The Wildnest-Tabbernor Transect: Attitti-Mirond Lakes Area (Parts of NTS 63M-1 and -2)[1]

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This paper deals with the central part of the Wildnest-Tabbernor Transect (Figure 1), which was begun in 1991 with a study of the Wildnest-Attitti lakes area (Ashton and Leclair, 1991). The area mapped in 1993 is centred about 20 km southeast of Pelican Narrows and 60 km northwest of Flin Flon, Manitoba. Field work was carried out by a five- to seven-person crew and consisted of chain and compass traverses and shoreline mapping. Topographic relief ranges over 85 m with supracrustal rocks generally occupying the low areas and granitoid rocks dominating the ridges.

The area was included in early reconnaissance studies by McInnes (1914), Satterly (1932), and Taylor (1958) and was subsequently mapped in more detail by Pyke (1966) and Macdonald (1974). Recent studies have been directed toward elucidating the tectonic history of the northern Hanson Lake Block (Lewry and Macdon-

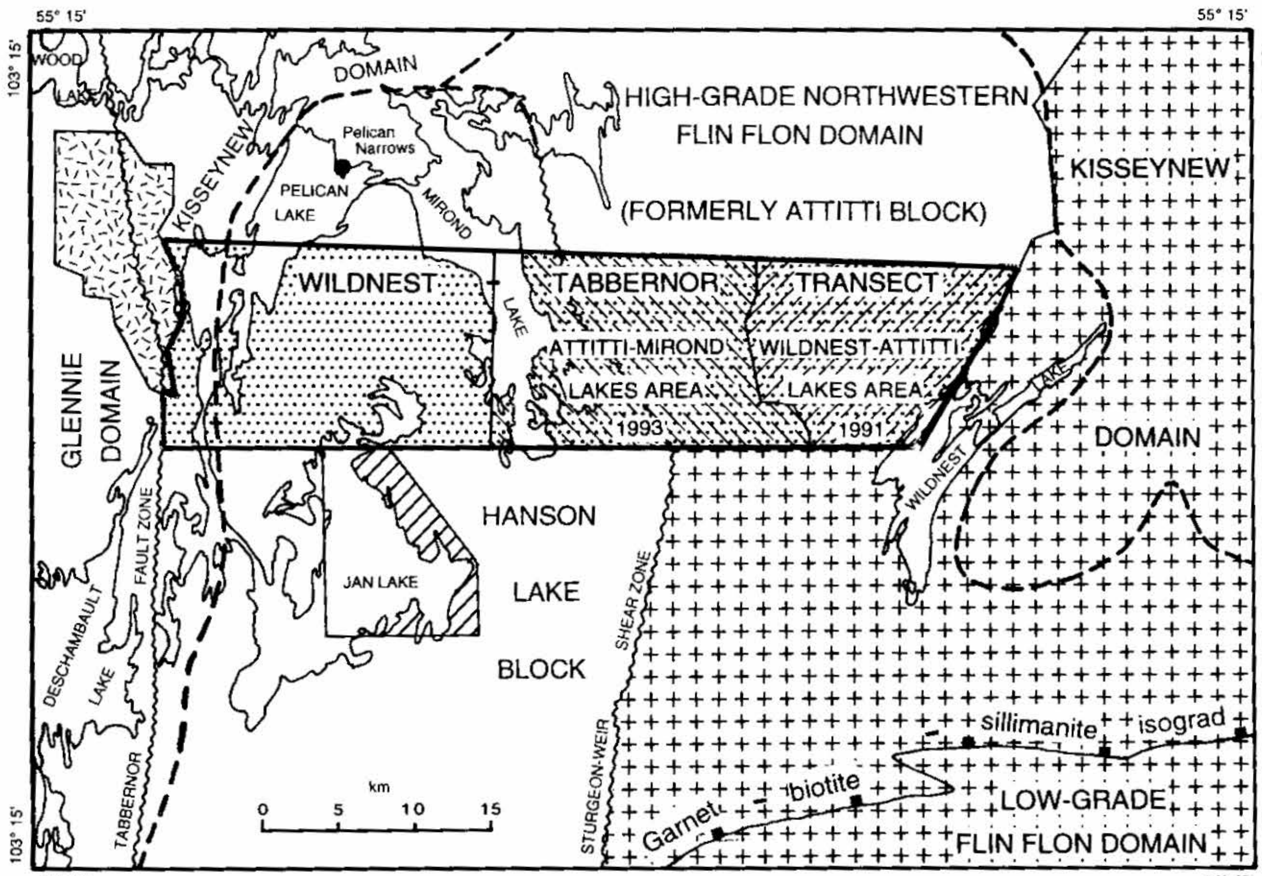

Figure 1 - Location of the Wildnest-Tabbernor Transect (dots) showing completed work (superimposed stripes). Other recent mapping in the vicinity: crosses=Mari Lake area by Ashton from 1985-1987; stipple=Nielsen Lake area by Wilcox from 1990-91; and wide stripes=Jan Lake East by Rupan in 1991. Figure modified from domain map of Macdonald (1981).

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ald, 1988; Lewry *et al.*, 1989; Craig, 1989; Rupan and Lewry, 1991, 1992; Sun *et al.*, 1991, 1992, in press).

1. General Geology

The Attitti-Mirond lakes area spans the boundary between the eastern Hanson Lake Block and the western part of the "Attitti Block", a suggested subdivision of the Kisseynew Domain (Macdonald, 1981; Figure 1) which is now thought to be the high-grade northwestern extension of rocks of the Flin Flon Domain (Ashton and Leclair, 1991). The Sturgeon-weir Shear Zone (MacQuarrie, 1979; Macdonald, 1981; Ashton *et al.*, 1987) has historically been used to define this boundary.

The oldest known rocks in the region are coarse-grained, partly retrograded charnockites comprising the Sahli granite (Macdonald, 1974, 1976) which is exposed in an irregular domal structure immediately west of the study area. It has yielded poorly constrained dates of 2410 ±40 Ma using Rb/Sr techniques (Bell and Macdonald, 1982) and ca. 2500 Ma using zircons (Van Schmus *et al.*, 1987; Sun *et al.*, in press), and is generally thought to be late Archean in age (Lewry *et al.*, 1990). Coarse-grained, largely retrograded granulite facies rocks of intermediate composition (here termed enderbitic rocks) in the western part of the study area grade into the Sahli granite along strike and are also thought to be of Archean age.

The enderbitic rocks are interfolded with, and perhaps intruded by, a widespread leucogranodioritic-tonalitic[4] rock previously designated as "felsic" or "Q" gneiss by Macdonald (1974) and "quartzofeldspathic gneiss" by later workers (Lewry and Macdonald, 1988; Lewry *et al.*, 1989). This enderbite-"Q" leucogranodiorite-tonalite complex is mantled by a structurally overlying protomylonitic to ultramylonitic package of intrusive and supracrustal rocks (Lewry and Macdonald, 1988; Lewry *et al.*, 1989) which has been referred to as the "Pelican Slide" (Lewry *et al.*, 1991; Sun *et al.*, 1991). The mylonites extend eastward to merge with the northern extension of the Sturgeon-weir Shear Zone (Ashton *et al.*, 1987). Farther east, the rocks are lithologically similar to the mylonites but less highly strained. They are readily identified as the more migmatized western extension of rocks mapped in the Wildnest-Attitti lakes area, which have been traced continuously into rocks of the Flin Flon Domain and interpreted as their deep crustal equivalents (Ashton and Leclair, 1991). This implies that: 1) rocks correlative with the Paleoproterozoic Flin Flon volcanic belt extend into the Hanson Lake Block where they are in tectonic contact with Archean basement; and 2) there is no justification in this area for a lithotectonic domain boundary along the Sturgeon-weir Shear Zone, which merges with the eastern part of the wide mylonite zone spanning the Archean/Paleoproterozoic contact.

Rocks of the study area generally exhibit a westward increase in the degree of deformation and grade of metamorphism. The gneissic supracrustal and intrusive rocks of the Wildnest-Attitti area (Ashton and Leclair, 1991) grade westward into migmatitic orthogneisses and diatexites in the central Attitti-Mirond lakes area (Figure 2). West of the Sturgeon-weir Shear Zone, the migmatitic to diatexitic rocks are more highly strained, forming an essentially continuous mylonite zone extending to the Sahli granite (the "Pelican Slide"). The westernmost area consists of the highly strained, "Q" leucogranodioritic-tonalitic rocks and infolded, largely retrograded enderbitic rocks of probable Archean age. These westernmost highly strained rocks are heavily intruded by a mafic dyke swarm and by late medium-grained to pegmatitic granitic rocks.

The metamorphic grade is generally upper amphibolite facies, but has locally attained granulite facies in the west. Most of the granulites are thought to be part of the inferred Archean basement but some mafic dykes, intruding both the enderbitic and the Paleoproterozoic rocks, contain orthopyroxene. Most prograde orthopyroxene has been retrograded to garnet-hornblende aggregates during and/or following the main shearing event.

At least one phase of isoclinal folding postdates development of the main regional foliation. Subsequent strong shearing resulted in widespread mylonitization in the west and is probably correlative with development of the Sturgeon-weir Shear Zone. Shearing was followed by three phases of folding, which include: a gently southeast-plunging phase with a steep northeast-dipping axial plane; a gently north-plunging phase with a moderately to steeply east-dipping axial plane; and a phase of broad upright east-plunging warping.

2. Unit Descriptions

a) Probable Archean Rocks

Enderbitic Rocks

Brown rubbly **enderbitic rocks (En)** appear to extend continuously northward from the southwest shore of Mirond Lake to the Sahli granite (Figure 2). They were originally coarse grained, but have been variably recrystallized to a fine- to medium-grained aggregate during or after the main shearing event. Orthopyroxene and/or clinopyroxene are recognizable in fresh samples but most rocks contain abundant garnet and hornblende, probably due to partial regression.

The outer margins of the occurrence were also coarse grained prior to deformation and recrystallization, but weather grey and contain abundant clinopyroxene and biotite. Straight variously oriented centimetre-scale

(4) Although the prefix "meta-" has not been used, it is understood that all rock types in the area have undergone high-grade metamorphism with the exception of the late medium-grained to pegmatitic granitoid rocks. Although primary features have generally been obliterated by the combined effects of metamorphism and deformation, an attempt has been made to identify precursors and to incorporate them in the rock name.

