Geology of the Attitti Block–Kisseynew Domain Contact, Belcher Lake Area

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The Belcher Lake area, centred about 20 km northeast of Pelican Narrows, straddles the contact zone between the mostly metasedimentary Kisseynew Domain and the dominantly volcanoplutonic Attitti block, which represents a highly metamorphosed extension of the Flin Flon Domain (Figure 1). Geological re-investigation of the area has been undertaken with the primary aim of better documenting the character and evolution of this major domainal boundary. This work extends previous mapping carried out to the south (Ashton *et al.*, 1995; Ashton and Leclair, 1991) and forms part of M.Sc. thesis work by the first author. Most of the area was last mapped by Kirkland (1976) at 1:100 000 scale and southern sections were previously mapped by Pyke (1966) at 1:63,360 scale.

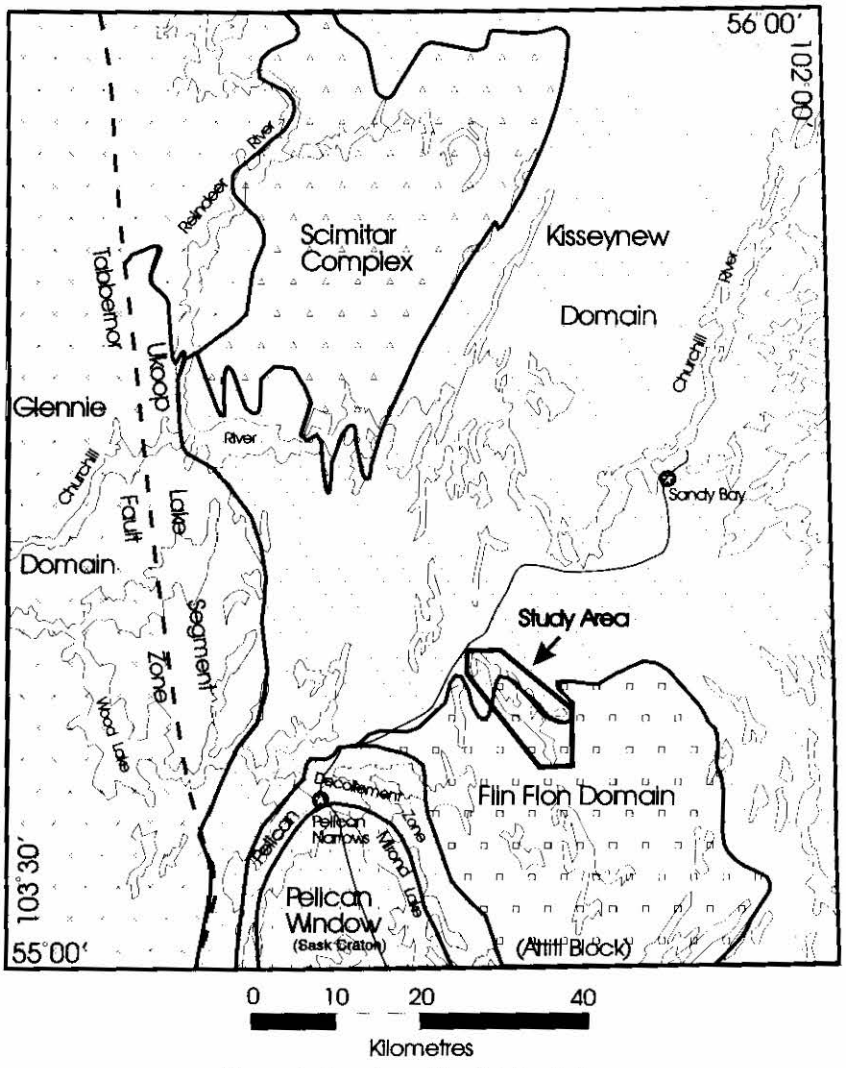

Figure 1 - Location of the Belcher Lake area.

