composition of the whole suite is 30% quartz, 40% plagioclase, 20% potassium feldspar and 10 to 15% biotite plus hornblende. Sillimanite occurs in a sheared and hydrothermally altered variety of the rock. Garnet occurs mainly in areas with inclusions or with abundant migmatitic neosome.

A medium grained magnetite- and garnet-bearing phase occurs at the northeast end of the Adamson Lake dome. The fabric of this rock type varies from a weak schistosity to a incipient augen gneiss with lenticular microcline megacrysts and discontinuous thin layers of mafic minerals. Amoeboid microcline megacrysts, <10 mm in length, occur in irregular shaped and anastomosing zones.

Plagioclase porphyry (6d)

South of Evans Lake porphyry is part of a pre-Missi dyke complex that intrudes the Amisk Group at the north contact of a tonalite (6) batholith. Unit 6d is seriate porphyritic with <10 mm long subhedral plagioclase grains. Total plagioclase content is 60%; the rest is fine grained quartz (15%), biotite and minor amphibole.

Sheets of leucocratic plagioclase porphyry (tonalite) intrude the Burntwood Suite southeast of Duval Lake. They are associated with plutonic breccia that contains felsic, mafic and ultramafic phases. The porphyry is similar to rocks that are considered to be syn-Missi in age (Ashton *et al.*, 1992).

INTERMEDIATE ROCKS

Quartz diorite, gabbro (7)

Sheets of quartz diorite form prominent outcrops along the east and north flank of the Big Island dome (C in Fig. 13); unit 7 gabbro occurs east Big Island north of Home Bay. The average mineral content of unit 7 is quartz (8%), plagioclase (55%), hornblende (32%) and biotite (5%). It is coarse- to medium-grained, has a hypidiomorphic granular texture and is weakly- to well-foliated. Areas that contain pyrite and trace amounts of chalcopyrite occur locally in the vicinity of Collins Point.

Dykes of dark gray, fine- to medium-grained quartz diorite and tonalite intrude Amisk Group amphibolite between Moody Lake and Martell Lake. This rock is strongly foliated. It is associated with gabbro (8) and is interpreted to predate the Missi Group.

Mesocratic hornblende-biotite gneiss (7a)

This rock type is exposed primarily in the north part of the Kississing Lake area, in an arcuate zone that extends from the east side of Big Island west to an area north of Collins Point. Minor occurrences are present south of Deep South Bay and on the south side of the Adamson Lake dome. The rock ranges from medium- to coarse-grained, is well foliated and contains white plagioclase-quartz *lits.* The average modal composition is quartz (10-15%), plagioclase (55%) hornblende (20%), biotite (10%), magnetite (0-2%) and sphene (0-1%). It is variably layered on a outcrop scale. Layering is defined by variations in the amounts of hornblende, biotite and quartz and the presence or absence of magnetite; some layers are amphibolitic. In areas intruded by 9, 7a contains subparallel discontinuous layers of microcline, quartz, epidote and poikiloblastic hornblende. An igneous precursor for 7a is suggested by the similarity of its more mafic layers to the quartz diorite or gabbro (7).

The apparent age relationships of the mesocratic gneiss are conflicting and uncertain. Unit 7a occurs as probable sills within 5a and 5b, and inclusions within 6b (interpreted as pre-Missi intrusions). These occurrences are not mappable in the Kississing Lake area at the present scale. Similar rocks are interpreted as Missi volcanic rocks and designated as part of 5g in the Batty Lake area. Apparently there were several types and ages of intermediate igneous rocks, shown as 7a or 5g.

Quartz diorite (7b)

An oval stock of quartz diorite, 4 km long, occurs southeast of Craik Lake, at the south end of a high-strain zone. It intrudes the Missi Group and is probably younger than unit 7. The foliated margin has a shallow dip, concordant with the surrounding gneisses. The rock weathers medium grey, and is nearly massive in the coarse grained core of the intrusion. Minerals are plagioclase (65%), in grains <10 mm long, coarse green amphibole (*ca.* 20%) with cores of relict pyroxene and overgrown with dark brown biotite (*ca.* 7%) and less than 10% quartz, apatite (*ca.* 0.5%) and sphene.

MAFIC AND ULTRAMAFIC ROCKS

Coarse grained amphibolite, metagabbro (8)

In the Kississing Lake area coarse grained amphibolite derived from gabbro outcrops primarily on the northeast side of Kississing Lake, on the southwest side of Big Island and to the immediate east within the Sherridon - Hutchinson Lake complex. In general, this amphibolite is dark grey to black and contains 40 to 60% hornblende and 60 to 40% plagioclase, rarely accompanied by quartz and garnet. An exception is a grey plagioclase-rich, quartz-bearing metagabbro that outcrops on the islands at the north end of Barrett Bay in the southwest part of Kississing Lake. A common characteristic of the amphibolite is the presence of zoned plagioclase grains. The rock is variably foliated to massive in some areas, as described by Froese and Goetz (1981), and gneissic with white granitic *lits* elsewhere. This change can be very abrupt as in the vicinity of Range Island on Kississing Lake, immediately north of the village of Cold Lake (Sherridon). There, the coarse grained amphibolite has been deformed and the planar zones of high strain have been injected by white quartz-plagioclase-rich *lits*. The volume of quartz is greater than normal and the presence of garnet is more common in these zones of deformation.

Hornblendite, melagabbro (8a)

An ultramafic to mafic intrusion, 2 km long, occurs in the core of the Moody Lake dome (I in Fig. 13). The rock has recrystallized to predominantly coarse grained (<10 mm) hornblende-diopside or medium grained hornblende with plagioclase (< 40%) and minor sphene. Much of the unit has a patchy structure with pale green diopside-rich domains in a dark green or black hornblende matrix.

Ultramafic rock (8b)

Apple green- to brown-weathering ultramafic rocks intrude 1e at Dow Lake and north of Drury Lakes. They consist of recrystallized pale green amphibole, diopside and magnetite. Partly serpentinized olivine and spinel are present at Dow Lake.

GRANITIC AND GRANODIORITIC ROCKS

Monzogranite and granodiorite (9)

This intrusive suite forms the main rock type in the Big Island dome and the Adamson Lake dome (C and D in Fig. 13). Weathered surfaces are generally stained reddish pink with hematite. The mineral content is quartz (35-40%), potassium feldspar (35-25%), plagioclase (30-40%), biotite (5%), magnetite (0-2%). It is medium- or, locally, coarse-grained. The quartz grains are lenticular; biotite is disseminated or in discontinuous lenses. Inclusions of magnetite-bearing quartzofeldspathic gneiss (possible 5b) suggest a post-Missi age.

In the Sherridon - Hutchinson Lake complex strongly foliated recrystallized granite mapped as 9 intrudes the Amisk Group and is unconformably overlain by the Missi Group. This rock has a U-Pb zircon age of 1873 $\pm$ 4 Ma (Hunt and Zwanzig, 1990). The average mineral content is quartz (35%), plagioclase (30%), potash feldspar (24%) and biotite (7%), variable amounts of hornblende, epidote and minor apatite, sphene and zircon. It is medium- to coarse- grained, but textures indicate grain size reduction during strain. The quartz grains are polygonized, flattened and elongated; microcline occurs in elongate groups of subgrains; the plagioclase is partly altered to white mica. Mafic grains occur in wispy 5 to 10 mm long aggregates. Locally there is bright green secondary amphibole, epidote, calcite and tourmaline. The alteration is most pronounced at the sheared eastern margin of the stock.

Sheets of 9 that occur in tightly folded Amisk Group rocks on the shores of Dow Lake are even more highly strained than the gneissic granite to the west. They contain flattened augen composed of composite grains of microcline.

Layered granite gneiss (9a)

Pink-weathering granite gneiss typically consists of two components; a fine- to medium-grained granoblastic gneiss, and coarser grained granitic neosome. Locally these components are tightly folded. The rock has a limited distribution, restricted to the northeast part of the Kississing - Batty lakes area, along the contact between the Burntwood Suite and Missi Group. Its protolith was granite or possibly pink felsic metavolcanic gneiss (5e).

Two-mica leucogranite (10)

Numerous small bodies of biotite-muscovite leucogranite intrude Burntwood Suite metagreywackes along the south margin of the Kississing - Batty lakes area. The intrusions are most extensive in several east-trending belts: (i) near the Kississing River south of Barrett Bay; (ii) south and east of Dumbell Lake; and (iii) southeast of Nokomis Lake. The rock weathers white and forms *lits* in the greywacke and large and small sill-like bodies <300 m thick. The periphery of the larger sheets is generally intruded by pegmatitic dykes. The margin of some intrusions is a raft complex, surrounded by a sill complex. The granite in these intrusions is relatively fine grained (generally less than 5 mm) and massive or moderately foliated. It is interpreted as syntectonic and syn-peak metamorphic. Its mineral content is potassium feldspar (generally in excess of plagioclase), quartz, biotite (1-5%) and muscovite (<4%). These minerals have an interlocking texture. Small biotite flakes occur along the boundaries of other grains and are magmatic. Much of the muscovite cuts across other grains and has a late paragenesis, possibly as an autometasomatic mineral. Where rafts of metagreywacke are abundant the granite locally contains small subhedral garnets.

Leucogranite and pegmatite (10a)

Lits or anastomosing vein networks of leucogranite are present throughout the Kississing - Batty lakes area north of the belt of two-mica granite. Bodies are large enough to map only in a few places on Kississing Lake such as on Moose Island in the northwest corner. The rock is most prominent as white *lits* in Burntwood Suite metagreywacke, but also occurs as pink *lits* in the Missi Group. It is commonly seriate pegmatitic or may have patches of that texture. Its composition is variable, but biotite content is ubiquitously low. Garnet is a local accessory, and sillimanite and muscovite are rare. *Lits* are commonly folded and boudinaged: the rock is syntectonic. It is probably comagmatic with two-mica granite, but occurs in the more highly metamorphosed migmatitic rocks at the site of anatexis rather than on the periphery of the migmatites where unit 10 abounds.

Pink granitic pegmatite (11)

Pink granitic pegmatite is present within a wide variety of rock types as *lits* or irregular vein networks. It forms mappable bodies at Kississing Lake in the area immediately southeast of Moore Island and also along the northwest corner of Big Island. This pink granite appears to be the youngest intrusive rock type observed in the map area. Some dykes intrude the axial surface of the latest set of folds in the Kississing - Batty lakes area (see structure section, below).

PALEOZOIC ROCKS

Mottled dolomite (12) is exposed over a 1.5 by 2.0 km area in central Limestone Point Lake. The beds comprise buff dolomite and reddish argillaceous dolomite. Beds are generally massive with well developed bedding plane partings. Thin breccia and conglomerate beds with green argillite clasts were observed in two locations.

Bedding attitudes in the carbonates range from subhorizontal to near vertical. The contact with Precambrian rocks is not exposed. The southwest limit of Paleozoic exposure lies within 3 m of a Precambrian fault. Isoclinal folds of 2 to 3 m amplitude plunge at 20° to the west. Well developed fracture cleavages in two directions combined with bedding plane partings result in a rubbly appearance to most exposures. Folding of Paleozoic rocks is not observed elsewhere in Manitoba: it may be related to a fault origin and structural dropping of the outlier.

Samples collected were examined by H.R. McCabe, who concluded that the dolomites look like known Ordovician rocks; (see also McCabe, 1987). McCabe suggested that, although extrapolation of regional structural trends to the Limestone Point Lake area is approximate at best, the Paleozoic outlier may be structurally low (120 m maximum) with respect to the base of the Ordovician projected north from the main outcrop belt in northern Manitoba.

METAMORPHISM

Metamorphic mineral assemblages in the Kississing - Batty Lake area are indicative of an upper amphibolite facies peak of regional metamorphism, which yielded the assemblage, sillimanite-biotite-garnet in rocks of appropriate composition. A general northerly increase in grade of metamorphism is indicated by; (i) increasing metamorphic grain size and loss of primary structures, (ii) zonation of mineral assemblages with the highest-grade assemblages of sillimanite-cordierite-garnet-biotite occurring to the north, and (iii) change from a mixture of metasedimentary rocks and fine grained gneiss to migmatites with prominent leucosome. This observation of increasing metamorphic grade northward is consistent with the regional metamorphic gradient described to the east of the project area from File Lake to the centre of the Kisseynew gneiss belt (Bailes and McRitchie, 1978). However, detailed variations in metamorphic grade suggest that the area contains slices of various grade. Preliminary work at Kisseynew Lake suggests that some very high-grade rocks may form windows in domal areas (possible core complexes) in the south, partly mantled with slices of lower grade rocks. Work is in progress to resolve these metamorphic details.

METAMORPHIC MINERAL ZONES

Two distinct mineral zones can be outlined in aluminous, K-poor rocks of the Burntwood Suite based on specific mineral reactions in the manner described by Bailes (1980b). These zones are subdivisions of the sillimanite-biotite garnet zone and are named after their characteristic mineral assemblages: *sillimanite-garnet-staurolite zone* (in K-poor rocks); and *sillimanite-cordierite-garnet zone* (in K-poor rocks). The pressure-sensitive assemblage, garnet-cordierite-anthophyllite occurs in restricted compositions within the higher-grade zone, but sillimanite-anthophyllite has been reported from an area to south. Along the boundary between the zones lies another diagnostic metamorphic feature, *the migmatite front.*

Sillimanite-garnet-staurolite zone

This zone, which is shown on Fig. 15 and as 2f on Map OF92-2-3, occurs immediately south of Duval Lake, where it is over 5 km wide and extends west into Saskatchewan. However, it narrows along a southeasterly trend and pinches out near Lobstick Narrows. The staurolite-bearing zone is flanked to the north by areas that contain muscovite-free, sillimanite-garnet-bearing, commonly migmatitic greywackes. The increase in the grade of metamorphism to the north is consistent with the regional metamorphic gradient.

In areas where muscovite is minor or absent in the *sillimanite-garnet-staurolite zone* (in K-poor rocks), staurolite occurs as subhedral porphyroblasts with minor alteration. However, staurolite is commonly corroded where muscovite is present. The metamorphic textures observed in the areas of staurolite resorption are characteristic of mineral formation by replacement through discontinuous reaction just above the sillimanite-biotite-garnet isograd. These textures are interpreted (Bailes, 1980) as follows:

(a) replacement of staurolite by prograde muscovite;
(b) replacement of staurolite by prograde plagioclase; and
(c) the occurrence of sillimanite in fibrolitic knots isolated from other aluminous minerals.

This zone then marks the first appearance of sillimanite and the beginning of the corrosion and replacement of staurolite. The observed textures are related to cation exchanges that occur at the sillimanite-biotite isograd during the reaction identified by Bailes (1980b):

(1) chlorite + muscovite + staurolite + quartz = sillimanite + biotite + H_2O,

and the subsequent continuous reaction,

(2) muscovite + staurolite + quartz = sillimanite + biotite + H_2O.

Through the complex sequence of cation exchange reactions, matrix muscovite and plagioclase are consumed forming sillimanite domains and liberating K^+, Na^+ and Ca^+:

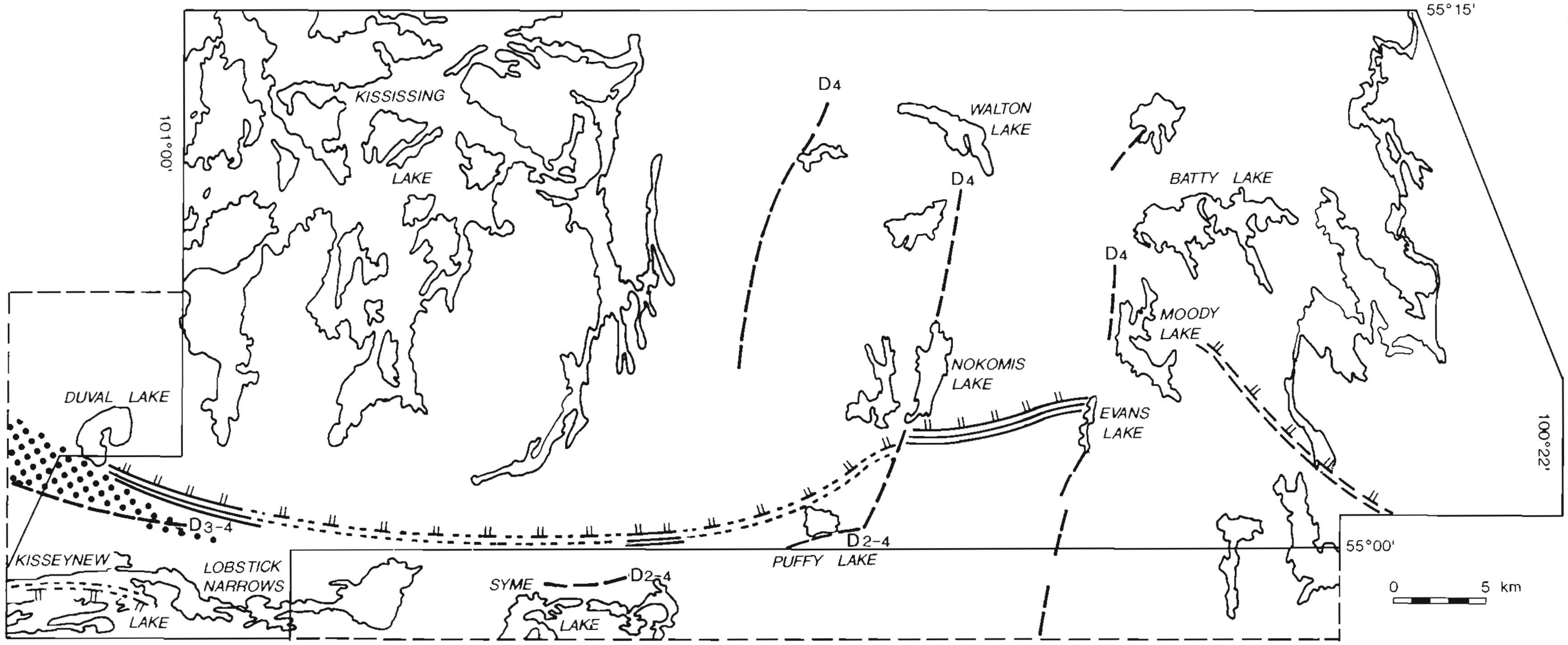


Fig. 15: Outline of the Kississing - Batty lakes map area, showing staurolite schist (dot pattern) and migmatite front (solid lines - approximate location; dashed lines - inferred location, ticks on the high-grade side). $D_{2\text{-}4}$ shear zones and D_4 faults are also indicated.

(3) plagioclase (in matrix) = sillimanite + quartz + Ca^+ + Na^+

The Na^+ and Ca^+ and K^+ from the breakdown of matrix plagioclase and muscovite respectively migrate and react with staurolite to form coarse grained prograde muscovite and plagioclase and biotite in the reaction:

(4) staurolite + quartz (matrix) + Na^+ + Ca^+ + K^+ = plagioclase + muscovite + biotite.

These reactions, which take place directly above the sillimanite-biotite isograd (Bailes, 1980), indicate that the area south of Duval Lake also lies close to this isograd. The metamorphic grade increases to the north and the south. The southerly increase is unusual, and it must indicate postmetamorphic deformation that may have produced either a postmetamorphic antiform or a metamorphic core complex at Kisseynew Lake. Diatexitic rocks (near-granulite grade) reported by Ashton (1989) from the west part of the lake supports the postmetamorphic structural relief.

Sillimanite-cordierite-garnet zone

North of the migmatite front the following diagnostic stable mineral assemblages are present;

(a) sillimanite-garnet-biotite,
(b) sillimanite-garnet-cordierite-biotite, and
(c) garnet-anthophyllite-cordierite.

The assemblage, sillimanite-garnet-cordierite-biotite is restricted in its occurrence to rocks of a certain composition. The assemblage occurs locally throughout the Burntwood Suite in certain pelitic layers of 2c. In the Kississing Lake area it occurs in quartz-rich rocks of unit 2c associated with layers of sulphide-bearing and anthophyllite-bearing rocks on Collins Point and Yakushavich Island. In the quartz-rich rocks of the Sherridon Suite the assemblage is associated with packages of anthophyllite-bearing rocks in units 4f and 4i. These rocks also exhibit an affinity for sulphide-bearing zones and are interpreted to be alteration zones related to volcanogenic sulphide deposition. Northwest and southeast of Walton Lake the assemblage, sillimanite-garnet-cordierite-biotite is very common in 3h. These quartz-rich aluminous rocks contain large sieve-textured garnet porphyroblasts and variable amounts of cordierite and sillimanite ± hercynite. They have an uncertain affinity and it is not known if they were altered by the same process as the Sherridon Suite.

The most reasonably assumed cordierite-forming reactions for the pelitic aluminous K-poor rocks is the final breakdown of staurolite after muscovite has been consumed:

(5) staurolite + quartz = cordierite + garnet + H_2O,
(6) staurolite + quartz = cordierite + garnet + sillimanite + H_2O.

Metamorphic textures indicate that biotite and sillimanite are a stable mineral pair in the cordierite-bearing assemblages. Conditions leading to their breakdown to form cordierite + garnet have apparently not been exceeded in the Kississing - Batty lakes area.

The apparently stable assemblages, garnet-sillimanite-cordierite and garnet-anthophyllite-cordierite occur in the altered rocks of the Sherridon Group with quartz and commonly with biotite (Froese and Goetz, 1981). Their conditions of metamorphism are on the low-pressure (higher temperature) side of the reaction:

(7) sillimanite + anthophyllite = garnet + cordierite + H_2O

Leroux (1989) described sillimanite-quartz aggregates armored from anthophyllite and garnet by cordierite. The "pockets" of quartz-cordierite sillimanite "surrounded by anthophyllite" are apparently unstable assemblages. These rocks should be investigated whether they have experienced reaction (7) during isothermal uplift rather than during increasing temperature.

The assemblage, sillimanite-garnet is widespread in Burntwood Suite units 2a and 2c. Plagioclase and quartz are the main constituents with plagioclase in excess of quartz. Sillimanite can form from the breakdown of staurolite, including reaction (2) or during metatexis, possibly in the reaction:

(8) muscovite + plagioclase + quartz + H_2O = melt + sillimanite.

MIGMATITE FRONT

The northward disappearance of staurolite near Duval Lake coincides approximately with an increase in metamorphic grain size and a change from metagreywacke containing veins of quartz with minor plagioclase to a migmatite with prominent veins of granitic leucosome, small bodies of pegmatite and sheets of leucogranite (10 and 10a). The migmatite front can be traced, albeit discontinuously, from Duval Lake east across the area to Evans Lake (Fig. 15). East of Evans Lake the higher-grade rocks appear to lie above the Moody Lake dome, as indicated by migmatites (2c) in the Batty Lake complex and farther northeast. This relationship suggests that the higher-grade rocks occur at upper structural levels and that the surface that defines the migmatite front is inverted. The hot-side-up metamorphism may be due to significant syn- to post-peak metamorphic thrust faulting, recumbent folding and posttectonic thermal equilibration. Local migmatite free areas west of the Batty Lake complex, suggest a complicated post-metamorphic deformation pattern that will be subject to further study. Other complications involve (i) development of more than one generation of migmatitic *lits*, (ii) fluxing by boron to produce low-temperature veins and (iii) injection of pegmatitic *lits* into rocks that show little sign of *in situ* melting. Consequently, the migmatite front is partly an intrusive feature and, south of Duval Lake, lies adjacent to the *sillimanite-garnet-staurolite zone* even though reactions (5) and (6), which mark the limit of the zone, do not generate melt.