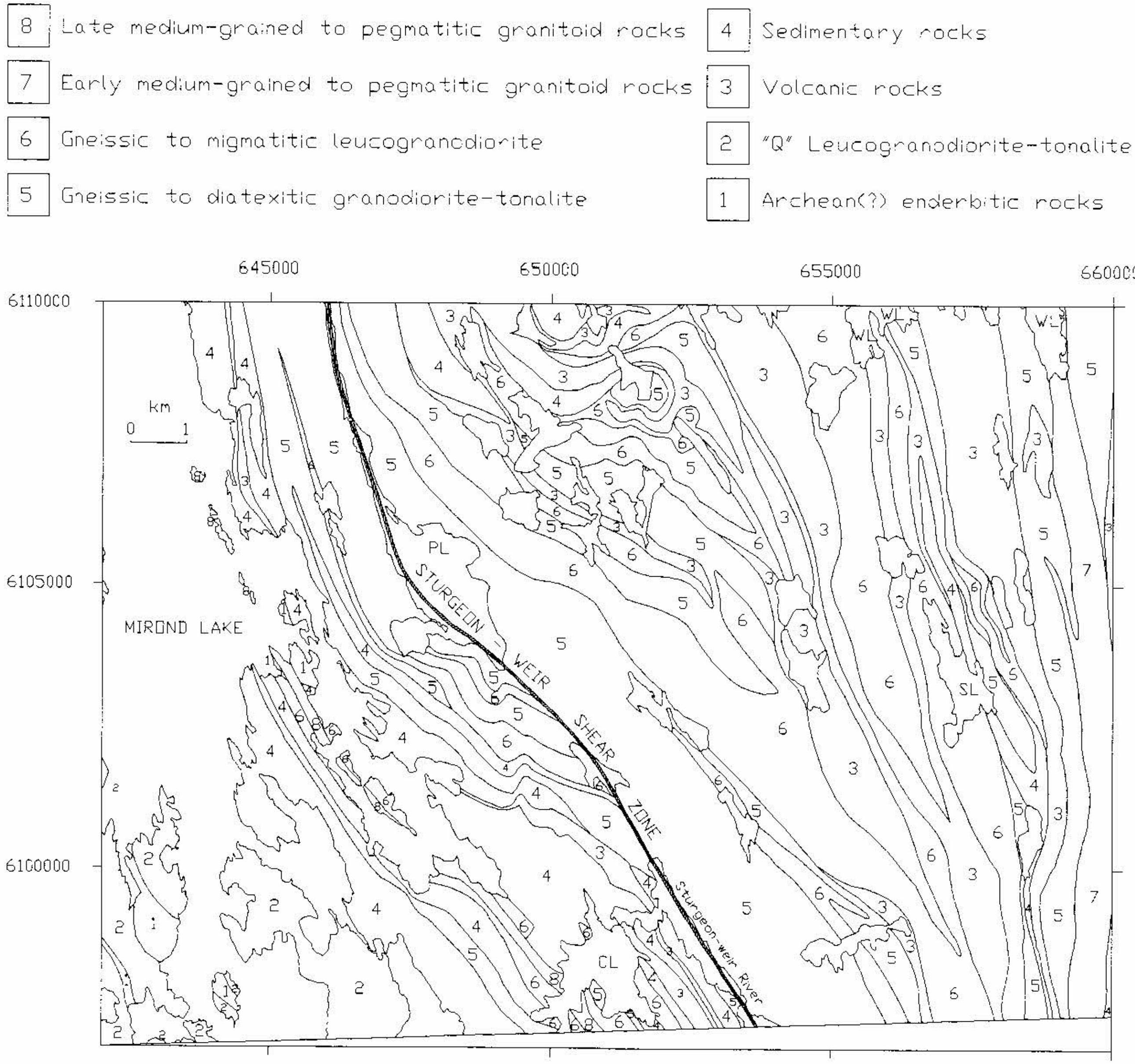

Figure 2 - Simplified geological map of the Attitti-Mirond lakes area: CL=Corneille Lake, PL=Parenteau Lake, SL=Sorenson Lake, and WL=Waskwei Lake. All rocks west of the Sturgeon-weir Shear Zone are mylonitic.

zones rich in green clinopyroxene are thought to result from carbonatization along syn-metamorphic fractures. The grey colour and lack of orthopyroxene in these marginal rocks probably results from syn-metamorphic contamination by a hydrous fluid phase associated with the Paleoproterozoic suite.

A more felsic granulite facies rock resembling the Sahli charnockite was observed in sharp contact with the enderbitic rocks in a weakly deformed outcrop on southwestern Mirond Lake (Figure 3). Mafic and brown-weathering aplitic varieties were also observed in this area.

A second occurrence of brown rubbly-weathering enderbitic rocks is exposed on the southeast shore of Mirond Lake. This eastern occurrence has a larger component of the grey tonalitic marginal rocks which contain 10 to 30 percent clinopyroxene, 0 to 10 percent biotite, and minor orthopyroxene, garnet, and hornblende (Figure 4).

Craig (1989) suggested that the enderbitic rocks and Sahli granite were originally connected, based on field observations, mineralogy, and whole rock chemistry. The results of the present study suggest that at least the western occurrence of enderbitic rocks is continuous under Mirond Lake to the Sahli granite.

b) Rocks of Uncertain Age

Layered Diorite/Gabbro

An unusually well-preserved **layered dioritic to gabbroic body (Gbl)** is exposed on two islands on central Mirond Lake. It contains the same foliation and lineation as the enclosing mylonitic rocks, but these fabrics overprint an apparently primary centimetre-scale rhythmic layering (Figure 5). The rock is locally net veined, probably by an injected metamorphic melt, and contains layers and boudins of possibly co-magmatic hornblendite. It is medium grained, grey, and contains 40 to 50 percent hornblende as 3 to 8 mm aggregates and 50 to 60 percent medium-grained plagioclase.

Anorthosite

Coarse-grained **anorthosite (An)**, exposed within mylonitic orthogneisses at a single outcrop on the north shore of Corneille Lake, also displays primary igneous features including plagioclase laths with interstitial pyroxene and glomeroporphyritic pyroxene aggregates (Figure 6). Grey plagioclase cores of possible primary composition are locally visible in the largely recrystallized white plagioclase-rich matrix. Coarse green clinopyroxene is rimmed by black metamorphic hornblende and garnet occurs locally at plagioclase-hornblende grain boundaries. The colour index grades from about 15 in most of the outcrop to 90 in a small mafic to ultramafic phase. The anorthosite is intruded by a fine-grained grey tonalitic(?) dyke.

"Q" Leucogranodiorite-tonalite

Much of the southwestern part of the area is underlain by a distinctive **leucogranodioritic to tonalitic rock (Gdq)** with a biotite content ranging from 3 to 8 percent. This unit is equivalent to the felsic gneisses (unit Q) previously mapped in the Pelican Narrows area (Macdonald, 1974). The "Q" leucogranodiorite is light grey-white to pink, medium grained, and remarkably homogeneous in comparison to the mylonitic gneisses exposed on the east side of Mirond Lake. It contains 15 to 30 percent white to pink, medium-grained melt, but otherwise layering is restricted to highly strained rocks in which subtle variations in biotite content result in a centimetre-scale gneissosity. Feldspar porphyroclasts occur in mylonitized variants and probably result from dismemberment of early pegmatite or melt.

The "Q" leucogranodiorite-tonalite is variably mylonitized and exhibits the same stretching lineation as the enderbitic rocks and structurally overlying Paleoproterozoic mylonites. It is infolded with the enderbitic rocks and may intrude them. Its age relative to rocks of the Paleoproterozoic mylonitic package is unclear.

Macdonald (1974) noted that the "Q" leucogranodioritic-tonalitic rocks "pass as a mappable unit into the meta-arkoses of Pyke (1966)". However, subsequent detailed field, petrographic, and geochemical studies suggest that they are metamorphosed plutonic rocks (Lewry *et al.*, 1989; Rupan and Lewry, 1992). Field relationships observed during this study also indicate derivation from plutonic protoliths.

c) "Amisk" Volcanic and Related Rocks

Widespread melting of most rock types and the generally high degree of strain make it difficult to identify, distinguish, and trace supracrustal rocks. This necessitated the use of some map units which comprise mixtures of rock types.

Intermediate to Mafic Volcanic Rocks[5]

Fine- to medium-grained, dark green to black **mafic volcanic rocks (Am)** form units up to several hundred metres wide. Most are homogeneous, weakly foliated, and consist of approximately equal proportions of hornblende and plagioclase with minor clinopyroxene. Up to 15 percent red garnet is present at some outcrops and locally defines metre-scale layers.

Although many mafic volcanic occurrences are only weakly layered to homogeneous, several consist of centimetre-scale alternating layers of fine-grained mafic rocks and pale green medium-grained rocks containing clinopyroxene, plagioclase and minor garnet, carbonate,

(5) A "metamorphic colour index" based on the percentage of mafic minerals in a rock was used in the field to name rocks of the volcanic suite. An index of 40 was used to distinguish mafic from intermediate rocks and 20 was used for the intermediate/felsic boundary.

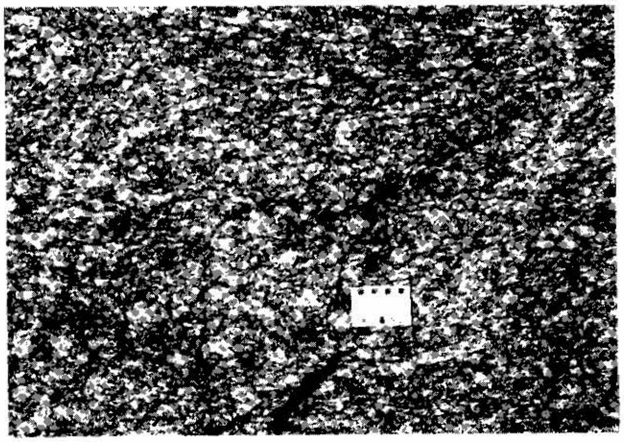

Figure 3 - Near-massive Sahli-type charnockite from inferred Archean enderbitic rocks on the southwest side of Mirond Lake.

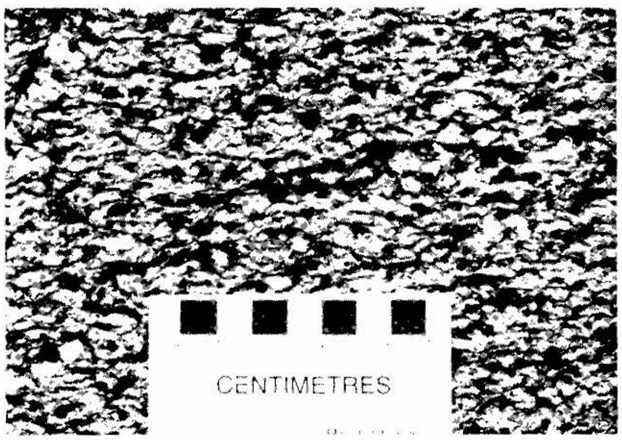

Figure 4 - Originally coarse-grained, grey tonalitic rock from inferred Archean unit containing subhedral green clinopyroxene and white recrystallized plagioclase; eastern Mirond Lake.

and quartz. Minor sulphides tend to concentrate in these calc-silicate lenses and layers. Calc-silicate rocks were also observed in the Wildnest-Attitti lakes area where they range from small lenses making up about 10 percent of the rock to layers continuous over at least several metres (Ashton and Leclair, 1991). They probably represent the high-grade transposed equivalents of the epidote-rich alteration common in many mafic volcanic rocks of the Flin Flon Domain.

Rare outcrop-scale carbonate-rich lenses in the inferred volcanic sequence contain variable proportions of clinopyroxene, Ca-rich amphibole, sphene, quartz, plagioclase and local garnet, scapolite, graphite, and pyrrhotite. They are thought to result from pre-metamorphic carbonatization of volcanic rocks.

