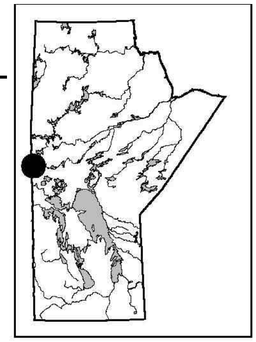
GS-1

# FLIN FLON TARGETED GEOSCIENCE INITIATIVE

by A.G. Galley[1] and A.H. Bailes



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## SUMMARY

Nine new projects have been initiated under the auspices of the Flin Flon Targeted Geoscience Initiative (TGI). These projects are designed to increase understanding of the volcanic and hydrothermal events influencing the setting of volcanogenic massive sulphide (VMS) deposits in the central Paleoproterozoic Flin Flon Belt. The primary objective of the project is to provide a sophisticated geological context that will permit mining and exploration companies in the area to undertake cost effective and, hopefully, successful exploration programs. This cross-border study brings together geoscientists from the Geological Survey of Canada (GSC), Manitoba Geological Survey (MGS), Saskatchewan Geological Survey (SGS), Laurentian University (LU) and the University of Manitoba (U of M) to collaborate with local exploration geologists from Hudson Bay Exploration and Development Co. Ltd. (HBED), Hudson Bay Mining and Smelting Co. Ltd. (HBMS), Aur Resources Inc. and M'Ore Exploration Services Ltd.

## INTRODUCTION

The Flin Flon Targeted Geoscience Initiative (TGI) is part of a $15 million, three-year federal initiative designed to develop new criteria to assist exploration and mining companies. The purpose of the TGI projects is to increase ore reserves, thereby stabilizing the economies of northern mining communities. Specific projects were selected through consultation with provincial and territorial governments and adjudication by industry representatives. Funding for TGI projects is provided jointly by the federal and provincial governments.

The Flin Flon TGI was initiated in the spring of 2000 with a $450 000 budget, which includes both operational and salary costs for the federal and provincial components of the project. The objectives of the Flin Flon TGI are to

- increase understanding of the volcanic and hydrothermal history of the central Paleoproterozoic Flin Flon volcanic belt;
- determine how these factors influenced the formation of contained VMS deposits; and
- assist the development of exploration strategies to support the discovery of new VMS deposits.

To ensure that the project objectives and components were recognized, understood and approved by local industry interests, an open meeting was held in Flin Flon during October 2000 to present the project outline and to discuss any concerns or additions that were tabled by the participants. This meeting was held in conjunction with an oral presentation of the aims and objectives of the program.

The Flin Flon TGI involves nine separate but integrated subprojects (Fig. GS-1-1) that straddle the Manitoba–Saskatchewan border and include most of the major VMS-hosting structural domains. The subprojects include four large-scale studies:

- delineation of oxygen-isotope patterns for regional-scale VMS-related hydrothermal systems
- trace-element research of all known VMS deposits and major sulphide occurrences
- a regional alteration study of the 'Bear Lake volcano'
- a 1:10 000 scale cross-border geological compilation of the Flin Flon area

In addition three detailed studies have been undertaken (Fig. GS-1-2):

- an alteration study of the Baker–Patton Rhyolite Complex
- a combination of detailed and large-scale hanging-wall studies of the Flin Flon VMS horizon
- a facies study of the volcaniclastic host strata to the Flin Flon–Triple 7 and Callinan deposits, which includes 1:500 scale mapping of volcanological and structural features along the Flin Flon 'mine horizon'

## REGIONAL SUBPROJECTS

### Oxygen-Isotope Mapping of VMS Hydrothermal Systems (Bruce Taylor [GSC] and Adrian Trimbal [GSC])

The purpose of this subproject is to generate domain-scale maps showing variations in oxygen-isotope values for volcanic and subvolcanic units associated with known or potential VMS mineralization. Taylor (in press) and Cathles (1993) demonstrated that oxygen isotopes are a sensitive tool in outlining areas of volcanic and subvolcanic rocks affected by subseafloor hydrothermal alteration. Furthermore, they demonstrated that anomalous isotope values, as defined by variations in $^{18}O/^{16}O$ normalized to modern seawater ($\delta^{18}O$) can assist in determining both high- and low-temperature parts of the hydrothermal