This summer, 1:20 000 scale mapping by the first author covered about 100 km². Exposure is generally poor (10 to 15 percent) save directly west of Belcher Lake where it reaches 25 percent. Granitoid rocks are generally well exposed, forming resistant ridges, while supracrustals occupy low-lying areas.

1. General Geology

The Belcher Lake area is underlain by attenuated zones of volcanic, sedimentary, and granodioritic rocks of the Attitti block and by dominantly aluminous wackes of the Kisseynew Domain (Figure 2). The Attitti and Kisseynew sedimentary rocks were not distinguished in the field due to their compositional similarity, but thick sequences of aluminous wackes have generally been interpreted as belonging to the Kisseynew Domain. In the north, a small area of arkose, possibly correlative with the Missi Group (Stauffer, 1990), is exposed.

Metamorphism at upper amphibolite grade resulted in widespread migmatization and destruction of most primary features. Three penetrative ductile deformational events are recognized in the following structures: a dominant S_1 foliation, tight to isoclinal F_2 folds with steeply east-dipping axial planes,

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and late northeast-plunging open F_3 folds with steeply south-dipping to vertical axial planes. High-strain/mylonitic fabrics similar to those of the Pelican Décollement Zone (Lewry *et al.*, 1989; Ashton *et al.*, 1996) were not seen, nor is there any other evidence of a significant structural break between the Kisseynew Domain and Attitti block in this area. Units of both domains are tightly interlayered/interfolded, with contacts that are typically gradational rather than abrupt. Economically, the area is of interest as calc-silicate rocks contain notable concentrations of sulphides.

2. Unit Descriptions

a) Volcanic Rocks

Mafic Volcanic Rocks

The volcanic rocks are dominantly of mafic composition and typically are grey to black, medium to fine grained, and moderately to poorly layered. They contain roughly equal proportions of hornblende and plagioclase, with minor clinopyroxene and sulphides. Garnet is locally abundant and is commonly enveloped by a thin white rim of cummingtonite and anorthite. A similar texture, seen in mafic dykes of the Pelican Window, is interpreted by Ashton and Shi (1994) to have formed through the reaction of hornblende and garnet to form cummingtonite and plagioclase.

In the area adjacent to the Belcher Lake pluton, the mafic volcanics appear to have been carbonatized to form **mafic calc-silicates** which contain abundant calcite, clinopyroxene, calcic amphibole, and sphene. Such carbonate layers commonly contain greater than 3 percent pyrrhotite±minor chalcopyrite.

Garnetiferous amphibolites, containing roughly equal amounts of hornblende and plagioclase with 15 to 30 percent garnet, are found along the southern shore of Belcher Lake and are tentatively interpreted as **altered mafic volcanics**. They grade southwards into a thin, more felsic, garnet-anthophyllite alteration zone.

