GS-8 GEOLOGY OF THE WESTERN PART OF THE FOX RIVER BELT (PARTS OF NTS 53M AND 53N)

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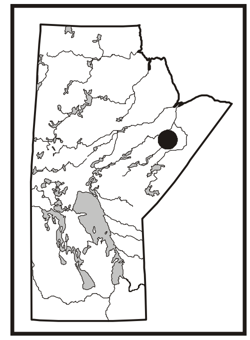

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SUMMARY

This paper summarizes the results obtained from reconnaissance geological studies conducted during the 2000 mapping programs in the western part of the Fox River Belt. Critical new observations include:

1) The Lower Sedimentary formation and the adjacent Archean orthogneiss of the Superior Province host one or more suites of mafic (gabbronorite) intrusions that were not previously recognized.
2) Granitic rocks locally intrude the Lower Sedimentary formation in the southwestern part of the Fox River Belt, and may relate to previously unrecognized Proterozoic felsic plutonism that appears to have occurred along the Archean–Proterozoic boundary.
3) Paragneiss units occurring immediately to the north of the Fox River Belt are turbiditic greywacke that has been folded and metamorphosed at the amphibolite facies. Sampling was carried out on these units in order to determine their Nd-Sm model ages.
4) Limited sedimentological studies of the Middle Sedimentary formation and upper parts of the Lower Sedimentary formation suggest a strong similarity to the distal marine sedimentary rocks in the prospective parts of the Ospwagan Group in the Thompson Nickel Belt. In the Fox River Belt, most of the sedimentary rocks are undeformed and consist of repeated cycles, tens of metres thick, of early clastic (mudstone, siltstone, greywacke) and later chemical (carbonate overlain by sulphidic mudstone and/or sulphide-facies iron-formation) sedimentation.

INTRODUCTION

The metallogenic and tectonic evolution of the Fox River Belt (FRB) and adjoining gneissic terranes (Superior Province to the south and presumed Proterozoic metasedimentary gneiss belt to the north) is currently being revisited following more than a decade of inattention from government surveys and academe. Exploration activity during this same period was also minimal, and involved surface exploration, lake-bottom sediment geochemical sampling and a 10-hole diamond-drilling program carried out by Westminer Ltd. (now Western Mining International Ltd.) in 1992 and 1993. The stimulus for the recent, increased levels of geoscience programming in the FRB was provided by the minerals industry, in particular Falconbridge Limited and B. Dunlop, who began regional exploration of the FRB for Ni, Cu and platinum-group elements (PGE) in 1998. In 1999, the Manitoba Geological Survey and the University of Manitoba initiated field and geochemical investigations in the FRB (Peck et al., 1999) with the support of Falconbridge Limited. This year, two B.Sc. theses were completed by University of Manitoba students (M. Huminicki and C. Osiowy), and a Ph.D. study, focusing on the metallogeny and petrogenesis of ultramafic-mafic intrusions in the FRB, commenced this fall (G. Desharnais, University of Manitoba).

Most of our current knowledge of the geology of the FRB comes from a regional diamond-drilling program completed intermittently between the late 1950s and early 1970s by Inco Ltd. Previous field investigations of the FRB were conducted by the Manitoba Mines Branch, mainly between 1969 and 1977. The results of this work, together with a thorough petrological investigation of more than 100 Inco Ltd. drillholes, underpinned the only available regional maps (1:50 000 scale) and geological descriptions for the belt (Scoates, 1981, 1990). Most previous field studies were carried out in the Fox River valley, between the Gowan and Bigstone rivers (Fig. GS-8-1), an area characterized locally by semicontinuous bedrock exposure in and adjacent to the main river channel(s). Detailed mapping by previous workers was focused in the Great Falls area of the Fox River and along the Stupart River (Fig. GS-8-1). Geological and exploration data acquired for the FRB up to the mid-1980s are synthesized by Scoates (1990). Subsequent exploration of the FRB for PGE by BP-Selco (mid- to late 1980s) and a related M.Sc. study (Schwann, 1989) provided additional insights into the mineral potential and petrology of the largest known intrusion in the belt, the Fox River sill. Despite thorough studies of the core from approximately 140 diamond-drill holes in the FRB and local, detailed mapping along the Fox and Stupart rivers, the regional geology of the FRB remains poorly understood.