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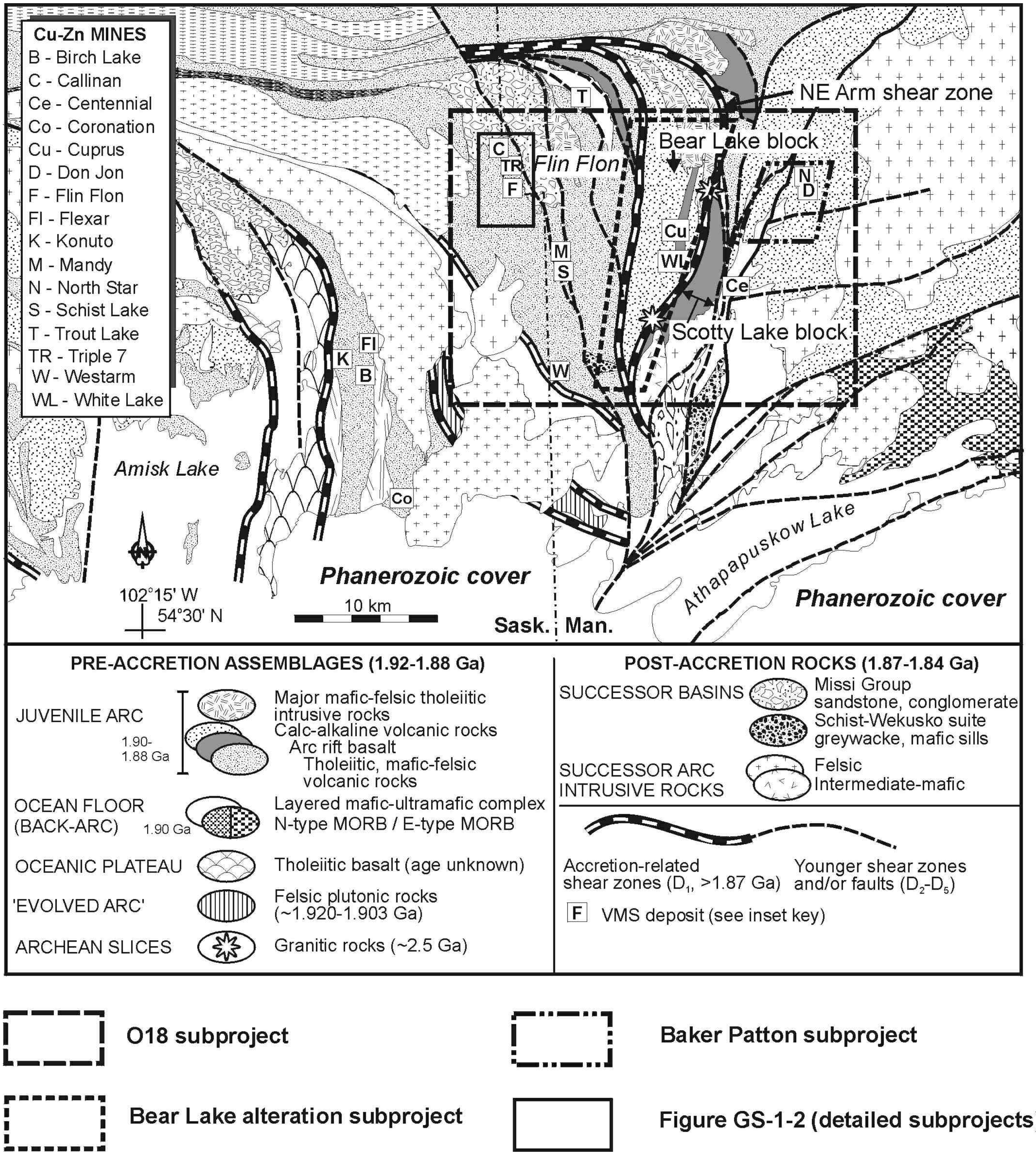


*Figure GS-1-1: Tectonic-assemblage map of the central portion of the Flin Flon Belt (after Lucas et al., 1996) showing the location of regional-scale Flin Flon TGI subprojects.*

system, which commonly bracket the potential VMS horizon.

Archived samples from MGS, as well as samples collected during other ongoing Flin Flon TGI subprojects, will be analyzed at the GSC. They will be used to develop oxygen-isotope maps at scales from 1:5 000 to 1:10 000, with the objective of delineating the size and nature of the hydrothermal systems associated with VMS deposits in the Flin Flon, Bear Lake and Baker–Patton domains (Fig. GS-1-1).