Near the migmatite front, bodies of syntectonic leucogranite contain biotite and muscovite. North of the front they contain biotite, in some places with sillimanite and/or garnet, and only local retrograde muscovite. The mineral contents are consistent with the conclusion that these rocks are S-type granites generated by anatexis of metasedimentary rocks during peak metamorphism. North of the front prograde muscovite is notably absent in the leucosome and the greywacke derived melanosome. Bailes (1980b) suggested that first melting signifies a potash feldspar (melt)-sillimanite zone produced by reaction (8). However, prograde muscovite has not been properly documented in the lower-grade metagreywacke in the Kississing - Batty lakes area, and sillimanite is not common in the migmatite. Open system behaviour with large-scale mobility of the leucosome and metasomatism during melting and crystallization has apparently destroyed the mineral relationships of *in situ* anatexis.

In the north, pink granitic *lits* are locally common in 5b. They comprise pinching and swelling vein networks, generally parallel to the local primary layering (bedding). Veins are commonly 2 cm thick and consist of two types; (i) pre-F_3 quartz with quartz-feldspar margins ± hornblende, and (ii) syn-F_3 slightly more crosscutting veins and sheets of pegmatite or granite. Pegmatite formed preferentially within units 5c and 5e near the migmatite front. Pink felsic (volcanic) gneiss may have been converted to layered granite gneiss (9a). Reactions (8) is involved in the development of migmatite in the Missi Group. However, sillimanite is not abundant and most leucosome in the Missi Group rocks is interpreted to have formed in the reaction:

(9) plagioclase + quartz + potassium feldspar + H_2O = melt.

Abundant quartz-plagioclase myrmekite replacing potassium feldspar in melanosome is evidence for this reaction (Lenton, 1981). Even in the highest-grade zone, leucosome is locally absent in the Missi Group, and at a few localities in the north, white mica is present. Reactions (8) and (9) were apparently inhibited by a low availability of fluid in these rocks (Bailes, 1980b) and white mica probably reappeared as a product of metasomatism during crystallization of the melt phase.

Muscovite and potassium feldspar-sillimanite distribution

Muscovite is relatively abundant in the southern part of the Kississing - Batty lakes area in potassium-rich rocks of the Missi Group, especially units 5c and 5e. Muscovite is very fine grained in felsic volcanic derived gneiss (5e) south of Lobstick Narrows, but near the migmatite front it is slightly coarser and more abundant; farther north in the migmatites it is much less abundant and is interpreted to be a retrograde phase. Evidence for prograde muscovite south of the migmatite front is its uniform distribution in apparently unaltered rocks and locally its intergranular texture. In these rocks potassium feldspar has a very fine granoblastic texture. It is interpreted to be microcline recrystallized from primary igneous potassium feldspar. Sillimanite exists where potassium feldspar occurs in isolated localities in the south, but the minerals are not in contact. The assemblage is restricted to veins that were probably injected into their host. The sillimanite forms elongated bundles of brownish fibrolite surrounded by quartz *(faserkiesel).* It is largely replaced by muscovite. In the north fibrolite has recrystallized to aggregates of small clear sillimanite. Microcline occurs commonly nearby in small porphyroblasts or coarser leucocratic mineral aggregates (leucosome).

CONDITIONS OF METAMORPHISM

The chemical composition of garnet, anthophyllite, cordierite and biotite at Star Lake have been used by Leroux (1989) to estimate peak conditions of *ca.* 660° C at *ca.* 7 kb, but pressure was determined with a large error. Pressure of slightly less than 6 kb is indicated by; (i) the regional absence of kyanite, (ii) sphalerite geobarometry (Goetz, 1980), and (iii) the position of reaction (7) on the petrogenetic grid of Carmichael (1987). Temperature estimated from reaction (8) on the P-T grid is *ca.* 700° C north of the migmatitic front.

Muscovite-free assemblages with garnet-sillimanite-staurolite and sillimanite-anthophyllite, indicative of *ca.* 660° at *ca.* 6 kb, exist south of the Kississing - Batty lakes area, at Syme Lake (Froese, written communication, 1992). Geothermometry and geobarometry in progress at the University of Calgary by T. Gordon (written communication, 1991) on rocks in the eastern and adjacent parts of the Batty Lake area, give preliminary results of metamorphic conditions of 550° C, 3.5 kb in the southeast (at File Lake) and 750° C, 6 kb in the northeast (at Burntwood Lake).

RETROGRADE METAMORPHISM

Retrograde mineral assemblages are best developed in late shear zones and areas of late-phase folding. The high-strain rocks contain white mica, chlorite, epidote, hematite and calcite. The most prominent zones of retrogression are in the fault zones along Nokomis Lake, south of Puffy Lake, north of Syme Lake (south of the map area) and along the Kississing River. In the late folds retrogression occurs on sets of brittle-ductile microfaults, several millimetres apart, parallel to, or cutting, the earlier fabrics.

Much of the regional distribution and texture of white mica, sillimanite and potassium feldspar are controlled by retrograde metamorphic reactions. White mica of unknown composition exists as a retrograde mineral throughout the highest-grade area and much of the white mica in the south has a late metamorphic paragenesis also. Most commonly the white mica is very fine grained and partly replaces plagioclase. Where late-stage deformation is prominent this clouding of plagioclase occurs in all units of quartzofeldspathic rocks. Slightly coarser grained white mica with a crosscutting fabric is partly a result of retrogression or late-stage potash metasomatism. Most sillimanite knots are partly replaced by muscovite. However, in some areas seemingly late muscovite is the product of prograde cation exchange reactions such as (4). In much of the rock the origin and composition of white mica is uncertain.

Potassium metasomatism of the Burntwood Suite to form garnet-free and retrograde muscovite-bearing rocks (2b and 2e) apparently took place locally along strike from bodies of two-mica leucogranite in the late stages of their crystallization or shortly afterwards. Typical retrograde textures in metagreywacke are corroded garnets rimmed with green biotite or nearly randomly oriented flakes of muscovite that crosscut partly bleached biotite grains that are aligned in the foliation.

STRUCTURE

INTRODUCTION

Structural analysis indicates that the high-grade paragneisses in the Kisseynew belt have been transported over the volcanic rocks on the margin of the Flin Flon belt. On the south flank of the Kisseynew belt the paragneisses (Burntwood Suite and Missi Group) are structurally interleaved with orthogneisses that include recognizable volcanic rocks. The gneisses overlie an infrastructure derived from intrusive and volcanic rocks (Amisk Group), and gneisses of uncertain origin (Sherridon Suite, Amisk Group equivalents). The gneisses in the infrastructure are consequently identified as high-grade equivalents of the rocks in the Flin Flon belt. Depositional contacts between the paragneisses and the metavolcanic succession are generally preserved where deformation is moderate but some contacts are interpreted as early faults.

The main displacement is interpreted to have occurred in three stages: first in fold nappes that had a southerly component of transport; then in nearly recumbent folds that deformed these nappes and show southwest transport; and finally in a system of regional NW-SE compression. Several gently NE-dipping detachment surfaces, which are situated in the northeast part of the Kississing - Batty lakes area are interpreted as ductile thrusts linked with the recumbent folds. Further work is required to test whether an extensional phase of metamorphic core complex formation followed the initial emplacement of nappes. Steeply dipping structures in the Kisseynew belt were formed during the latest stages of deformation, but steep structures that occur on the north margin of the Flin Flon belt started to develop much earlier.

HISTORY OF DEFORMATION

Patterns of cross folding and variations in structural trend provide evidence for polyphase deformation. The early deformation (D_1) occurred before deposition of the Missi Group. This deformation is evident in the southern part of the Kississing - Batty lakes area from cutoffs along the pre-Missi unconformity. Small fold nappes (large isoclinal recumbent folds) were developed during D_2, coeval with metamorphism, but before the thermal peak. A well developed subhorizontal foliation was formed at this time. These early structures were further attenuated, possibly by horizontal extension, and refolded on nearly recumbent D_3 folds during migmatization nearly at the thermal peak. Some D_3 folds die out against detachment zones. The youngest structures (D_4) form upright folds and related fault zones. The four stages in the structural evolution of the gneisses in the Kississing - Batty lakes area is outlined in Table 4 (modified after Zwanzig, 1990).

Table 4: History of Deformation

D_1	Pre-Missi deformation: development of steeply dipping margins of plutons, probably with attendant upright folding and faulting.
D_2	Pre- to peak-metamorphic deformation: development of regional foliation; formation of small fold nappes leading to crustal thickening, deep tectonic burial and high grade metamorphism.
D_3	Peak- to late-metamorphic deformation: continued flattening on a subhorizontal foliation and extensive boudinage; subsequent or intermittently synchronous recumbent to reclined folding with southwesterly transport but variable fold-trends; detachment occurred during folding; syntectonic granite intrusion and migmatization dated at 1815 Ma (Gordon *et al.*, 1990); north-side-up reverse-sinistral faulting along the Flin Flon belt north margin (Fig. 15).
D_4	Waning-metamorphic deformation: upright folding (north- to east-trending); steepening and folding of early structures; uplift and late pegmatite intrusion; east-side-up block faulting and possible south-side-up, dextral brittle faulting along the Flin Flon belt north margin (Fig. 15).

Pre-Missi deformation (D_1)

Steeply dipping contacts in the Amisk Group at the margin of dome-shaped pre-Missi intrusions such as that east of Spider Lake (G in Fig. 13) are interpreted to be preserved from D_1 deformation. Steeply dipping foliation occurs where the pre-Missi intrusions are weakly deformed, preserving a D_1 fabric. Locally a younger foliation in the Missi Group is also steep; however, in the older rocks it is coplanar with, and cannot be distinguished from, vertical D_1 structures.

The interpretation of pre-Missi deformation and significant uplift are supported by the presence of various units and local truncations beneath the unconformable base of the Missi Group. The unconformity generally has an acute cutoff angle because of high post-Missi strain. However, at Puffy Lake and northeast of Spider Lake it truncates parts of the Amisk Group and cuts down into pre-Missi intrusions. Near Moody Lake the unconformity seems to truncate the Burntwood Suite. D_1 folding or faulting is implied by these stratigraphic cutoffs. Evidence for pre-Missi (D_1) faulting is also suggested by the regional relationship between the unconformity in sequence 1 (Missi Group on Amisk Group and intrusions) and sequence 2 or 3 (Missi Group overlying a thin amphibolite unit or directly on Burntwood Suite). North of Spider Lake, and from Puffy Lake west to Piat Lake, and north to Jungle Lake, the unconformity is consistently in sequence 1 on one limb of a tight syncline, and sequence 2 on the other. This relationship is maintained for more than 50 km along strike. The Amisk Group and Burntwood Suite in these sequences represent different depositional environments and are likely in fault contact over a long strike length below the Missi Group. This fault must have formed during D_1.

Early fold nappes (D_2)

Major recumbent folds were formed during D_2 in the Missi and Burntwood paragneisses. These nappes were emplaced above the Missi conglomerate that lies unconformably on Amisk Group rocks and the early granitic intrusions of sequence 1. Deformation in the metasedimentary rocks is interpreted to have involved large-scale horizontal transport of sequences 2 and 3. During the early, low-grade metamorphic stages of D_2 the more competent rocks that compose sequence 1 in the Flin Flon belt may have acted as a rigid infrastructure .

The D_2 fold nappes are sheet-like and recognized only from stratigraphic reversals; their axial surfaces are assumed to lie within individual units of gneiss. Synclinal nappes that developed in the Missi Group and anticlinal nappes in the Burntwood Suite are the most recognizable D_2 structures. These structures were affected by later folding (Fig. 16). The D_2 structures are parallel to the regional foliation and were refolded by NE- to NW-trending cross folds and fault zones. Some D_2 folds are molded around the structural domes of orthogneiss. They are attenuated into ribbon-like structures in the southern and eastern mantle of the Sherridon - Hutchinson Lake complex. Around the Big Island and Adamson Lake domes, the lower nappe appears to have been disrupted during D_3 into large rootless folds or sheath folds. The part of the most southerly D_2 syncline that lies north of Spider Lake is upright. This fold may have formed in that attitude at the base of the fold pile during reactivation of D_1 structures or it may have been steepened at a late stage. The Sherridon Suite and much of unit 3 were probably part of the infrastructure that formed nappes during the latest stages of D_2.

The structural transport direction during D_2 may be approximated from the geometric relationship of the stratigraphic sequences and the proposed sedimentary facies changes within them. The relationship suggests a significant component of southerly transport of sequence 2 and 3.

Recumbent to reclined folding (D_3)

The third phase of deformation took place shortly after the thermal peak of metamorphism, after tectonic burial of the south flank under the D_2 nappes and development of early migmatitic *lits* and subhorizontal gneissic foliation. Large-scale boudinage and horizontally extended porphyroblasts with shallow-plunging pressure shadows imply D_3 horizontal extension and vertical compression of the early nappes, possibly during stretching of a D_2-thickened, thermally weakened crust. At this time the Defender Lake dome and possibly the Moody Lake dome may have been emplaced as metamorphic core complexes. Possible early D_3 normal faults may have placed slightly lower-grade

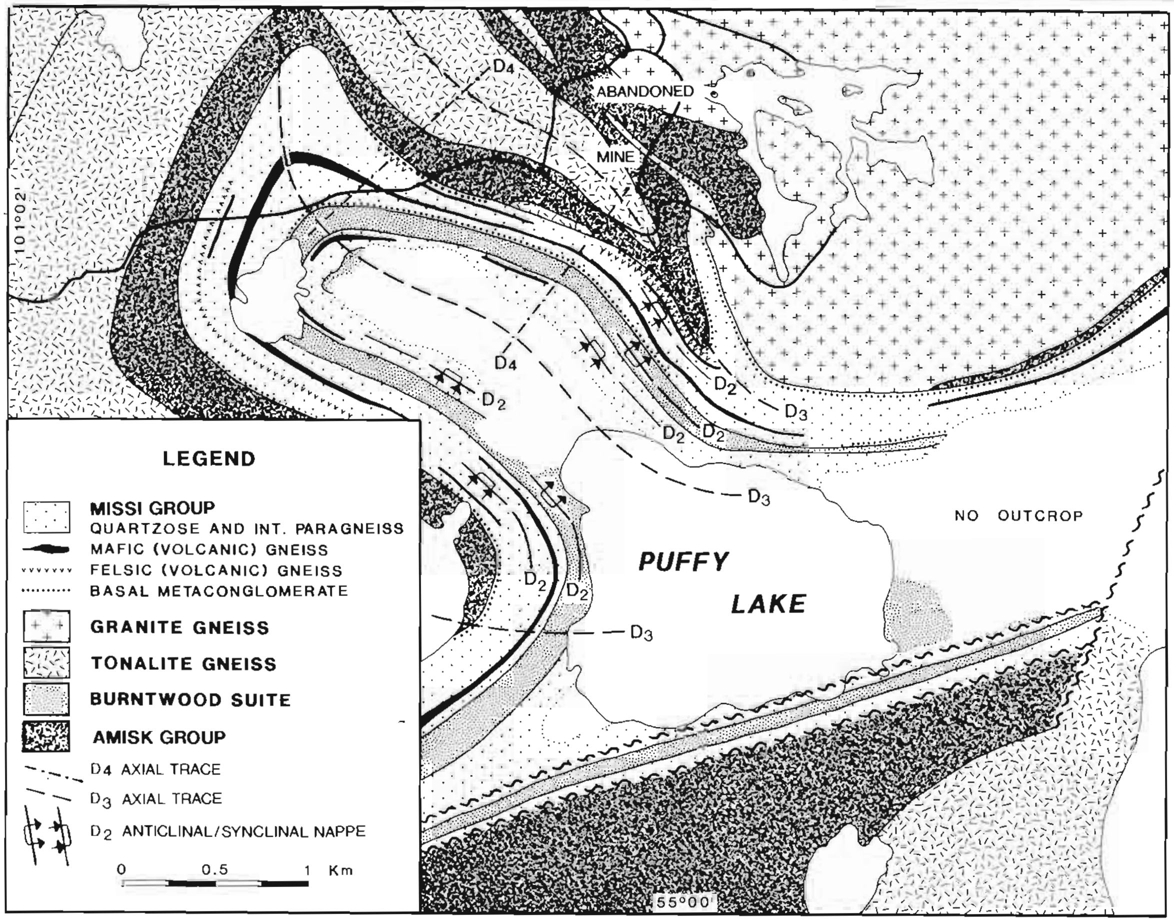


Fig. 16: *Map of the Puffy Lake area showing D_2 fold nappes, refolded during D_3 about NE-dipping axial surfaces (dashed lines), and during D_4 about upright axial planes (dash-dot lines).*

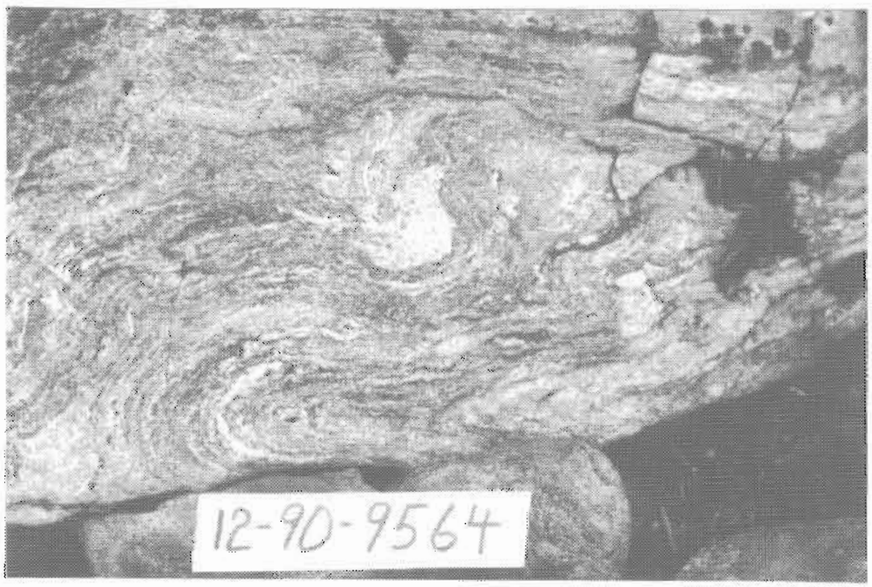


Fig. 17: *Missi conglomerate with pebbles highly stretched and transposed into the foliation during D_2, and then folded in the core of a major D_3 reclined fold southeast of Puffy Lake Mine.*

rocks on the domes. During the main stages of D_3 the migmatites in the core of the Kisseynew belt were transported SW over the south flank on a new set of large asymmetric recumbent folds. These folds were linked with detachment surfaces that locally developed into ductile shear zones. The D_3 deformation was thick skinned, and involved the paragneisses, metavolcanic rocks and intrusions. It resulted in subhorizontal to oblique upward displacement of the large orthogneiss complexes, smaller overturned granitic domes and closed structures (possible sheath folds).

The D_3 folds are superposed flexure (bending) folds of type 1 as described in model experiments (Skjernaa, 1975; Ghosh and Ramberg (1968). They involve the plutons of the Sherridon-Hutchinson Lake complex and Batty Lake complex, which were initially flattened. Some D_3 folds are disharmonic (Turner and Weiss, 1963), others box shaped and die out against straight belts of gneiss, a geometry that implies the existence of detachment surfaces. Some detachments are presently not obvious high-strain zones, but may have recrystallized during peak metamorphism. They appear to coincide with the axial surfaces of D_2 synclines. The linkage of the two ages of structures indicates reactivation of D_2 folds during D_3. In the Kisseynew belt core zone some detachment surfaces are intruded by large sheets of leucogranite (Zwanzig, 1990a).

The D_3 major folds trend NE to NW and are superposed on the earlier structures. Axial surfaces dip easterly at moderate to shallow angles. In some areas the regional foliation is axial planar to the folds, but generally it is involved in the folding (Fig. 17). Veins of migmatitic leucosome developed near the thermal peak of regional metamorphism clearly show a synkinematic relationship to D_3 folds. Some veins are folded for part of their length, but change direction and cut across the layering, thus becoming parallel to the axial plane (Fig. 18). Most of the veins and *lits* in the Burntwood Suite are folded in D_3 structures. The direction of plunge is variable. It depends on the earlier geometry upon which the folds were superposed and on the amount and direction of stretching and rotation of the hinges during advanced stages of D_3 and later deformation. The folds are commonly asymmetric, S-shaped and west- to NW-verging, south- to SW-verging or sheath shaped with a gentle NE plunge and `hair pin' bends in plunge closing upwards and to the southwest. The preferred NE plunge and common alignment of hinge lines with mineral (stretch) lineations is consistent with SW tectonic transport in an area of high ductile noncoaxial strain (Hanmer and Passhier, 1991). Absence of NE-verging folds is strong support for this conclusion. A second preferred orientation of hinge lines is WNW-ESE. These folds are coeval and coplanar with those of different orientations and may have formed in the plane of flow but perpendicular to the direction of flow.

Upright folding and ductile to brittle deformation (D_3-D_4)

Late structures comprise a system of upright folds, faults, shear zones, kinks and crenulations. They are concentrated in northerly and easterly trending zones, which lend a block pattern to parts of the Kississing - Batty lakes area. North- to east-trending upright folds affecting older structures are all assigned to D_4. They are open to closed flexure folds with variable plunge. Easterly trending upright folds may have reactivated an older fabric or formed during early stages of D_4. North to NE-trending upright antiforms commonly have a steeper west limb (Fig. 19). Together, these structures record NW-SE compression, which is also documented as a late feature elsewhere in the Kisseynew belt (Zwanzig, 1990a). The plunge lies at the intersection of the previously deformed layering and the steeply dipping axial planes. Large box-shaped folds are commonly detached from planar gneisses along fault zones. Locally, a steeply E-dipping NNE-trending crenulation cleavage is developed (Fig. 20) and in many places large NNE-trending pegmatite dykes have intruded D_4 axial planes.