To redress this, the current regional geological program was designed with the following principal objectives:

1) Carry out reconnaissance, helicopter-borne, aerial surveys and follow-up surface investigations of previously unrecognized or undocumented outcrop areas.
2) Carry out detailed stratigraphic studies of volcanic and sedimentary formations in selected, well-exposed river outcrop areas (e.g. Syme et al., 1999);
3) Map and sample (for Nd-Sm isotopic analysis and possibly U-Pb detrital zircon geochronology) outcrops of paragneiss belonging to the Northern Gneiss Belt (age unknown) and orthogneiss belonging to the Southern Gneiss Belt (northern margin of the Superior Province; terminology *after* Scoates, 1981, 1990), in order to determine their age and tectonic significance.

The study area (Fig. GS-8-1) includes the western part of the FRB, adjacent parts of the Archean Superior Province to the south, and the southern part of the Northern Gneiss Belt. The centre of the study area is situated approximately 50 km south-southeast of the town of Gillam. The eastern boundary of the area is marked by the Stupart River, which also marks the eastern limit of outcrop in the FRB. Throughout the study area, bedrock outcrop is restricted to incised valleys that have been formed by the major rivers, which typically flow northeasterly toward Hudson Bay.

SYNOPTIC REGIONAL GEOLOGY

The Fox River Belt, as described by Scoates (1981, 1990), is an approximately 300 km long and 10 to 30 km wide, supracrustal sequence of approximately Proterozoic age that is intruded by coeval ultramafic and mafic sills and dykes. It is a significant part of the Superior Boundary Zone (SBZ), which separates Archean orthogneiss terranes and granite-greenstone belts of the Superior Province from arc and marine sedimentary-basin assemblages of the Trans-Hudson Orogen. The FRB represents a homoclinal, north-dipping and north-facing

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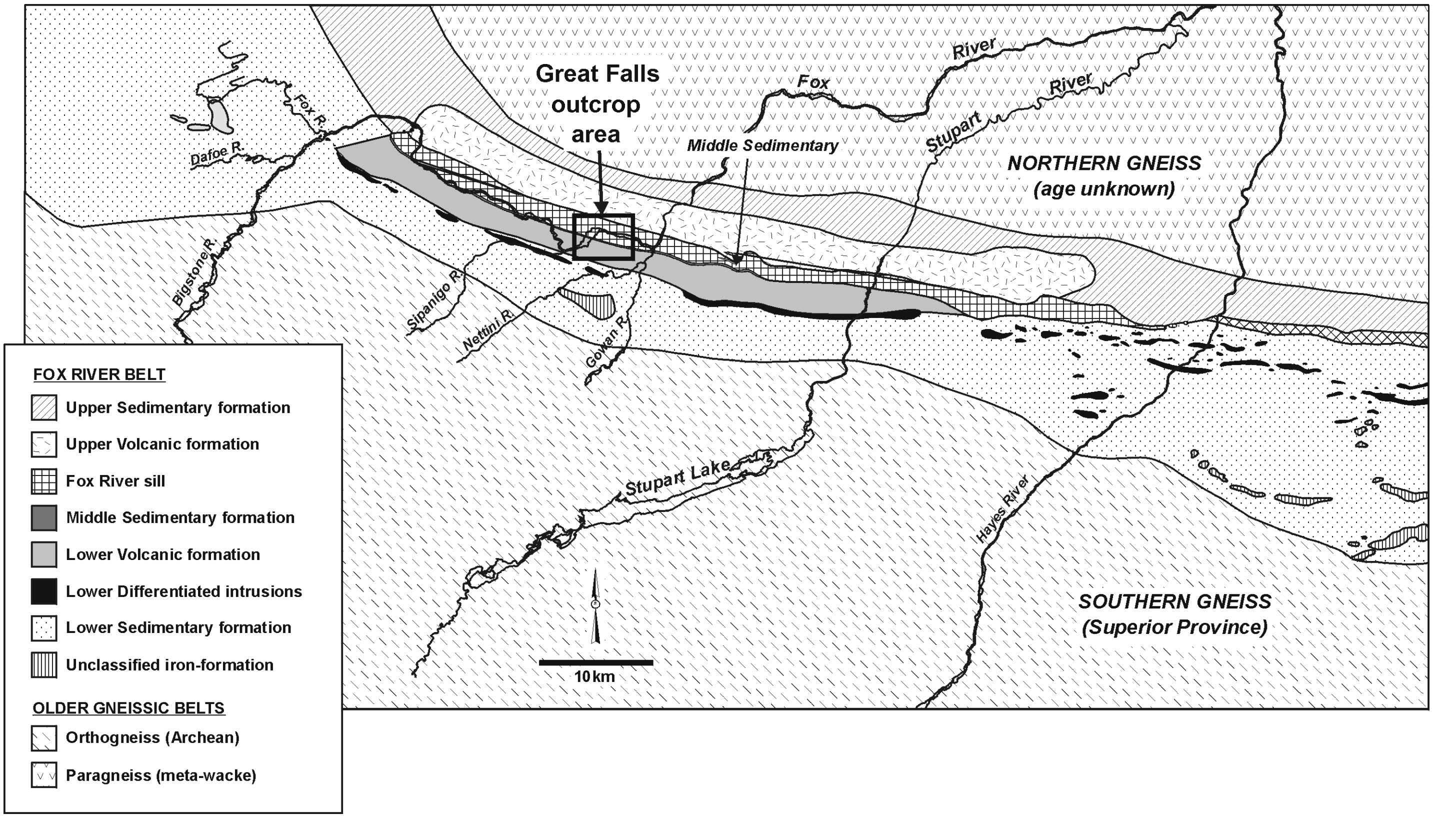