**Trace-Element Signatures of Flin Flon VMS Deposits (Ian Jonasson [GSC], Doreen Ames [GSC] and Tom Heine [MGS])**

An interesting aspect of current metallogenic studies is profiling Canadian VMS deposits through their trace- and rare-earth–element signatures. These signatures are considered to be a function of 1) the nature of the hydrothermal fluid; and

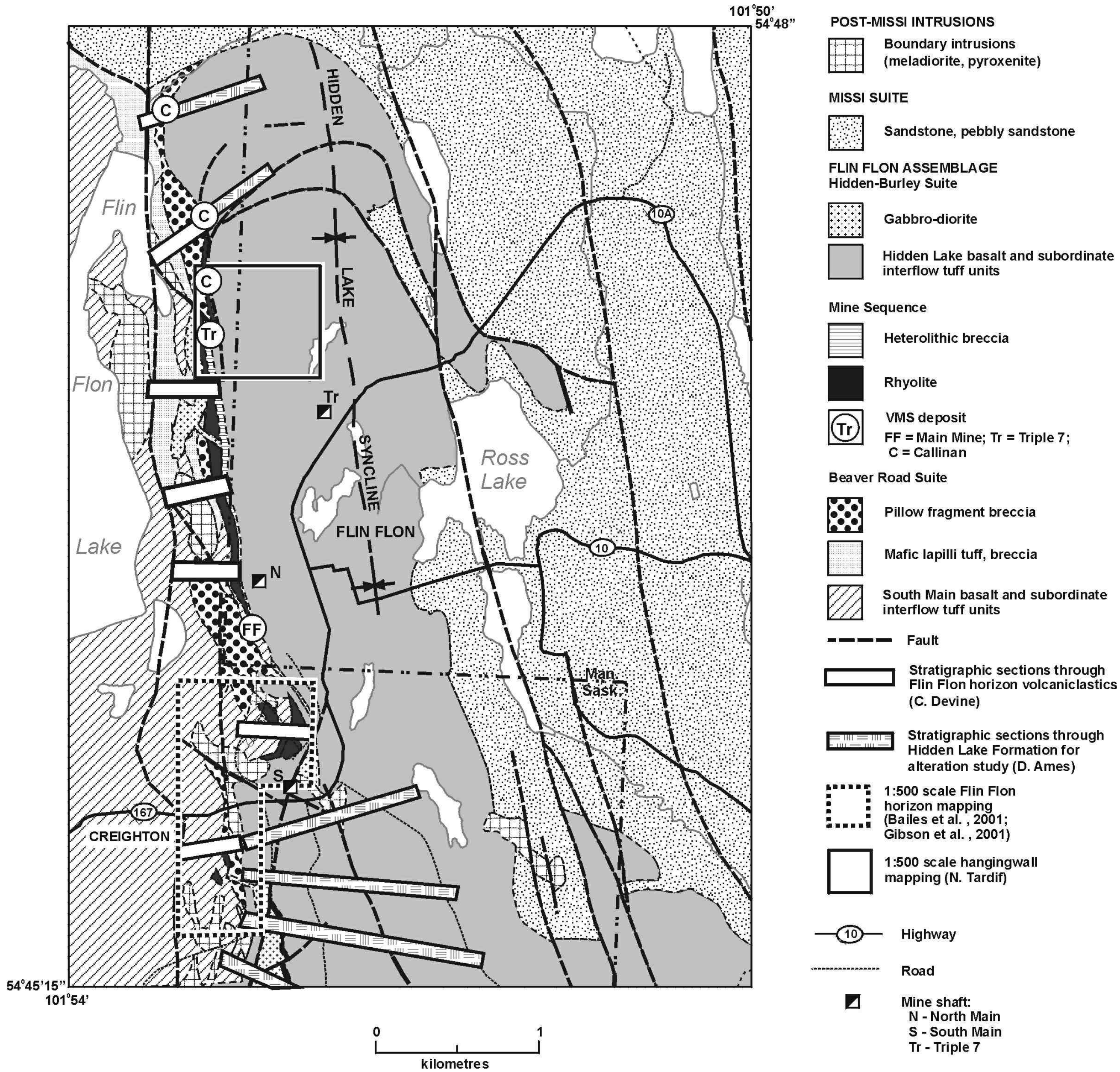


*Figure GS-1-2: Simplified geology of the Flin Flon-Creighton area (after Syme et al., 1996), showing the location of subprojects in the immediate area of the Flin Flon-Triple 7-Callinan mine horizon.*

2) the chemistry of the footwall strata, which supply metals and other elements to the hydrothermal fluid. Since the chemistry of these footwall rocks can be unique to the particular tectonic environment in which the VMS deposits were formed, it follows that VMS trace- and rare-earth–element signatures should also be unique and reflect this tectonic setting. The Flin Flon belt, with its wide range of VMS-hosting tectonic environments (Syme and Bailes, 1993; Lucas et al., 1996), is an ideal area in which to undertake an examination of the relationship of VMS trace-element signatures to their tectonic environment.