Northerly trending fault zones containing retrograde mineral assemblages were developed during the latest stages of D_4 (Fig. 15). Preliminary observations on stratigraphic separation and slickensides suggest that the northerly tending faults are upthrown on the east side. Other high-strain zones have a long history of deformation that is not presently resolved. On the north margin of the Flin Flon belt, ductile and locally brittle deformation that produced shear zones with sinistral reverse displacement is assigned to D_3. In these easterly trending zones small faults, fault breccia and pseudotachylite overprint the shear zones (Fig. 21). Some retrogression occurs also in these

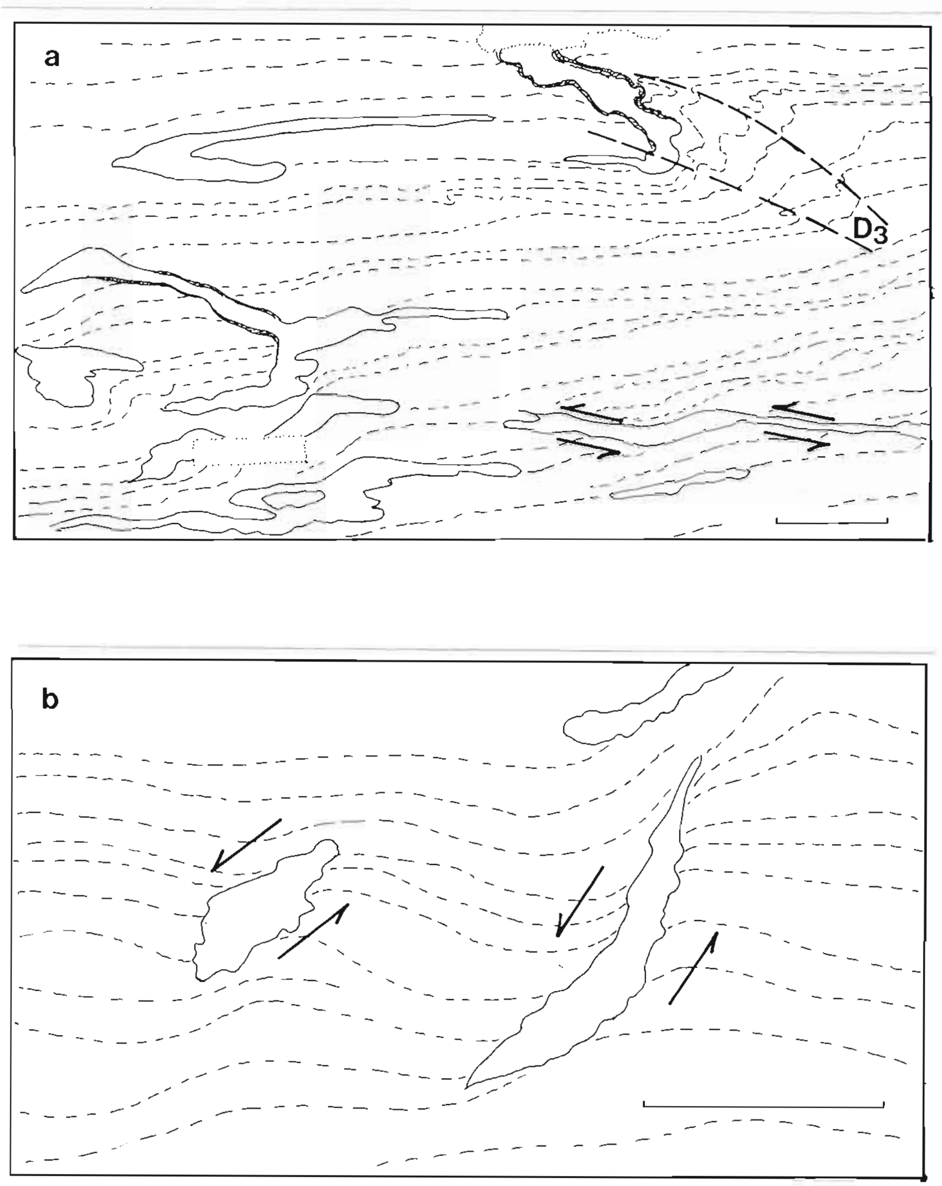


Fig. 18: *Syntectonic veins (shown in solid lines) in the Missi Group (5b) at Jungle Lake intrude the axial planes (heavy dashed lines in 18a) of D_3 minor folds in layering (light dashed lines) and related compressional shear bands (arrows in 18a). Vein injection implies hydraulic fracturing in the migmatite. Extensional shear bands (18b) contain veins with pegmatitic texture and diffuse margins. These veins also show sinistral displacement (arrows in 18b), consistent with the S-shaped folds. Scale bars are 10 cm long.*

Fig. 19: *Open, upright D_4 fold in metagreywacke (2a), Evans Lake. Observer is looking north, down the shallow plunge. Tape is 10 cm long.*

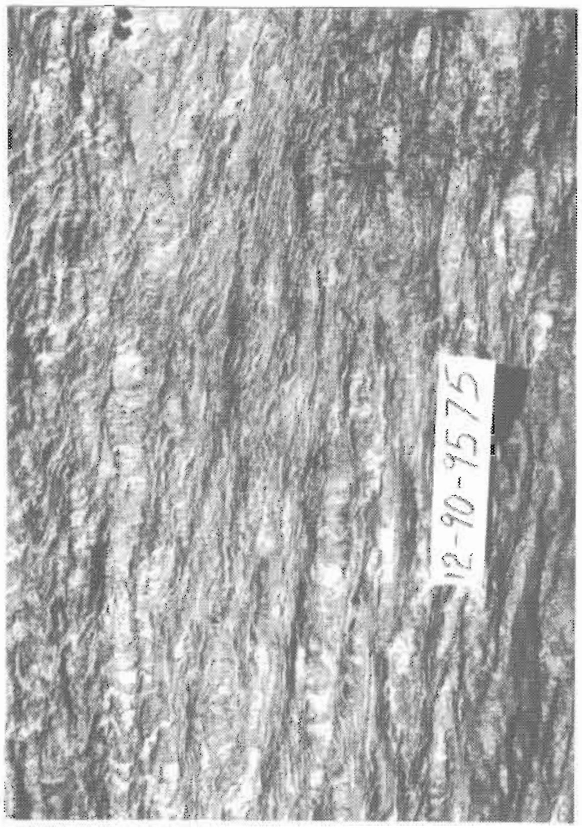


Fig. 20: *Steeply dipping, NNE-tending crenulation cleavage formed during D_4 in Missi Group mafic porphyritic rock (5g), Evans Lake.*

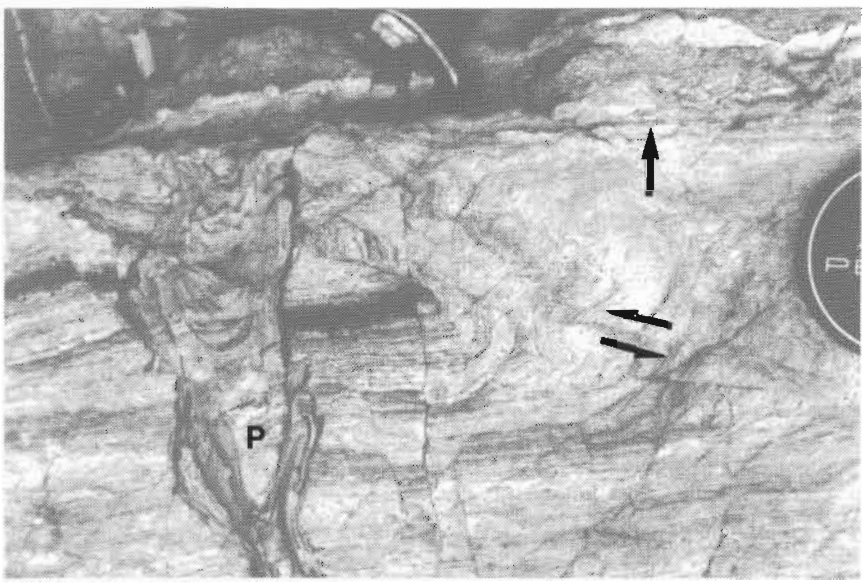


Fig. 21: *Fault (single arrow), fold and small faults with sinistral displacement (arrows) in mylonitic gneiss cut by wedge-shaped pseudotachylite (P), Kississing River shear zone.*

zones, but the timing of the deformation is uncertain. Under conditions of high fluid pressure some brittle structures may have formed at high temperature. Small, late WNW-striking faults apparently have dextral separation and associated flexure folds and crenulations have a consistent dextral asymmetry.

STRUCTURAL GEOMETRY AND FABRICS

Structural Domains

Three easterly trending structural domains have been delineated based on metamorphic grade, lithology and variations in the age and style of the dominant structures (Fig. 22). These are from south to north: (i) the north margin of the Flin Flon belt, which is underlain by predominant volcanic and intrusive rocks that have retained their early steep fabric; (ii) the south flank of the Kisseynew belt, which was derived from intrusive, volcanic and sedimentary rocks in an interleaved succession showing recumbent folds; and (iii) part of the core zone of the Kisseynew belt, where shallow-dipping gneisses were derived from the Burntwood Suite of metasedimentary rocks, and intrusive rocks.

The nature of the boundary between the Flin Flon belt and the south flank of the Kisseynew belt is complex. This boundary has been set at the sillimanite-garnet isograd (Bailes, 1979). However, the isograd is defined only east of the Kississing - Batty lakes area in Manitoba and to the west in Saskatchewan (Ashton *et al.*, 1992). Rocks of appropriate composition to develop sillimanite from muscovite-staurolite-quartz are absent in the most southerly part of the Kississing - Batty lakes area, or were modified by retrograde reactions and deformation. Between Kisseynew Lake and Evans Lake the north boundary of the Flin Flon belt is marked by (1) an increase in metamorphic grain size, (2) the southern limit of Burntwood Suite pelites that locally contain sillimanite, (3) the southern limit of structurally transported paragneisses, and (4) the change from steeply dipping structures to recumbent folds. Each of these transitions defines a slightly different line in a zone of change that is several kilometres wide. Sillimanite at Syme Lake suggests that the isograd lies south of the structural and textural boundaries. High-strain zones, south of Puffy Lake, and north of Syme Lake have locally disrupted the structural continuity, and in this report are considered to be the local boundary between the Flin Flon belt and the Kisseynew belt. The stratigraphic contact between the Amisk and the Missi groups is generally preserved from Lobstick Narrows to Evans Lake so that, in areas that are not disrupted by high strain, the southern limit of the Burntwood Suite is taken to be the boundary. The Flin Flon belt margin steps south along the Elbow Lake - Moody Creek fault zone because the more highly recrystallized rocks east of the Evans Lake are best considered part of the Kisseynew belt.

The boundary between northern and central domains is marked by a sharp increase in magnetic signature produced by the change from predominantly, graphitic greywacke derived migmatites (Burntwood Suite) to magnetite-bearing rocks comprising orthogneisses (6-9), paragneisses (Missi Group) and rare amphibolite, all interleaved with units of the Burntwood Suite.

The large-scale map units and the intermediate-scale fabric of each domain are controlled by local structures such as the granitic complexes. Consequently the fold pattern is noncylindrical and the trend of fold axes is highly variable (Fig. 23). The regional structure is therefore analyzed in a series of typical subareas in which the axes have consistent orientations (Fig. 22).

Flin Flon belt north margin (Southern domain)

The part of the Flin Flon belt that has been remapped during this project or by Froese (1984) extends from the south shore of Kisseynew Lake east-northeast to an area south of Evans Lake. Part of this domain is not shown on the enclosed maps, but the simplified geology is shown in Figures 22 and 23. Post-Missi structures (D_2-D_4) predominate in this part of the Flin Flon belt, but the effects of pre-Missi deformation (D_1) are also recognized. The extended structural history is preserved in the rocks around Spider Lake, where they were partly protected from later deformation by the adjacent granitic domes. The domain is considered to be the autochthonous reference point for structural displacements in the Kississing - Batty lakes area. The other domains are interpreted to have been displaced toward the southwest, overriding the Flin Flon belt and each other.

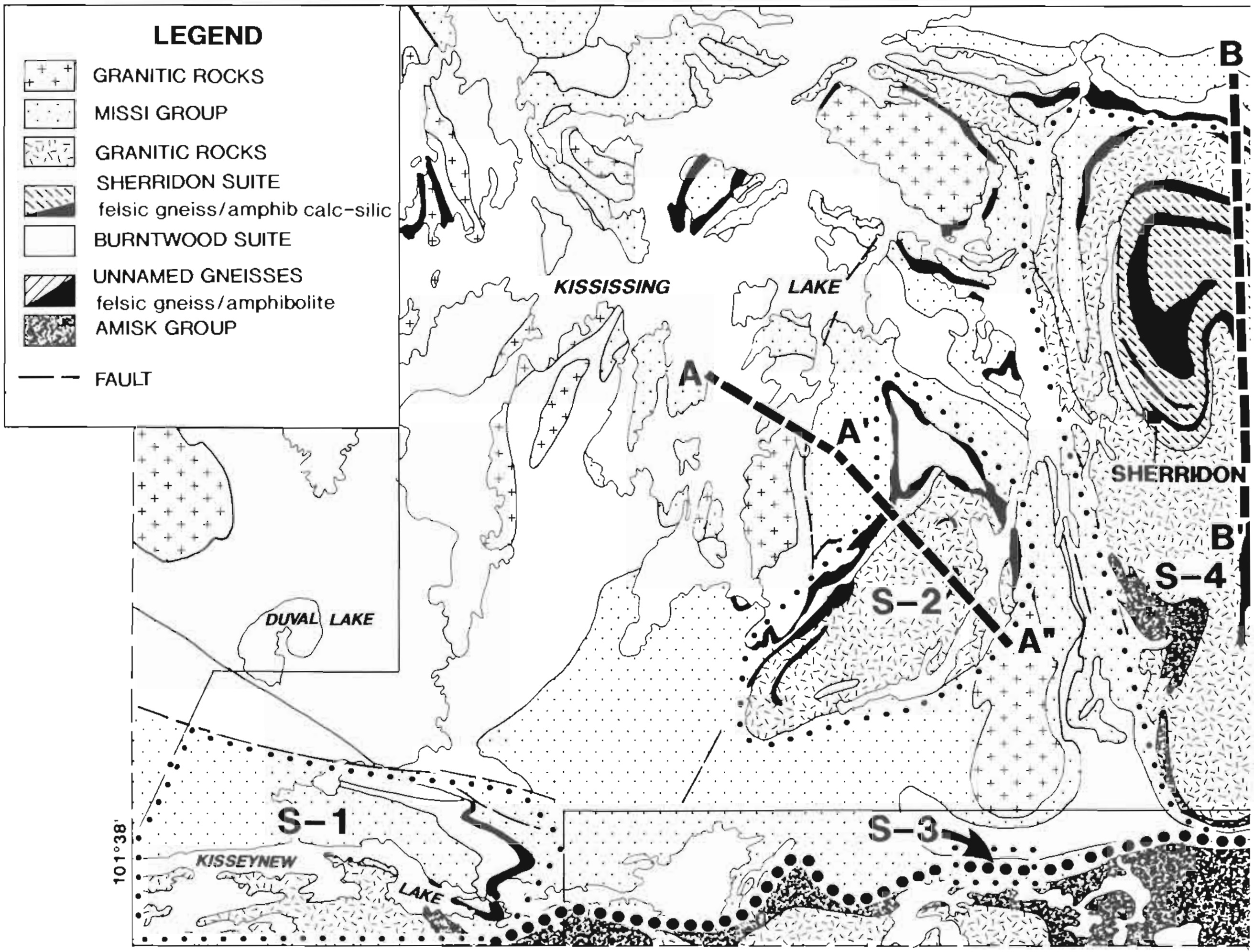


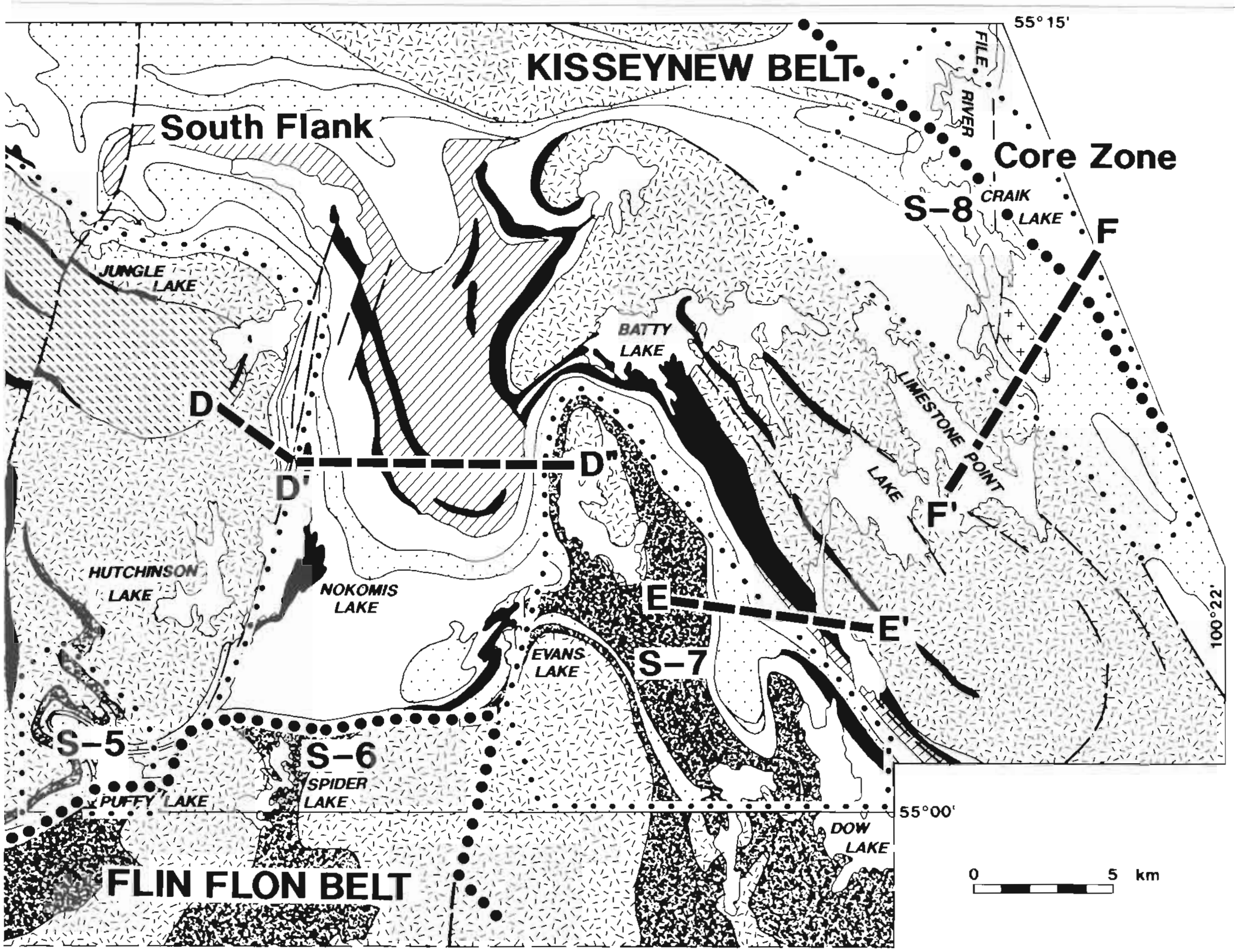
Fig. 22: Simplified map of the Kississing - Batty lakes area, showing locations of the following:

- *Lithostructural domains (Kisseynew Belt Core Zone, South Flank and Flin Flon belt), separated by bold dots;*
- *Subareas analyzed in detail (**S-1** to **S-8**), outlined by small dots; for explanation see text;*
- *Lines of structure sections (A-A'-A" to F-F').*

SPIDER LAKE SUBAREA

Most supracrustal rocks in the subarea have a fine grained metamorphic texture; intrusive rocks have retained igneous textures such as relict oscillatory zoning of plagioclase. The subarea spans parts of two tonalite intrusions at Spider Lake and their mantles of Amisk Group volcanic rocks with hypabyssal intrusions (**S-6** in Fig. 22). These rocks are unconformably overlain by Missi Group rocks along the north margin of the subarea. Along the west part of this margin there are shear zones situated north of Syme Lake. The eastern limit of the subarea is the extension of the Elbow Lake shear zone (Syme, 1991).

The area has a distinctive structural style characterized by steeply dipping foliation and upright folds. Generally, the Amisk Group rocks dip away from the pre-Missi tonalite domes in a pattern that is related to the original shape of the intrusions. Minor fold axes in the supracrustal rocks have a steep plunge. Folding is noncylindrical and foliation poles are not distributed along a great circle on a stereo plot (Fig. 24a). Linear fabrics have a plunge that changes from one part of the area to another.



This fabric is interpreted to have formed progressively and in distinctive stages during pre- and post-Missi deformation. The earliest deformation (D_1) is indicated by steep contacts and parallel foliation preserved between weakly deformed pre-Missi plutons and their Amisk Group host rocks. The narrow belts of Amisk Group rocks are roof pendants that were eroded before deposition of Missi conglomerate to a crustal depth where foliation produced by contact strain must have had a steep dip. Northeast of Spider Lake the unconformity truncates a tonalitic injection complex hosted in Amisk Group biotite schist that had a strong pre-Missi fabric. The presence of a single main schistosity (S_{1-3}) in the rock is interpreted to be the result of coplanar pre- and post-Missi deformation (D_1-D_3). The latest stages of deformation are indicated by D_4 folding of S_{1-3}.

A roof pendant south of Evans Lake shows increasing metamorphic grade from the roof zone south to the enclave between two plutons along the east boundary of the domain (Fig. 22). The contact metamorphism that produced the gradation predated the Missi Group and is probably related to D_1.

Kisseynew south flank (Central domain)

The south flank of the Kisseynew belt forms a central domain that encompasses the greater part of the Kississing - Batty lakes area. This domain lies structurally above the Flin Flon belt (Zwanzig, 1990), and the various gneisses within it display large D_3 reclined to recumbent folds, linked detachment surfaces and high-strain zones that are interpreted to indicate southwest transport.

Nevertheless, the internal displacement in this domain was dominated by the earlier (D_2) emplacement of nappes that are recognizable despite overprinting by D_3 and D_4 deformation.

The gneisses are arranged in structural levels that are represented by sequences 1-3, and that display different structural styles. Some levels with large S-shaped or tongue-shaped folds alternate with planar panels of NE-dipping gneisses. Such folds die out upward against the planar gneisses, which they apparently carried, piggy back, and which were probably separated from them by unmapped detachment surfaces. Orientations of fold axes also vary with structural level, locally alternating between NE and NW-SE (Fig. 22).