Intermediate volcanic rocks (Ai) occur interlayered with their mafic counterparts and in separate units up to hundreds of metres in apparent thickness. They contain variable proportions of hornblende, biotite, plagioclase, and quartz with local clinopyroxene, garnet, and cummingtonite.

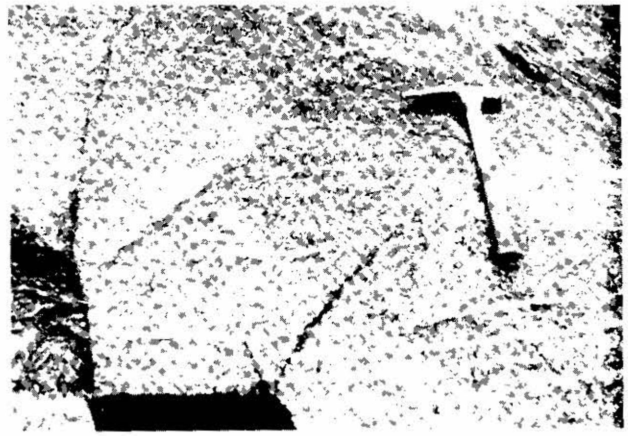

Figure 5 - Centimetre-scale primary(?) layering in diorite/gabbro on southern Mirond Lake.

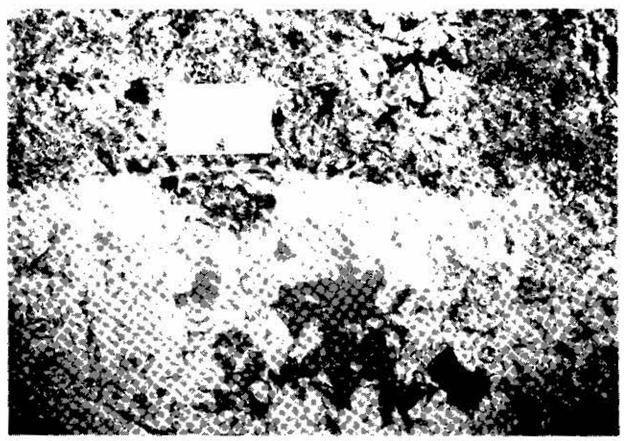

Figure 6 - Coarse-grained anorthosite exhibiting recrystallized plagioclase laths separated by interstitial pyroxene and glomeroporphyritic pyroxene phenocrysts. Rocks are partly underwater along north shore of Corneille Lake.

In the migmatitic central part of the area, the intermediate to mafic volcanic rocks are commonly injected with variable amounts of white, medium- to coarse-grained, plagioclase-quartz melt to form **mafic migmatites (Mgm)**.

The intermediate to mafic volcanic unit is thought to include the high-grade derivatives of volcanic and volcaniclastic rocks of andesitic to basaltic composition. Some of the more homogeneous rocks may have been derived from intrusive protoliths.

Felsic to Intermediate Volcanic Rocks

Quartzofeldspathic rocks, thought to be derived from **felsic to intermediate volcanic protoliths (Af and Ai)**, are less abundant than in the Wildnest-Attitti lakes area and rarely form continuously mappable units. Most are spatially associated with more mafic rocks and many are thinly interlayered with biotite-rich rocks of inferred sedimentary origin. Typical samples contain 0 to 25 percent combined biotite and hornblende with local garnet, clinopyroxene, and minor pyrrhotite.

The local gradation of felsic to intermediate volcanic rocks into calc-silicates containing clinopyroxene, sphene, and carbonate is thought to indicate pre-metamorphic carbonatization of a volcanic precursor.

The inferred volcanic origin for these quartzofeldspathic gneisses is based on their compositional and textural similarity to felsic to intermediate rocks of the northern Flin Flon Domain, where primary diagnostic features can be observed. Most are likely dacitic in composition, but silicified mafic volcanic rocks, which are common in the southern part of the Flin Flon Domain (Thomas, this volume), would not be sufficiently distinct in this area to be recognizable.

d) Sedimentary Rocks

Grey- to rusty-weathering **sedimentary rocks** range from gneissic to migmatitic in the east to diatexitic in the west. They are divided into calcic and aluminous varieties as in the Wildnest-Attitti lakes area.

Calcic Wackes

Gneissic to migmatitic **calcic wackes (As)** generally occur as thin recessive units intercalated with volcanic rocks and contain 20 to 30 percent combined hornblende and biotite, minor red garnet, and trace graphite. They are tentatively thought to be derived from components of the Amisk volcanic suite on the basis of their composition and inclusion in a lithological association which can be traced discontinuously along strike to Amisk Lake.

Aluminous Wackes

Gneissic to diatexitic **aluminous wackes (Aw)** are locally interlayered on a metre-scale with their calcic counterparts, but also form extensive units in the southwest. They contain 20 to 30 percent biotite with 5 to 10 percent pink subhedral to euhedral garnet and trace graphite. One outcrop of cordierite-garnet-anthophyllite-biotite migmatite occurs 3 km southeast of Sorenson Lake (UTM 658715E 6100367N). Cordierite may be a common phase in all of the aluminous wackes, but the fine grain size, resulting from mylonitization in the west, makes it difficult to recognize. Anthophyllite was also observed without cordierite at several other localities.

The mylonitized sedimentary rocks in the west consist of fine-grained, sugary-textured gneisses containing abundant centimetre-scale clasts of dismembered leucosome, about 10 percent garnet porphyroblasts/porphyroclasts up to 1 cm, rare biotite±sillimanite-rich melanosome (Figure 7), and medium-grained, post-tectonic prismatic sillimanite.

The aluminous wackes are similar both to rocks making up much of the southern flank of the Kisseynew Domain (Ashton, 1987; Ashton *et al.*, 1987) and to low-grade compositional equivalents in the Amisk-Welsh (Byers and Dahlstrom, 1954; Ashton *et al.*, 1987), Embury (Gilbert, 1988), and File lakes (Bailes, 1980) areas of the Flin Flon Domain. Although they are thought to have been derived by sedimentary re-working of Amisk volcanic rocks (Bailes, 1980), recent geochronological studies at File Lake, in which detrital zircons at least as young as 1860 Ma were recovered (David *et al.*, in press), suggest that they may include some younger unrelated sedimentary rocks.

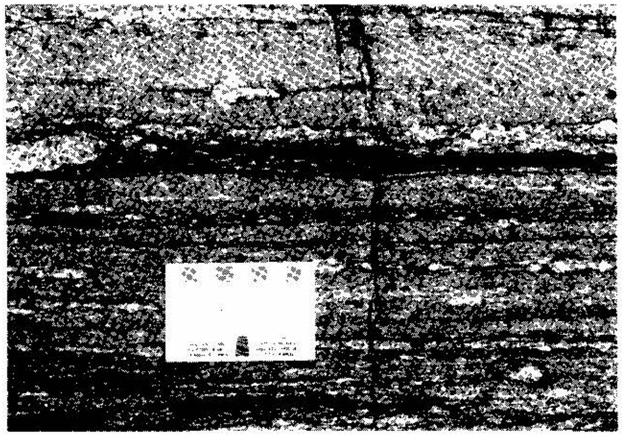

Figure 7 - Biotite±sillimanite melanosome developed at paleosome/leucosome boundary in mylonitized aluminous wackes on southern Mirond Lake. Note dismembered nature of leucosome.

e) Pre- to Syn-D_3 Intrusive Rocks

Intrusive rocks underlie more than 50 percent of the Attitti-Mirond lakes area. They range in character from gneissic in the east, where they are easily divided into the units used during mapping of the Wildnest-Attitti lakes area (Ashton and Leclair, 1991), to migmatitic and diatexitic in the west, where they have been largely mylonitized. In the absence of diagnostic textural information in the highly modified migmatitic and mylonitic rocks, classification has been based solely on composition.

Quartz Monzodiorite

A thin highly attenuated unit of homogeneous pink **quartz monzodioritic rocks (Md)** occurs about 1 km east of the Sturgeon-weir Shear Zone. Metamorphic recrystallization has reduced its grain size from coarse to medium and it consists of 15 to 35 percent hornblende, 0 to 10 percent clinopyroxene (commonly rimmed by hornblende), and variable amounts of K-feldspar, plagioclase, quartz, and magnetite. Rare mafic inclusions and centimetre-scale clots of hornblende were also observed.

The quartz monzodioritic rocks are similar in general appearance, composition, and mineralogy to an intrusive suite which includes the Snake Rapids Pluton in the southwest part of the Flin Flon Domain (Ashton, 1990, 1992a).

Gneissic, Migmatitic and Diatexitic Granodiorite-Tonalite

In the east, **gneissic granodiorite-tonalite (Gdh)** occurs as thin, laterally continuous bodies. They are foliated heterogeneous rocks containing numerous mafic schlieren and 15 to 30 percent white partial melt. The main intrusive component is a medium-grained, grey granodiorite-tonalite containing 5 to 15 percent hornblende and 5 to 15 percent biotite. The partial melt phase is coarser grained, white, and contains 5 to 10 percent hornblende and 0 to 5 percent biotite. It generally occurs as centimetre-scale concordant layers, reflecting strong transposition relative to the cross-cutting network of veins characterizing this unit in the Wildnest-Attitti area to the east (Ashton and Leclair, 1991).

To the west, **migmatites (Mgg)**, similar in composition to the gneissic granodiorite-tonalites, are thought to represent their higher-grade equivalents. The migmatites contain about equal portions of plutonic paleosome and neosome. The paleosome is grey with a 1 to 3 mm grain size and contains about 10 to 15 percent biotite, 0 to 5 percent hornblende, and subhedral, ovoid and anhedral porphyroblasts and/or porphyroclasts of plagioclase and K-feldspar. The leucosome is medium grained and contains about 10 percent hornblende with minor magnetite and sphene. The hornblende is typically concentrated at the paleosome boundary as a solid phase product of the melting reaction. Rare centimetre-scale pods of hornblendite are also present in most outcrops, along with mafic inclusions and schlieren (Figure 8).

Approaching the Sturgeon-weir Shear Zone, the paleosome and leucosome fractions of the migmatitic granodiorite-tonalites locally appear to homogenize, forming a probable **diatexite (Dx)**. Minor leucosome occurs as vaguely defined layers of more quartzofeldspathic material. Mafic schlieren and hornblendite pods are present at most outcrops but the diatexites also contain angular mafic inclusions with an internal gneissosity different from that of the host rock. Typical rocks are medium-grained, grey to white, and contain 10 to 15 percent hornblende, 10 percent biotite and plagioclase and/or K-feldspar porphyroblasts or porphyroclasts up to 2 cm (Figure 9). Magnetite, which is ubiquitous in the leucosome of the migmatitic granodiorite-tonalite, has been replaced in the diatexitic equivalent by minor pyrrhotite.