Trace- and rare-earth element–signatures of VMS deposits also have applications as exploration vectors, since sulphide minerals intercepted during drill programs or through prospecting can be analyzed, and their signatures compared to the geochemical archive developed during the Flin Flon TGI. This will assist companies in determining the nature of the intersected sulphide horizons, and possibly their potential with respect to metal ratios.

More than 300 samples from 14 VMS deposits and major sulphide occurrences have been collected and processed for geochemical analysis, with additional samples and deposits slated for collection and analysis in 2002. To date, only whole-rock analysis has been completed, but sulphide separates (pyrite, sphalerite, pyrrhotite and chalcopyrite) will be available for future analysis. Samples being analyzed are from GSC archives, HBED and the first two years of the project. In addition to analysis, samples are being slabbed, polished and photographed. The photographs will become part of a digital Flin Flon TGI datafile, and the slabs will be available for permanent display at a still-to-be-determined venue in Flin Flon.

**Bear Lake Alteration Study (Alan Galley [GSC] and Alan Bailes [MGS])**

The study of the Flin Flon volcanic assemblage by Bailes and Syme (1989) showed the fault-bounded Bear Lake structural domain to contain part of a flow-dominated basaltic andesite volcanic edifice that is topped to the east by a cauldron complex hosting the Cuprus and White Lake VMS deposits (Fig. GS-1-1). A large, epidote-rich alteration zone, affecting more than 40% of the volcanic stratigraphy in the Bear Lake structural domain (Bailes and Syme, 1989), is the target of this study. This alteration type commonly defines higher temperature parts of subseafloor alteration systems that are in close spatial association with subvolcanic sills and feeder dyke swarms (Gibson and Watkinson, 1990; Galley, 1993; Galley and Koski, 1999). If this large area of epidote-rich alteration was produced by a high-temperature hydrothermal system, this implies that much larger quantities of metals were mobilized than those sequestered within the known and mined Cuprus and White Lake deposits of the Bear Lake area. The purpose of this project is to increase understanding of the Bear Lake alteration system and to evaluate its potential to have more associated sulphide mineralization than has currently been identified.

Surface cross-sections every 500 to 1000 m through the exposed volcanic stratigraphy are documenting alteration morphologies and mineralogical variations, and relating these features to changes in volcanic-flow facies and abundance of synvolcanic dykes and sills. During the 2001 field season, 10 traverses were completed and a total of 140 samples collected. The original quarter-mile airphotos of Bailes and Syme (1989) were employed for making the cross-sections, in order that maximum use could be made of their existing geological database and archived sample set. Sampling on the cross-sections included most- and least-altered volcanic examples from each outcrop, as well as samples of synvolcanic dykes and sills to demonstrate their alteration relative to that undergone by the adjacent volcanic host rock. Empirical observations indicate

- noticeable variations in the epidote to quartz content of altered, pillowed to massive flows;
- the presence of semiconformable zones of silicification and disseminated sulphide mineralization; and
- discrete, discordant zones of sulphide veining and vesicle infilling unrelated to the known massive sulphide deposits.

**DETAILED SUBPROJECTS**

**Baker–Patton Rhyolite Complex Alteration Study (Dianne Mitchinson [M.Sc. student, LU] and George Gale [MGS])**

The Baker–Patton Rhyolite Complex is the easternmost VMS-hosting domain within the Flin Flon volcanic-arc assemblage (Fig. GS-1-1) and, taking into account folding and fault duplication, is the largest volume of felsic volcanic rock within this part of the Flin Flon Belt. Due to several bounding regional faults, its relative stratigraphic position to other components in the central Flin Flon Belt remains unknown. Despite its large volume, it is host to only small past-producing mines (Pine Bay, Don Jon and Northstar) and subeconomic occurrences (Baker–Patton, Cabin zone and Leo Lake). At the request of companies working in the area, a complex-wide alteration study was undertaken to determine whether hydrothermal-mineral alteration vectors would assist in the further evaluation of the area's VMS potential.

