GS-13 Far North Mapping Initiative: reconnaissance bedrock mapping and sampling of the Great Island Domain, Manitoba (parts of NTS 54L, M, 64I, P)

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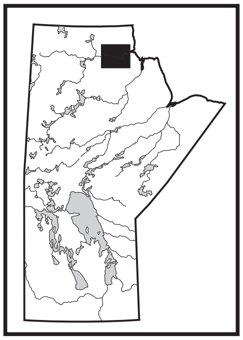

Summary

In 2008, the Manitoba Geological Survey completed two weeks of reconnaissance bedrock mapping and sampling in the Great Island Domain at the southeastern margin of the Hearne craton in Manitoba's far north. This work focused mainly on metavolcanic and metasedimentary outcrops along the lower Seal and North Knife rivers, and included the collection of representative bedrock samples of all the major rock types identified by previous mapping in the Great Island Domain. These samples will be submitted for lithogeochemical, Sm-Nd isotopic and/or U-Pb geochronological analysis, in preparation for a more concerted mapping program planned for the 2009 field season as part of the Manitoba Geological Survey's Far North Mapping Initiative.

Introduction

This report provides an update of fieldwork completed in 2008 as part of the Manitoba Geological Survey's ongoing Far North Mapping Initiative. The purpose of this initiative is to study the southeastern margin of the Archean Hearne craton in Manitoba, with the goal of furthering understanding of the nature, evolution and mineral potential of one of the principal geological building blocks of Manitoba's Precambrian shield. This initiative was launched in 2004 with a Sm-Nd isotopic study of archival granitoid samples collected by D.C.P. Schledewitz throughout the NTS 64P map sheet (Böhm et al., 2004), and was followed up with targeted bedrock and surficial mapping and sampling at Nejanilini Lake in 2005 (Anderson and Böhm, 2005; Anderson et al., 2005; Matile, 2005) and in the Kasmere and Putahow lakes areas in 2006 (Anderson and Böhm, 2006; Böhm and Anderson, 2006a, b; Matile, 2006a, b; Figure GS-13-1). From a bedrock geological perspective, the Nejanilini Lake study provides insight into the tectonothermal evolution of plutonic and subordinate sedimentary cover rocks inboard of the Hearne craton margin, whereas the study of the Kasmere–Putahow lakes area provides insight into evolution of the mainly sedimentary cover rocks at the craton margin.

The 2008 fieldwork consisted of eight days of reconnaissance bedrock mapping and sampling in the area of the lower Seal and North Knife rivers, which are situated within the Great Island Domain at the southeastern extent of the Hearne craton. The major goal of this fieldwork was to obtain a suite of representative samples for geochemical and geochronological analysis in preparation for a more concerted bedrock mapping campaign planned for the 2009 and 2010 field seasons. The Great Island Domain, which was last mapped in 1974–1975 by the Manitoba Geological Survey (Schledewitz, 1986), includes key exposures of metasedimentary cover rocks, as well as the only known occurrences of metavolcanic rocks in Manitoba's far north, the age and significance of which have yet to be determined. The bedrock exposures examined in 2008 ranged up to 160 km west of Churchill, although the project also included a one-day visit to Munroe Lake, located 260 km west-northwest of Churchill. The study area was accessed by float plane from Landing Lake south of Churchill. The bedrock mapping and sampling was helicopter supported from the Sosnowski Lake camp of Western Warrior Resources Inc., which is located 114 km west-northwest of Churchill.

The 2008 field studies included detailed petrographic-petrological and structural mapping of bedrock exposures at 46 stations (Figure GS-13-2), which were chosen from Schledewitz's (1986) maps to include all of the major rock types in the region. Emphasis was placed on known occurrences of supracrustal rocks. At each station, representative bedrock samples were collected for laboratory analysis; in most cases the quality and volume of the material collected are sufficient for geochemical, isotopic and/or geochronological analysis. Representative and least-altered samples of cached drillcore from the Eppler Lake project of Western Warrior Resources Inc. (2006 drilling program) and the Polar Gold project of Homestake Mineral Development Co. (1988 drilling program; Assessment File 93536, Manitoba Science, Technology, Energy and Mines, Winnipeg) were also collected.