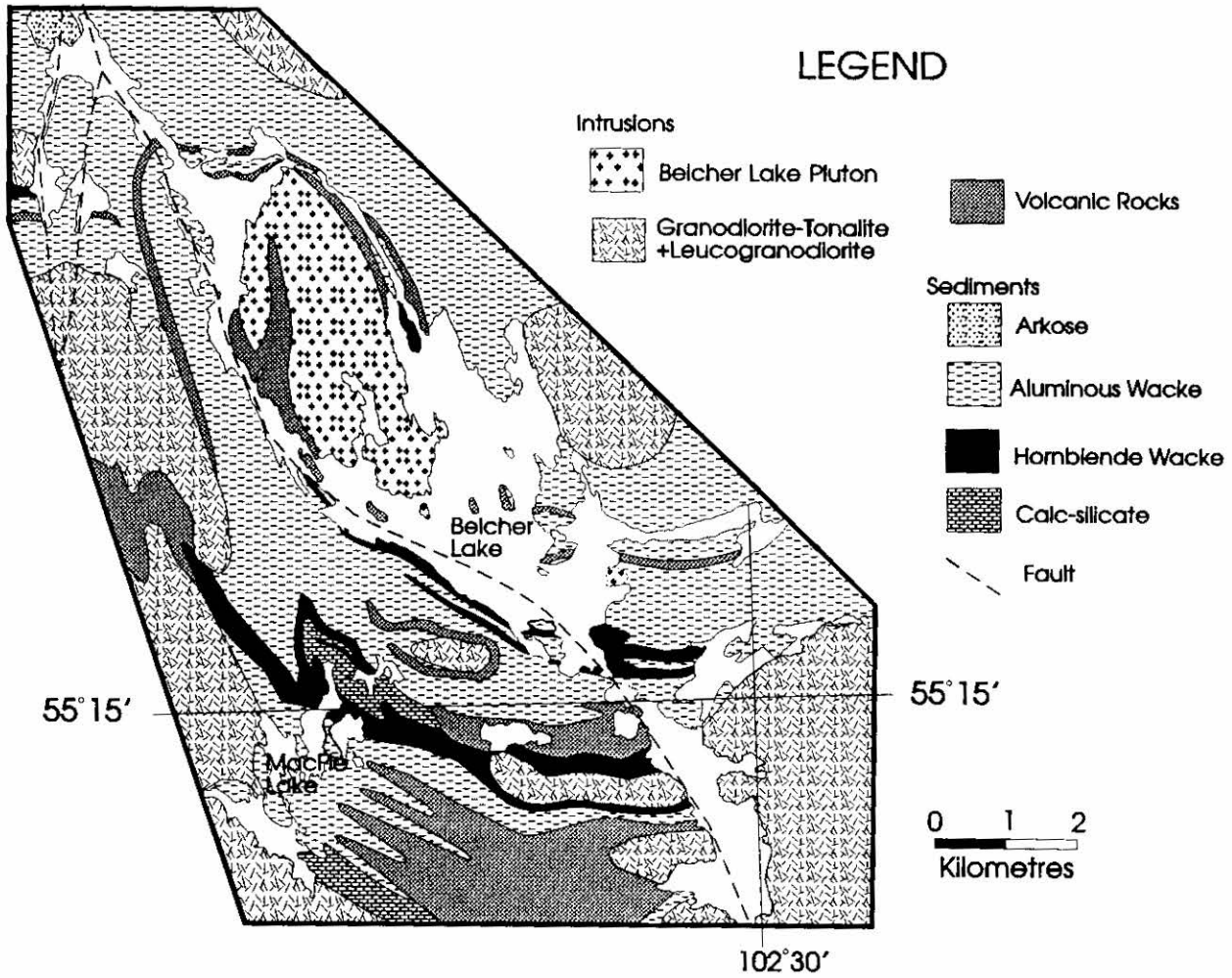

Figure 2 - Simplified geology of the Belcher Lake area.

Felsic Volcanic and Volcaniclastic Rocks

These white to light grey rocks are fine grained, moderately layered, and comprise plagioclase, quartz, and up to 20 percent combined biotite and hornblende. Garnet, clinopyroxene, and graphite are locally abundant, and pyrrhotite (±chalcopyrite) is nearly ubiquitous. Graphite, where present, probably indicates an epiclastic origin.

In places, the felsic volcanic rocks grade laterally into calcite-diopside-sphene-rich **felsic calc-silicates**, and it is suggested that the same carbonatization event that affected the mafic volcanics has also altered some of the felsic volcanics.

b) Sedimentary Rocks

Aluminous Wacke

Medium grey, fine- to medium-grained, moderately to well-layered aluminous wackes are the dominant rock type in the area. They comprise biotite, plagioclase, and quartz, with varying amounts of graphite and pink garnet. Sillimanite is only rarely found whereas cordierite was identified in one location, rimming and replacing garnet. The aluminous wackes are invariably migmatitic; psammitic layers remain unmelted, but the more pelitic paleosome components incorporate an abundant grey-white quartz-feldspar leucosome. This typically forms 2 to 5 cm thick layers which are subparallel to S_1. In some outcrops, especially in the east, spatially-associated garnet-biotite melanosomal restite lenses and boudinaged pods are prominent. In the west, leucosomal melt material tends to be less intimately intermixed with paleosomal material, but instead forms larger coherent bodies within the sedimentary assemblage.