The main thrust of this study is an X-ray diffraction (XRD) mineral and electron microprobe mineral-chemical study of archived and infill samples, the latter collected during the 2001 field program. The objective is to complete a mineral-alteration map of the entire Baker–Patton Complex. One goal of the 2001 field program was to generate field-based lithological and alteration maps that will provide a 'reference frame' in which to evaluate the XRD and mineral-chemical study. This is necessary because the XRD study will be dominated by archived samples. With this objective in mind, samples were collected that best represent 1) relatively unaltered to strongly altered rhyolite units of the complex, and 2) various physical components of the rhyolite flows (altered and unaltered massive facies, lobes and microbreccia).

With these samples, we can place XRD alteration mineralogy into its context (e.g., flow facies and degree of alteration) within individual rhyolite flows. This will provide the framework for evaluating the XRD alteration mineralogy relative to various VMS deposits and occurrences in the Baker–Patton Complex.

**Flin Flon Hanging-Wall Alteration Study (Doreen Ames [GSC])**

One of the most interesting and least known aspects of VMS metallogeny is the nature and extent of alteration halos within the hanging-wall stratigraphy to massive-sulphide deposits. Hanging-wall alteration can be formed as a result of the continuation of hydrothermal activity after burial of lava flows or by the generation of argillaceous hydrothermal sediments (e.g., by prolonged low-temperature exhalations in the waning stages of ore formation at depth). This concept was reinforced by studies of the Horne (Kerr and Gibson, 1983), Kidd Creek (Barrie et al., 1999) and Ansil (Galley, 1994; Galley et al., 1996) VMS deposits, which demonstrated that at least some thickness of hanging-wall stratigraphy was present as the economic portions of these deposits were formed or reworked. Hydrothermal-fluid leakage has been documented 500 m upsection from the Ansil deposit (Galley et al., 2000). If the nature and extent of this hydrothermal leakage can be quantified, it may become an ideal exploration tool to focus in on potential VMS-hosting stratigraphic intervals. These processes may also lead to the development of stacked ore lenses (e.g., Amulet A and Upper A deposits, Noranda); therefore, the potential exists within hanging-wall alteration haloes for future discoveries higher in the stratigraphy.

The Flin Flon hanging-wall study is based on detailed observations of volcanic-flow facies changes and alteration characteristics within the thick succession of massive to pillowed Hidden Lake basalt and basaltic andesite flows (Bailes and Syme, 1987). These basalt flows directly overlie the rhyolite and volcaniclastic host strata to the Flin Flon, Triple 7 and Callinan deposits (Fig. GS-1-2). One of the most interesting aspects of this basalt succession is the occurrence of abundant interpillow sediment, composed of varying ratios of hydrothermal chert, hyaloclastite and alteration minerals. These hydrothermal-hyaloclastite sediments form cohesive interflow units at several levels of the hanging-wall stratigraphy, with one of the thickest units marking the top of the Hidden Lake basalt between Louis and Phantom lakes (Fig. GS-1-2). The amount of sediment present in this formation, and its high degree of hydrothermal modification, suggest that it was an ideal medium for migrating hydrothermal fluids.

Six sections were completed across the Hidden Lake basalt from the north end of Phantom Lake to the Club Lake Fault, where the section is in fault contact with younger Missi Group sedimentary strata (Fig. GS-1-2). In addition to detailed section mapping at 1:2000 scale, occurrences of interflow and interpillow sediment were sampled (more than 200 samples) to evaluate variations in mineralogy, mineral chemistry, and major- and trace-element chemistry.

Fieldwork next summer will involve the completion of several surface and drill-core sections where the hanging-wall strata are overlain by the infrastructure of the town of Flin Flon, and a more detailed examination of a possible high-temperature reaction zone associated with sills low in the hanging-wall section, between the Railway and Club Lake faults.

**Triple 7 Hanging-Wall Stratigraphy and Alteration Study (Nicole Tardif [M.Sc. student, LU])**

Whereas the hanging-wall study by Ames is taking a regional-scale approach to determining the presence of hydrothermal plumes above known and perhaps unknown deposits along the Flon Flon horizon, this study will focus on the immediate hanging wall to the Triple 7 deposit, in order to detect and document hydrothermal leakage. This study entails sampling and 1:1000 scale surface mapping of the hanging-wall Hidden Lake basalt above the Triple 7 VMS deposit, between the lower contact of the basalt with the Railway Volcaniclastic unit and the axial trace of the Hidden Lake $F_2$ synform (Fig. GS-1-2). This area (approximately 300 by 600 m) directly overlies the up-plunge extensions of the two 'arms' of the Triple 7 and the Callinan South massive-sulphide lens. To date, four principal flow units have been defined, along with numerous dykes and sills of varying compositions and ages. Some flow facies are characterized by abundant interpillow sediment and by altered pillow cores. Disseminated sulphide mineralization appears to be restricted to certain parts of the stratigraphy and is probably related to the distribution and variability of primary permeability, and the possible damming effect of basalt feeder dykes.