In June 2008, prior to the start of the 2008 field program, the project geologists and the Director of the Manitoba Geological Survey (MGS) conducted a one-day visit to the Sayisi Dene First Nation at Tadoule Lake. The purpose of this trip was to provide the Band Council with an overview of planned MGS activities in the Sayisi Dene First Nation Traditional Use Area. During this visit, the authors were also allowed access to cached drillcore from the 2005 drill program by Canstar Resources Inc. on the Seal River project, which was completed under the terms of an option agreement with BHP Billiton Diamonds Inc.

Geological setting

In Manitoba, the Archean continental crust of the

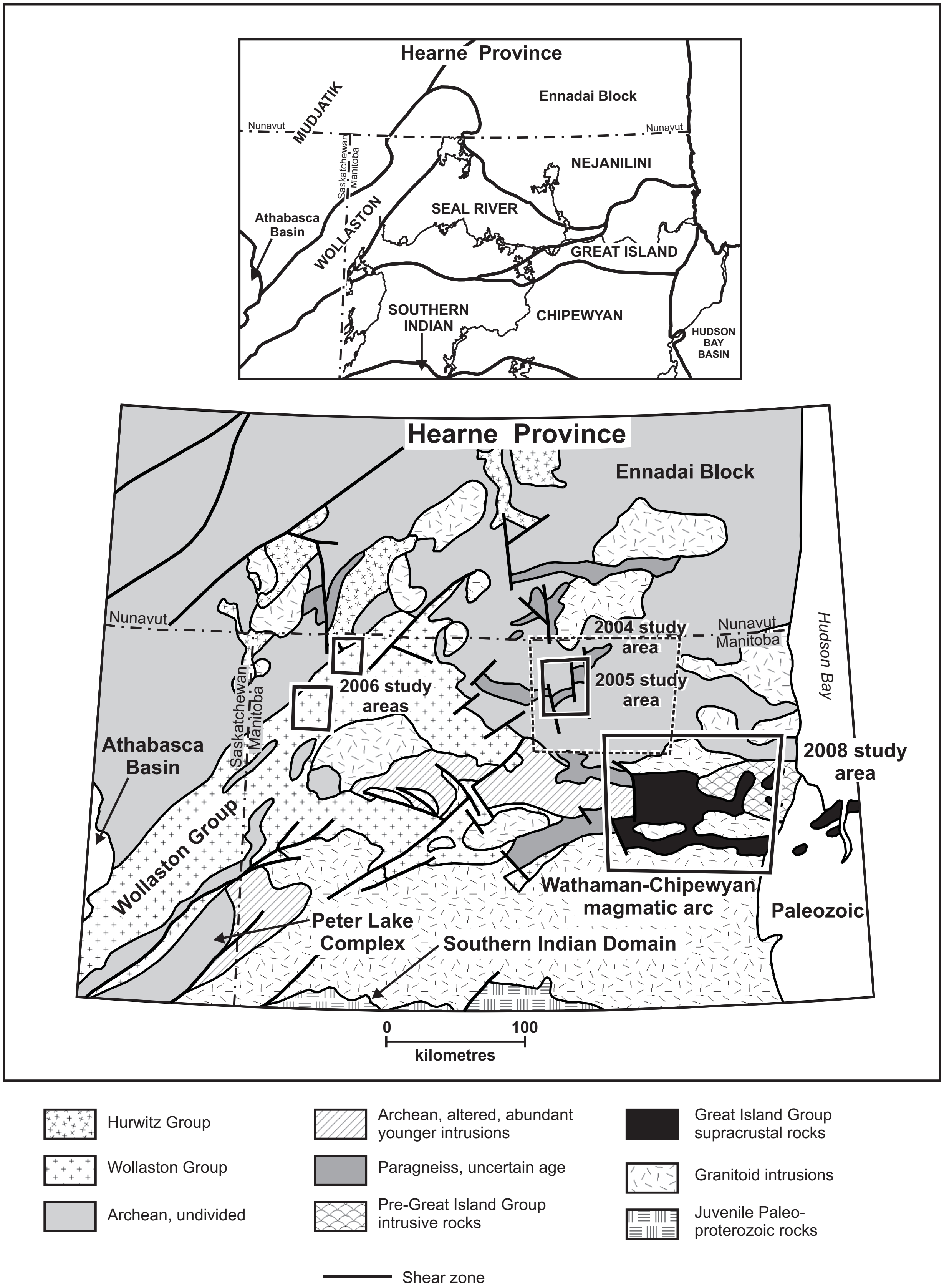

Figure GS-13-1: *Lithotectonic elements of the Trans-Hudson Orogen–Hearne craton region (*after *Manitoba Industry, Trade and Mines, 2000) with the 2004, 2005, 2006 and 2008 study areas outlined. Inset map shows the major geological domains in Manitoba's far north.*