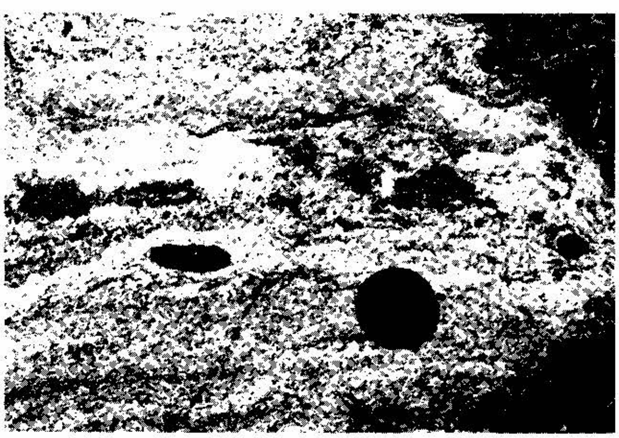

Figure 8 - Migmatitic granodiorite-tonalite (Mgg) containing hornblendite pods and abundant melt with associated hornblende porphyroblasts; southwestern Parenteau Lake.

The gneissic granodiorite-tonalite rocks (Gdh) are interpreted as the high-grade metamorphic equivalents of the 1845 to 1860 Ma (Ansdell and Kyser, 1991) granodiorite-tonalite suite in the Flin Flon Domain. Their transition into migmatitic rocks (Mgg), in the central part of the area, is consistent with a westward increase in metamorphic grade. Rehomogenization of the various fractions in the migmatite, together with the presence of angular "second-generation" inclusions (probably xenoliths) exhibiting a discordant gneissosity, argues for near-complete melting of the granodiorite-tonalite to form diatexite (Dx).

In the mylonitic rocks of the west, intrusive precursors are difficult to distinguish. Rocks with the composition of the migmatitic to diatexitic granodiorites and tonalites are grey, fine-grained, and recrystallized to a sugary texture. Most contain about 10 percent hornblende porphyroblasts which have clearly grown during and after the main shearing event. Centimetre-scale tectonic clasts of quartzofeldspathic material are all that is left of dismembered coarse-grained leucosome and pegmatitic dykes (Figure 10).

Gneissic to Migmatitic Leucogranodiorite

The **gneissic leucogranodioritic rocks (Gdb)** identified in the Wildnest-Attitti lakes area extend westward into the present study area. They are distinguished from the gneissic granodiorite-tonalite (Gdh) on the basis of a lower colour index, higher biotite:hornblende ratio (hornblende may be absent), and by the near-ubiquitous presence of accessory magnetite. The "Q" leucogranodiorite to the west has a more homogeneous appearance, lower colour index, and lacks magnetite and hornblende.

Leucogranodiorite bodies range from homogeneous continuous units up to 1 km wide to outcrop-scale sheets. Occurrences in the east contain 15 to 30 percent medium- to coarse-grained, white to pink, biotitic leucosome in a white to less commonly pink, medium-grained leucogranodiorite containing 5 to 15 percent bi-

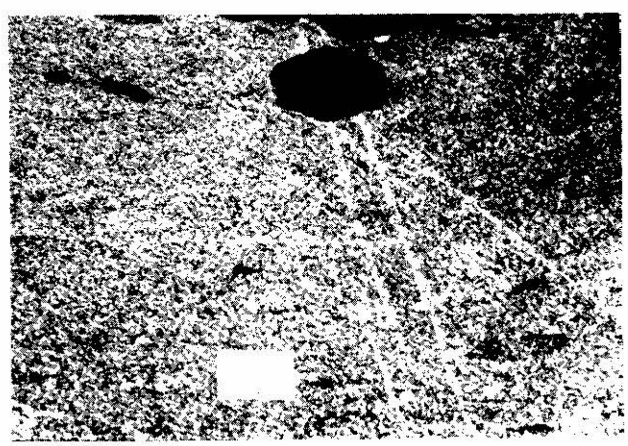

Figure 9 - Diatexitic granodiorite-tonalite (Dx) containing lenticular mafic schlieren, feldspar porphyroclasts/blasts and hornblendite pods. The exposure is crosscut by late hematized fractures; east shore of Parenteau Lake.

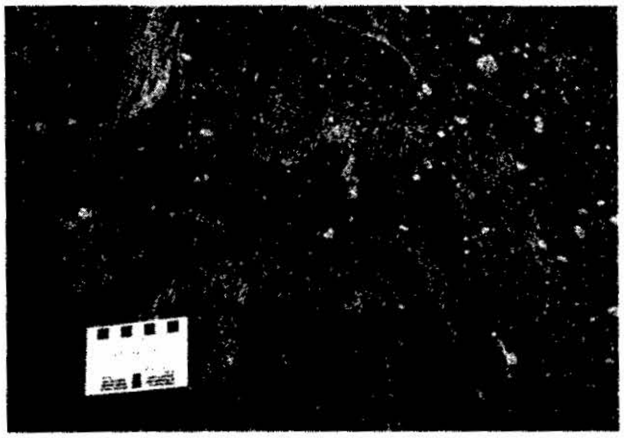

Figure 10 - Mylonitic granodiorite-tonalite exhibiting highly attenuated layering, hornblendite pods, feldspar porphyroclasts/blasts, and pervasive hornblende blastesis; southeast Mirond Lake.

otite, minor magnetite, and local garnet, muscovite or hornblende. Mafic inclusions are locally common.

Migmatitic leucogranodioritic rocks (Mgl) are common in the central part of the area. Some may be derived as mobilized partial melts of supracrustal rocks, but most have been interpreted as high-grade equivalents of the gneissic leucogranodiorite (Gdb). Diatexitic equivalents are probably also included in this unit but are difficult to distinguish from unrelated partial melts due to their compositional similarity. Typical outcrops are extremely heterogeneous and locally contain several or all of the following: the leucogranodiorite protolith; derived pink partial melt containing 1 to 3 percent biotite; abundant mafic inclusions and schlieren; an injected white plagioclase-rich melt, generally associated with the mafic supracrustal rocks; hornblendite pods; and the white hornblende-bearing melt, generally associated with the migmatitic granodiorite-tonalite (Mgg). In addition, the heterogeneous leucocratic migmatites are locally interlayered on a scale of metres to tens of metres with intermediate to mafic gneisses derived from the gneissic to migmatitic granodiorite-tonalite and supracrustal rocks. This interlayering of many rock types suggests a sheet or dyke-like mode of emplacement for the leucogranodiorite; alternatively, it may be due to strong attenuation of units following emplacement.

Mylonitized leucogranodiorites were distinguished from granodiorite-tonalites only on the basis of composition and the general absence of late hornblende porphyroblasts (Figure 11). A porphyritic phase of the mylonitized leucogranodiorite is exposed on a small island on eastern Corneille Lake (UTM 651409E 6098126N). It contains about 30 percent evenly distributed white feldspar megacrysts which are strongly flattened in the shear plane.

In the Wildnest-Attitti lakes area, the leucogranodiorite intrudes both supracrustal rocks and gneissic to migmatitic granodiorite-tonalite (Ashton and Leclair, 1991). A sample from the south end of Kakinagimak Lake has yielded a U/Pb zircon crystallization age of 1852 +6/

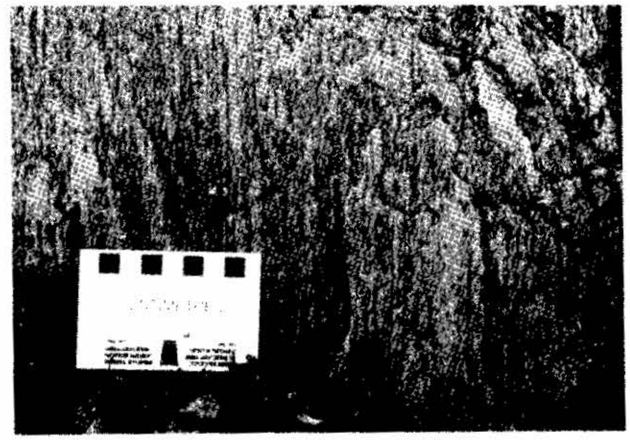

Figure 11 - Mylonitic leucogranodiorite from eastern Mirond Lake exhibiting a strong stretching lineation.

-4 Ma (Heaman *et al.*, this volume). This suggests that the leucogranodiorite was emplaced as part of the 1845 to 1860 Ma suite of granodioritic to tonalitic rocks found throughout the Flin Flon Domain (Ansdell and Kyser, 1991) rather than syn-tectonically, as previously thought (Ashton and Leclair, 1991). This result is also consistent with a U/Pb zircon age of 1855 +4/-3 Ma (Heaman *et al.*, 1992) for the Mari Lake Pluton, a similar leucogranodiorite located about 40 km east of the study area in the south flank of the Kisseynew Domain.

Ultramafic Intrusive Rocks

In the Attitti-Mirond lakes area, **intrusive ultramafic rocks (Um)** similar to those seen in the Wildnest-Attitti lakes area (Ashton and Leclair, 1991) are difficult to differentiate from metamorphically derived hornblendites and modified mafic volcanic rocks. Several small exposures of coarse-grained amphibolite, containing about 80 percent hornblende, 20 percent clinopyroxene, and trace pyrrhotite including one dyke-like or attenuated body on the west shore of north Parenteau Lake, may be correlative.

Mafic Dykes

Mafic dykes (Gb) are common and range in appearance from deformed, homogeneous sheets and boudins to inclusion trains and net-veined amphibolites. In the east, most dykes are preserved as homogeneous centimetre- to metre-scale layers and boudins containing about equal proportions of medium-grained hornblende and plagioclase. Those emplaced in supracrustal rocks commonly contain several percent garnet and/or clinopyroxene.

The protoliths of mylonitized mafic inclusions in the west are difficult to determine. Trains of widely separated metre-scale mafic boudins are thought to have once formed continuous dykes. Many of these inferred dismembered dykes in the sedimentary units display green clinopyroxene-garnet-plagioclase cores and black amphibolitic margins. Where these inferred dykes are more highly dismembered, the green cores are easily mistaken for calc-silicate inclusions.

Elsewhere in the mylonitic zone, lineated, salt-and-pepper textured gabbroic rocks occur as homogeneous boudins tens of metres in size and locally contain up to 5 percent white plagioclase-garnet blebs. These blebs typically range up to 4 cm by 0.5 cm in size, have an internal 1 to 2 mm grain size, and contain 0 to 5 percent garnet. They are interpreted as metamorphosed plagioclase phenocrysts, but could represent a partial melt. Post-Missi plagioclase-phyric mafic dykes are also known from the Mari Lake area (Ashton, 1992b).

The blebby mafic dykes intrude the enderbitic rocks and "Q" leucogranodiorite-tonalite. They occur as transposed layers and boudins forming up to 20 percent of many outcrops and probably account for several percent of the exposed rock in the west. The largest boudins are zoned with a black amphibolitic margin and a brown to black core containing abundant garnet and/or pyroxene in addition to hornblende and plagioclase.

Early Medium-Grained to Pegmatitic Granitoid Rocks

Variably foliated to sheared **early medium-grained to pegmatitic granitoid dykes and irregular segregations (Gp)** occur throughout most of the area but rarely comprise more than about 20 percent of an outcrop. They range from white to pink and most occur as concordant or near-concordant medium-grained to pegmatitic biotite-quartz-feldspar dykes less than 1 m thick. They were probably intruded over an extended time range but many are thought to have been formed during and immediately following peak metamorphic conditions, mainly as injected partial melt fractions.