Mapping has also identified several low-angle, deformed faults, the presence of which supports the occurrence of an early, thin-skinned, fold-thrust event. This is important because of the potential displacement and duplication of both volcanic stratigraphy and associated massive sulphide bodies. These results will be linked with the structural study presently being carried out underground by HBMS.

Following surface mapping and sampling, two drillholes were chosen for logging and sampling. These long holes, collared several hundred metres into the Hidden Lake basalt formation, intersected the Triple 7 sulphide mineralization at depth. These drillholes permit detailed sampling for alteration directly above the economic portion of the mineralization. Approximately 200 samples collected during the 2001 field season are currently being processed for petrographic and geochemical analysis.

**Stratigraphy and Structure of the Flin Flon Mine Area**

The Flin Flon VMS-hosting stratigraphy includes a variable and complex suite of rocks affected by deformational events that include stratigraphy-parallel thrust faults. In 2001, a number of projects were initiated that are designed to elucidate both the detailed stratigraphy and the structural modification of the Flin Flon mine horizon. They include

- 1:500 scale mapping of the mine area;
- structural studies of the mine-hosting stratigraphy; and
- a facies analysis of volcaniclastic rocks within the stratigraphic footwall to the main ore deposits.

***1:500 scale mapping (Alan Bailes [MGS], Harold Gibson [LU], Ric Syme [MGS], Ghislain Tourigny [SGS] and Debbie Bray [B.Sc. student, U of M])***

Effective delineation of the VMS-hosting stratigraphy at Flin Flon has been hampered in the past by the location of the mine stratigraphy along the border between Manitoba and Saskatchewan, with the attendant division of responsibilities between two provincial geoscience agencies. Cross-border mapping at 1:500 scale was undertaken to resolve some long-standing controversies about the location and nature of the Flin Flon mine horizon. The 1:500 scale of mapping was chosen because less detailed scales were totally inadequate for effective portrayal of the geological features required to resolve structural and stratigraphic problems in the mine area. The 1:500 scale mapping program will continue into the 2002 field season and probably beyond. In 2001, 1:500 scale mapping projects were undertaken

- around the South Main shaft by Alan Bailes and Ric Syme (MGS), including detailed mapping and study of primary features in the South Main Rhyolite Complex by Debbie Bray (B.Sc. student, U of M); and
- on 'Millrock Hill' by Harold Gibson (LU), Ghislain Tourigny (SGS), Alan Bailes (MGS) and Ric Syme (MGS).

*South Main mapping*

Cross-border mapping at 1:500 scale was undertaken in the vicinity of the Flin Flon South Main shaft (Preliminary Map 2001F-2) to resolve some long-standing controversies about the location of the southern extension of the Flin Flon mine horizon. The South Main area has been mapped several times at less detailed scales, with differing geological interpretations of this important area and conflicting implications for the location of the Flin Flon mine horizon.

Mapping by Stockwell (1960) at 1:12 000 scale indicated that the ore-hosting rhyolite for the Flin Flon VMS deposit linked to the south with some large rhyolite complexes (north of the South Main shaft) in a broad, curving, open Z-shaped structure, and then with smaller rhyolite complexes farther to the south at 'Millrock Hill'. Mapping at 1:20 000 scale by Bailes and Syme (1989) suggested that 1) the mine horizon continues straight to the south and east of the South Main shaft area; 2) the rhyolite complex north of the South Main shaft comprises high-level intrusions still in the footwall stratigraphy to the mine; and 3) the mine horizon is structurally offset, perhaps by a dextral fault, to link up with rhyolite complexes at 'Millrock Hill'. Mapping at 1:10 000 scale by Thomas (1992, 1994) supported this finding but proposed that offset of the mine-hosting rhyolite package was the product of folding and not a consequence of a fault. Geologists from HBED and HBMS have generally supported the interpretation proposed by Stockwell (1960) but have considered the possibility that the Flin Flon–Triple 7 and Callinan VMS mineralization represents the product of two mineralizing events (i.e., two horizons).