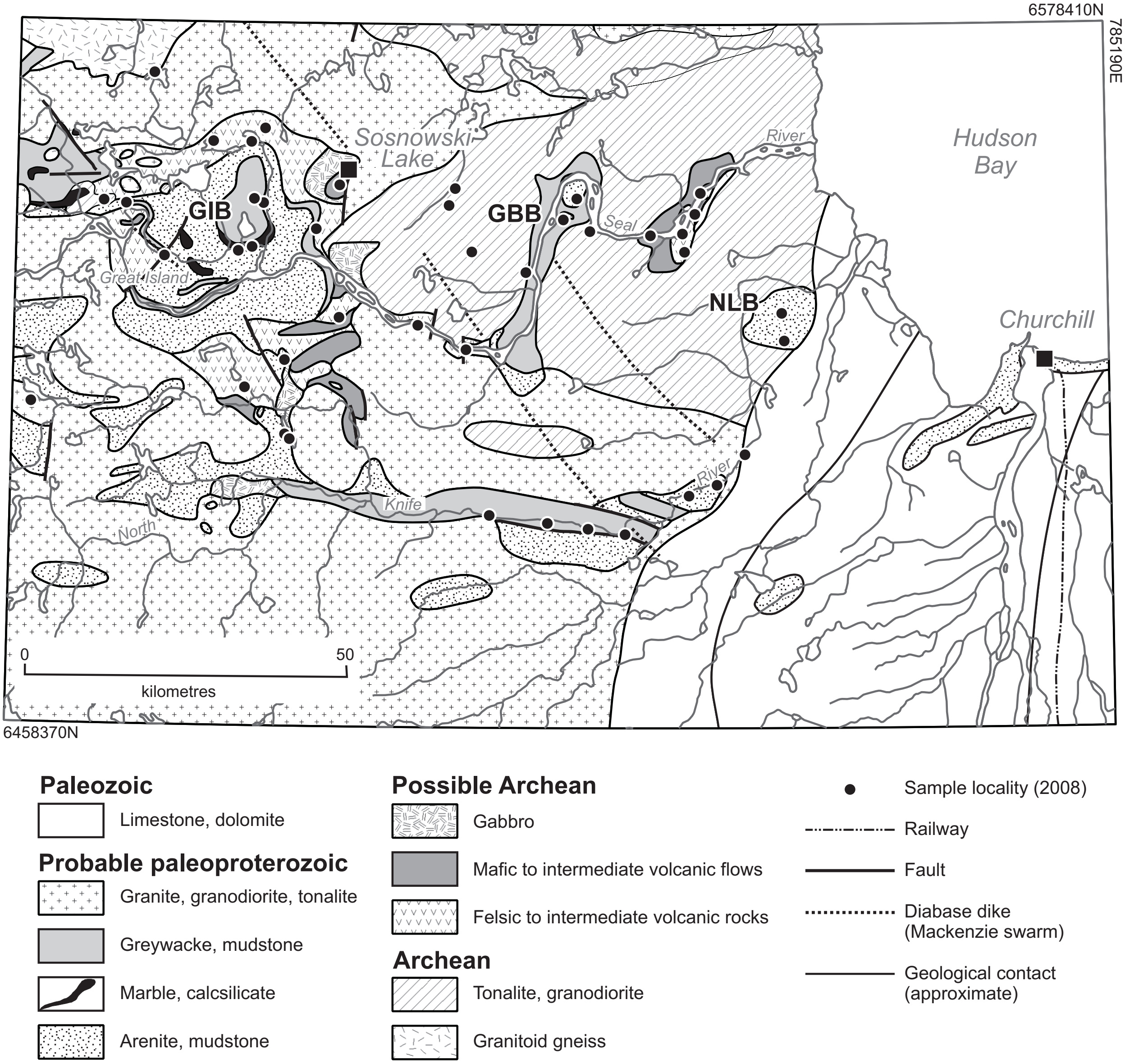

***Figure GS-13-2:** Simplified geology of the Great Island Domain, showing the station locations from the 2008 mapping and sampling program. Abbreviations: GBB, Grand Bend basin; GIB, Great Island basin; NLB, Nowell Lake basin.*

Hearne craton is overlain by Paleoproterozoic cover rocks and, together with the cover rocks, has undergone varying degrees of thermotectonism during the Paleoproterozoic Trans-Hudson orogeny (Cree Lake Ensialic Mobile Zone; Lewry et al., 1978; Lewry and Sibbald, 1980). The ensialic mobile zone has been subdivided into six domains in Saskatchewan and Manitoba: the Mudjatik, Peter Lake, Wollaston, Seal River, Great Island and Nejanilini domains. The domains are distinguished by their cover rocks, the proportion or absence of basement rocks, and their dominant structural trends. With the exception of Monroe Lake, the areas investigated during the 2008 summer mapping program lie wholly within the Great Island Domain, which is bounded to the north by the Nejanilini Domain and to the south by the Wathaman–Chipewyan plutonic complex (Figure GS-13-1). To the west, the Great Island Domain transitions into partially equivalent, though generally higher-grade rocks of the Seal River Domain (Schledewitz, 1986).