An approximately 1 km wide zone containing 30 to 90 percent injected pink, medium-grained to pegmatitic granitoid rocks (Gp) extends from east Waskwei Lake southward to the map boundary. The host rocks are mainly gneissic granodiorite-tonalite (Gdh) and leucogranodiorite (Gdb), but the early granitoid rocks (Gp) also intrude supracrustal hosts. The eastern boundary of the zone is sharp and generally marked by a topographic high associated with the large volume of competent granitoid rocks. The western boundary is tentatively placed where the abundance of medium-grained to pegmatitic granitoid material drops below about 30 percent.

Well-developed to irregular layering of intruded granitoid and country rocks in the injection zone ranges from a centimetre to several metres in thickness, and mafic inclusions and schlieren make up 10 to 30 percent of most outcrops. The injected medium-grained to pegmatitic granitoid rocks contain 0 to 10 percent hornblende, 0 to 10 percent biotite, and up to 5 percent magnetite. Garnet and rare clinopyroxene porphyroblasts displaying rims of hornblende occur in patchy distribution.

Rocks in this injection zone are variably deformed. In places, pegmatitic rocks have been dismembered, and derived feldspar porphyroclasts display evidence of milling due to shearing. A weak northeast-plunging stretching lineation is locally developed and some quartz in the pegmatite is ribbony, displaying aspect ratios of about 5:1. A second foliation, defined by flattened quartz, and axial planar to intrafolial folds, is generally present and most easily recognized in the deformed pegmatitic rocks.

The abundance and sharp eastern contact of the medium-grained to pegmatitic granitoid rocks may result from injection along a developing structural discontinuity. Shearing probably accompanied emplacement and accounts for the local pegmatite dismemberment and ribbony quartz. A similarly sheared pegmatite from 6 km south of the study area yielded a U/Pb zircon age of 1806 ±2 Ma (Ashton *et al.*, 1992).

A lens of similar early medium-grained to pegmatitic granitoid rocks is located about 2 km southwest of Sorenson Lake.

Pegmatite dykes, intruding the grey tonalitic marginal rocks of the eastern occurrence of enderbitic rocks, range from weakly deformed to mylonitic. In their least deformed state, they resemble much younger dykes except that the coarse feldspars exhibit a rounding not observed in post-deformational pegmatites. The enclosing enderbitic rocks have probably acted to insulate these dykes from the mylonitic event.

f) Post-D_3 Intrusive Rocks

Intrusion Breccia

Outcrop-scale occurrences of **intrusion breccia (Bx)** intrude the "Q" leucogranodiorite-tonalite on the south shore of Mirond Lake. The breccia varies from near massive to strongly foliated and lineated, suggesting that it postdates much of the early shearing in the area. It consists of abundant rounded to amoeboid fragments up to 50 cm in size in a grey-white granodioritic-tonalitic matrix (Figure 12). Most of the fragments are fine- to medium-grained intermediate to mafic rocks, although rare felsic fragments are also present.

Figure 12 - Intrusion breccia (Bx) on the southwest shore of Mirond Lake.

g) Late Medium-Grained to Pegmatitic Granitoid Rocks

Late pink medium-grained to pegmatitic granitoid rocks (Pg) are abundant from the Sturgeon-weir Shear Zone westwards and probably comprise 10 to 20 percent of that area by volume. The suite includes a variety of rock types, apparently all with a granitic composition. The two most common phases are a pink, medium-grained granite containing about 10 to 30 percent pegmatitic feldspar phenocrysts and pink granitic pegmatite. Both generally occur in the form of subconcordant dykes and sheets up to several metres thick. More extensive exposures include a 200 m thick sheet extending through islands and peninsulas on the east side of Mirond Lake and smaller lenses of homogeneous medium-grained granite east of northern Mirond Lake. These larger bodies are multi-phase complexes involving numerous pegmatites and minor aplite as well as the dominant medium-grained granitic rocks. Most phases contain 1 to 5 percent biotite with rare white mica and garnet as accessories. The pegmatites exhibit graphic granite textures at a variety of scales.

A porphyritic phase, exposed on the Sturgeon-weir River, contains 60 to 70 percent trachytic K-feldspar phenocrysts 10 mm by 2 mm in size in a granitic matrix with 10 percent biotite.

Most of these late granitic rocks are massive but many exhibit a weak biotite and/or cleavage fracture foliation which is axial planar to north-plunging folds.

A similar, probably correlative suite of late granitic rocks in the southern and central Hanson Lake Block has been collectively termed the Jan Lake Granite (Macdonald and MacQuarrie, 1978) and dated at ca. 1770 Ma (Bickford *et al.*, 1987; Ashton *et al.*, 1992).

The composition of the Jan Lake Granite suite is close to that of a minimum partial melt. The suite may represent final emplacement and crystallization of metamorphic magmas generated at depth during the main tectonothermal events.

3. Metamorphism

P-T results in the 6.6 to 7.9 kbar and 630° to 725°C range indicate that metamorphic conditions in the Wildnest-Attitti lakes area were significantly higher than those attained in the southern part of the Flin Flon Domain or in most of the Kisseynew Domain (Ashton and Leclair, 1991; Digel *et al.*, 1991; Perkins, 1991; Ashton and Digel, 1992). These higher conditions reflect a westward increase in grade which culminated in the Archean Sahli charnockite where conditions have been estimated at greater than 10 kbar and 800°C (Craig, 1989).

The westward transition from gneissic granodiorite-tonalite and leucogranodiorite to migmatitic and diatexitic equivalents in the Attitti-Mirond lakes area is attributed to this westward increase in regional metamorphic grade. In pelitic sedimentary rocks, the increase in grade is responsible for stabilizing cordierite-garnet-anthophyllite-biotite which replaces the characteristic garnet-sillimanite-biotite assemblage of the Wildnest-Attitti lakes area (Ashton and Leclair, 1991) and south flank of the Kisseynew Domain extending to Manitoba (Ashton *et al.*, 1986). Orthopyroxene in the enderbitic rocks and some mafic dykes indicates that the grade reaches granulite facies conditions in the west part of the area.

The transition from gneissic granodiorite-tonalite to migmatite involves a reaction in which hornblende is produced together with abundant K-feldspar-rich melt (Figure 8). Winkler (1974) summarized early work dealing with the melting of granodioritic rocks in the modified reaction:

biotite+plagioclase+quartz=K-feldspar-rich melt+
hornblende±magnetite±sphene

in which excess Fe from biotite is taken up by magnetite and excess Ti goes into sphene. This seems to explain the observed mineralogy and textural relationships, including the presence of significant amounts of magnetite, which is absent in the gneissic granodiorite-tonalites. The magnetite is restricted to the leucosome as predicted, and is locally accompanied by sphene. The appearance of trace sulphides, at the expense of magnetite in the diatexites, may indicate a reducing environment during more advanced near-complete melting and rehomogenization.

Hornblende porphyroblasts developed during melting tend to concentrate at the leucosome margins. Centimetre-scale lenses of hornblendite in the migmatitic to diatexitic granodiorite-tonalite described above (Figures 8 and 9) may result in cases where the complementary melt is squeezed out of the reaction site.

Numerous occurrences of garnet-anthophyllite± cordierite rocks have been reported in the northwest part of the Flin Flon Domain, where most have been associated with minor sulphides and attributed to premetamorphic Fe-Mg metasomatism (Ashton *et al.*, 1987; Ashton and Leclair, 1991). In the Attitti-Mirond lakes area, this assemblage was observed in both altered volcanic rocks and graphitic wackes. Anthophyllite occurs at several localities in the most argillaceous sedimentary layers. A sedimentary cordierite-garnet-anthophyllite-biotite occurrence in the east marks the appearance of cordierite-garnet migmatites. This assemblage may be common throughout the area but its recognition is hampered by the high-degree of strain in the west. The appearance of cordierite-garnet migmatites is generally attributed to the breakdown of coexisting biotite, sillimanite/kyanite and quartz (Winkler, 1974). Similarly, gedrite (an end member of the anthophyllite-gedrite series) is produced by the reaction:

Al-rich biotite+quartz=K-feldspar component+
gedrite+H_2O (Winkler, 1974).

Sillimanite is a common phase in mylonitized aluminous wackes, but the coarse prismatic habit suggests that it postdates the main shearing event. Kyanite was not recognized.

The mafic rocks in the area do not appear to have undergone melting. The only possible melt fraction is in the form of plagioclase-garnet blebs in some gabbroic rocks, but these are more likely to result from the metamorphism of plagioclase phenocrysts. The mineralogy of the relatively fine-grained mafic dykes awaits petrographic work, but granulite facies assemblages are anticipated from some western occurrences.

At least some of the inferred Archean enderbitic rocks contain orthopyroxene. The brown rubbly hornblende± garnet rocks of this unit are thought to represent retrograded granulites. The restriction of granulite facies assemblages to the inferred Archean rocks and mafic dykes suggests that relatively dry conditions were required. The Paleoproterozoic suite was probably metamorphosed under similar temperature and pressure conditions, but the presence of water, derived mainly from the sedimentary rocks, effectively stabilized upper amphibolite facies assemblages.

Unreasonably low P-T results from aluminous wackes of the Wildnest-Attitti lakes area indicate that peak metamorphic assemblages have undergone retrogression (Ashton and Digel, 1992). The general texture of the western mylonitic rocks and presence of medium- to coarse-grained, randomly oriented hornblende and sillimanite porphyroblasts implies late recrystallization which may be linked to this retrograde event.

4. Structure

The moderately east-dipping straight zone characterized by pegmatite-injected orthogneisses west of Attitti Lake (Ashton and Leclair, 1991) gives way to a regional north-plunging fold couplet to the west which decreases in amplitude from north to south. Farther west, the northern extension of the Sturgeon-weir Shear Zone coincides with the eastern margin of the mylonitic rocks defining the "Pelican Slide". These mylonitic rocks extend westward to the Sahli charnockite and are affected by several subsequent folding events.

Primary features in the Attitti-Mirond lakes area were largely obliterated by deformation and upper amphibolite to granulite facies regional metamorphism. Preserved igneous features include inferred primary layering in the gabbro exposed on Mirond Lake (Figure 5) and primary crystallization textures in the anorthosite on northern Corneille Lake (Figure 6).

a) D_1 Structures

The earliest recognizable planar fabric is a well-developed moderately east-dipping foliation (S_1) defined by compositional layering, lithological contacts and preferred alignment of biotite and/or hornblende. Associated fold closures were not recognized.

b) D_2 Structures

Tight to isoclinal minor folds (F_2), defined by the main regional foliation (S_1) and by early leucosomal material, generally have east-dipping axial planes and plunge moderately northeast to southeast. Most megascopic intrafolial folds are interpreted as D_2 structures although more than one folding event may be included in this phase. D_1 and D_2 are thought to be broadly coeval with the first two phases of regional folding in the southern Flin Flon Domain (Reilly *et al.*, in press) and southern flank of the Kisseynew gneiss belt (Ashton, in press).

c) D_3 Structures

The intense mylonitization exhibited in nearly all rocks within the "Pelican Slide" and Sturgeon-weir Shear Zone is thought to have developed during D_3 deformation. In addition to the main mylonite zone which stretches continuously from the Sturgeon-weir Shear Zone to the Sahli granite, there are numerous thinner discrete shear zones in the rocks farther east. The north-south straight zones west of Attitti and Wildnest lakes (Ashton and Leclair, 1991) are also thought to have developed during this time.