Figure GS-8-1: General geology of the western part of the Fox River Belt, showing the locations of reconnaissance mapping areas investigated in 2000 (modified from Scoates, 1981, 1990).

sequence that developed in a marginal rift during the Paleoproterozoic (ca. 1.9 Ga). The belt is relatively undeformed and exhibits low metamorphic grades (sub-greenschist to lower greenschist facies). It is likely the best preserved Paleoproterozoic rift basin sequence on Earth, contrasting with the complexly deformed rocks present in the Thompson Nickel Belt segment of the SBZ. Past and current exploration interest in the FRB is partially a reflection of the fact that it occurs in a regional metallotect (SBZ) for Ni-Cu-PGE deposits that hosts the Raglan camp in northern Quebec and the Thompson Nickel Belt in central Manitoba. The belt consists of three sedimentary rock formations, the Lower, Middle and Upper Sedimentary formations (Fig. GS-8-1; Scoates, 1981), that enclose an igneous domain comprising the Lower and Upper Volcanic formations and laterally continuous ultramafic-mafic intrusions that range from less than 50 m to more than 2.5 km in thickness. The largest intrusion in the FRB is the Fox River sill (*see* Scoates, 1990 for detailed descriptions). Smaller ultramafic to mafic intrusions (Lower Differentiated intrusions) occur in the northern part of the Lower Sedimentary formation.

REGIONAL FIELD PROGRAM – PRELIMINARY RESULTS

Although the general stratigraphy for the western part of the FRB (Scoates, 1981, 1990) is now well established, the lack of bedrock outcrop in the belt (<1% on average) has precluded a more detailed understanding of its geology and tectonic evolution. Nonetheless, many of the limited outcrop areas available for study are either not mapped or not studied in detail. Fieldwork was conducted during July and August 2000, concurrent with detailed mapping and prospecting in the Great Falls area on the Fox River (Desharnais et al., GS-9, this volume). The general locations of the outcrop areas studied during the current program are shown on Figure GS-8-1. Additional regional geological studies are planned for 2001, after which a revised 1:50 000 scale compilation map for the FRB will be prepared.

Gowan–Nettini Rivers Section

Two days were spent examining outcrops on the northern part of the Gowan River and the northeastern part of the Nettini River (Fig. GS-8-1). Bush outcrop located adjacent to the Nettini River is situated within the Lower Volcanic formation. Plagioclase-phyric massive flows of the upper part of the Lower Volcanic formation are present on the Gowan River, north of the mouth of the Nettini River. The flows are up to 25 m thick, have a well developed lower colonnade and upper entablature (*see* Syme et al. (1999) for relevant, detailed volcanological descriptions for the FRB). One of the flows has a distinctive, upper, rubbly flow-top that has been affected by shearing along the contact between the top of this flow and the base of the overlying flow. The plagioclase phenocrysts are interpreted to represent xenocrysts entrained from a subvolcanic, differentiated magma chamber. They display strong resorption by the enclosing basaltic matrix and are up to 1.5 cm in length. These flows are plagioclase-phyric throughout and have an overall basaltic composition.

Outcrops in and adjacent to the Gowan River consist of massive and pillowed flows of basalt and komatiitic basalt. Massive flows appear to predominate in the north, proximal to the confluence of the Gowan and Fox rivers, whereas pillowed flows are more prevalent at and south of the northeastern termination of the Nettini River (Fig. GS-8-1). The volcanic architecture and flow regimes appear to be similar to those described for the Lower Volcanic formation outcrop areas along the Fox River (Scoates, 1981; Syme et al., 1999).