The Nejanilini Domain is dominated by granulite-grade felsic intrusive rocks, with only minor enclaves of metasedimentary rocks, and is interpreted to include vestiges of the Meso- to Neoarchean basement rocks of the Hearne craton (Böhm et al., 2004). The Great Island Domain, in contrast, is dominated by metasedimentary and metavolcanic rocks of generally lower metamorphic grade that are presumed to overlie the basement rocks of the Hearne craton (e.g., Schledewitz, 1986), although the ages and contact relationships of these rocks remain to be determined. The Wathaman–Chipewyan plutonic complex, which is interpreted as a remnant of a vast continental magmatic arc (Meyer et al., 1992), separates the

Great Island Domain supracrustal rocks from accreted juvenile Paleoproterozoic terranes farther to the south in the Reindeer Zone of the Trans-Hudson Orogen.

On regional-scale aeromagnetic maps, the Great Island Domain is clearly delineated by a generally lower total magnetic intensity as compared to the surrounding domains. Unlike the typically abrupt and linear magnetic gradients at domain boundaries farther to the west in the ensialic mobile zone, which are suggestive of steep crustal-scale faults, the margins of the Great Island Domain are characterized by diffuse and irregular magnetic gradients that are suggestive of intrusive and depositional relationships with the adjacent domains. Determining the nature of these domain boundaries is one of the goals of this mapping campaign.