The rocks in the deepest level comprise intrusive orthogneisses, various gneisses interpreted as highly metamorphosed volcanic rocks (Amisk Group) and coarse grained gneisses of uncertain origin (Sherridon Suite and unit 3h). All of these rocks are tentatively assigned to the magmatic arc assemblage (sequence 1) and may represent more highly metamorphosed equivalents of rocks in the

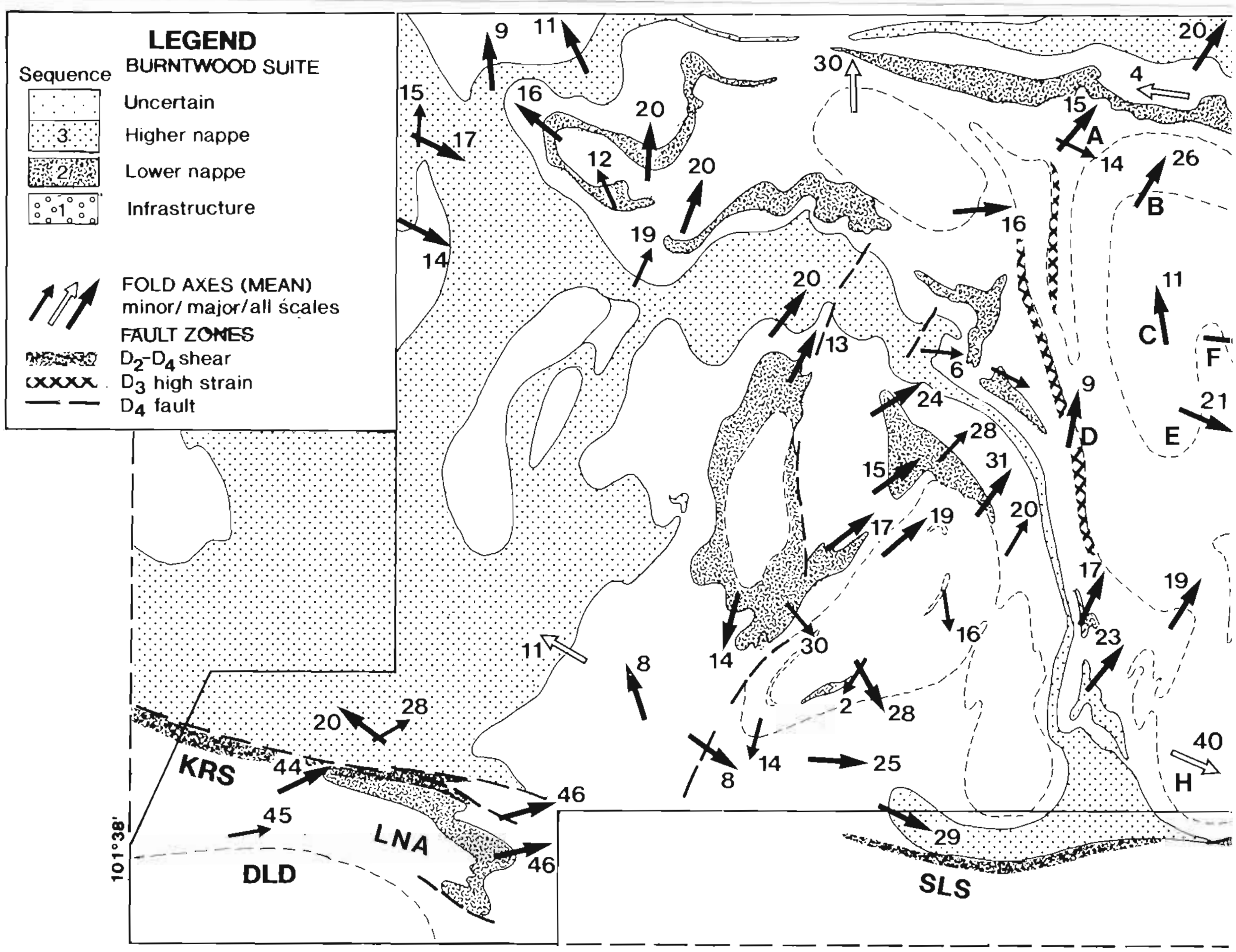
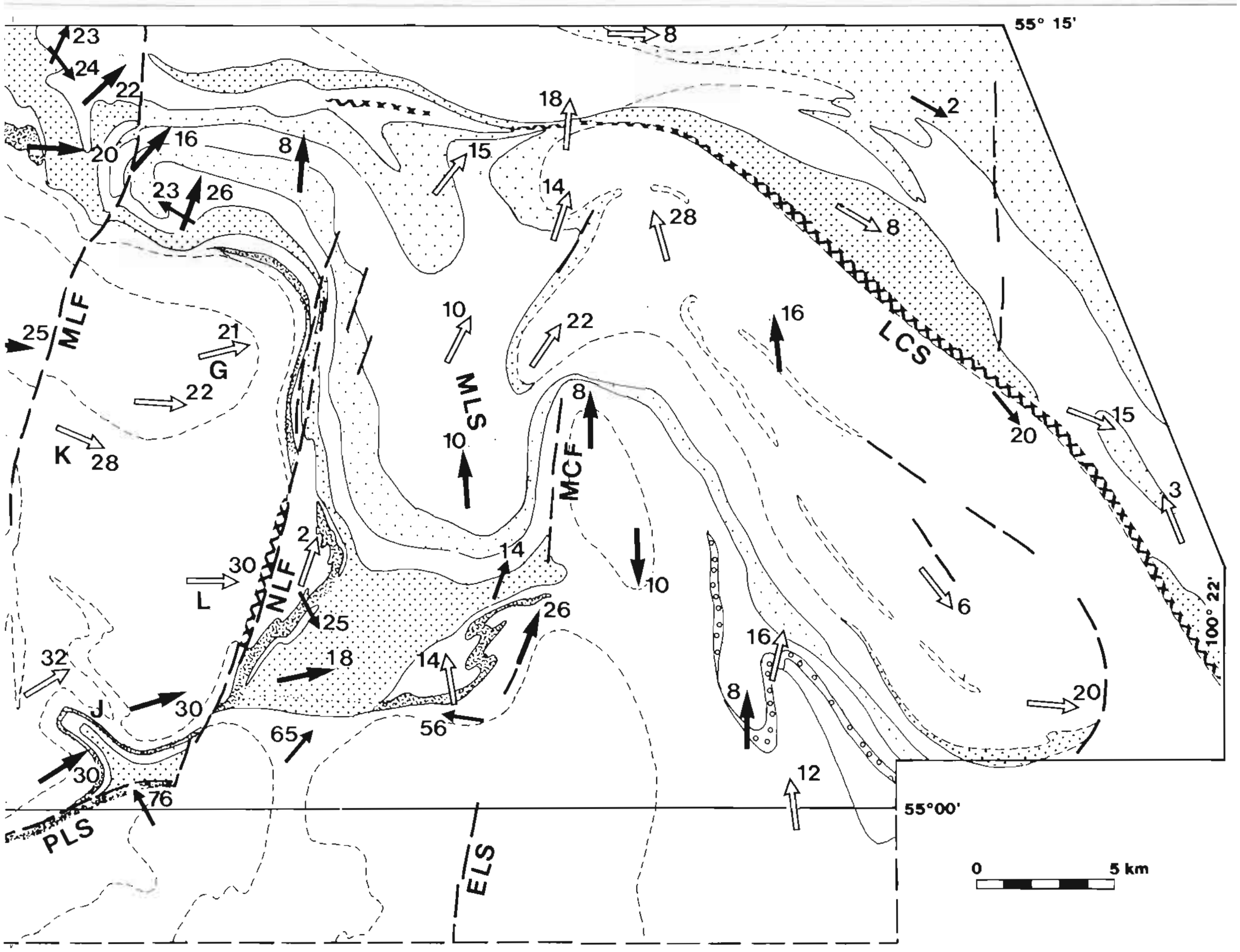


Fig. 23: Interpretive structure map of the Kississing - Batty lakes area, showing the following features:

- *Burntwood Suite gneisses (patterned) as assigned to three structural levels representing para-autochthonous infrastructure and the overlying anticlinal D_2 nappes; different stratigraphic sequences in successive levels are interpreted as proximal to distal facies, (1) magmatic arc, (2) basin-margin and (3) deeper basin.*
- *Average azimuth and plunge of fold axes (mainly D_3), taken from stereograms (not shown) of 88 structural subareas; axes A to L are shown on Figure 28;*

Flin Flon belt. These infrastructural rocks occur in large overturned granitic domes and culminations that are a product of mainly D_2 and D_3 deformation. The largest culminations are the Defender Lake dome, the Batty Lake complex and the Sherridon - Hutchinson Lake complex. During the advanced stages of deformation (D_3-D_4) strain was concentrated around the granitic complexes in strike faults and northerly trending transverse folds and faults (Fig. 23).

Intermediate structural levels comprise sequences 2 and 3, which are dominated by highly attenuated D_2 fold nappes of paragneisses. Two or three pairs of fold nappes are stacked, one on top of the other, in the late synforms, and extend across the infrastructural culminations. The nappes are well preserved in the Meat Lake synform (MLS in Fig. 23), which lies between the Sherridon - Hutchinson Lake complex and the Moody Lake dome. Other large areas of paragneiss surround the granitic complexes at Kississing Lake. Each of the proposed nappes is developed in a somewhat different stratigraphic sequence (Fig. 23). A lower synclinal nappe in the Missi Group generally lies



♦ *Main faults and ductile shear zones according to stages of displacement.*

Acronyms: DLD - Defender Lake dome; ELS - Elbow Lake shear zone (northern extension); KRS - Kississing River shear zone; PLS - Puffy Lake shear zone; LCS - Limestone Creek high stain zone; LNA - Lobstick Narrows antiform, MCF - Moody Creek fault; MLF - Molly Lake fault; MLS - Meat Lake synform; NLF - Nokomis Lake fault. Contacts with intrusive complexes are dashed.

with one limb on orthogneisses or on Amisk Group rocks of sequence 1. This limb is upright except where it was overturned in D_3 folds. The Missi Group contains coarse grained quartzose metasandstone with scattered pebbles and local conglomerate beds. The unconformity is preserved along much of the lower contact. In the inverted limb the Missi Group is in contact with a thin amphibolite and Burntwood Suite metagreywacke of sequence 2, which forms the core of the overlying anticlinal nappe. In numerous localities the unconformity with basal conglomerate is also preserved in the inverted limb.

The higher pair of fold nappes is developed in sequence 3 where amphibolite and conglomerate are absent, and Burntwood Suite metagreywacke is in direct, structurally conformable contact with metasandstone of the Missi Group. This architecture of sedimentary facies in successive nappes is consistent with a hypothesis of simple structural telescoping during D_2: basin facies were emplaced at the higher levels over basin-margin facies that were, in turn, emplaced over the magmatic arc facies.

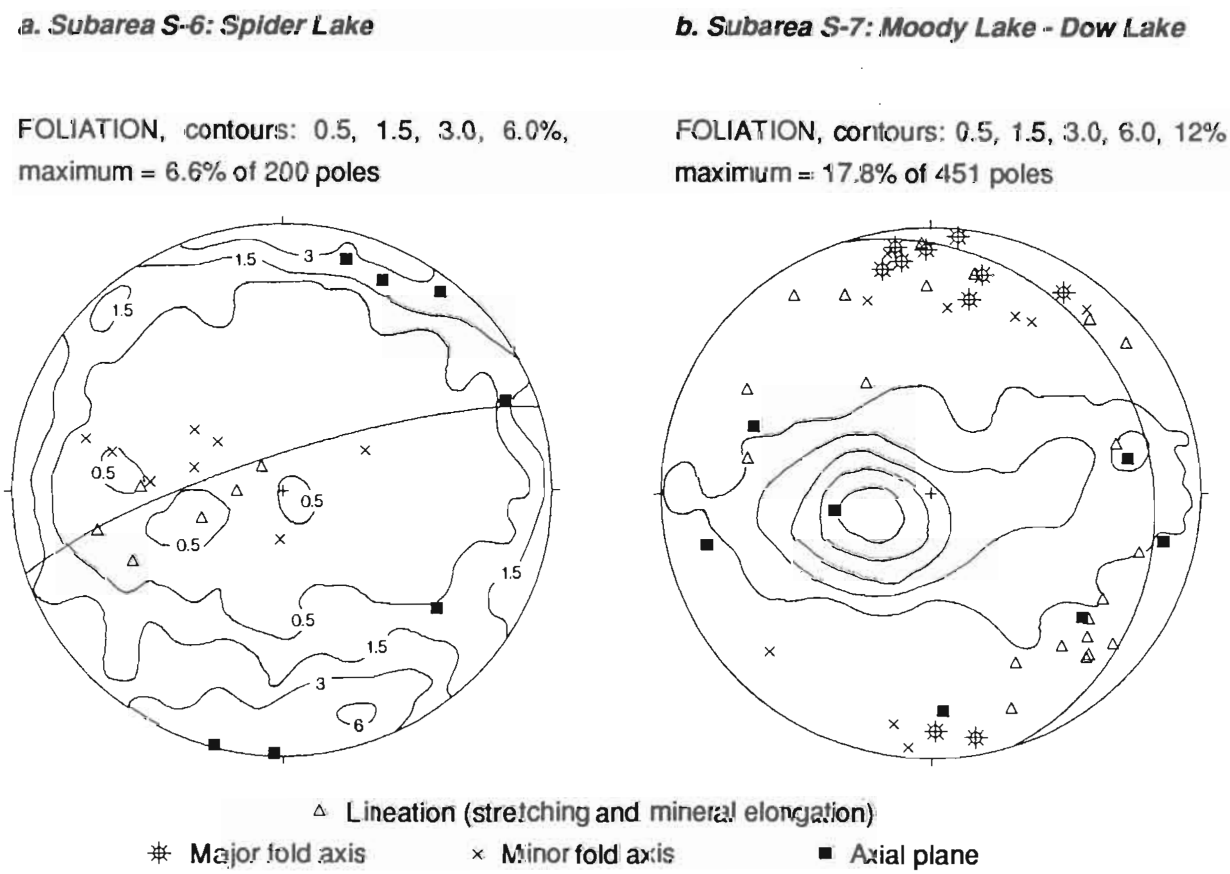


Fig. 24: Equal area stereoplots of various subfabrics; for location of subareas see Figure 22.

-a: Spider Lake subarea (Flin Flon domain), showing contours of poles to foliation with a great circle representing the mean strike and dip (steep). Minor fold axes and lineations have a variable to steep plunge.

-b Moody Lake - Dow Lake subarea (Kisseynew south flank), showing shallow-dipping fabric of recumbent folds with a concentration of poles to foliation (contoured). The girdle axis and fold axes have a shallow, northerly plunge. Lineations are scattered in the shallow, E-dipping D_3 plane of flow (great circle).

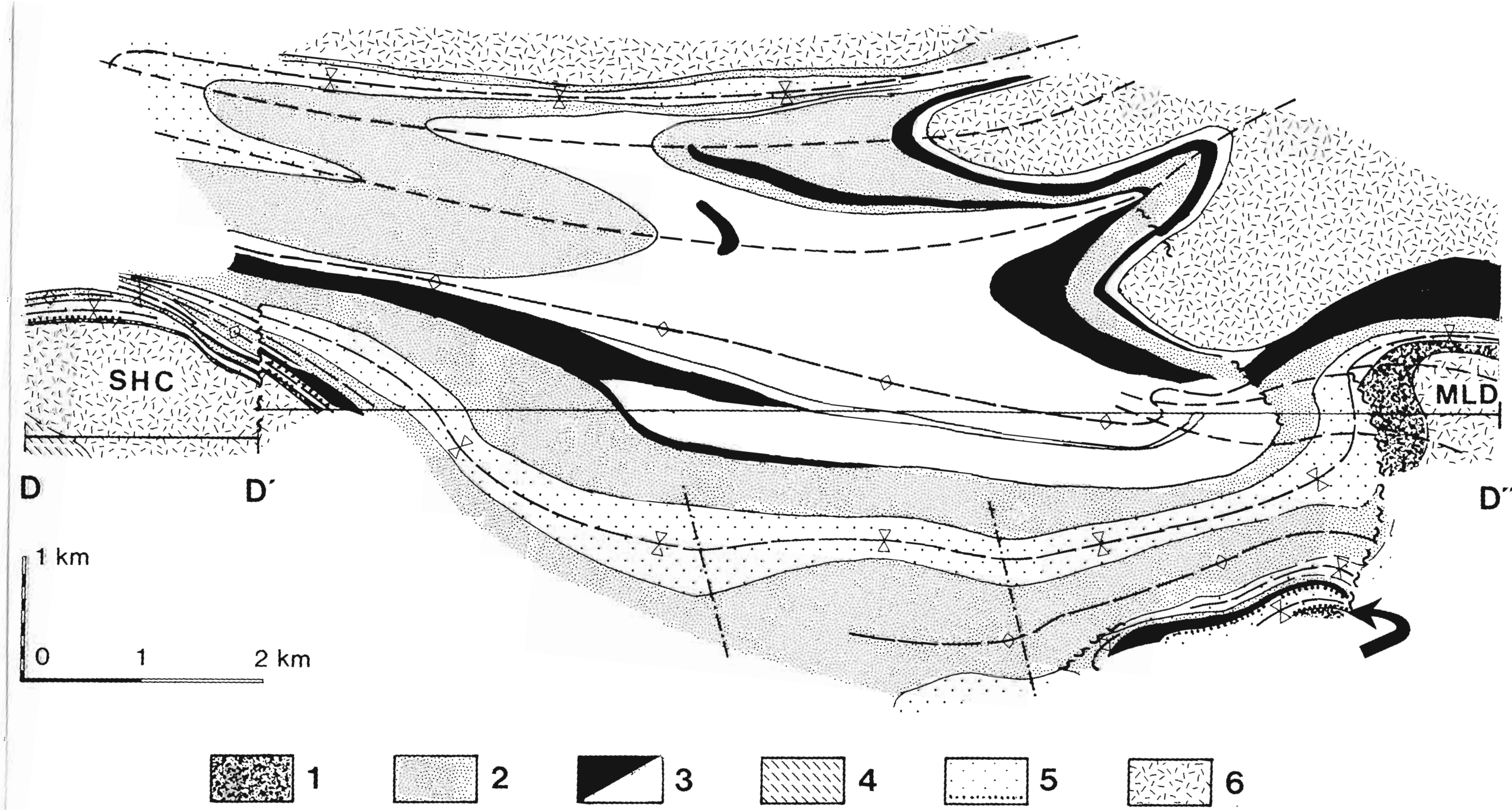


Fig. 25: *Composite vertical structure section of the Meat Lake synform, viewed towards the north, and showing the following features:*

- *Structural culminations, SHC - Sherridon - Hutchinson Lake complex, MLD - Moody Lake dome;*
- *D_2 fold nappes (ornamented dashed line as axial surfaces);*
- *D_3 recumbent folds (short dashes as axial surfaces);*
- *D_4 upright open folds (dash-dot line as axial surfaces).*

Units: 1 - Amisk Group, 2 - Burntwood Suite, 3 - unnamed amphibolite / felsic gneiss, 4 - Sherridon Suite, 5 - Missi Group (dots are basal conglomerate, eg. arrow), 6 - granitic rocks.
Section is nearly vertical; line of section is shown on Fig. 22.

MOODY LAKE - DOW LAKE SUBAREA

This subarea (**S-7** in Fig. 22) is the most northerly salient of relatively well preserved Amisk Group rocks, which surround the Drury Lakes and Moody Lake granitic domes (H and I in Fig. 13), and are unconformably overlain by the Missi Group. The rocks belongs to sequence 1 and in the infrastructure of the Kisseynew belt south flank. These rocks extend from the Elbow Lake shear zone - Moody Creek fault zone (ELS - MCF in Fig. 23) east to the straight belt of gneisses adjacent to the Batty Lake complex and southeast into the lower-grade rocks of the Flin Flon belt. The stratigraphy in the subarea is similar to that at Spider Lake but amphibolite interpreted as metabasalt is more schistose. The granitic rocks are highly recrystallized and contain local garnet and sillimanite at Moody Lake. The structure is characterized by recumbent folds typical of the south flank of the Kisseynew belt.

A belt of large S-shaped fold pairs extends northwest across the subarea from Dow Lake to an area beyond the Moody Lake dome. The folds are typical D_3 structures with NNW-trending axial surfaces, overturned to the west and nearly recumbent. They formed in the footwall of the straight belt of supracrustal gneisses, underneath the Batty Lake complex. The fold pair northwest of Dow Lake has nearly isoclinal limbs dipping east at *ca.* 15°. The plunge is northerly at a shallow angle (girdle axis = 5° towards 354° (Fig. 24b)). Linear structures are highly dispersed in the plane of flow. Granitic rocks (6b and 9) involved in the folding have extreme flaser texture and augen structure, and attest to high ductile strain during D_3. The asymmetry of the S-folds suggests that the overlying supracrustal rocks and the Batty Lake complex were transported piggy back towards the west or southwest during the folding of the infrastructure.

The D_3 S-folds form a belt of large intrafolial structures that were apparently detached from the underlying and overlying gneisses. The folds die out upward such that the Missi Group in the hinge zone of the overlying D_2 syncline apparently became a ductile detachment zone (Fig. 26).

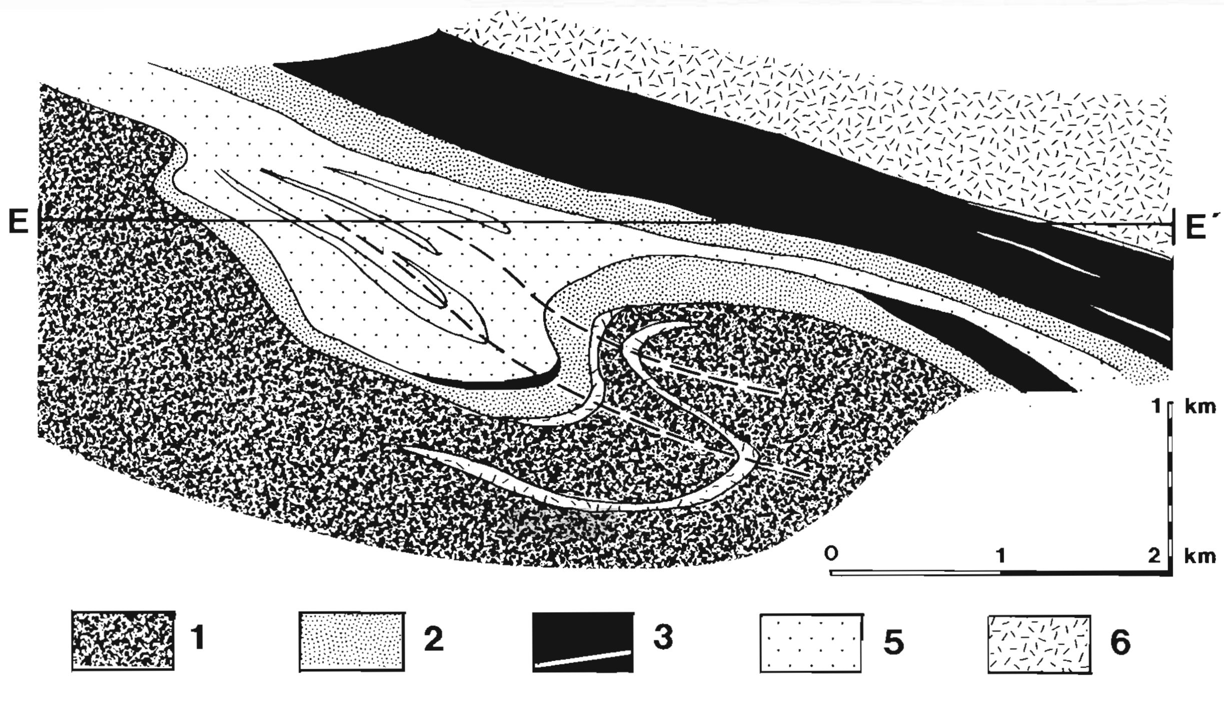


Fig. 26: Vertical structure section of the area northwest of Dow Lake, viewed towards the north, and showing S-shaped D_3 fold pair; traces of axial surfaces are dashed lines; the folds die out upward in the Missi Group gneiss that is interpreted to occupy a D_2 synclinal fold nappe.

1 - Amisk Group, 2 - Burntwood Suite, 3 - mafic to felsic gneiss, 5 - Missi Group, 6 - tonalite gneiss (Batty Lake complex). Line of section is shown on Figure 22.

The recumbent structures also die out downwards and towards the southwest across the Drury Lakes dome. There is a transition within the dome from shallow-dipping gneissic rocks in the northeast to better preserved granitic rocks in the west with steeper, but weaker, foliation. The gneissosity is oblique to the easterly striking upright structures that occur farther west in the Spider Lake subarea. These relationships indicate that during D_3 upright granitic domes, like those in the Flin Flon belt, were overturned towards the west, and were flattened and sheared in the plane of the shallow dipping gneissosity in the Kisseynew belt. The west side of the overturned domes were locally cut by later northerly trending faults in the northern extension of the Elbow Lake shear zone.

SHERRIDON - HUTCHINSON LAKE COMPLEX

The Sherridon - Hutchinson Lake complex (**S-4** in Fig. 22 and F in Fig. 13) is considered to be a large culmination or refolded nappe in infrastructure of the Kisseynew belt south flank. Unlike the Moody Lake - Dow Lake subarea, which is stratigraphically connected to the Flin Flon belt, the Sherridon - Hutchinson Lake domain is separated from the Flin Flon belt by a narrow belt of paragneisses and a mylonite zone along the south shore of Puffy Lake. Nevertheless, the rocks within the complex resemble high-grade equivalents from the Flin Flon belt. They are interpreted to have developed from a group of pre-Missi plutons and their host rocks. Gneissic tonalite and granite (6b and 9) occur throughout the complex; Sherridon Suite gneisses (4a-4i) occur in the north half of the complex, and Amisk Group gneisses in the south (Fig. 22). The Sherridon Suite may represent a window into a highly metamorphosed structural level below the granitic rocks. It is interpreted to occupy an upward and southwesterly closing tongue-shaped fold or overturned dome in the core of the complex. The Amisk Group occupies a roof zone and forms large screens on the south side of the complex. The Missi unconformity extends around the outside of the granitic rocks, and truncates the Amisk Group screens. The unconformity and overlying nappes of paragneisses were apparently continuous over the top of the complex, and extend for an unknown distance beneath it.