A single, large outcrop of the Middle Sedimentary formation occurs less than 1 km south of the confluence of the Gowan and Fox rivers. The outcrop comprises thinly bedded, turbiditic mudstone-siltstone-wacke sequences but, unlike most of the known Middle Sedimentary formation outcrops, does not appear to contain pyritic mudstone (Scoates, 1990). No outcrops of the Fox River sill or any Lower intrusions were recognized.

Northern Gneiss Belt

Part of one day was spent examining river and bush outcrop of Northern Gneiss Belt rocks in the Fox River, approximately 500 m north of the inferred northern contact of the Fox River Belt (Fig. GS-8-1). Several samples were collected from the paragneiss units that were observed in these outcrops. These samples will be used to study the Nd-Sm model ages for the rocks, an extension of the work being done by Ch.O. Böhm, M.T. Corkery and L.M. Heaman (University of Alberta) on the geochronology and tectonic evolution of the northwestern part of the Superior Boundary Zone (Corkery et al., GS-25, this volume). The Northern Gneiss Belt outcrops investigated are interpreted as representing distal marine turbiditic greywacke and display planar bedding in the form of decimetre-scale, alternating gritty and muddy layers. The rocks are folded about south-dipping axial planes and appear to have been recrystallized at mid-amphibolite facies, which promoted minor incipient melting of pelitic components. However, their age and tectonic relevance remains equivocal. They could represent Archean paragneiss, perhaps similar to those rocks occurring north of the Assean Lake Fault and between the FRB and the Thompson Nickel Belt segments of the SBZ (e.g., Corkery et al., GS-25, this volume). Alternatively, these gneiss units could represent Paleoproterozoic ocean-floor sequences analogous to parts of the Trans-Hudson Orogen in northern and western Manitoba (Kisseynew Domain). If the Nd-Sm work is successful, detrital zircon U-Pb geochronology may be undertaken to obtain more precise depositional ages for the rocks.

Southern Gneiss Belt

The Southern Gneiss Belt rocks have now been observed and sampled at three locations within the study area: 1) south Stupart River, 2) southern fork of the Sipanigo River, and 3) Bigstone River. These rocks do not appear to have ever attained granulite facies grade, and are therefore unlikely to be part of the Pikwitonei Domain, which flanks or is part of the northwestern segment of the Superior Boundary Zone. The metamorphic grade is estimated, from petrology, to be middle amphibolite facies and is therefore similar to the grade observed in the Northern Gneiss Belt. At the Bigstone River, a massive granodiorite pluton can be followed in outcrop along the river for at least 8 km to the south of the inferred contact with the Fox River Belt. The contact appears to be exposed on the Bigstone River, and seems to involve a planar, unfaulted contact between the granodiorite to the south (?Archean) and a gabbro±sedimentary sequence to the north (base of the Fox River Belt). This outcrop area requires further study when water levels are lower.

Fox River South

Scattered outcrops occur in the bush and in the river within the southern part of the Fox River valley, immediately west of Great Falls and continuing west for up to 20 km. These outcrops expose the Lower Volcanic formation and, rarely, the Middle Sedimentary formation (Scoates, 1981, 1990). A forest fire (August 2000) affected many of these outcrops, which should therefore be more amenable to detailed mapping following the spring runoff in 2001. Accordingly, detailed investigations of these outcrops has been deferred until next year.

Gabbroic Intrusions in the Southern Part of the Fox River Belt

Based on outcrops inspected during the 1999 and 2000 field programs, it is believed that there are two or more suites of east-striking (080–100º) mafic intrusions that occur on either side of the contact between the Southern Gneiss Belt and the FRB. One of these occurs within the southern part of the FRB (Bigstone gabbro) and is likely hosted by the lower part of the Lower Sedimentary formation. The other occurs in the Southern Gneiss Belt, which represents the northernmost part of the Superior Province, immediately to the south of the FRB (Stupart dykes).

The Bigstone gabbro refers to gabbronorite bodies of presently unknown dimensions that are exposed in outcrops on the Bigstone River (Fig. GS-8-1). These exposures occur approximately 0.5 to 1 km north of the indicated contact (Scoates, 1990) between the Southern Gneiss Belt and the Fox River Belt. The Bigstone gabbro may also include gabbroic bodies recognized by staff of Falconbridge Ltd. in 1999, during reconnaissance studies along the Sipanigo River, several kilometres southwest of its junction with the Fox River (Fig. GS-8-1). All of these gabbro bodies have been metamorphosed at greenschist facies grade and appear to be hosted by the lower to middle parts of the Lower Sedimentary formation. They are distinguished from more magnesian intrusions (Lower Differentiated intrusions) that have been intersected in diamond-drill holes in the upper part of the Lower Sedimentary formation (Scoates, 1990). Additional, more detailed investigations of the gabbroic rocks exposed in the Bigstone River are planned for the 2001 field season.