One objective of the B.Sc. thesis study of the South Main Rhyolite Complex by Debbie Bray is to determine whether primary features, geochemistry and map distribution of the South Main Rhyolite Complex support an intrusive or extrusive origin, and whether or not this rhyolite complex is the extension of the 'Mine rhyolite' that hosts the Flin Flon VMS deposit. The objective of the 1:500 scale mapping by Bailes and Syme is to provide the broader geological context for the South Main rhyolite bodies and a more refined stratigraphy for the Flin Flon mine area. The projects will together provide a single 1:500 scale map of the South Main area (Preliminary Map 2001-F2).

These projects have considerably refined our geological understanding of the South Main area and have brought to light a number of critical pieces of information which, although preliminary at this point, challenge some of the currently held views about the setting of the Flin Flon VMS deposit. Some of the more important observations are:

- The South Main rhyolite is composed of three recognizable units that are part of a flow-dome complex. Although parts of the rhyolite complex are clearly intrusive, there is considerable evidence that the complex is, at least in part, extrusive.
- The South Main rhyolite is emplaced/extruded within a volcaniclastic package (previously unrecognized) that is composed of mafic wacke-siltstone, monolithologic rhyolite breccia, and arenite containing detrital quartz and lithic felsic clasts. The South Main volcaniclastic package shares many characteristics with those hosting rhyolite bodies at 'Millrock Hill'.
- Basalt flows stratigraphically overlying the South Main Rhyolite Complex are broadly folded and appear to correlate with similar flows directly to the south, across the trace of the fault proposed by Bailes and Syme (1989) and the fold proposed by Thomas (1992).

These observations raise some serious questions about the Flin Flon mine stratigraphy as proposed by Bailes and Syme (1989). Clearly, further 1:500 scale mapping and systematic geochemistry of both basalt and rhyolite flows in the immediate Flin Flon area are needed to resolve this important geological issue. A key outcome of understanding the stratigraphy in the immediate area of the Flin Flon mine horizon will be more effective identification of the mine-hosting package elsewhere and more cost-effective exploration of this sequence on the east side of the Hidden Lake syncline, in Manitoba, and on the west side of the Flin Flon anticline, in Saskatchewan.

*Millrock Hill mapping*

The 1:500 scale mapping of Millrock Hill (Preliminary Map 2001F-1) builds upon previous 1:5000 scale mapping by Price (unpublished map, Hudson Bay Exploration and Development Co. Ltd., 1992) and a detailed report by Syme (1998). The structural geology of the area is reported in the next section.

The predeformation Millrock Hill geology comprises volcaniclastic rocks that are interpreted to have infilled a volcanic-tectonic depression on an underlying basalt sequence. The volcaniclastic rocks, which were accompanied by extrusion of rhyolite complexes, had a dual mafic and felsic source. The basalt breccia and mafic components in these volcaniclastic rocks are interpreted to have been derived from an external source (i.e., basalt basement from the margins of the depositional basin). The felsic components are interpreted to have been derived locally within the basin from the syndepositional rhyolite domes. Rapid thickness variations of some units in the depositional basin indicate that synsedimentation subsidence occurred during infilling of this volcanic-tectonic depression.

Determining the provenance and mechanism of deposition of the volcaniclastic rocks in the volcanic-tectonic depression could play an important role in guiding VMS exploration in the mine sequence at Flin Flon. A separate M.Sc. project by Christine Devine, targeting this aspect of the volcaniclastic rocks, is described in a following section.

### *Structural observations on Millrock Hill (Ghislain Tourigny [SGS])*

Structural observations are being collected concurrent with 1:500 scale mapping. The objective is to delineate structural events that have affected the mine-hosting stratigraphy. This report summarizes structural observations made in the Millrock Hill area during the 2001 field season. The structures are shown on Preliminary Map 2001F-1 of the Millrock Hill area.

Planar and linear structural elements observed at Millrock Hill result from two principal generations of structures, $D_1$ and $D_2$. The $D_1$ structures formed a weak $S_1$ foliation that is mainly observed in the hinge zone of $F_2$ folds, where it lies at a high angle to the dominant regional schistosity, $S_2$. The $S_1$ foliation is subhorizontal and seems almost completely transposed and obliterated by $S_2$. At the outcrop scale, $S_1$ has no significant effect on the geometry of strata.