The interpretation that the Sherridon complex is a structural culmination is supported by the systematic variations in dip and plunge defined by large folds within the complex and its mantle. Dips on the margin of the complex vary from nearly vertical, on parts of the south side, shallow to moderate towards ENE on the west side, and shallow N and E on the north and east sides. The structure is highly flattened and interpreted to close towards the south, and extend to the northeast at depth (Fig. 27). Earlier interpretations have included a dome-shaped structure (Bateman and Harrison, (1946) but Robertson (1953) favoured a basinal shape for the Sherridon structure. The northerly trending Sheila Lake fold (F in Fig. 23) and the NW-trending folds at Puffy Lake (J) are D_3 structures that considerably modified the geometry of the complex to point to the earlier interpretation as a basin.

Plunge of fold axes vary from NNE in the area northwest of the core structure to ENE on the southeast side (Figs 23 and 28a). All axes lie in the 25° ENE-dipping plane of flow defined by D_3 structures as in the Moody Lake - Dow Lake subarea and elsewhere on the south flank. Plunge diverges about the centre of the Sherridon structure, supporting the interpretation that the body is rooted at depth and to the northeast. The variation appears to represent a smooth hair-pin turn open to the NE and possibly due to sheath folding. The geometry provides support for SW displacement and stretching during D_3. This affected the already complex upright and recumbent fold patterns produced during D_1 and D_2.

The gneisses along the margins of the Sherridon - Hutchinson Lake complex generally have a very strong late metamorphic fabric; a number of closely spaced curvilinear high-strain zones underlie the complex on the west. The structural geometry in the hanging wall northwest of Cold Lake (Sherridon) is dominated by a gently N-plunging synform containing Missi Group in the core. Its geometry is similar to the S-shaped folds near Dow Lake. A zone of rootless recumbent folds in the footwall of the high-strain zones was apparently developed from an adjacent D_2 anticlinal nappe where it was overturned and overridden by the Sherridon - Hutchinson Lake complex during D_3.

A younger, brittle-ductile structure, the Nokomis Lake fault zone (NLF in Fig. 23), lies on the east side of the Sherridon - Hutchinson Lake complex. It extends from the margin of the Flin Flon domain, where it truncates the Puffy Lake shear zone and dies out to the north at Walton Lake. It is interpreted to be a D_4 structure superimposed on a D_3 high-stain zone. This zone features 500 m of

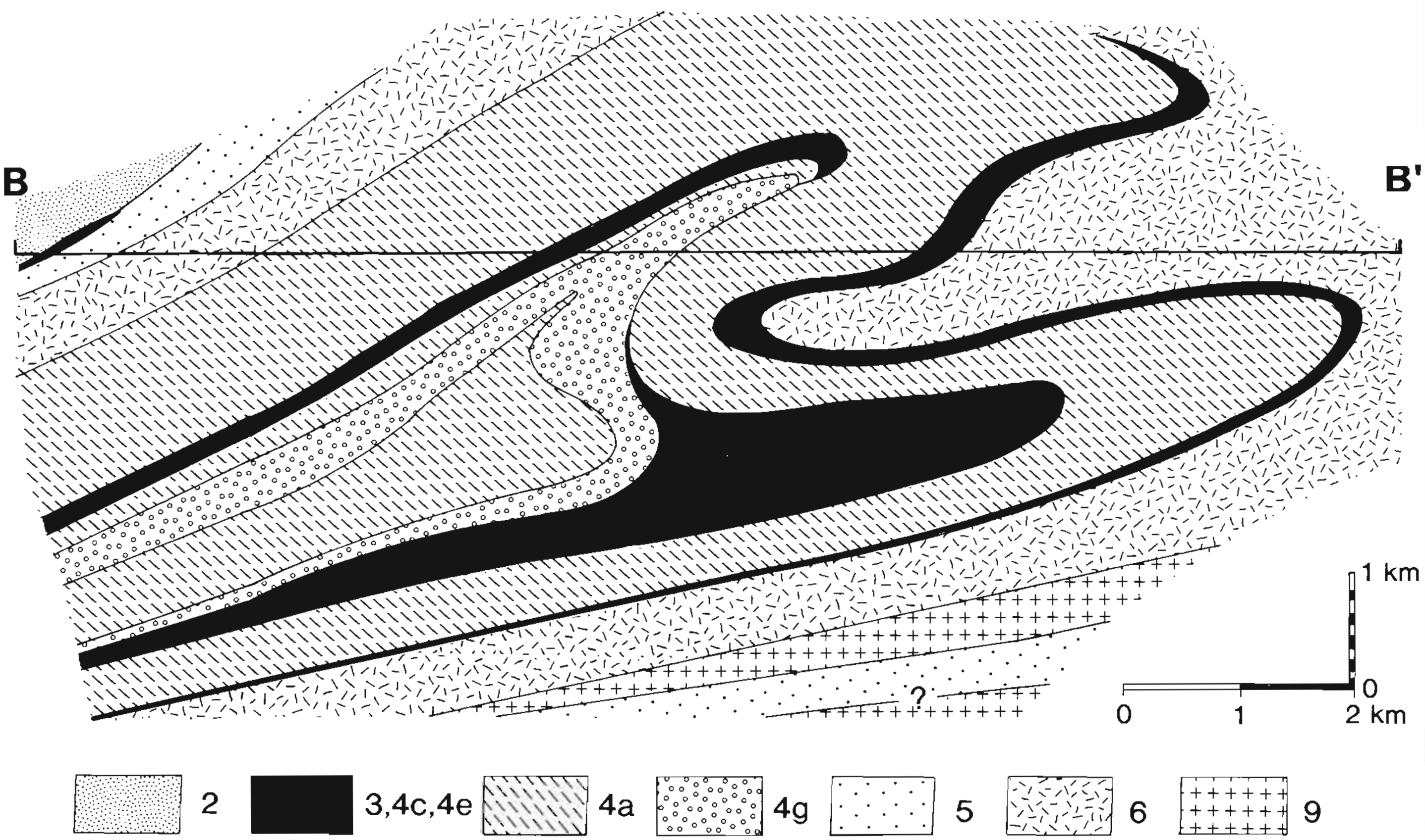


Fig. 27: Interpretive vertical section of the Sherridon structure, viewed towards the east, and showing south-vergent D_2 nappe with superposed D_3 folds; 2 - Burntwood Suite; 3,4c,4e - amphibolite and calcareous gneiss, 4a - Sherridon Suite (quartz-rich gneiss); 5 - Missi Group; 6 - tonalite gneiss; 9 - granite gneiss. Line of section is shown on Fig. 22.

well developed foliation and retrogression from upper amphibolite facies mineral assemblages to chlorite-epidote-hematite-bearing rocks that are commonly silicified. Several overlapping, discrete faults occur in an *en echelon* pattern. Locally these contain spectacular fault breccia or phyllonite. Rare, curved slickensides have steeply E-plunging slickenlines. One fault dips *ca.* 70° to the east and reverse dip slip has produced a 300 m wide repetition in the moderately E-dipping strata on the north end of Nokomis Lake.

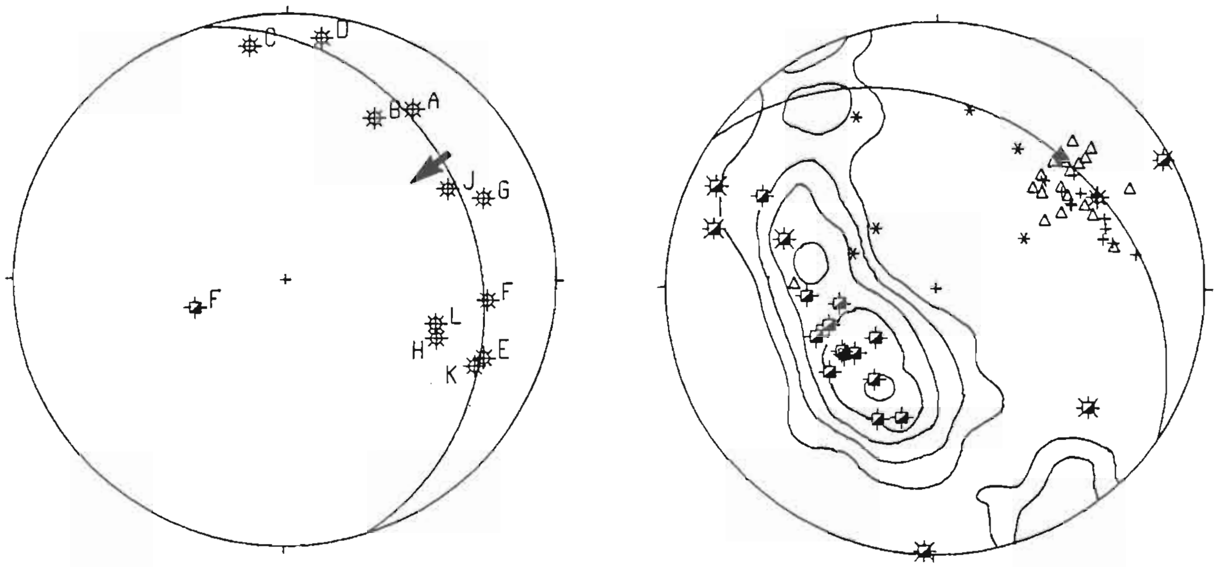
The Molly Lake fault (MLF in Fig. 23) probably has the same sense of displacement as the Nokomis Lake fault, producing a sinistral separation.

At Puffy Lake the south contact of the Sherridon - Hutchinson Lake complex and D_2 nappes in the adjacent paragneisses are refolded into tight S-shaped D_3 structures. They are cylindrical and plunge 30° towards 060° axial surfaces dip NE (Fig. 28). A strong collinear mineral lineation suggests that the folds were stretched and rotated into the NE-plunging direction of structural

a. Composite area S-4: Sherridon - Hutchinson Lake complex

b. Subarea S-5: Puffy Lake

FOLIATION, contours: 0.5, 1.5, 3.0, 6.0, 12.0
maximum = 12.5% of 193 poles



⋕ Major fold axis
✦ Axial plane (Sheila Lake fold)

△ Lineation (mineral and stretching)
+ D_3 minor fold axis
∗ D_4 minor fold axis
✦ D_3 axial plane
✱ D_4 axial plane

Fig. 28: *Equal area stereoplots of fabrics in the Sherridon - Hutchinson Lake complex (areas **S-4** and **S-5** in Fig. 22).*

-a *Synoptic diagram showing the D_3 plane of flow (great circle) and divergence in pitch of mean fold axes, **A-D** from subareas northwest of the core area and **E-K** from subareas to the southeast; (see Fig. 22 for location); the arrow is the direction of flow if the structure is interpreted as a sheath fold.*

-b *Puffy Lake area (J in Fig. 28a), showing girdle of poles to foliation (contoured) from S-shaped D_3 folds; the D_3 minor fold axes and lineations are parallel to the girdle pole and suggest southwesterly stretching and flow. The D_4 minor folds have a variable plunge and steep axial planes indicating NW-SE compression.*

flow. These structures die out abruptly against the Puffy Lake shear zone. Mylonitic foliation and kink folds were developed during late-stage displacement (D_3-D_4) along the high-strain zone.

MEAT LAKE SYNFORM

The gneisses north of Spider Lake occupy a late synform centred at Meat Lake and bounded by the Moody Lake dome and the Sherridon - Hutchinson Lake complex in the east and west. The synform is an open structure with shallow dips throughout, preserving the recumbent attitude of earlier folds within its core. This geometry is best seen in vertical structure section (Fig. 25).

A stack of three pairs of D_2 fold nappes lies above the Missi unconformity in sequence 1 (arrows in Fig. 25) and on the Sherridon - Hutchinson Lake complex. The lower nappes display the typical structurally upward changes in lithology from basin-margin to deeper basin facies of metasedimentary rocks. Felsic gneiss, garnet gneiss and amphibolite (3h and 3a-c) in the core of the Meat Lake synform structurally overlie the sedimentary rocks. Some of the core gneisses are interpreted to have a volcanic origin (with alteration and sulphide occurrences). They are interpreted to occupy a higher, anticlinal nappe, refolded in a D_2-D_3 interference structure. They may been detached from the magmatic infrastructure and overrode the early sedimentary nappes in the late stages of D_2.

During D_3 the upper limb of this nappe and the northwest part of the Batty Lake complex were thrown into large S-shaped recumbent folds that are detached from the more planar gneisses above and below. The highest structural level is a N-dipping sheet of orthogneisses; an architecture that is consistent with southerly and westerly tectonic transport in the Meat Lake synform.

During D_4 the complex structural package was down-warped to form the present shape of the Meat Lake synform (Fig. 25). The gently east-dipping limb of the synform displays these open upright folds most clearly. Reverse faults with mainly east-side-up displacement affected the margins of the granitic complexes. Upright flexure folds, kinks, crenulations and *en echelon* faults at Evans Lake, Moody Creek and Hayhurst Lake may form a northern extension to the Elbow Lake shear zone (Syme, 1990). Compression associated with the upright folds is interpreted to be NW-SE.

SOUTH BAY SUBAREA

At Kississing Lake the pattern of cross folds, granitic domes and high-strain zones does not allow all the individual early structures to be delineated or traced for a significant strike length (Fig. 22). A tentative structural interpretation for the area features two anticlinal nappes, each with a core of Burntwood Suite. During D_3 these were apparently refolded over the South Bay and the Adamson Lake domes (Fig. 29). The structurally lowest rocks are probably in the Adamson Lake dome. The lower anticlinal nappe in the Burntwood Suite also contains amphibolite and may be part of the basin-margin facies, although no conglomerates are known in the overlying Missi Group. The nappe was dismembered into rootless folds during the D_3 deformation. Throughout some of these closed structures the plunge is NE, parallel to the inferred transport direction as in sheath folds (Fig. 30a). Bending of the D_2 axes around the granitic body may have led to sheath folding.

In the upper structural level the folds plunge NW-SE, nearly perpendicular to the lower folds. The upper folds appear to have the same age (D_3), but apparently developed perpendicular to the SW-directed flow. Other anticlinal nappes appear to be defined by belts of Burntwood Suite north of the Big Island dome.

BATTY LAKE COMPLEX

The Batty Lake complex (K in Fig. 13) is a 30 km long, 6 km thick sheet that dips 35° NE and is dominated by quartz-rich tonalitic gneisses. It lies at a relatively high structural level, and is structurally underlain by amphibolite, felsic supracrustal units and a pair of fold nappes developed in paragneisses. It is structurally overlain by the Missi and Burntwood suites. The outer contact and the distribution of supracrustal screens within the Batty Lake complex outline a tight, overturned (nearly recumbent) dome. The north end of the dome plunges 20° towards 350°. The south end plunges 20° towards 110°and the plunge changes smoothly in a SW-closing curve (Fig. 23). This vergence

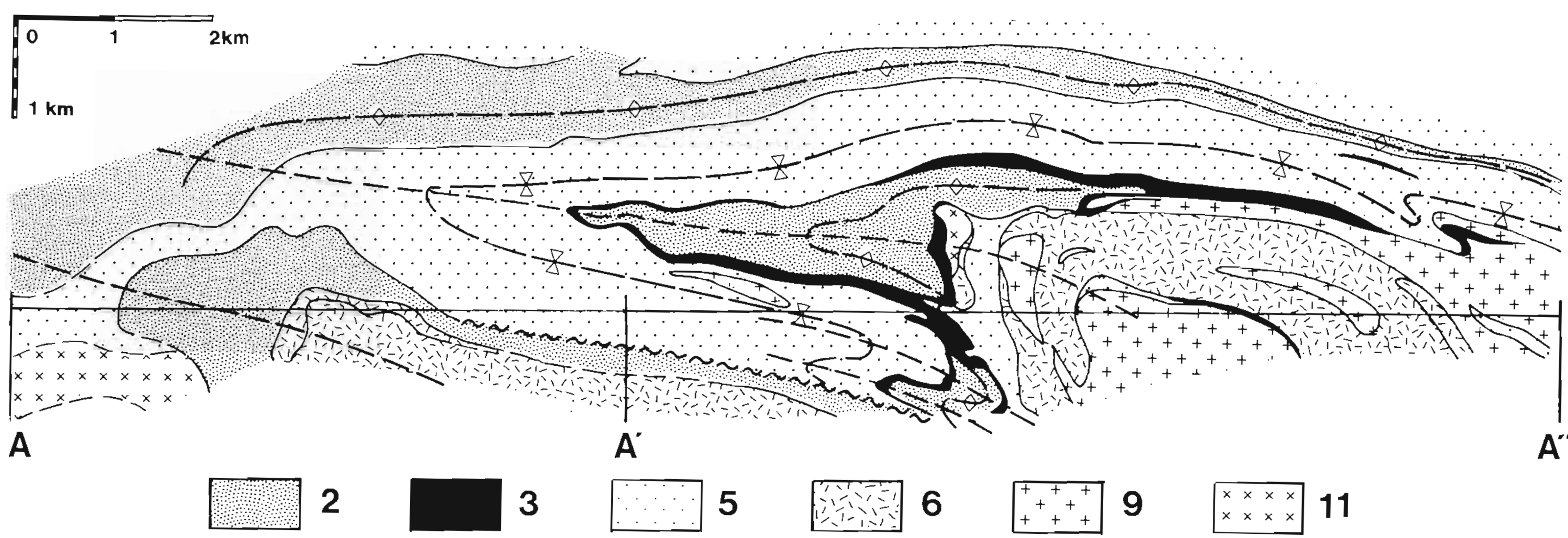


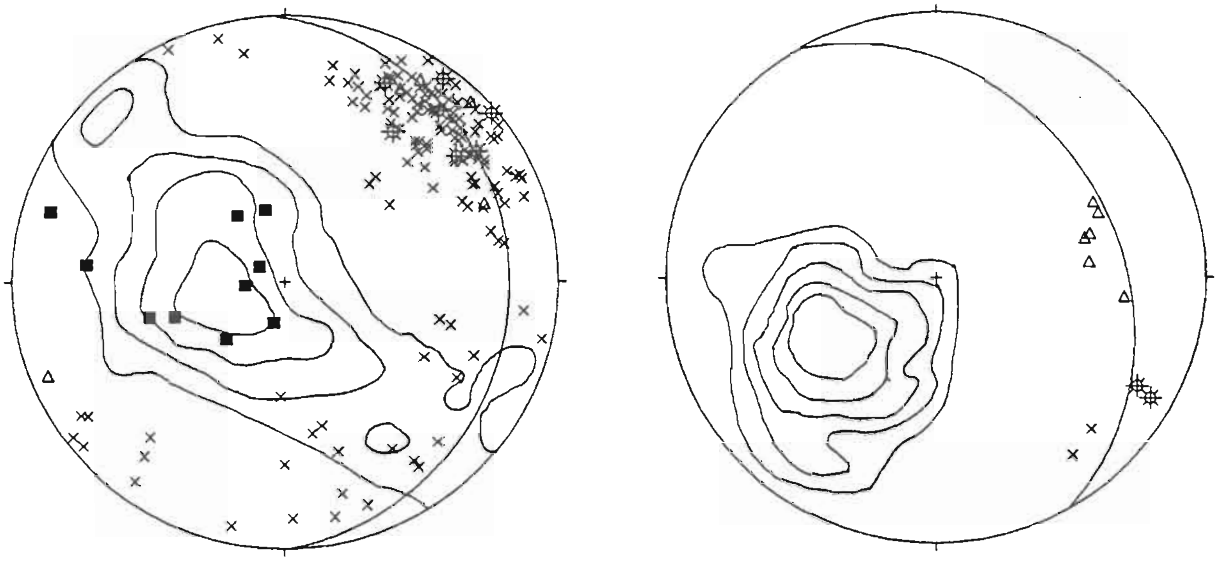
Fig. 29: *Composite vertical structure section of the Adamson Lake - South Bay area, viewed towards the northeast; S-shaped D_3 fold pairs (short dashes as axial surface) involve the infrastructure (units 6 and 9) and refold D_2 nappes developed in units 2, 3 and 5 (inferred axial surfaces are ornamented as synclines or anticlines). Structures in the core are rootless folds or sheath folds;*
2 - Burntwood Suite, 3 - amphibolite, 5 - Missi Group, 6 - tonalite gneiss; 9 - granite gneiss; 11 - pegmatite; lines of section are shown on Figure 22.

a. Subarea S-2: Adamson Lake dome

FOLIATION, contours: 0.5, 1.5, 3.0, 6.0%
maximum = 10.0% of 442 poles

b. Subarea S-8: Craik Lake

FOLIATION, contours: 0.5, 1.5, 3.0, 6.0, 12%
maximum = 21.8% of 211 poles



△ Lineation (stretching and mineral elongation)
× Minor fold axis ⋕ Major fold axis
■ Axial plane

Fig. 30: *Equal area stereoplots of predominantly D_3 fabrics; for location of subarea see **S-2** and **S-8** in Fig. 22.*

- ***-a*** *Vicinity of Adamson Lake dome, showing poles to foliation (contoured) with shallow, predominantly NE-plunging folds parallel to the girdle axis; a second set of fold axes falling into the SE quadrant occurs locally but predominate at high structural levels. The two sets of folds show no obvious age distinction and their axial surfaces are coplanar (average plane shown as great circle).*
- ***-b*** *Kisseynew core zone - south flank transition, Craik Lake area, showing strong planar fabric of the foliation (poles contoured, average as great circle), SE-plunging fold axes and ENE-plunging lineation (direction of flow ?).*

indicates that the Batty Lake complex is rooted down to the northeast and has been structurally emplaced from that direction.

Evidence that the Batty Lake complex was probably transported towards the southwest, like the underlying rocks, is provided by strong foliation in the gneiss, especially at the northeast contact, which forms the Limestone Creek high-strain zone. The intermediate-scale fabric in this zone, and in the underlying tonalite gneisses is similar to that in the Craik Lake area. It suggests that the displacement direction was the same for all of these rocks. At microscopic scale, strong mortar texture and highly flattened, polygonized grains indicating high strain throughout the complex. (See description of unit 6a). The observed evidence for annealing of these textures and for continued strain is consistent with (D_3) deformation during peak metamorphism.

Core zone - south flank boundary zone (Northern domain)

The metamorphic core zone of the Kisseynew belt (Fig. 22) contains shallow- to moderately-dipping gneisses and migmatites derived from metagreywacke (Burntwood Suite), and granitic rocks. These gneisses occupy the uppermost structural level in the area and have apparently been displaced towards the southwest, overriding the rocks in the central domain. Much of the displacement occurred during D_3 as a result of recumbent folding and presumably ductile thrusting during peak metamorphism as discussed earlier.

CRAIK LAKE SUBAREA

The Craik Lake subarea (**S-8** in Fig. 22) is typical of the boundary region between the Kisseynew belt core zone and the south flank. NE-dipping Burntwood Suite metagreywacke derived migmatites in the northeast are part of the core zone, which represents the highest structural level in the area. These gneisses have been transported during D_2 over the Missi Group as fold nappes such that the contact was inverted. The nappes were further displaced over the orthogneisses in the Batty Lake complex on shallow NW-SE plunging D_3 folds that are SW verging (Fig. 31). Evidence for detachment exists where discontinuous structural slices form the Limestone Creek high-strain zone at the base of the nappe complex. Quartz-rich pegmatite and extensively altered rocks, are common within this zone, but mylonite and stretch lineations were not observed. Instead, the rocks in the contact zone are tightly folded about a subhorizontal S-intersection.