Rocks within the mylonite zones were migmatitic to diatexitic prior to mylonitization. The strain varies in intensity across the main "Pelican Slide" but most rocks are mylonitic to ultramylonitic. **Classic mylonitic textures are rarely preserved due to metamorphic recrystallization**, leading Pyke (1966) to originally group these rocks with hornblendic gneisses of inferred volcanic origin exposed to the east. However, mylonitization is indicated by a dramatic reduction in grain size from medium to fine or very fine. The mylonites also contain features resulting from the related dismemberment of leucosomal material including the "beaded" and porphyroclastic textures previously described by Lewry *et al.* (1989).

Typical mylonitic orthogneisses are thinly layered, fine grained, and sugary textured (Figure 10). Leucosomal layers are highly attenuated and generally dismembered with locally preserved centimetre-scale porphyroclasts of feldspar or feldspar-quartz aggregates. Mafic inclusions and hornblendite pods were locally rotated during shearing and are variably preserved. Extensive hornblende blastesis outlasted shearing in the granodioritic mylonites, producing scattered hornblende porphyroblasts 1 to 3 mm in size.

The mylonitic equivalents of the migmatitic to diatexitic wackes are fine grained, well foliated, and contain 20 to 30 percent medium- to coarse-grained feldspar±quartz porphyroclasts derived by attenuation and progressive dismemberment of the leucosome. Rounded pink garnets have either survived the shearing or grew later. Coarse prismatic sillimanite and hornblende porphyroblasts postdate the main shearing in the aluminous and calcic wackes, respectively.

A gently to moderately northeast-plunging D_3 lineation is well developed throughout the area (Figure 13). In the east, it is a mineral lineation defined by quartz, hornblende, and quartz-feldspar aggregates. In the highly strained rocks of the west, including the Sturgeon-weir Shear Zone, and in thin discrete eastern shear zones, the lineation is extensively developed and clearly formed by stretching due to tectonic transport (Figure

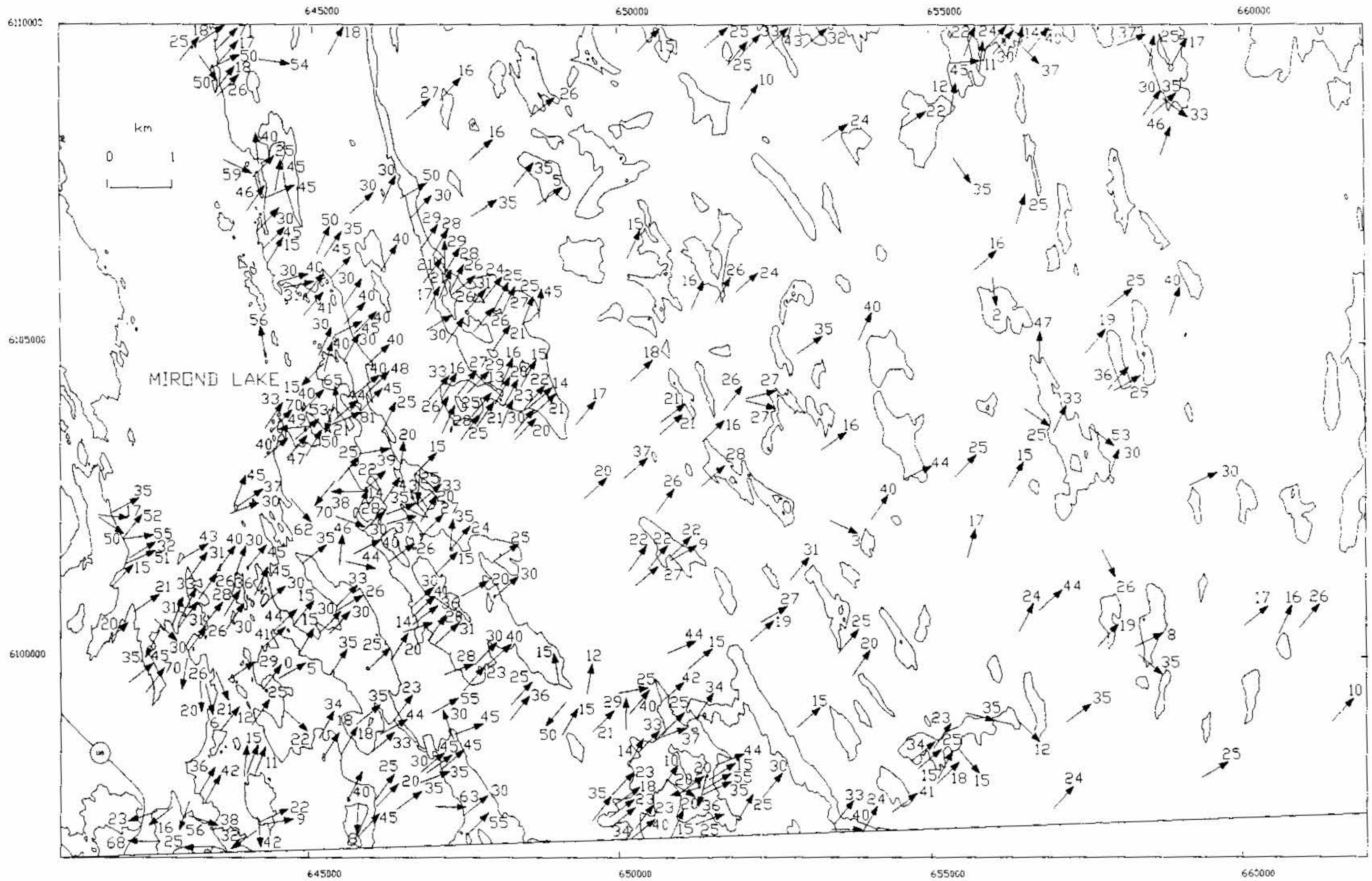

Figure 13 - Map of Attitti-Mirond lakes area showing extent of consistently northeast-plunging mineral-stretching lineation.

11). Kinematic indicators in the form of winged porphyroclasts (Figure 14) and less common asymmetric pull-aparts are abundant and consistently indicate southwest vergence or oblique reverse-dextral shear. The inability to differentiate the Sturgeon-weir Shear Zone from the main mylonite zone implies that both reflect the same thrusting event and supports the suggestion that the Sturgeon-weir Shear Zone is rooted in the "Pelican Slide" (Lewry *et al.*, 1989). The southward divergence of the Sturgeon-weir Shear Zone suggests that it cut up section at a relatively steep angle to higher crustal levels.

d) D_4 Structures

A set of gently to moderately southeast-plunging tight to open minor folds deform the sheared fabric and fold the D_3 stretching lineation. The folds are developed throughout the area but are most common in the southwest. Axial planes dip moderately to steeply northeast. The geometry of these folds is consistent with development during continued northeast-southwest compression.

e) D_5 Structures

Gently to moderately north-plunging open to tight D_5 folds extend throughout the area (Figure 15). Axial planes dip moderately to steeply east and are commonly marked by a quartz flattening foliation, which is particularly well developed in the early medium-grained to pegmatitic granitoid rocks (Gp). Medium-grained pink granitic segregations lie along the axial planes of some folds suggesting that the region had not completely cooled prior to D_5 time. Hinge lines and rare co-linear "b" lineations in the east typically trend about 020° and can generally be distinguished from the average 050° trends of the D_3 stretching lineations.

The broad open fold couplet in the north-central part of the area is interpreted as a D_5 structure. It is thought to be coeval with the Bentz Bay Antiform and Ewen Lake Synform in the Wildnest-Attitti lakes area (Ashton and Leclair, 1991).

Figure 14 - Rotated winged feldspar indicating reverse sense of shear. Looking north at vertical face in mylonitic wackes on west shore of Sturgeon-weir River.

Rare north-plunging D_5 folds and a weak, variably developed axial planar foliation defined by biotite and a fracture cleavage were also recognized in the late medium-grained to pegmatitic granitoid rocks (Pg). The ca. 1770 Ma age (Bickford *et al.*, 1987; Ashton *et al.*, 1992) of the probably correlative Jan Lake Granite provides an approximate age constraint for D_5 deformation.

f) D_6 Structures

Broad upright east-plunging D_6 folds are responsible for local outcrop-scale interference (Figure 16) and correlate with similar warping observed in the Wildnest-Attitti lakes area (Ashton and Leclair, 1991). Their age relative to D_5 structures is inferred from their open, upright geometry and lack of an associated axial planar fabric.

g) D_7 Structures

Late brittle faulting overprinting the Sturgeon-weir Shear Zone farther south (Ashton *et al.*, 1987) can be traced into the Attitti-Mirond lakes area through Parenteau Lake (D_7). The fault consists of minor brecciation and

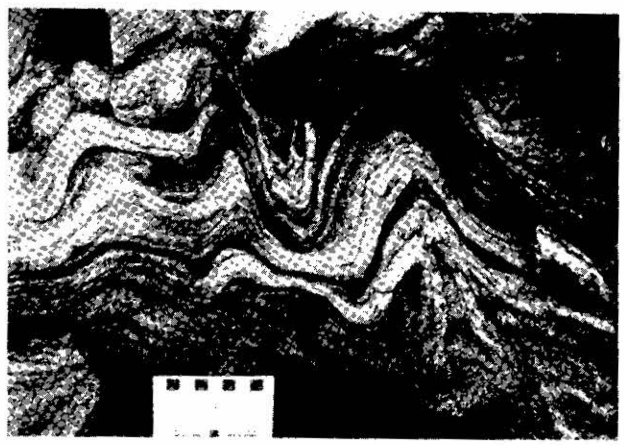

Figure 15 - Typical north-plunging D_5 folds from southeastern Mirond Lake. Note variably developed axial planar foliation and early refolded D_2 fold at lower right.

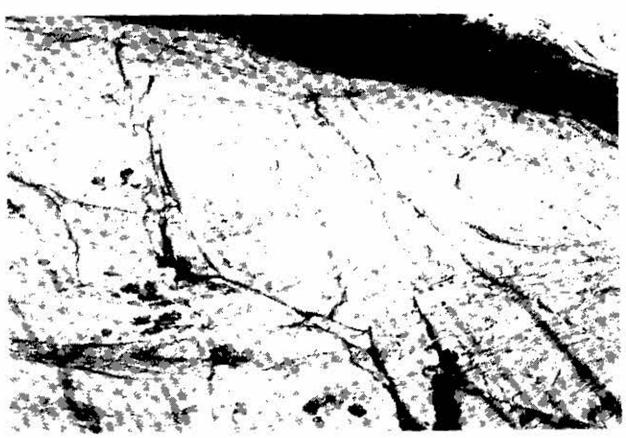

Figure 16 - Type 1 interference pattern caused by interaction of $F_{4/5}$ and F_6 folding, southern Mirond Lake.

numerous fractures, which are generally coated by hematite and/or epidote. Hematite and chlorite pervade the wall rocks up to several centimetres from individual fractures, and quartz veining is common.

The late brittle faults are probably related to a widespread set which includes the Ross Lake, Granite Lake (Ashton *et al.*, 1987; Ashton, 1992b), and Tabbernor (Wilcox, 1991) faults.