Last year, a suite of easterly trending, layered gabbroic dykes was recognized in bush outcrops occurring within Archean basement gneiss, approximately 2 km south of the southern boundary of the Fox River Belt and adjacent to the Stupart River (Fig. GS-8-1). These intrusions, emplaced into partially migmatized tonalitic gneiss and derived granodiorite intrusions, are referred to as the Stupart dykes. This year, another mafic dyke was recognized in approximately the same position relative to the southern margin of the FRB, along the south fork of the Sipanigo River (Fig. GS-8-1). This dyke was also emplaced into tonalitic gneiss and is tentatively correlated with the Stupart dykes. In 1999, a sample of a pegmatitic gabbro/diorite pod was obtained (DCP) for U-Pb zircon geochronology (L. Heaman, University of Alberta) from an approximately 40 m thick, well layered mafic dyke occurring in the Southern Gneiss Belt (Superior Province), adjacent to the Stupart River. Age determinations were not available at the time this report was written.

These recent observations may be significant from both a tectonic and metallogenic viewpoint. Previously, it was believed that the first major intrusions emplaced into the FRB were the Lower Differentiated intrusions. The existence of the Bigstone gabbro and Stupart dykes indicates that the volume of mafic and ultramafic intrusions in the FRB is much larger than previously believed, and that the entire Lower Sedimentary formation may be permeated with sills and dykes of mafic to ultramafic composition. All of these intrusions should be explored for Ni, Cu and platinum-group element mineralization. The Stupart dykes may be coeval with mafic and ultramafic intrusions in the FRB and are parallel to stratigraphic layering in the FRB. In this way, the Stupart dykes are analogous to the Molson dykes (Scoates and Macek, 1978), most of which are parallel to the Thompson Nickel Belt and coeval with ultramafic bodies in that belt.

GENERAL OBSERVATIONS

The western part of the FRB is the only part of the belt where it is possible to collect critical field data. Observations made during the current and previous projects provide key constraints on both the metallogenic and tectonic evolution of the FRB. For this reason and because of the paucity of outcrop throughout the belt, it is important to continue with detailed studies of available outcrop areas. This work should include detailed mapping, lithogeochemical sampling, structural studies and, where appropriate, geochronological studies. Field observations will help to constrain and refine lithogeophysical mapping (based mainly on airborne magnetic data) of the unexposed parts of the FRB, which represents the only practical method of regional correlation that can be applied to the FRB. This approach must also rely heavily on drilling results. To date, more than 140 diamond-drill holes have been completed in the FRB. Some of the more recent drillholes have been relogged as part of the current program. Some key, initial results include the following:

1) The upper part of the Lower Sedimentary formation comprises repeated cycles of marine sedimentation. Each cycle consists of a

lower, clastic mudstone-siltstone sequence and an upper, thinner, chemical sedimentary sequence that includes a lowermost carbonate and/or calc-silicate unit and an overlying sequence of iron-formation units and sulphidic mudstone (locally graphitic). These sedimentary cycles are typical of distal marine basins and may mark the change from passive (clastic sedimentation) to active (chemical sedimentation) rifting in the FRB. They are also strikingly similar in their internal stratigraphy to the Ospwagan Group in the Thompson Nickel Belt, which hosts most of the most valuable Ni deposits in that belt.

2) A series of ultramafic and mafic intrusions occurs between the main Lower intrusions and the base of the Lower Sedimentary formation. These intrusions were intersected by Westminer Ltd. drillholes (1993). Their position in the FRB suggests that the Lower Volcanic formation is, at least locally, thinner than was previously believed, and that there are several levels of emplacement for these intrusions.

The large body of massive to weakly foliated granite to granodiorite exposed on the Bigstone River may signify a syn- or post-rifting period of felsic plutonism in the FRB and the adjacent part of the Superior Province. A sample of this granite was collected for geochemical analysis and possible U-Pb geochronology. Similar granitic rocks were observed in a boudinaged dyke emplaced into sheared metasedimentary rocks along the Dafoe River, several kilometres west of the Bigstone River and presumably in the southern part of the Lower Sedimentary formation.

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