Intermediate-scale fabric elements in the Craik Lake area are dominated by the D_3 structures. The close concentration of poles to foliation on an equal area stereoplot (Fig. 30b) is evidence for a planar fabric (mean S-surface = 330°/36°). This geometry is interpreted to be a product of high strain. Mineral lineations probably represent the local stretching direction and line of flow (mean L = 38° towards 075°). The fabric is consistent with southwesterly tectonic transport. Alternatively, the lineation may represent an early fold direction.

In summary, the Craik Lake belt is interpreted to be a zone of displacement where the Burntwood Suite paragneisses were transported southwest from the Kisseynew metamorphic core zone over the heterogeneous gneisses of the south flank.

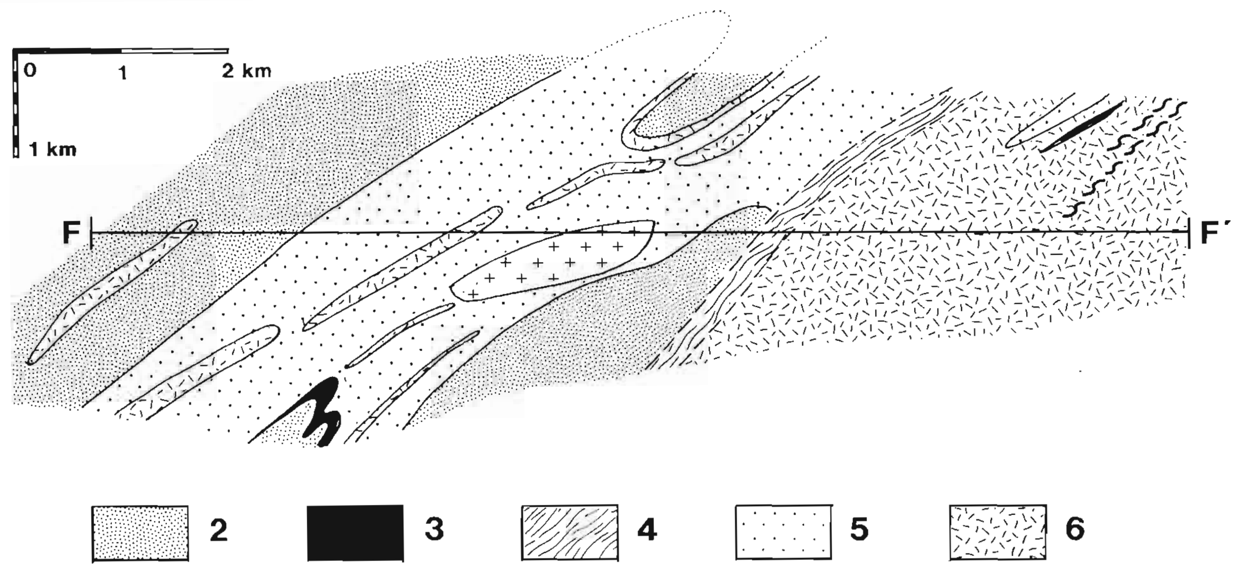


Fig. 31: Interpretive vertical structure section of the Craik Lake subarea (core zone - south flank transition), viewed towards the southeast, and showing Burntwood Suite (2) - Missi Group (5) contact interpreted to have been overturned during D_2 and refolded in southwest-vergent D_3 folds; various rock types occur in the Limestone Creek high strain zone (4) at the sheared margin of the tonalite gneiss (6) of the Batty Lake complex including rare amphibolite (3). Line of section are shown on Fig. 22.

Flin Flon belt - Kisseynew belt boundary zone

The structural boundary between the Flin Flon and Kisseynew belts is interpreted to be a complicated, long lived feature. It is characterized by a change from steeply dipping structures in the south, to recumbent structures in the north. The D_2 nappes are tilted and steepen progressively as they approach the boundary, and do not extend beyond it. The D_3 folds are detached from the steep structures along discontinuous high-stain zones. D_3 displacement was apparently sinistral and north-side-up. However, the presence of the Missi Group north of the structural boundary and its absence in the south indicate that at some stage in the deformation the Flin Flon belt was uplifted with respect to the Kisseynew belt. The infrastructure at Kisseynew Lake may have become exposed in a metamorphic core complex formed by crustal extension in the early stages of D_3. Alternatively, it may be an anticlinal culmination produced by postmetamorphic compression. Both hypotheses provide an explanation for the reversal in metamorphic grade from high in the Defender Lake dome to moderate in its mantle along the Kississing River shear zone, and higher again farther north. Core complexes are generally bounded by low-angle normal faults, but such a fault has not been positively identified on Kisseynew Lake.

Steep, east-trending shear zones occur north of Syme and Fay lakes and south of Puffy Lake. The shallow-dipping D_2 and D_3 structures, which are typical of the Kisseynew belt, steepen to nearly vertical within less than 1 km of the shear zones. The D_3 folds that occur within the region of steepening foliation are cylindrical, and fold axes are parallel to a strong lineation that plunges moderately NE (Figs. 28b, 32a). This fabric suggests that strain was noncoaxial and the folds may have been rotated. The asymmetry of the folds is consistent with a sinistral reverse sense of displacement of the Sherridon - Hutchinson Lake complex in relation to the Flin Flon belt during D_3. In the area north of Syme Lake (**S-3** in Fig. 22), under current investigation, mylonitic foliation strikes E and dips steeply N. Stretch lineation plunges 26° towards 086° (Fig. 32b). Minor faults are sinistral and indicate strike-slip movement with a component of reverse slip.

More complex history is suggested by new structural evidence from reconnaissance mapping in the burned-over area, south of Puffy Lake, along the Puffy Lake shear zone that bounds the Flin Flon belt. Minor S-shaped folds and shallow east plunging lineations suggests a history of D_3 ductile sinistral transpression and uplift of the Kisseynew belt during amphibolite facies conditions of metamorphism. Small brittle faults with dextral separation, and NE-trending Z-shaped post-metamorphic crenulations suggest D_4 history of dextral slip along the Puffy Lake shear zone.

Nevertheless, on both sides of the Puffy Lake shear zone an apparently similar stratigraphy (massive amphibolite, pillow basalt and felsic dykes) occurs in the Amisk Group mantle of the Sherridon - Hutchinson Lake complex west of Puffy Lake and in the Flin Flon belt south of the lake. The resemblance suggests that the two domains may have been contiguous during deposition and that displacement in the infrastructure was no more than a few kilometres across the boundary. On the other hand, the abrupt changes in stratigraphy from sequence 1 to sequences 2 and 3 over a few tens of metres across the axial surfaces of the lower D_2 nappes suggest that there may have been many kilometres of earlier displacement in the suprastucture of the Kisseynew belt. These early, shallow-dipping structures were probably tilted along the Flin Flon belt boundary in the late stages of D_3 in a process akin to fault-bend folding above a thrust ramp. Strain partitioning (Hanmer and Passhier, 1991) caused by contrasting ductilities and structural styles across the boundary is interpreted to have produced the shear zones in response to D_3 NE-SW transpression and D_4 NW-SE compression.

KISSEYNEW LAKE SUBAREA

The most complicated transition between the Kisseynew and Flin Flon belts is in the vicinity of Kisseynew Lake and north to the Duval Lake road (**S-1** in Fig. 22). The major structures there are, from south to north: (i) the Defender Lake dome; (ii) a probable fault in its mantle along the north shore of Kisseynew Lake, and along the south shore of Weldon Bay; (iii) the Lobstick Narrows antiform; and (iv) the Kississing River shear zone (Fig. 23). The subarea is characterized by moderately N- and NE-dipping foliation and NE-plunging folds and well developed parallel lineations (Fig. 32a).

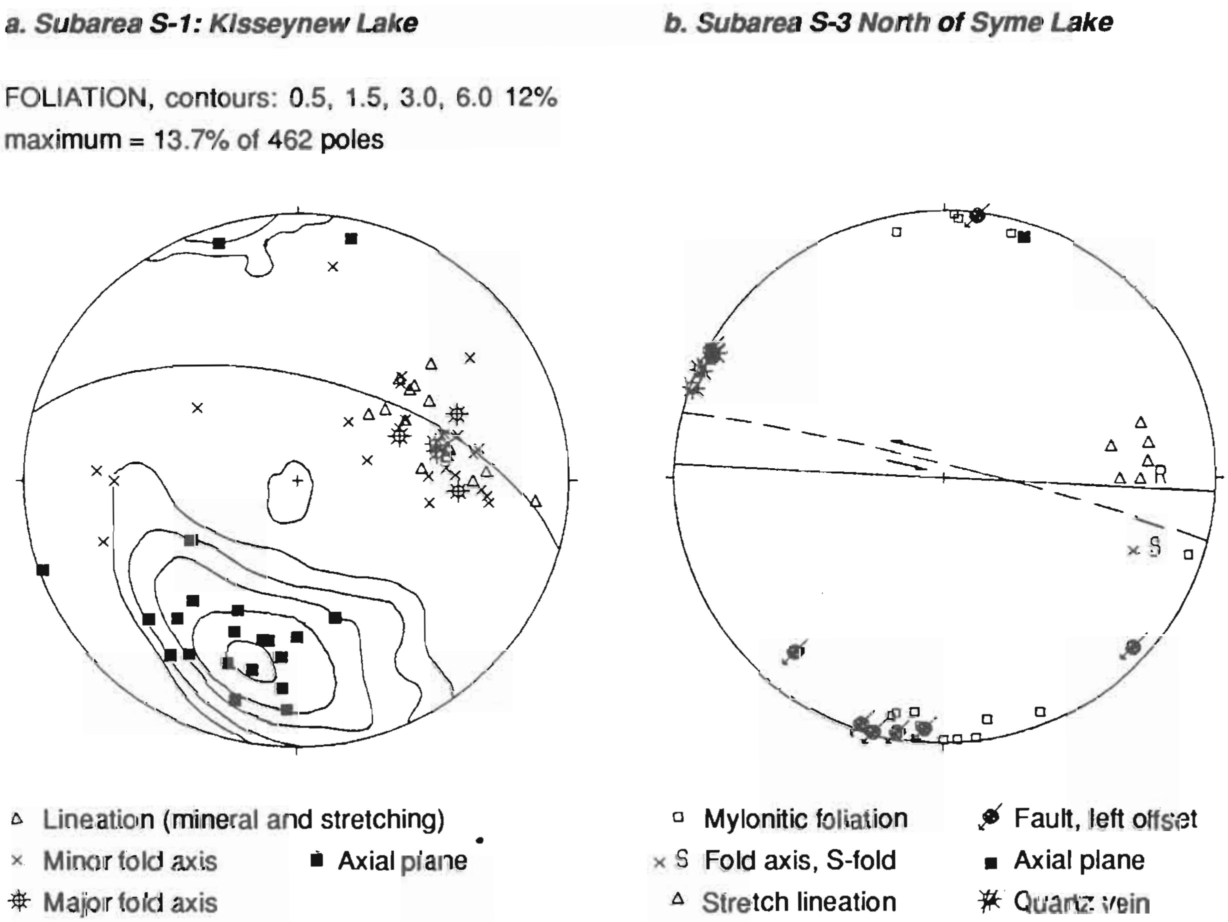


*Fig. 32: Equal area stereoplots, Kisseynew belt - Flin Flon belt transition; for locations see **S-1** and **S-3** in Fig. 22.*

-a Kisseynew Lake - Kississing River subarea; D_3 structures showing transition to steeper dipping foliation; poles are contoured and mean plane shown as great circle. Folding is cylindrical: lineations and most axes are parallel to the NE-plunging pole of a partial girdle.

-b Shear zone north of Syme Lake showing poles to mylonitic foliation active during D_3 and D_4. Small D_3 faults, and a slip line (R) defined by stretch lineation and slickenlines suggesting sinistral offsets. Faults indicate periodic shortening of the shear zone, veins periodic extension. Note that the slip line lies in the regional flow plane of D_3 folds north of the shear zone, which serves as detachment or oblique ramp.

The Defender Lake dome is overturned to the southwest. Only its northeast part was remapped. There, the foliation dips steeply N to moderately NE. The steep dips may be preserved from pre-Missi deformation where the early foliation was not transposed into the recumbent D_3 plane of flow. The dome is an enigmatic feature in that it contains migmatitic orthogneisses surrounded on three sides by lower-grade supracrustal rocks. Small subhedral and locally large poikiloblastic garnets occur in melanosome and veins of leucosome. Sillimanite occurs locally in granite gneiss, such as in a steeply N-dipping shear zone in Lobstick Bay. Unmigmatized Missi Group metasandstones overlie the dome and its thin mantle of Amisk Group amphibolite. Where the upper contact of the mantle is exposed at Lobstick Bay and on the south shore of Weldon Bay there is no basal conglomerate. At Weldon Bay an 8 cm thick layer of coarse gneiss very rich in garnet occurs at the contact. This can be interpreted as a pre-peak metamorphic fault, which placed Missi Group on Amisk Group, possibly cutting out part of the section (conglomerate). The proposed fault extends west through Lobstick Narrows where the hanging wall truncates the D_2 anticlinal nappe developed in the Burntwood Suite and the synclinal nappe developed in the Missi Group. The fault probably extends farther west along the north shore of Kisseynew Lake where high-strain foliation is locally overgrown by microcline porphyroblasts. If it is a normal fault it can be interpreted to be related to the extensional emplacement of the Defender Lake dome as a metamorphic core complex. No clear evidence of extension has been documented, but this was probably obliterated by later folding and metamorphism. Alternatively, the structure may be a thermal dome or a late-metamorphic (D_3-D_4) antiform. Petrofabric work and determination of a temperature-pressure-time path are required at Kisseynew Lake to test these hypothesis.

The Lobstick Narrows antiform (LNA in Fig. 23) is a tight, cylindrical, D_3 structure with limbs dipping 55° N and a hinge plunging 45° towards 075° and closing NE. It is superposed on a D_2 anticlinal nappe developed in sequence 2. These rocks are moderately well preserved and make up the mantle of the Defender Lake dome. The Burntwood Suite in the core of the nappe contains slightly deformed staurolite porphyroblasts. The inverted panel of Missi Group (locally with downward-facing crossbedding) is part of sequence 1 and contains conglomerate-bearing (proximal) metasandstone. The upright panel is sequence 2. The whole structure section from the Defender Lake dome along plunge (NE) is very similar to the south mantle of the Sherridon - Hutchinson Lake complex at Puffy Lake, and to the northwest mantle of the Drury Lakes dome at Evans Lake. It also contains the same gold metallotect. (See *Stratabound gold* below.) These structures may be fragments of the same nappe.

The Kississing River shear zone (KRS in Fig. 23 and after Norman, 1992) lies in the back limb of the Lobstick Narrows antiform. It is a a 500 m wide ductile high-strain zone with superimposed brittle structures that include fault breccia and pseudotachylite. It dips *ca.* 65° N and contains a NE-plunging lineation. Poorly developed kinematic indicators suggest sinistral-reverse slip, but the direction of displacement may have changed during the history of the zone.

North of KRS the dominant folds (D_3?) plunge NW-SE and locally NE, and linear structures are weak (Norman, 1992). South of KRS there is a strong linear fabric parallel to the cylindrical ENE-plunging folds. The change in structural style is typical for the development of large-scale intrafolial D_3 folds, which are detached from the adjacent structural panels. The NW-SE trending folds probably express compression, whereas the ENE-trending structures express noncoaxial strain. The structural style in the south is consistent with fold rotation produced by strain with a significant component of sinistral, north-side-up simple shear.

ECONOMIC CONSIDERATIONS

Base- and precious-metal occurrences were studied on the south flank of the Kisseynew gneiss belt during the geological mapping and under concurrent MDA projects (Gale and Ostry, 1984; Peloquin, *et al.*, 1985; Ostry, 1986, 1987, 1988, 1989). An attempt was made to identify the controls of known occurrences. This analysis is still in progress; only a preliminary overview of the relationship of these occurrences with structure and stratigraphy is provided in this report. The most important of these relationships are given in Table 5.

BASE METALS

Massive sulphide mineralization in the Flin Flon belt and is hosted in the Amisk Group; those on the south flank of the Kisseynew belt are hosted in the Sherridon Suite. These deposits and occurrences lie in the better preserved infrastructure between the south shore of Weldon Bay and Spider Lake, and in the higher-grade structural culmination at Sherridon. They are associated with garnet-anthophyllite rocks interpreted to be hydrothermal alteration related to volcanogenic massive sulphide deposition.

Table 5: Base and Precious Metal Occurrence Types and Controlling Structures on the Kisseynew South Flank

OCCURRENCE TYPE	LITHOSTRATIGRAPHY	CONTROLLING STRUCTURE
BASE METALS		
Massive sulphide (Cu-Zn) and disseminated Fe sulphide	Sherridon Suite (quartz-rich gneiss, possibly volcanic)	Sherridon core-structure in areas with alteration
	Unit 3h (garnet gneiss (in part volcanic)	East limb of Meat Lake synform
Massive sulphide (Zn-Cu-Pb-Ag)	Burntwood Suite; unit 3 (sedimentary; volcanic)	D_2 nappe, NE side of Kississing Lake
Trace sulphide	Unit 3; Sherridon Suite; orthogneiss; Amisk Gp.	Infrastructure (sequence 1)
	Burntwood Suite (sedimentary)	D_2 nappe, NE side of Kississing Lake
GOLD		
Structurally controlled	Amisk Group (volcanic and sedimentary)	Sherridon-Hutchinson complex, quartz veins & alteration
	Intrusive rock (granitic sheet)	Martell Lake, quartz veins & alteration
Stratabound	Unit 3d (mottled intermediate gneiss)	Lower nappe (sequence 2), near Flin Flon belt

Massive Cu-Zn sulphide ± Au

WELDON BAY - FAY LAKE OCCURRENCES

An occurrence south of Weldon Bay (C_9 in Fig. 33) is sphalerite-rich. It is associated with disseminated Fe-sulphide in a graphitic layer along strike to the east. Base metal occurrences at Fay Lake (C_{11}), immediately south of the Kississing Lake map sheet, are associated with a thin unit of felsic volcanic rocks with a siliceous zone (Parberry, 1986) or garnet ± anthophyllite mineral assemblages indicating alteration. Gold has also been reported from these showings.

SHERRIDON DEPOSITS AND OCCURRENCES

Six massive sulphide Cu-Zn deposits are hosted in the Sherridon Suite within the Sherridon-

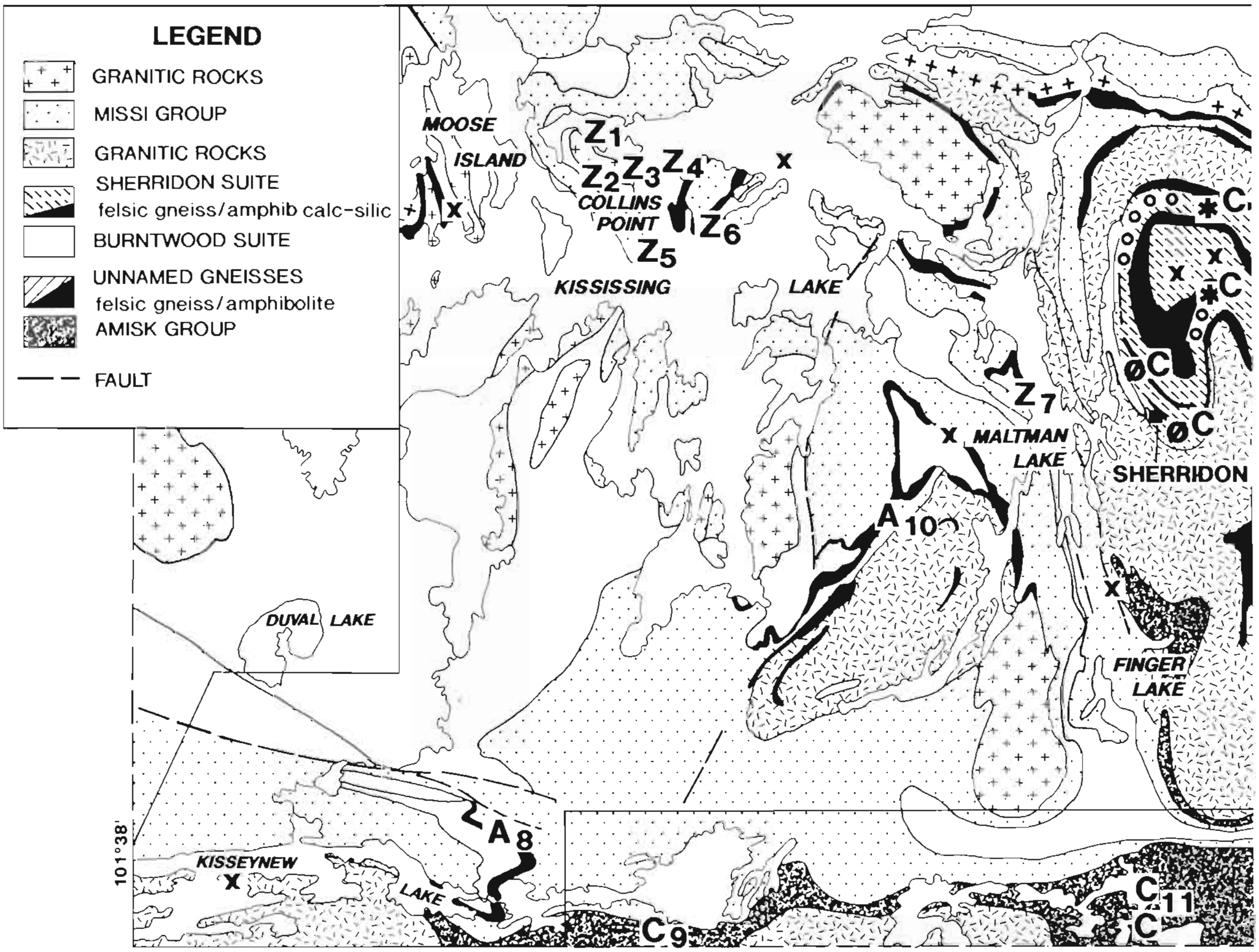


Fig. 33: Simplified geology of the Kississing - Batty lakes area, showing selected mineral deposits and occurrences; numbered locations are discussed in text.