5. Economic Potential

Unlike the Wildnest-Attitti lakes area to the east (Ashton and Leclair, 1991), sulphide occurrences are rare in the Attitti-Mirond lakes area. Anthophyllite-garnet±cordierite rocks, which have generally been thought to reflect premetamorphic Fe-Mg metasomatism based on their association with volcanic rocks and/or sulphides (Ashton *et al.*, 1987; Ashton and Leclair, 1991; Ashton 1992b), occur in two settings in the Attitti-Mirond lakes area. Most are found in migmatitic paragneisses and are thought to be derived from the high-grade metamorphism of aluminous wackes. However, an occurrence in mafic volcanic rocks about 1 km south of Waskwei Lake (UTM 657958E 6108487N) probably results from the metamorphism of hydrothermally altered rocks.

6. Timing of Deformation and Tectonic Implications

The close similarity of rock types and their proportions west of the Sturgeon-weir Shear Zone with high-grade equivalents of the northwest part of the Flin Flon Domain (previously termed the Attitti Block) to the east (Ashton *et al.*, 1987; Lewry *et al.*, 1990; Ashton and Leclair, 1991) brings the placement of a domain boundary along the Sturgeon-weir Shear Zone into question. It is expected that further work will lead towards a broad correlation between rocks of the Flin Flon Domain and Hanson Lake Block.

The inferred sequence of deformational events differs little from those of other workers (Table 1) but there are discrepancies concerning the timing and vergence of the main shearing event and the distinction of the southeast-plunging D_4 folds.

The most recent tectonic model for this region involves south- or southeast-vergent thrusting of the Paleoproterozoic rocks over the dominantly granulite facies Archean rocks during a protracted D_1-D_2 continuum (Lewry *et al.*, 1989, 1990). However, this model was primarily based on information from the Glennie Domain and western part of the Hanson Lake Block where complications related to late folding and the Tabbernor Fault Zone make determination of tectonic transport direction and relative timing difficult.

The relative timing of early deformational events is somewhat clearer in the low- to medium-grade southern Flin Flon Domain. In that region, the north-trending traces of F_2 regional folds are displaced tens of kilometres westward by the oblique sinistral-reverse Annabel Lake Shear Zone (Byers and Dahlstrom, 1954; Ashton

Table 1 - Correlation of deformational events in the Hanson Lake Block and northwestern Flin Flon Domain.

Deformational Event	Hanson Lake Block[1]	Attitti-Mirond lakes area[2]	Wildnest-Attitti lakes area[3]
Brittle faulting	D_5	D_7	D_5
ENE-plunging open folds	D_4	D_6	D_4
NNE-plunging tight folds	D_3	D_5	D_{3b}
SE-plunging folds		D_4	
Main shearing event	D_{1-2}	D_3	D_{3a}
Isoclinal folds	D_2	D_2	D_2
Main regional foliation	D_1	D_1	D_1

[1] Lewry *et al.*, 1989; Lewry *et al.*, 1990; Rupan and Lewry, 1991
[2] this study
[3] Ashton and Leclair, 1991

et al., 1987; Wilcox, 1990; Thomas, this volume), but then continue northwards to extend into the Wildnest-Attitti lakes area (Ashton and Leclair, 1991). The southwest-vergence of the Annabel Lake Shear Zone and widespread coeval minor folds suggest that they were formed at the same time as the Sturgeon-weir Shear Zone and "Pelican Slide". This is supported by the regional extent of gently to moderately northeast-plunging mineral-stretching lineations which are co-linear with D_3 mineral-stretching lineations in the Attitti-Mirond lakes area. These lineations have been reported from areas throughout the south flank of the Kisseynew Domain (Zwanzig and Schledewitz, 1992; Norman and Williams, 1992; Ashton, in press) and are generally thought to be coeval with southwest-verging D_3 folds and thrust faults.

Therefore, the main southwest-verging shearing event throughout the Kisseynew Domain, northern Flin Flon Domain, and eastern Hanson Lake Block postdates the first two periods of regional folding. Geochronological studies provide further constraints on the timing of the southwest-vergent D_3 deformation. A maximum age of 1806 ±2 Ma (Ashton *et al.*, 1992) was determined for the Sturgeon-weir Shear Zone from a sheared pegmatite of the early medium-grained to pegmatitic granite suite. Assuming the concentration of these pegmatites along north-south straight zones is the result of developing D_3 discontinuities, 1806 ±2 Ma should represent the approximate age of the southwest-verging event. Further evidence comes from the southern flank of the Kisseynew Domain in Manitoba where three granitoid rocks emplaced along the axial planes of southwest-verging folds yield similar monazite dates of 1799 ±2, 1799 ±3, and 1801 ±3 Ma (Ansdell and Norman, in press).

Textural relationships suggest that peak metamorphism occurred at or shortly before the southwest-vergent D_3 deformational event (Norman and Williams, 1992; Zwanzig and Schledewitz, 1992). A zircon date of 1807 +3/-2 Ma (Heaman *et al.*, 1992) from the Wildnest-Attitti lakes area is interpreted as marking the peak of metamorphism, and is consistent with other recent estimates from the southern flank of the Kisseynew Domain (Ashton *et al.*, 1992). Together, these relationships suggest that the regional southwest-verging transport responsible for thrusting the Flin Flon and Kisseynew domains over the Sahli granite took place at about 1810 to 1800 Ma (Table 2).

The broad structural relationships within the Reindeer Zone have generally been attributed to the collision between the Archean Superior and Rae-Hearne provinces. Early east-west trending structures have been interpreted as reflecting northward subduction whereas later more open northeast-trending folds have been attributed to either northwest-directed closure (Gibb, 1983) or sinistral transpression resulting from northward-directed (Hoffman, 1988) collision of the Superior Province. Recent LITHOPROBE seismic reflection data suggests the existence of a third cratonic block of probable Archean age underlying Paleozoic cover south of the Glennie Domain and possibly extending as far east as the central Flin Flon Domain (Lucas *et al.*, 1993). The Sahli charnockite and enderbitic rocks in the northern Hanson Lake Block are thought to represent tectonic windows or slices of this inferred Archean block.

Table 2 - Inferred geological history based on field relationships and previous geochronological studies in the region.

Age	Event	Phase
1690-1770	Brittle faulting, cataclasis	D_7
	East-plunging folding	D_6
1800-1770	Jan Lake Granite	
	North-plunging folding	D_5
	Igneous breccia	
1810-1800	Southeast-plunging folding	D_4
	Southwest-vergent thrusting over Archean	D_3
	Sturgeon-weir Shear Zone	D_3
1810-1806	Peak of metamorphism	
1850-1810	Isoclinal folding	D_2
	Main regional foliation	D_1
	Mafic dykes	
	"Q" leucogranodiorite-tonalite	
1860-1850	Gneissic to migmatitic leucogranodiorite	
	Gneissic to diatexitic granodiorite-tonalite	
1910-1850	Wacke sedimentation	
1910-1880	"Amisk" volcanism and sedimentation	
Archean	Sahli charnockite and enderbitic rocks	

The overriding of Archean crustal material, represented by the exposed Sahli granite, by the Paleoproterozoic package along a thick fundamental mylonite zone was a crucial part of the tectonic model proposed by Lewry *et al.* (1989, 1990). The model also predicted that the Sturgeon-weir Shear Zone was rooted in the "Pelican Slide". The modifications suggested here are that: 1) the vergence of the proposed tectonic transport was southwest rather than southeast, effectively thrusting the Kisseynew Domain, northern Flin Flon Domain and eastern Hanson Lake Block over the largely unexposed Archean block represented by the enderbitic rocks on Mirond Lake (Figure 17); and 2) that this southwest transport took place relatively late in the regional deformation, around 1810 to 1800 Ma.

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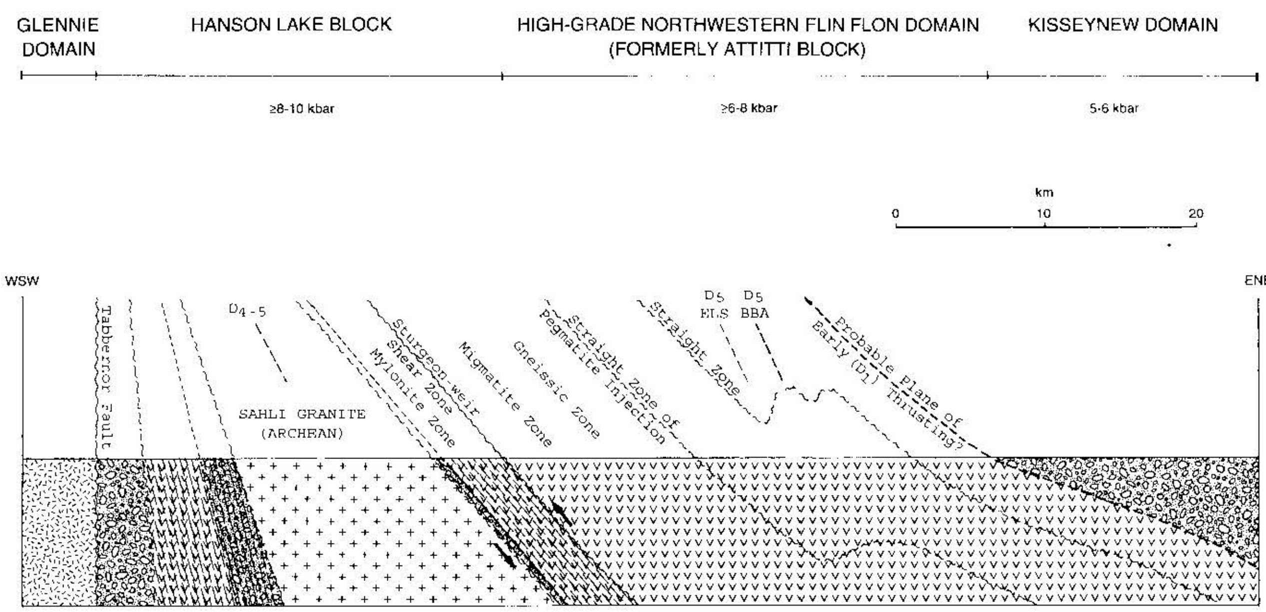

Figure 17 - Schematic west-southwest-east-northeast cross-section showing proposed tectonic relationships in the Wildnest-Mirond lakes area: crosses=Archean Sahli granite; V's= dominantly volcanic and intrusive rocks; pebbles=sedimentary rocks; stipple=Glennie Domain; striped overprint=mylonitized rocks of the "Pelican Slide"; ELS=Ewen Lake Synform; and BBA=Bentz Bay Antiform. Average domain pressures are compiled from geobarometric studies (see text).

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8. References

Ansdell, K.M. and Kyser, T.K. (1991): Plutonism, deformation, and metamorphism in the Proterozoic Flin Flon greenstone belt, Canada: Limits on timing provided by the single-zircon Pb-evaporation technique; Geol., v19, p518-521.

Ansdell, K.M. and Norman, A.R. (in press): The timing of magmatism, deformation, and metamorphism along the southern flank of the Kisseynew Domain; *in* Hajnal, Z. and Lewry, J.F. (eds.), LITHOPROBE, Trans-Hudson Orogen Transect, Rep. on 1993 Workshop.