The $D_2$ deformation produced the prominent folds ($F_2$), the associated axial-planar regional $S_2$ schistosity, $L_2$ lineations and late $D_2$ fault zones. The structural pattern of the area is dominated by the presence of a major $F_2$ fold, which is obliquely truncated and dismembered by northwest-trending ductile faults (Preliminary Map 2001F-1). This fold, a major synclinal flexure plunging at 35° toward the southeast, is largely responsible for the spatial distribution of rock types. Most outcrops are located on its west limb, where a series of parasitic, Z-shaped $F_2$ folds are well developed within interlayered volcaniclastic units. Metre-scale, Z-shaped $F_2$ folds are homoaxial and plunge moderately (30–40°) toward the southeast. They are tight and similar in style. The regional $S_2$ schistosity is essentially coplanar with the axial plane of $F_2$ folds. The $S_2$ planes contain a strongly developed stretching lineation ($L_2$), defined by elongation of ellipsoidal markers such as lapillis and blocks in volcaniclastic flows, as well as by the elongation of amphibole crystals or aggregates of phyllosilicates. These lineations plunge at a general angle of 35° toward the southeast and are essentially collinear with the $F_2$ fold axis.

A well-developed network of anastomosing fault zones formed at a very low counter-clockwise angle to $S_2$ (Preliminary Map 2001F-1). Fault zones vary from 15 cm to 2 m in width, show a lateral continuity of several hundred metres and dip steeply to the east. The fault zones contain rock types with a steep east-dipping foliation and well-developed extension lineations. Fault rocks consist of chlorite-epidote-carbonate schist with local protomylonite. The fault-zone foliation and lineations represent accentuated $S_2$ and $L_2$ fabrics. Within the faulted rock panels, the inherited $S_2$ schistosity is slightly reoriented and bends to the left, thus indicating a sinistral displacement in plan view. The extension lineations plunge at an average angle of 35° toward the southeast; this attitude mimics perfectly the $L_2$ lineations external to the faulted panels. The attitudes of the internal foliation and the extension lineation within the fault zones indicate that these structural discontinuities are northwest-verging, oblique-reverse faults with minor sinistral displacement. They are interpreted as late $D_2$ structures.

A set of younger, north-northeast-trending brittle faults produced right-lateral displacement of lithological contacts and earlier structures (Preliminary Map 2001F-1). These dextral strike-slip faults are subvertical and less that 1 m wide. The dextral strike-slip displacement measured along these brittle faults reaches a maximum of 18 m in plan view.

The finite geometry and styles of major tectonic structures recognized in the Millrock Hill area result from a northeast- to east-northeast-trending subhorizontal shortening and oblique, dip-slip elongation. The anastomosing character of the major $D_2$ fault system suggests a bulk inhomogeneous flattening type of deformation.

### *Analysis of footwall volcaniclastic rocks (Christine Devine [M.Sc. student, LU)*

Volcaniclastic rocks within the footwall to the main ore deposits in the Flin Flon mine stratigraphy have previously received only limited detailed analysis (e.g., Syme, 1997, 1998). The main purpose of this study of the volcaniclastic rock package is to analyze the basin in which they occur, across the mine section from its northernmost edge, exposed near the surface expression of the Callinan deposit, to its southern edge, exposed at Millrock Hill. The three main objectives of this study are to

- determine the mechanism of emplacement of the various breccia units within the volcaniclastic package;
- ascertain their provenance; and
- identify their environment of deposition.

Four main areas in the volcaniclastic basin have been examined. In each area, a detailed stratigraphic section (or sections) has been measured to document up-section variations in depositional units with respect to clast size. In addition, clast counts and measurements were taken along these sections where variations in the units were observed. Clast counting involved measuring the three largest clasts of each rock type within a square area. A grid was used to perform a clast count in each area, thus identifying the percentage of matrix and different clast types present. A detailed description of each unit includes the sorting, matrix composition and relationship to other depositional units, along with a detailed description of contained clasts (including their colour, shape, size range, amygdule or phenocryst size and percentage, and orientation). Trace-element geochemistry and petrography of significant clast components will further identify the source and significance of the clasts in the volcaniclastic rocks. Mapping of two areas at 1:500 scale was undertaken within the mine site to augment information collected on the breccia units across the basin.

## FUTURE PLANS

During the 2001 field season, emphasis was on 1) initiating field work for M.Sc. and B.Sc. thesis studies; and 2) acquiring sample sets for the alteration studies (oxygen isotope study, Bear Lake study, Flin Flon hanging-wall study). The cross-border 1:500 scale mapping and structural studies that were initiated during the 2001 field season will be the major emphasis of the 2002 field season. In 2002, the B.Sc. theses will be completed and M.Sc. thesis studies will be into data processing and initial write-up. The alteration and the VMS studies will proceed with analysis of samples collected during 2000 and 2001; where required, further samples will be collected and analyzed in 2002.


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