Sulphide/metal assemblages:

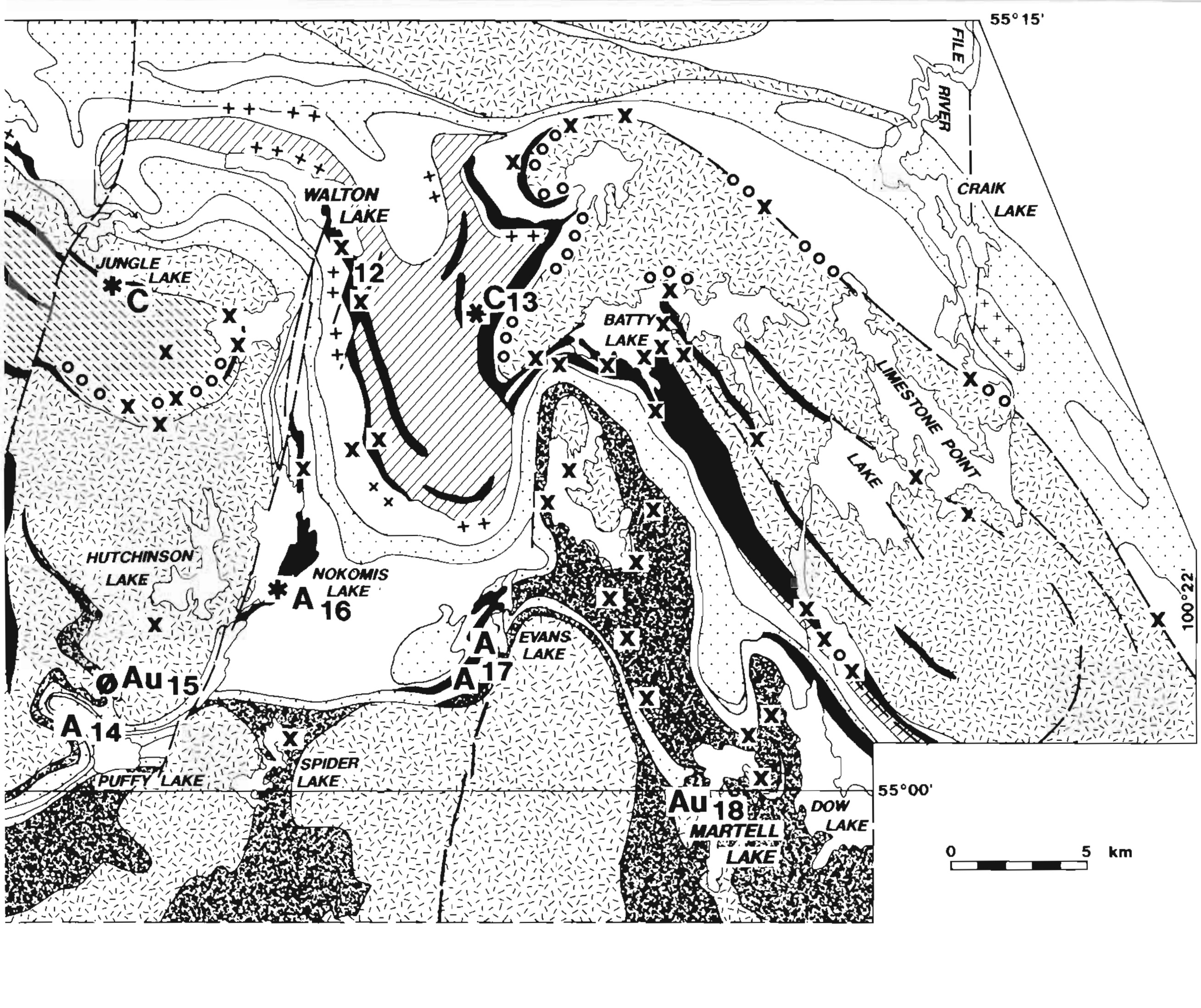
***C** = Cu-Zn or Zn-Cu,* ***Au** is structurally controlled*

***Z** = Zn-Cu-Pb-Ag,* ***A** is stratabound Au-Fe-As*

Hutchinson Lake complex. They comprise two depleted ore bodies at Sherridon, and the smaller but similar deposits to the north, all of which have been previously described (Froese and Goetz, 1981). Additional details are provided by Ostry and Trembath (1992). In this report they are only briefly discussed as a group.

The Cu-Zn mineralization occurs in the quartz-gneisses of uncertain origin (4a), generally adjacent to units of amphibolite or calc-silicate gneiss. The deposits are high-grade, generally copper-rich and coarsely recrystallized (Bailes, 1971). They have the characteristics of volcanogenic massive sulphide deposits. They are stratiform and have high length to thickness ratios, but evidence of high regional strain indicates that their shape is largely a result of deformation.

Several of the deposits are spatially associated with cordierite-anthophyllite±garnet-rich rocks



Past producer

+++ Zone of trace Fe-sulphide

* Deposit

oooo Cordierite-anthophyllite rocks

Sulphide occurrence or selected trace showing, mainly pyrrhotite-pyrite ± Cu-Zn.

interpreted to be hydrothermal alteration caused by Mg-Fe-enrichment before regional metamorphism. The quartz-rich nature of the host rock, and the widespread occurrence of the rocks with unusual compositions such as quartz-garnet-rich rocks ± amphibole (4b), cordierite-anthophyllite rocks (4f) and abundant disseminated iron sulphide showings suggest that the alteration was produced in regional hydrothermal systems. The most highly altered and mineralized rocks are confined to the Sherridon-Hutchinson Lake complex. They are enclosed within the granitic orthogneisses that are equivalent to predominantly pre-Missi intrusions in the Flin Flon belt to the south. The general absence of alteration in the orthogneisses suggests that the massive sulphide deposits in the Sherridon Suite and the associated hydrothermal alteration predate the intrusion of the granitic rocks. However, the contact between the altered Sherridon Suite and unaltered orthogneisses may be structural.

AKE ZONE DEPOSIT

A sulphide deposit (C_{13} in Fig. 33) with 1 to 2% Cu and <0.5% Zn (Ostry and Trembath, 1992) occurs in garnetiferous gneiss (3h) near the contact with intermediate gneiss (3d) 3 km west of Batty Lake. Volcanic rocks and mineral assemblages suggesting alteration occur along strike.

Massive Zn-Cu-Pb-Ag sulphide

Mineralization at Kississing Lake generally has zinc values that exceed or equal copper values. Galena is a common but highly variable constituent. The mineral occurrences were observed in trenches and diamond drill holes at the Ideal showing and in the area of Yakushavich Island and Collins Point (Z_{1-7} in Fig. 33).

The mineralization lies primarily in a mixed succession comprising garnet-biotite gneiss (2a), lenses of rusty-weathering graphitic-garnet±hornblende/cummingtonite-biotite gneiss (3g), and lenses of rusty amphibolite to calc-silicate rock. The mineralization appears to be stratabound, disseminated to near solid sulphide (Gale, 1980). However, mineralization occurs also in other rock types such as the granodiorite (6b) and the mesocratic gneiss on Collins Point.

IDEAL SHOWING

The Ideal showing (Z_7) is exposed in several trenches and a vertical exploration shaft several metres deep. The showing lies within an area of garnet-biotite gneiss and rusty graphitic-garnet-amphibole-biotite gneiss (3g) that occupies the core of a recumbent fold that dips NE and plunges SE at a shallow angle. The southwest limb of the structure appears to be truncated by a shallow NW-dipping fault. Gale (1980) has described the showing as "60 cm thick near solid sulphide (Sp-Ga-Cp-Py-Po) mineralization...underlain by an anthophyllite-rich rock (alteration zone) and overlain by a quartzitic (cherty) layer. Minor sphalerite mineralization with associated alteration (biotite-garnet-anthophyllite) present south of the main sulphide zone may represent a second mineralized layer or merely a part of the alteration zone associated with the sphalerite-rich sulphide layer."

YAKUSHAVICH ISLAND OCCURRENCES

The mineralization on the east shore of Yakushavich Island (Z_6) lies within a narrow sliver of garnet-biotite gneiss. The gneiss is exposed over a width of *ca.* 90 m on the underlimb of a N-plunging NW-dipping recumbent fold. The mineralized zone structurally underlies a suite of sulphide-bearing amphibolites and appears to be truncated to the east by a shallow NW-dipping fault zone.

The mineralization is in near-solid lenses, 25 to 90 cm thick. It comprises sphalerite, pyrite and chalcopyrite in a dark green biotite matrix. It is structurally overlain by a quartz-rich layer that contains blue grey plagioclase. Gale (1980) interpreted this layer as an exhalative chert deposit. This, in turn, is overlain by a rusty garnetiferous-cordierite-tourmaline-bearing quartzofeldspathic gneiss. The mineralization is underlain by a 45 cm thick layer of biotite and acicular amphibole.

COLLINS POINT AND VICINITY

Mineralization with Zn-Cu>Pb, or Zn-Pb>>Cu occurs on Collins Point (Z_{1-5}) in three different host rocks:

(1) fine-to medium- grained granodiorite-tonalite (6b);

(2) rusty garnet-biotite gneiss (2a);
(3) mesocratic magnetite-hornblende gneiss (7a).

Type 1, mineralized granodiorite to tonalite was observed only in drill core. Diamond drill hole 11-11-3 located between Yakushavich Island and Collins Point (Z_4) intersected a conductor beneath Kississing Lake. The drill section contains garnet-biotite gneiss and a 4 m thick granodiorite that contains a mineralized chlorite-rich zone. The mineralization comprises sphalerite, chalcopyrite, pyrite and pyrrhotite and the assay results are 1.05% Zn; .33% Cu and 3.43 g/ton Ag.

A second diamond drill hole (11-8-1) tested an EM conductor associated with mineralized granodiorite in the middle of Collins Point (Z_2). The mineralization is disseminated and in thin layers of massive pyrrhotite with chalcopyrite, minor galena and gahnite. It occurs in two, *ca.* 6 m thick chloritic and siliceous zones in the granodiorite. Assay values indicate 0.01 to 0.7% Cu and 0.01 to 0.09% Zn. The variation in zinc/copper ratios in the granodiorite are similar to variations observed in the surrounding gamet-biotite gneiss, rusty rock suite (Zn > Cu in units 2a, 3g), and the amphibolite (Cu subequal to Zn in units 3b, 3c) on Collins Point. The ratios suggest that the mineralized zones in the granodiorite are partly assimilated inclusions of mineralized country rock.

The type 2 host rock relationship was observed in a drill hole located in Kississing Lake *ca.* 500 m north of Collins Point (Z_1) and in a set of trenches on the east shore of Collins Point (Z_3). The trenches were cut into a suite of rusty layered gneisses lying within a sliver of garnet-biotite gneiss (*ca.* 300 m in length and <150 m thick) that wedges out to the west. The garnet-biotite gneiss is in contact with granodiorite to tonalite (6b) to the north and a magnetiferous hornblende-biotite quartzofeldspathic gneisses (5a, 7a) to the south. An EM conductor, which coincides with the mineralized zone, dies out to the west but extends to the east under the lake.

The rusty-layered gneisses observed in and around the trenches comprise layers of:
(1) epidotized amphibolite (hornblende and actinolite);
(2) amphibole (hornblende and cummingtonite)-biotite-plagioclase-quartz (5-85%);
(3) muscovite-plagioclase-quartz;
(4) sillimanite-garnet-biotite-cordierite (5-30%)-plagioclase-quartz.

The mineralization is disseminated to near solid sulphide (Sp, Ga, Py, Po) in quartzose layers (Gale, 1980).

Diamond drill hole 11-9-1 intersected another mineralized zone north of Collins Point (Z_1). This zone is 20 cm thick and contains 2.07% Zn and 0.68% Pb. The main rock type described in the drill log is a variable sillimanite-bearing, garnet-biotite gneiss with local thin layers (*ca.* 3 m) of amphibolite, quartz-rich biotite gneiss (*ca.* 5 m) and sills or dykes of granodiorite (7-29 m). A 2.8 metre thick section of siliceous sillimanite-biotite-gneiss with minor calc-silicate layers and sills of pegmatite with green plagioclase contains the highest zinc and lead values.

Mineralization in type 3 host rock is exposed in a trench at the southeast tip of Collins Point (Z_5). This mesocratic hornblende-biotite gneiss (7a) lies within an area of hornblende-bearing magnetiferous biotite gneisses (5a). The mineralization occurs within and on the margins of a *ca.* 1.5 m thick rusty tourmaline-bearing quartz vein that cuts the mesocratic gneiss. The vein is tightly folded and plunges at 10° towards 018°. The near parallelism of the erosion surface with the shallow plunging axis of the fold makes it possible to trace the crest of the fold down plunge for 70 m north of the trench.

The mineralization comprises pyrite, sphalerite, trace galena and trace chalcopyrite as disseminated grains and as stringers in a matrix of quartz (75%) and black fine grained tourmaline (20%). The quartz and tourmaline are layered (2-10 mm thick) and the layering parallels the margins of the vein. The layering has been deformed and intruded by granite pegmatites. The pegmatites within, and on the margins of, the vein contain amazonite and coarse grained tourmaline. The emplacement of the mineralized quartz-tourmaline vein is interpreted to be premetamorphic since tourmaline is found as inclusions within metamorphic hornblende grains in the country rock along the margins of the vein.

Trace sulphides

Small showings of disseminated sulphides are scattered throughout the Kississing - Batty lakes area (unnumbered in Fig. 33). In the south they are most common in Amisk Group amphibolite and intermediate rocks; most of these contain disseminated pyrrhotite and pyrite. Elsewhere, sulphide showings are locally abundant in units 2, 3 and 4 with fine grained pyrrhotite, pyrite and scattered chalcopyrite and sphalerite.

Stratabound disseminated iron sulphide occurs in rusty-weathering Burntwood Suite gneiss on the northeast shore of Walton Lake. The gneiss adjoins a white- to rusty-weathering fine grained felsic rock (3e) on the east shore of the lake. Rusty Burntwood Suite gneisses form a similar layer that is a prominent conductor intersected in drill holes west of Hayhurst Lake. The mineralized layers at Walton and Hayhurst Lakes lie between coarsely garnetiferous gneiss ± cordierite-sillimanite (3h) on one side and amphibolite (3b) on the other. A similar sulphide-bearing Burntwood Suite gneiss occurs on the north side of Big Island on Kississing Lake and extends east to Three Fingers Lake. This rusty rock contains irregularly shaped lenses of graphitic garnet-hornblende-biotite gneiss (3g). Southwest of Batty Lake 1% fine grained disseminated pyrrhotite and pyrite occur in layers and lenses <1 m wide.

Traces of copper mineralization (chalcopyrite and malachite) occur rarely within the basal Missi conglomerate.

BATTY LAKE COMPLEX AND VICINITY

Showings in the vicinity of the Batty Lake complex were recorded during the regional mapping (Zwanzig and Lenton (1987). They were subsequently examined in greater detail and sampled for geochemical analysis (Ostry, 1989). Estimated sulphide contents range from trace to 10%. Metal contents of grab samples range up to 550 ppm Cu and 200 ppm Zn over a few centimetres or metres. The data are further summarized below. They focus on units and structures that have high background base metal contents. Analyses were done by partial dissolution ICP (Ostry and Trembath, 1992).

The trace showings in and around the Batty Lake complex occur in three types of host rocks:

(1) thin units and layers of fine grained felsic gneiss (3e) and intermediate gneiss (3d) within amphibolite (3a, 3b);
(2) screens of amphibolite (3a, 3b) in the Batty Lake complex;
(3) garnetiferous quartzofeldspathic gneiss (4b) and cordierite-anthophyllite-bearing rock (4f);

Type 1 showings are in a belt of amphibolite and felsic rocks (unit 3) that extends from the south side of Batty Lake to Fairwind Lake. These rocks are interpreted to contain volcanic, sedimentary and intrusive components. Some mafic rocks were altered to produce carbonate-bearing mineral assemblages (mapped as part of 3a) and in one locality (Fairwind Lake) garnetiferous or cordierite-anthophyllite rock (shown as 3b, f). These altered rocks occur in the vicinity of the sulphide showings but are not necessarily the immediate host rock, which is predominantly felsic.

Type 1 showings contain trace to *ca.* 8% fine, disseminated pyrrhotite, and scattered pyrite (<10%), disseminated and in blebs. The thicknesses of the zones are <5 m. Metal contents range from 37 to 295 ppm Cu, 5 to 201 ppm Zn and trace to 0.5 ppm Ag. The host rock at Batty Lake is the fine grained siliceous variety of 3e (tuff?); at Fairwind lake the host varies from siliceous to intermediate and calcareous (3d). At one place near the shore of Fairwind Lake a cordierite-anthophyllite schist (alteration zone) occurs in the underlying amphibolite. Elsewhere the amphibolite locally contains carbonate stringers, which have probably developed by alteration of the mafic rocks.

Type 2 showings are less abundant because of the low volume of amphibolite screens in the complex. The margins of the screens are commonly sheared. These showings apparently form narrower zones than type 1. Their pyrrhotite content is <3% and base metal contents are comparable to type 1. One showing, hosted in garnet-anthophyllite gneiss (alteration) within a larger amphibolite screen, yielded 550 ppm Cu.

Type 3 showings with Fe-Mg alteration (4b, 4f) are hosted in various types of felsic rocks on the margin of the Batty Lake complex, particularly in the Limestone Creek high-strain zone. The showings generally contain <2% fine, disseminated pyrrhotite. Base metal contents are 8 to 473 ppm Cu and 10 to 53 ppm Zn. Where the widths of the sulphide-bearing zones are known, they range from 10 cm to 3 m.

Near Hayhurst Lake cordierite-anthophyllite schist occurs in a wide zone at the contact of the Batty Lake tonalitic complex. Along the logging road the minerals are locally exposed in patches or lenses within garnetiferous quartzofeldspathic gneiss. The most mafic Fe-Mg-rich domains are stained rusty with traces of oxidized sulphide minerals. They represent the best exposed examples of alteration products in the Batty Lake complex. The less altered gneiss (with garnet as the only indicator mineral) grades into typical tonalitic orthogneiss (6a). Hydrothermal activity has affected the tonalite protolith and screens of supracrustal rocks; several stages of alteration such as those described in the Snow Lake area (Bailes, 1987, 1988; Bailes and Galley, 1989) may have been involved.

Massive to disseminated iron sulphide

Two massive to disseminated Fe sulphide occurrences (12 in Fig. 33) are southeast of Walton Lake. They are hosted in a heterogeneous succession of felsic gneisses and amphibolite, mainly of unit 3. Ostry (1986) reported <10 m of disseminated to massive pyrrhotite mineralization exposed in old trenches just south of the lake and farther southeast. For the larger, southeastern showing he reported that "mineralization occurs locally over a thickness of approximately 5 to 10 m and consists of 20% disseminated fine grained pyrrhotite ± pyrite, near solid pyrrhotite mobilizate, scattered lenses of thin (<2 mm) veins of pyrite, and a layer (<3 cm) of pyrite. ...Host rocks include structurally overlying coarse grained garnet-anthophyllite rock. The main zone has a probable minimum strike length of approximately 200 m."

Trenching and drilling of the amphibolite sequence on Yakushavich Island, Collins Point and the southeast corner of Moose Island in Kississing Lake (Fig. 33) indicates layers of massive pyrrhotite , pyrite and minor chalcopyrite are present in addition to zones of disseminated sulphides. Trenches in amphibolites near Maltman Lake and Three Fingers Lake (southwest Kississing Lake) also contain massive and disseminated sulphides.

GOLD

Structurally controlled gold

Gold mineralization 1 km north of Puffy Lake (Au_{15} in Fig. 33) is hosted in gneisses interpreted to be equivalents to the Amisk Group (Hunt and Zwanzig, 1990), and locally within the Missi Group. These rocks form a supracrustal mantle on the south side of the Sherridon-Hutchinson Lake complex. The main Puffy Lake deposit lies within a succession of amphibole- and biotite-bearing gneisses interpreted to be metavolcanic and metasedimentary rocks. Much of the mineralization is in biotite schist, probably a product of alteration. A gold occurrence at Martell (Wood) Lake (Au_{18}) is hosted in potassium-rich zones within large dykes intruded into the Amisk Group. This occurrence lies immediately south of the Kississing - Batty lakes area and is not described here in detail (but see Ostry, 1987).

These deposits share the following common characteristics:

(1) structural control,
(2) quartz veining with shallow NE dip, parallel to NW-trending D_3 axial surfaces,
(3) remobilized and recrystallized sulphides, and
(4) probable potassium and/or carbonate alteration of the host rock.

PUFFY LAKE DEPOSIT

Ostry (1986, 1988) and Ostry and Trembath (1992) suggested that the geology of the Puffy Lake deposit is complex. Mineralization lies within deformed quartz veins and their host rocks. Veins and foliation strike NW and dip *ca.* 35° NE. The veins formed in the back limb of a D_3 fold, parallel to the axial plane, or were transposed into that orientation during D_3. Ostry (personal communication) has suggested that the veins were boudinaged and refolded by open, upright D_4 structures into which some gold appears to have been mobilized. Arsenopyrite associated with the gold is locally aligned with the lineation in the D_3 folds.

The Mineralization exposed in the early exploration trench is described by Ostry (1986) as follows: "Blebs, disseminations, vugs and veins of arsenopyrite, pyrrhotite and pyrite ± chalcopyrite, sphalerite and galena form 15% of undeformed white to smokey grey quartz vein(s) that are 0.2 to 1.0 m in thickness. Fine grained biotite-rich (<50%) quartzofeldspathic rock is the immediate host to the quartz vein(s). Adjacent to the quartz vein(s).....the biotite-rich rock commonly has <20% arsenopyrite as thin wisps, laminae, and lenticular clots (less than 5 by 20 mm). Ubiquitous, thin (1-2 cm) quartz veins parallel or subparallel to the main vein exhibit crystal growth perpendicular to the walls."

Information from preproduction drilling and from the underground development carried out by Pioneer Metals between 1987 and the shut-down in 1989 is presented by Ostry and Trembath (1992). Apparently, three parallel "zones of auriferous quartz-sulphide mineralization....occur within an intermediate to mafic, layered" biotite-bearing gneiss (altered Amisk Group?) "with interlayered amphibolite, ultramafic rock and felsic gneiss. ...Visible sulphide mineralization within the host rocks is restricted to 1-2 m from the vein margins." These zones were originally considered to provide a 2 m mining width and the main zone to be over 1000 m long. The zones are in the order of tens of metres apart. A fourth, parallel zone lies structurally higher in Missi Group rocks. The mine was considered to have a reserve of 3.54 million tonnes grading 7.88 g/t (0.23 oz/ton). Operations were closed in 1989 .

The deposit is probably a deformed, structurally controlled, vein deposit. The alteration associated with the veins contains abundant black biotite (rather than white mica, which is common in gold deposits hosted in lower-grade rocks). The extent of alteration to biotite-rich rocks and calc-silicate rocks is uncertain because the protolith of the host rock is unknown. The structural framework of the Puffy Lake area suggests that the deposit developed near a long-lived structural break that existed between the Flin Flon belt and the Kisseynew belt. Along part of this break the Puffy Lake shear zone has acted as a detachment surface. This zone outcrops 3 km south of the deposit and may be shallow dipping at depth, thus providing opportunities for local fluid flow and quartz veining in the overlying rocks. However, shear fabrics have not been identified in main zones in the mine and the exact relationship between the veins, the mineralizing event(s) and deformation is not known.

Stratabound gold

Stratabound gold is hosted in mottled quartz-hornblende-plagioclase gneiss (3d) along the south margin of the Kisseynew belt. A small, currently uneconomic deposit of this kind is on the southeast shore of Nokomis Lake (A_{16} in Fig. 33) and other occurrences are located southwest of Evans Lake (A_{17}). Showings also exist north of Lobstick Narrows (A_8), north of the Adamson Lake dome (A_{10}), and a trace showing northwest of Puffy Lake (A_{14}). Each occurrence along a strike-length of 40 km has the same stratigraphic position within the amphibolite and the amphibolite lies in sequence 2 between the Burntwood Suite and the Missi Group. All the gold occurrences lie near the proposed long-lived (and therefore early) structural break between sequences 1 and 2, and most are close to the structural boundary of the Kisseynew belt.

Several marker units serve as a guide to locating the position of this metallotect (Fig. 34). All the showings are hosted in intermediate mottled gneiss (3d), which is overlain and underlain by amphibolite (3a-3c) with a distinctive unit of garnet amphibolite (3c) directly, stratigraphically below 3d. The Missi Group basal conglomerate lies stratigraphically above and the Burntwood Suite stratigraphically below this package of rocks. The origin of the mottled gneiss (3d) is suggested to be metasedimentary by Ostry and Trembath (1992). However, hydrothermally altered igneous rocks cannot be ruled out to be the protolith. Evidence of alteration includes the presence of albite, amphibole-rich stockwork and the common colour mottling that suggests patchy replacement of elements.