Hornblendic Wacke

The hornblendic wackes are dark grey, fine to medium grained, moderately to poorly layered, and hornblende-rich. Hornblende content reaches up to 40 percent in some outcrops, whereas biotite, cummingtonite, and garnet are only locally abundant. Graphite is a common constituent, locally making up 2 to 3 percent of the rock. In many places, hornblendic wackes are interlayered with aluminous wackes on a decimetre to metre scale. As previously noted by Ashton and Balzer (1995), high hornblende content and proximity to mafic volcanic rocks suggests derivation from volcanic sources.

Arkose

Arkoses underlie a small area at the far northern edge of the map area. They are pink, fine to medium grained, weakly layered, and comprise mainly K-feldspar, plagioclase, quartz, and 5 to 15 percent biotite. Magnetite, which typically forms several percent of the rock, gives rise to an anomalously high aeromagnetic signature. This unit may be related to the Missi Group but no basal unconformity was recognized.

Calc-silicate (Impure Marble)

There are minor occurrences of sedimentary calc-silicate and impure marble in the area. They are white, medium-grained, well-layered rocks which weather to a rusty brown, and are composed mainly of calcite with minor amounts of dolomite, diopside, sphene, and graphite.

c) Plutonic Rocks

Granodiorite and Tonalite

The largest intrusive body in the area is the Belcher Lake pluton, which Kirkland (1976) described as a "quartz-rich quartz diorite". It is a homogeneous pluton consisting of grey, medium-grained, foliated granodioritic to tonalitic rocks containing 10 to 20 percent combined biotite and hornblende, and up to 3 percent magnetite. It is characterized by having a very high quartz content which locally exceeds 50 percent. Much of the quartz occurs in pancake-shaped lenses up to about 5 cm by 0.5 cm. In highly strained rocks, these lenses are flattened and form resistant ridges on the weathered surface. A close examination reveals that some of the lenses are linked by thin stringers of quartz, suggesting that the lenticular quartz texture formed by the boudinage of extensive quartz veining. Individual veins are locally 0.5 to 1 cm thick. Intensely deformed mafic country rock xenoliths are common in the marginal zones of this body. Preliminary work indicates that this may be a highly silicified shallow intrusion.

Several other large plutonic bodies occur in the area. They generally comprise xenolith-rich granodiorite with up to 20 percent biotite+hornblende. The xenoliths are dominantly mafic volcanic rocks and sedimentary blocks are subordinate. Sediments surrounding these plutons are commonly highly migmatitic to diatexitic.

Leucogranodiorite bodies, generally containing less than 10 percent biotite are also represented. These are lithologically similar to leucosomal melt components in the migmatitic wackes and may thus represent large-scale crustal melt concentrations derived from pelitic rocks.

Gabbro

A homogeneous, black, coarse-grained metagabbro body occurs in the northwest corner of the area. It comprises roughly equal amounts of hornblende and plagioclase, with clinopyroxene and rimmed garnet as minor constituents.

Mafic Dykes and Sheets

Medium- to fine-grained diabasic intrusions were seen in a few localities. Those which cut the Belcher Lake pluton are clearly silicified, suggesting that the silicification event which affected the pluton also postdated the mafic intrusion. Most of the mafic intrusions are subparallel to the S_1 foliation plane; only a few are markedly discordant.

Granite Pegmatite

Moderately deformed, pale pink to white, coarse-grained to pegmatitic leucogranitoid bodies occur in many places as dykes and sheets up to 20 m thick. These granitoid rocks, although apparently not as abundant as documented farther south (Ashton *et al.* 1995), were seen in about 20 percent of all outcrops.