Ashton, K.E. (1987): Preliminary geological map of the Kisseynew gneisses between the Sturgeon-weir River and Kisseynew Lake, Saskatchewan (parts of 63K/13, 63L/15, 16, 63M/1, 63N/4); Geol. Surv. Can., Open File 1410.

__________ (1990): Geology of the Snake Rapids area, Flin Flon Domain (parts of NTS 63L-9 and -10); *in* Summary of Investigations 1990, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 90-4, p4-12.

__________ (1992a): Geology of the Snake Rapids area: Update; *in* Summary of Investigations 1992, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 92-4, p97-113.

__________ (1992b): Geology of the Mari Lake area, Saskatchewan; Geol. Surv. Can., Open File 2444, 1:50 000 map.

__________ (in press): Structure of the southern flank of the Kisseynew gneiss belt in Saskatchewan; *in* Hajnal, Z. and Lewry, J.F. (eds.), LITHOPROBE, Trans-Hudson Orogen Transect, Rep. of 1993 Workshop.

Ashton, K.E. and Digel, S. (1992): Metamorphic pressure-temperature results from the Attitti Block; *in* Summary of Investigations 1992, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 92-4, p114-116.

Ashton, K.E. and Leclair, A.D. (1991): Revision bedrock geological mapping, Wildnest-Attitti lakes area (parts of NTS 63M-1 and -2) *in* Summary of Investigations 1991, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 91-4, p29-40.

Ashton, K.E., Hunt, P.A., and Froese, E. (1992): Age constraints on the evolution of the Flin Flon volcanic belt and Kisseynew gneiss belt, Saskatchewan and Manitoba; *in* Radiogenic Age and Isotopic Studies: Rep. 5, Geol. Surv. Can., Pap. 91-2, p55-69.

Ashton, K.E., Wheatley, K.J., Moser, D., Paul, D., and Wilcox, K.H. (1986): The Kisseynew gneisses of Saskatchewan: Update; *in* Summary of Investigations 1986, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 86-4, p145-148.

Ashton, K.E., Wilcox, K.H., Wheatley, K.J., Paul, D., and de Tombe, J. (1987): The boundary zone between the Flin Flon domain, Kisseynew gneisses, and Hanson Lake block, northern Saskatchewan; *in* Summary of Investigations 1987, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 87-4, p131-134.

Bailes, A.H. (1980): Origin of Early Proterozoic volcaniclastic turbidites, south margin of the Kisseynew sedimentary gneiss belt, File Lake, Manitoba; Prec. Res., v12, p197-225.

Bell, K. and Macdonald, R. (1982): Geochronological calibration of the Precambrian Shield in Saskatchewan; *in* Summary of Investigations 1982, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 82-4, p17-22.

Bickford, M.E., Van Schmus, W.R., Collerson, K.D., and Macdonald, R. (1987): U-Pb zircon geochronology project: New results and interpretations; *in* Summary of Investigations 1987, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 87-4, p76-79.

Byers, A.R. and Dahlstrom, C.D.A. (1954): Geology and mineral deposits of the Amisk-Wildnest lakes area, Saskatchewan; Sask. Dep. Miner. Resour., Rep. 14, 177p.

Craig, L. (1989): Geology of the Pelican Narrows area of east central Saskatchewan; unpubl. Ph.D. thesis, Univ. Sask., 268p.

David, J., Machado, N., Bailes, A., and Syme, E. (in press): U-Pb geochronology of the Flin Flon–Snow Lake Belt: New results; *in* Hajnal, Z. and Lewry, J.F. (eds.), LITHOPROBE, Trans-Hudson Orogen Transect, Rep. of 1993 Workshop.

Digel, S., Ashton, K.E., and Wilcox, K.H. (1991): Metamorphic P-T investigations in the southern part of Kisseynew and western part of Flin Flon domains; *in* Summary of Investigations 1991, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 91-4, p41-46.

Gibb, R.A. (1983): Model for suturing of Superior and Churchill plates: An example of double indentation tectonics; Geol., v11, p413-417.

Gilbert, H.P. (1988): Geological investigations in the Tartan Lake–Embury Lake area; *in* Report of Field Activities 1989, Manit. Energy Mines, Miner. Div., p35-42.

Heaman, L.M., Kamo, S.L., Ashton, K.E., Reilly, B.A., Slimmon, W.L., and Thomas, D.J. (1992): U-Pb geochronological investigations in the Trans-Hudson Orogen, Saskatchewan; *in* Summary of Investigations 1992, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 92-4, p120-123.

Hoffman, P.F. (1988): United plates of America, the birth of a craton: Early Proterozoic assembly and growth of Laurentia; Earth Planet. Sci., Ann. Rev. 1988, v16, p543-603.

Lewry, J.F. and Macdonald, R. (1988): Observations on deformation in the Glennie Domain and Hanson Lake Block; *in* Summary of Investigations 1988, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep., 88-4, p35-41.

Lewry, J.F., Macdonald, R., and Stauffer, M.R. (1989): The development of highly strained rocks in the Pelican Window during high-grade metamorphism and pervasive anatexis; *in* Summary of Investigations 1989, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 89-4, p58-65.

Lewry, J.F., Sibbald, T.I.I., and Hayward, N. (1991): Revision bedrock geological remapping of the Southeast Arm, Deschambault Lake–Northern Lights area (parts of NTS 63L-10, -11, and -14); *in* Summary of Investigations 1991, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 91-4, p57-65.

Lewry, J.F., Thomas, D.J., Macdonald, R., and Chiarenzelli, J. (1990): Structural relations in accreted terranes of the Trans-Hudson Orogen, Saskatchewan: Telescoping in a collisional regime?; *in* Lewry, J.F. and Stauffer, M.R., (eds.), The Early Proterozoic Trans-Hudson Orogen of North America, Geol. Assoc. Can., Spec. Pap. 37, p75-94.

Lucas, S.B., Green, A., Hajnal, Z., White, D., Lewry, J., Ashton, K., Weber, W., and Clowes, R. (1993): Deep seismic profile across a Proterozoic collision zone: Surprises at depth; Nature, v363, p339-342.

Macdonald, R. (1974): Pelican Narrows (west) area, reconnaissance geological survey of 63-M-2(W); *in* Summary Report of Field Investigations 1974, Saskatchewan Geological Survey, Sask. Dep. Miner. Resour., p30-37.

__________ (1976): Compilation geology, Pelican Narrows (63M) and Amisk Lake (63L); *in* Summary of Investigations 1976, Saskatchewan Geological Survey, Sask. Dep. Miner. Resour., p53-57.

__________ (1981): Compilation bedrock geology: Pelican Narrows and Amisk Lake areas (NTS 63M, 63L, part of 63N and 63K): Preliminary geological map; *in* Summary of Investigations 1981, Saskatchewan Geological Survey, Sask. Miner. Resour., Misc. Rep. 81-4, p16-23.

Macdonald, R. and MacQuarrie, R.R. (1978): Geological re-investigation mapping, Jan Lake area (part of NTS Area 63M); *in* Summary of Investigations 1978, Saskatchewan Geological Survey, Sask. Miner. Resour., Misc. Rep. 78-10, p16-24.

MacQuarrie, R.R. (1979): Geological re-investigation mapping, Birch Portage south, NTS area (63L-15S); *in* Summary of Investigations 1979, Saskatchewan Geological Survey, Sask. Miner. Resour., Misc. Rep. 79-10, p29-38.

McInnes, W. (1914): The basins of the Nelson and Churchill rivers; Geol. Surv. Can., Mem. 30, 146p.

Norman, A.R. and Williams, P.F. (1992): Development of compressional structures during prograde metamorphism along the southern margin of the Kisseynew gneiss belt, Trans-Hudson Orogen, central Manitoba; *in* Hajnal, Z. and Lewry, J.F. (eds.), LITHOPROBE, Trans-Hudson Orogen Transect, Rep. 26, p4-19.

Perkins, D. (1991): Metamorphism of the Kisseynew gneisses and related rocks of the Reindeer Zone, Trans-Hudson Orogen, northern Saskatchewan; Can. J. Earth Sci., v28, p1664-1676.

Pyke, M.W. (1966): The geology of the Pelican Narrows and Birch Portage areas, Saskatchewan; Dept. Miner. Resour., Rep. 93, 68p.

Reilly, B., Thomas, D.J., Slimmon, W.L., Ashton, K.E., and Heaman, L.M. (in press): Structural history of the Flin Flon Domain in Saskatchewan; *in* Hajnal, Z. and Lewry, J.F. (eds.), LITHOPROBE, Trans-Hudson Orogen Transect, Rep. of 1993 Workshop.

Rupan, S. and Lewry, J.F. (1991): Origin and kinematic history of highly strained gneisses in the Jan Lake East area; in Summary of Investigations 1991, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 91-4, p169-174.

__________ (1992): Origin of highly strained gneisses of the Pelican Slide: Modal analysis and geochemistry; *in* Summary of Investigations 1992, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 92-4, p179-183.

Satterly, J. (1932): Pelican Narrows area, Saskatchewan; Geol. Surv. Can., Summ. Rep. 1931, Pt C, p26-36.

Sun, M., Kyser, T.K., Kerrich, R., and Stauffer, M. (1992): Age, origin, and tectonic significance of granitoids from the Pelican Slide; *in* Hajnal, Z. and Lewry, J.F. (eds.), LITHOPROBE, Trans-Hudson Orogen Transect, Rep. 26, p121-123.

__________ (in press): Diverse granitic gneisses in the Pelican Slide: Their significance to the accretionary history of the Trans-Hudson Orogen; *in* Hajnal, Z. and Lewry, J.F. (eds.), LITHOPROBE, Trans-Hudson Orogen Transect, Rep. of 1993 Workshop.

Sun, M., Stauffer, M.R., Lewry, J.F., Edwards, G., Kerrich, R., and Kyser, T.K. (1991): Chemical signatures of igneous and metasedimentary rocks from the Pelican Slide area: Implications for their sources and tectonic environments; *in* Summary of Investigations 1991, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 91-4, p162-168.

Taylor, F.C. (1958): Pelican Narrows, Saskatchewan; Geol. Surv. Can., Map 1-1958, with marginal notes.

Van Schmus, W.R., Bickford, M.E., Lewry, J.F., and Macdonald, R. (1987): U-Pb geochronology in the Trans-Hudson Orogen, northern Saskatchewan, Canada; Can. J. Earth Sci., v24, p407-424.

Wilcox, K.H. (1990): Geology of the Amisk-Welsh lakes area, Saskatchewan; unpubl. M.Sc. thesis, Univ. Calgary, 244p.

__________ (1991): Geological relationships in the Wood Lake area, Tabbernor Fault Zone, Saskatchewan; *in* Summary of Investigations 1991, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 91-4, p135-143.

Winkler, H.G.F. (1974): Petrogenesis of metamorphic rocks (3rd ed.); Springer-Verlag, New York, 320p.

Zwanzig, H.V. and Schledewitz, D.C.P. (1992): Geology of the Kississing-Batty lakes area: Interim report; Man. Energy Mines, Open File OF92-2, 87p.