The enclosing carbonate-bearing amphibolite locally resembles metadiabase. There are also fine grained (metabasaltic?) units and layered metasedimentary amphibolites (silicate iron formation). This part of the succession is tentatively interpreted to be mafic flows and sills, and chemical sedimentary rocks. These conclusions and the stratabound habit of the gold occurrences over a strike length of 40 km suggests a syngenetic origin for the mineralization.

The assemblage of amphibolites and minor intermediate gneiss (3a-3d) has been traced for tens of kilometers during the current project. It can serve as a guide for further gold exploration. The assemblage is easy to locate because of its distinctive stratigraphy. Current work will test if the chemistry of basalts indicates a back-arc origin like a similar succession on the north flank of the Kisseynew belt described by Zwanzig (1990a). This would further distinguish the mineralized succession from other mafic units in the Kississing - Batty lakes area, which are considered to be arc derived because of their felsic volcanic association and types of mineral deposits.

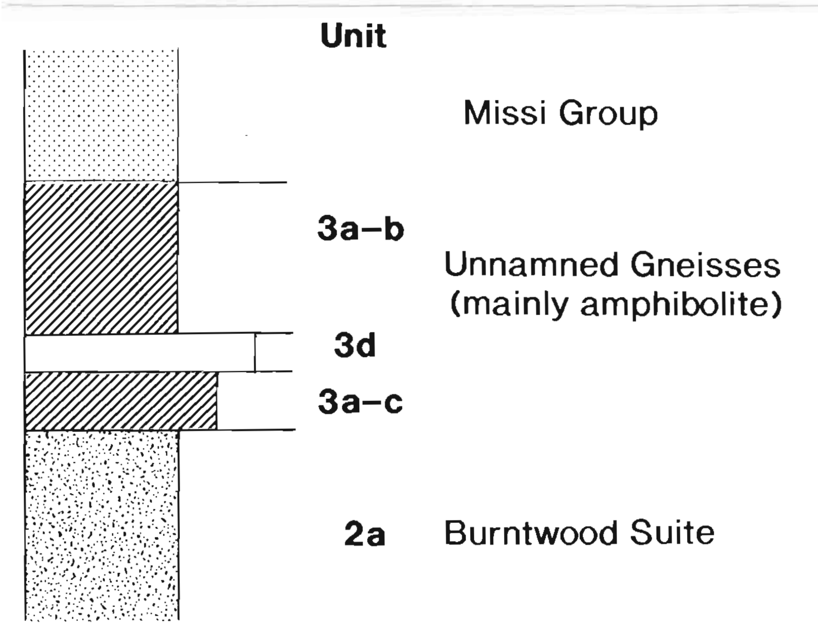


Fig. 34a Stratigraphic position of unit 3d at Nokomis Lake and Evans Lake gold occurrences.

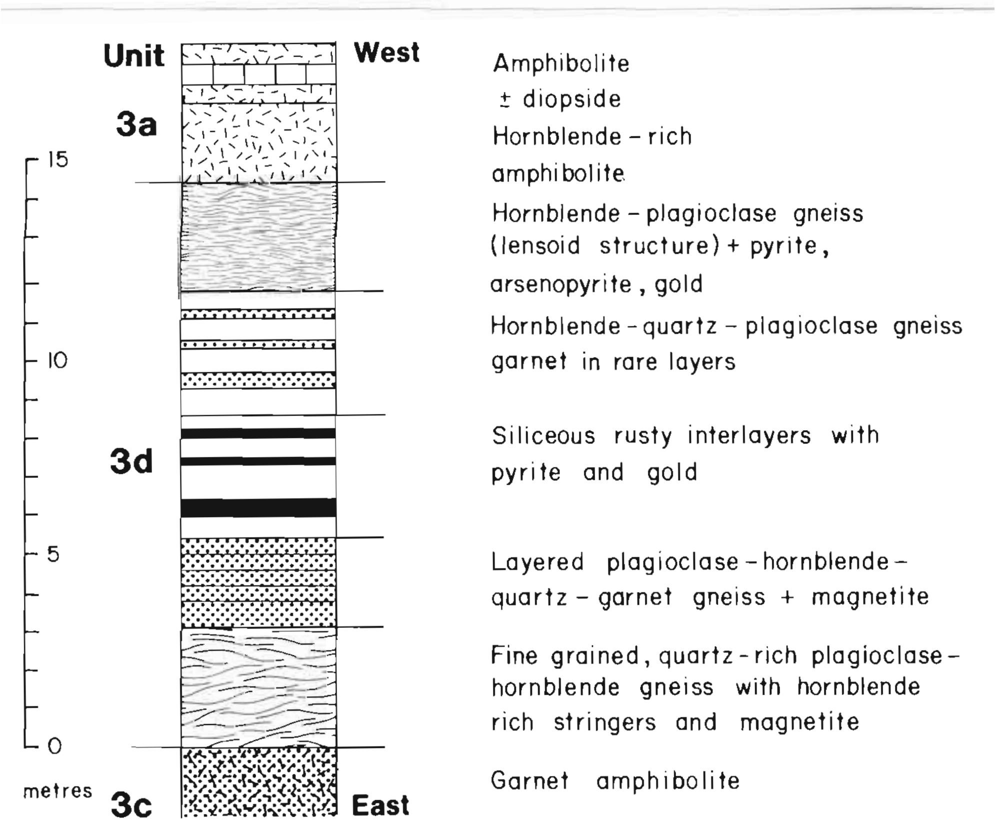


Fig. 34b Generalized section (east to west) showing details of gold-bearing unit (3d) east of Nokomis Lake.

NOKOMIS LAKE DEPOSIT

The section at Nokomis Lake (A_{16} in Fig. 33) is structurally inverted. It contains the thickest unit of mottled gneiss with considerable internal variation and locally the highest content of stratabound gold in the Kississing - Batty lakes area (Fig. 34b). The mottled gneiss is from a few centimetres to 10 m thick and extends for 8 km along the east shore of Nokomis Lake. It dips gently eastward and probably extends in the subsurface in the Meat Lake synform for the 7 km distance east to Evans Lake.

Gold occurs in sulphide minerals, which constitute <15% of the rocks and comprise pyrrhotite, pyrite and arsenopyrite. Traces of chalcopyrite, sphalerite, galena and scheelite are also present. The highest concentrations of sulphides and gold occur in thin silicious layers within the mottled gneiss. The sulphides are recrystallized, as can be seen from randomly oriented needles of arsenopyrite. Locally the sulphides are weakly laminated. Ostry and Trembath (1992) reported that the mineralized zone is *ca.* 100 m long, 1.5 m thick (on average) and that Rio Tinto outlined a deposit that contains 90 700 tonnes grading 10.3 g/t Au.

EVANS LAKE OCCURRENCES

The mineralized section at Evans Lake (A_{17}) is inverted in the underlimb of the same D_2 nappe as the Nokomis Lake deposit, but lies in the east limb of the Meat Lake synform, generally dipping NW. The section is refolded into a complexly shaped structure. The stratigraphy is virtually identical to that at Nokomis Lake, but the stratigraphically upper amphibolite (3b) more closely resembles fine grained metadiabase or basalt. Ostry and Trembath (1992) reported that lenses of mineralization "comprise <5% disseminated pyrite, pyrrhotite ± arsenopyrite and rare chalcopyrite" and scheelite. Minor amounts of sulphides also occur in amphibolite. Reported assays from drill hole intersections range from 14.1 g/t Au over 4.27 m, to 2.2 g/t over 1.77 m.

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APPENDIX: Summaries and Mineral Contents of Units

(next page)

APPENDIX: Summaries and Mineral Contents of Units

UNIT	LITHOLOGIES	MINERAL CONTENTS (DECREASING ABUNDANCE)	PROTOLITHS
A M I S K G R O U P (Sequence 1)			
1	Amphibolite; intermediate gneiss; biotite gneiss	(below)	volcanics; intrusives; sediments
1a	amphibolite	hb pg±dp±ga±bo	volcanics, intrusives
1b	amphibolite	hb pg±dp±ga±ep	basalt
1c	felsic gneiss	qz pg bo hb±ep±mv	dacite flows, dykes
1d	felsic gneiss	qz pg kf bo±mv±ga	rhyolite dykes, flows
1e	biotite gneiss	pg qu bo±sm±ga±mt±hb	mainly sediments
B U R N T W O O D S U I T E (Sequences 2 and 3)			
2a	garnet-biotite gneiss	pg qu bo ga(2 mm) ±sm±hb±py±gp±tm	greywacke-mudstone
2b	biotite gneiss	pg qu bo±gp±py ±mv±ep	greywacke-mudstone
2c	metatexite	pg qu bo ga±sm±cd ±kf±hb±gp±py±tm	greywacke-mudstone
2d	diatexite	pg qu bo ga±sm±cd ±kf±gp	greywacke-mudstone with 10a
2e	muscovite-biotite gneiss	pg qu bo±gp±py±mv±ep	greywacke-mudstone
2f	staurolite-sillimanite gneiss	pg qu bo ga±st ±sm±gp±py±ep	greywacke-mudstone
U N N A M E D G N E I S S (* sequence 1 or unknown; ** sequence 2)			
3	amphibolite, intermediate and felsic gneiss (undivided)	(below)	(below)
3a	diopside-bearing amphibolite	* hb pg dp±ep±ct ±cm±sc±sp±mt±py	volcanic, intrusive sedimentary
		** hb pg dp±ct±ep	

MINERAL CODES: bo=biotite ct=calcite cd=cordierite cm=cummingtonite dp=diopside ep=epidote ga=garnet (almandine) gp=graphite hb=hornblende kf=K-feldspar mt=magnetite units continued from left page

	DESCRIPTION	FIELD RELATIONSHIP	DISTRIBUTION
1	fine- medium-grained, layered	intruded by 6, 6b, 6c, 6d, 8, 9; unconf. overlain by Missi G	Kisseynew-Puffy, Spider-Evans, Moody-Dow lakes
1a	fine- medium, uniform or layered		
1b	fine-medium grained, pillowed		
1c	fine grained, ±plagiophyric	interlayers or dykes in 1a, 1b	Spider-Evans lakes
1d	fine grained, buff weathered		Kisseynew-Evans lakes
1e	fine- medium grained light grey weathered	contacts interlayered with 1; screens in 6b	Dow-Martell lakes; Bess-Hutchinson lakes
2a	rusty weathered, dark grey fresh; fine grained, layered	intruded by 6d, 10, 11; overlain by unit 3 or Missi Group	Kississing River to Evans Lake
2b	rusty- grey-weathered; fine grained, layered-massive		
2c	grey weathered, white *lits*, fine-medium grained, layered	intruded by 6a-d, 7, 10a, 11; overlain by unit 3 or Missi Gp.	Kississing-Limestone Point lakes
2d	light grey weathered, nebulosic-schlieric, medium-coarse grained	intruded by 6d, 10, 11; overlain by unit 3 or Missi Group	central Kississing L.; NW of Walton Lake
2e	rusty- grey-weathered; fine grained, layered to schistose	intruded by 10a, 11; interlayered with 2b	Kississing River-Evans Lake
2f	rusty- grey-weathered; fine-medium-grained, layered	intruded by 6d, 10, 11, interlayered with 2a	S of Duval Lake, NW of Lobstick Narrows
3	layered or uniform	* units of 3 interlayered; stratigraphic position variable: below 2 or as screens in 6a-9	* Walton-Batty-Fairwind lakes, locally Kississing L.
3a	interlayered grey-green and black, medium grained		
	dark grey, uniform,	** units of 3 interlayered; stratigraphically underlain by 2, unconformably overlain by Missi Group	** Lobstick Narrows, Adamson, Puffy- Nokomis-Evans lakes

mv=muscovite pg=plagioclase py=pyrite/pyrrhotite qz=quartz sc=scapolite sm=sillimanite sp=sphene st=staurolite tm=tourmaline

UNIT	LITHOLOGIES		MINERAL CONTENTS (DECREASING ABUNDANCE)	PROTOLITHS
UNNAMED GNEISS (CONTINUED) (* sequence 1 or unknown; ** sequence 2)				
3b	amphibolite	*	hb pg±ga±dp±bo±py±mt	volcanic; intrusive
		**	hb pg±ep±bo	
3c	garnet amphibolite	*	hb pg ga±bo ±qz±dp±ct	volcanic, intrusive sedimentary
		**	hb pg ga bo mt±sp±ap±py	iron formation
3d	intermediate gneiss	*	pg qz hb bo±ga±ep ±dp±sc±ct±mt±py	sedimentary, volcanic
		**	pg qz hb bo±ga ±ct±mt±py±Au	uncertain
3e	felsic gneiss		qz pg±kf bo±mv±ga±gp±py	
3f	biotite gneiss		pg qz bo py±sm-cd±tm±ct	
3g	hornblende-biotite gneiss		pg qz bo hb ga gp py±cm	
3h	garnet gneiss		pg qz bo ga±cd-sm ±hc±mt±py±gp	uncertain (altered?)
SHERRIDON SUITE (SEQUENCE 1)				
4a	quartz-rich gneiss		pg qz bo±ga±hb±kf ±mv±sm±mt±sp±ap	uncertain
4b	quartz-garnet gneiss		qz pg ga bo±hb±cm ±mt±sp±at±cd±py	alteration product
4c	mafic-intermediate gneiss		pg hb±qz±bo±ga ±ct±cm±at±sp	altered volcanic(?)
4d	calc-silicate rock		pg qz bo hb dp±ct ±ga±kf±sp±ep±sc±ap	uncertain
4e	marble		pg kf qz ct bo sp ±gr±dp±ep±sc±ap	uncertain

MINERAL CODES: ap=apatite at=anthophyllite bo=biotite ct=calcite cd=cordierite cm=cummingtonite dp=diopside ep=epidote ga=garnet (almandine) gp=graphite gr=grossularite

	DESCRIPTION	FIELD RELATIONSHIP	DISTRIBUTION
3b	uniform, medium grained	* as above	* as above
	fine grained, black	interlayered sediments at top; unconformably overlain by Missi	** as above
3c	layered to veined; uniform	*	*
	rusty-black, locally well layered	stratigraphically overlies 2a, 3a or 3b;	**
3d	cream- grey-weathered, medium grained	*	*
	mottled, grey; local quartzose layers	stratigraphically overlies 3c; overlain by 3a or 3b	**
3e	very fine grained white/brown/pink	*	*
3f	rusty, discontinuous layers	associated with 2c	north-central Kississing Lake, Collins Point - Three Finger Lake
3g	rusty, fine grained		
3h	grey, coarse grained, locally fine grained	associated with units 2 and 3	Walton-Meat lakes
4a	uniform light grey to lensoid or layered	Sherridon body interpreted as structurally below 6b-6c	Sherridon-Star Lake, locally Walton-Batty lakes
4b	lensoid to layered	irregular domains in unit 4a; mantle on 6a orthogneiss	(Sherridon structure) (Batty Lake complex)
4c	lensoid to layered	discontinuous units in 4a, 4b	
4d	layered	units in 4a, 4b	
4e	layered	unit surrounds the core of the Sherridon structure	

hb=hornblende hc=hercynite kf=K-feldspar mt=magnetite mv=muscovite pg=plagioclase py=pyrite/pyrrhotite qz=quartz sc=scapolite sm=sillimanite sp=sphene tm=tourmaline

UNIT	LITHOLOGIES	MINERAL CONTENTS (MOST TO LEAST)	PROTOLITHS
SHERRIDON SUITE (SEQUENCE 1)			
4f	cordierite-anthophyllite rock	qz cd at bo±ga±pg ±sm±hc±mt±ap	alteration product
4g	garnet-biotite gneiss	pg qz bo gr±hb	sediment
4h	amphibolite	hb pg±ga±qz	intrusive; volcanic
4i	garnet-sillimanite-biotite gneiss	qz bo ga sm pg±cd±py	alteration product(?)
MISSI GROUP			
5a	hornblende-bearing gneiss	pg qz hb bo mt±kf±ep±sp	calcic sandstone, mudstone; ±tuff or intrusive rock(?)
5b	quartz-rich paragneiss	qz pg bo±kf-sm-mv ±ep-ct-sp±ga mt he	sandstone
		pg qz bo kf±sm-mv ±hb-ep-ct mt he±sp	sandstone
5c	quartzofeldspathic gneiss	qz pg kf mv mt he	arkose
5d	varicoloured gneiss	qz pg bo±kf±mv±hb±ep mt	sandstone-argillite
5e	felsic gneiss	qz pg kf mv bo±sm mt±ap±fl	rhyolite, tuff, arkose, microgranite
5f	metaconglomerate, paragneiss		interbedded sandstone and conglomerate
5g	amphibolite-intermediate gneiss	pg hb±bo±ep±qz mt	flows, tuff, intrusions
5f	metaconglomerate, ribbon gneiss		basal conglomerate
PALEOZOIC ROCKS, (ORDOVICIAN)			
12	dolomite		

MINERAL CODES: ap=apatite at=anthophyllite bo=biotite ct=calcite cd=cordierite ep=epidote fl=fluorite ga=garnet hb=hornblende hc=hercynite he=hematite kf=K-feldspar mt=magnetite

	DESCRIPTION	FIELD RELATIONSHIP	DISTRIBUTION
4f	generally very coarse grained	lenses and small units most common in 4a-e, 3a, 6a	
4g	uniform grey	unit within 4a, 4b	(Sherridon structure core)
4h	uniform, fine-medium grained	layers in 4d, 4b	
4i	rusty multi-component layers	thin unit within 4a, 4b	(NE Sherridon structure)
		intruded by some of 6a-11	
5a	fine grained, dark grey	associated with 5g	Kississing R.-Puffy Lake
	medium grained, well layered	irregular, discontinuous units	Kississing-Walton lakes
5b	pale grey, medium-coarse grained, (cross?)bedded	local interbeds of conglomerate (5h)	N of Kisseynew Lake
	grey-pale pink, fine-medium grained, layered, ±pink *lits*	interlayered with other Missi units	Kississing-Craik lakes
5c	buff-weathered, layered-veined	grades into 5b, adjoins 5e	Kississing R.-Dow Lake
5d	pink, grey and green layered		
5e	uniform pink, pseudo-gneissic, very fine grained ±qz/pg-phyric	bodies in 5a-g, sharp to graded conformable contacts	
5f	felsic matrix with mainly felsic and quartz clasts		
5g	fine grained, layered-uniform, aphyric,±hb/pg-phyric		
5h	mafic-felsic clasts and matrix	unconformably overlies 1-1d and some of 6-9; low-angle unconformity on 2-2c, 3-3c	Kississing R.-Dow Lake; locally Kississing-Batty lakes
12	mottled buff	fault-bounded, folded	Limestone Pt. Lake

mv=muscovite pg=plagioclase py=pyrite/pyrrhotite qz=quartz sm=sillimanite sp=sphene

Summaries and Modes of Intrusive Rocks

UNIT	LITHOLOGIES	AVERAGE MODE (%)				MAFIC & ACCESS. MINERALS
TONALITE-GRANODIORITE		QZ	PG	KF	MF	
6	tonalite	30	58	0	12	bo hb
6a	quartzose tonalite gneiss	40	45	+	12	bo hb ±ga ep ±mt sp
		40	50	+	10	hb bo ±ga mt
6b	tonalite-granodiorite gneiss	33	58	+	9	bo ep hb mt
		29	55	6	9	bo ±ga
		30	57	3	10	bo hb ep mt
		26	56	<6	12	bo ±hb mt
		30	40	20	10	bo hb
6c	granodiorite-granite gneiss	34	43	12	3	bo
		32	32	28	8	bo ga sm ±mv
		30	35	15	20	bo hb
		30	40	20	10	bo hb ±sm ±ga ±ep ±sp
		qz	< pg	kf	bo	ga mt
6d	plagioclase porphyry	15	60	0	25	bo hb
		qu	< pg		bo	
7	quartz diorite-gabbro	8	55	0	32(hb)	5(bo)
7a	mesocratic gneiss	15	55	0	20(hb)	10(bo) mt sp
7b	quartz diorite	<10	65	0	20(hb)	7(bo) cp sp ap
8	metagabbro		pg		hb	±qz ±ga
8a	hornblendite-melagabbro		<40	<	hb	dp sp
8b	ultramafic rocks					px am mt ±ol ±se ±sn
9	monzogranite-granodiorite	35	35	30	5	bo mt
		35	30	24	7	bo mt ep sp ap
9a	granite gneiss	qz	pg	kf	bo	
10	two-mica leucogranite	qz	< pg	kf	bo<5	mv<4
10a	leucogranite	qz	< pg	kf	bo<5	±ga ±sm ±gp/mt

MINERAL CODES: am=amphibole ap=apatite bo=biotite cp=clino-pyroxene dp=diopside ep=epidote ga=garnet hb=hornblende kf=K-feldspar mf=mafic minerals mt=magnetite

units continued from left page

	GRAIN SIZE (mm)	DESCRIPTION	FIELD RELATIONSHIP	DISTRIBUTION
6	3-8	subhedral pg <10 mm	unconf. overlain by Missi	Spider Lake
6a	f-med.	inequigranular	intrudes 1, 2	Defender L. complex
	med.	granoblastic-mortar text.	intrudes 2c, 3, 5(?)	Batty Lake complex
6b	2-5	moderately foliated	intrudes 1, cut by 6c	Drury Lakes dome
	<7	weakly gneissic	intrudes 1	Moody Lake dome
	1-5	foliated-gneissic	unconf. overlain by Missi	Sherridon-Hutchinson L.
	med.	partly remobilized	inclusions of 2c, 5b	Guthrie L
			inclusions of 2c, 3, 5b	South B.-Adamson L.
6c	1-5	foliated, lineated	intrudes 1, 6b	Drury Lakes dome
		strongly foliated	cut by 10a	Moody Lake dome
	<5	strongly foliated	margin phase of 6b-c	Hutchinson-Nokomis lakes
	<3	local kf <8 mm	near N margin	Defender Lake dome
		kf augen <10 mm	NE end	Adamson Lake dome
6d	fine	with subhedral pg <10	pre-Missi, NE margin	NE-Spider L. body
	med.	subequant pg	intrudes 2a, 2f	S Duval Lake
7	med.	hypidiomorphic granular	better preserved than 7b	NE Big Isl., S Moody L.
7b	med.	foliated, layered	sheets in 5a, 5b	Kississing Lake N
7b	coarse	foliated-massive	intrudes 5b	SE of Craik Lake
8	med.	foliated-gneissic	sheets in 1, 4a-g, 5a-b	NE Kississing-Moody L.
8a	coarse	patchy (hb/dp domains)	small body in 1,	Moody Lake dome
8b	coarse	foliated, pale green, black	small bodies in 1, 4g	N of Sherridon, Dow L.
9	med.	foliated-gneissic	inclusions of 5b(?)	Big I., Adamson L. domes
	med.	highly foliated	unconf. overlain by Missi	Puffy-Hutchinson lakes
9a	med.	granoblastic, layered	sheets between 2c & 5b	Three Finger-Craik lakes
10	variable	white-weathered	sills, *lits* in 2, 5	Duval-Evans lakes
10a	variable	white-weathered	sills, *lits* in 2, 5	N of areas with 10

mv=muscovite ol=olivene pg=plagioclase px=pyroxene qz=quartz se=serpentine sm=sillimanite sn=spinel sp=sphene