Crosscutting, undeformed pink pegmatite dykes, which may represent part of the Jan Lake Suite (Macdonald and Macquarrie, 1978), are much less common.

3. Structure

Four deformational episodes are recognized.

a) D_1 Structures

A well-developed regional foliation that dips moderately to steeply to the east throughout most of the area is the oldest preserved tectonic structure. Primary layering, where preserved, is transposed into the S_1 foliation plane. In some granitoid bodies, the early deformation is expressed as a pure L fabric with little or no related planar fabric. No major or minor F_1 folds were recognized.

b) D_2 Structures

Tight to isoclinal north-south-trending F_2 folds are seen both in outcrop and at the map scale. They are generally inclined to reclined structures with axial planes dipping steeply to the east and have doubly plunging axes.

c) D_3 Structures

The most prominent F_3 structure is the major Belcher Lake fold, which is clearly visible on air photographs. This is an open, northeast-plunging synform with a steeply south-dipping to vertical axial plane. Smaller macroscopic and mesocopic folds of the same generation are common and have a similar geometry and orientation. A coeval, moderately northeast-plunging crenulation is locally developed throughout the area. The axial surface traces of F_2 folds are deflected about the Belcher Lake fold, from a north-south orientation in the north, to east-west in the south.

d) D_4 Structures

The youngest structures in the area are a series of northerly trending brittle faults which show only minor strike displacement and indeterminate net-slip. The faults are recognized on the basis of linear air photo trends, coupled with the occurrence of slickensides on fracture surfaces and pseudotachylyte.

4. Metamorphism

Metamorphic mineral assemblages are consistent with upper amphibolite facies P-T conditions. Garnet-biotite±sillimanite typifies the metamorphic assemblage in pelitic rocks. Cordierite was identified in only one location, rimming and apparently replacing earlier garnet. The aluminous wackes are migmatitic throughout the area and incorporate coherent sheets of leucosomal melt in the east. Elsewhere, leucogranodiorite bodies are interpreted as leucosomal melt fractions of the pelitic rocks that have accumulated and become separated from their original production site. Restite layers and pods, seen toward the east, are composed primarily of garnet and biotite. Migmatite production is compatible with an upper amphibolite temperature-pressure regime.

5. Economic Geology

Previous reconnaissance mapping by Kirkland (1976) documented several sulphide occurrences in the Belcher Lake area. Four new sulphide showings were located as a result of the more detailed mapping reported here. Most of these comprise pyrrhotite± chalcopyrite and are hosted by carbonate layers in mafic and felsic volcanics close to the Belcher Lake pluton. Ten to fifty metre thick gossan zones are commonly associated with the mineralization. One garnet-anthophyllite-rich alteration zone is found along the southern shore of Belcher Lake. In 1969-70, Western Nuclear Mines Ltd. conducted airborne magnetic, electromagnetic, and radiometric surveys over the area as well as a ground electromagnetic survey follow up over the western shore of Belcher Lake. Conductors were examined with 13 diamond drill holes over a total length of 2,912 feet. Numerous intersections of pyrite were recorded within calc-silicate layers, but only disseminated chalcopyrite was identified and no assays were completed. In 1980, the Saskatchewan Mineral Development Corporation flew additional airborne surveys with some follow up prospecting. An expanded summary of exploration is available in the Saskatchewan Mineral Deposits Index, Report 0357.

6. Conclusions

Field work in the Belcher Lake area leads to the following preliminary conclusions:

1) The contact between rocks of the Attitti block and the Kisseynew Domain does not appear to be a major tectonic break as suggested by Lewry *et al.* (1989). There is no evidence of early mylonitic rocks or of later faulting in the vicinity of this boundary.

2) Differentiation of Burntwood Supergroup pelitic rocks of the Kisseynew Domain from those of Flin Flon/Attitti domain affinities was very difficult if not impossible.

3) Numerous occurrences of sulphides in calc-silicate layers, gossan zones, and altered mafic volcanic rocks make the Belcher Lake area attractive for exploration.

7. Acknowledgments

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