Geology of the Great Island Domain

Due to a combination of scarce bedrock exposures, complex structure, locally high-grade metamorphic recrystallization, widespread late-tectonic plutonism and the absence of reliable radiometric ages, Schledewitz (1986) adopted a 'nonstratigraphic' nomenclature for metavolcanic and metasedimentary rocks in Manitoba's far north. In this scheme, supracrustal rocks were subdivided into two regional groups: Sequence I, which includes a diverse suite of metasedimentary and metavolcanic rock types for which an Archean age was considered possible and Sequence II, which consists of a relatively coherent suite of metasedimentary rocks that were considered to be no older than Paleoproterozoic. The Great Island Domain was thought to include both Sequence I and II rocks, with the former represented mainly by the extensive exposures of metavolcanic rocks that surround Great Island on the Seal River, and the latter by overlying quartzite-dominated metasedimentary successions that define a series of irregular basins throughout the Great Island Domain. Although useful for discussions of regional-scale bedrock geology, the Sequence I and II terminology is not utilized in this report and the supracrustal rocks are described according to rock type and geographic area.

As described by Böhm et al. (2004), Anderson et al. (2005) and Böhm and Anderson (2006a), metasedimentary rocks throughout Manitoba's far north are thought to be broadly correlative with the Paleoproterozoic Wollaston Supergroup in Saskatchewan and northwestern Manitoba (ca. 2.1–1.9 Ga; Kays, 1972; Weber et al., 1975; Ray and Wanless, 1980; Ansdell et al., 2000; Yeo et al., 2000; Tran, 2001; Tran et al., 2003; Harper et al., 2005a) and the partially time-equivalent Hurwitz Group in Nunavut (ca. 2.4 to 1.9 Ga; Patterson and Heaman, 1991; Heaman and LeCheminant, 1993; Davis et al., 2000). The age and possible correlation of metavolcanic rocks in the Great Island area remain unknown; samples obtained during the 2008 program will be utilized to resolve outstanding questions regarding the age, provenance and correlation of all the major supracrustal rock types in the Great Island Domain.

Supracrustal rocks in the Great Island Domain are intruded by syn- to late-tectonic granodiorite, quartz monzonite and granite plutons. Similar plutons in the Wollaston Domain in Saskatchewan yielded ages ranging from 1.80 to 1.84 Ga (Annesley et al., 1992, 1997), which corresponds to the main period of Hudson granite emplacement throughout the western Churchill Province (Peterson et al., 2000, 2002).

Metamorphic mineral assemblages indicate that the metamorphic grade in the Great Island Domain generally ranges from low in the southeast to high in the northwest. Lower greenschist facies metasedimentary rocks are exposed in the deeply incised banks of the lower North Knife River, whereas upper amphibolite or granulite-facies metaplutonic rocks are exposed in extensive outcrop fields north of Great Island, at the southern margin of the Nejanilini Domain.

Finite strain varies from moderate to intense in the examined outcrops. Structural trends in the south are generally east-west and mesoscopic deformation structures indicate at least two generations of tight to isoclinal folds, the latter of which is associated with the development of a penetrative, generally east-trending transposition fabric. In the north, structural trends are much more variable and reflect the presence of macroscopic dome-and-basin–style folds, the most prominent example of which is centred on Meades Lake, north of Great Island, and was referred to as the 'Great Island Basin' by Schledewitz (1986). Observed bed forms and younging criteria indicate that metasedimentary rocks in this portion of the study area occupy synclinal keels, whereas metaplutonic and minor metavolcanic rocks occupy the intervening anticlinal culminations. Other prominent synclinal basins occur along the north-trending section of the lower Seal River approximately 30–40 km west of Hudson Bay (herein referred to as the 'Grand Bend' basin) and to the west of the north-trending section of the lower North Knife River (herein referred to as the 'Nowell Lake' basin).

Observations and preliminary results

The following provides brief descriptions of the rock types mapped and sampled during the 2008 program, with emphasis on metavolcanic and metasedimentary rocks. Metavolcanic rocks were examined in several locations along the margins of the Great Island basin and along the lower Seal River east of Great Island, whereas metasedimentary rocks were examined in the cores of the Great Island, Grand Bend and Nowell Lake basins, as well as along the lower North Knife River.

Metavolcanic rocks

North of the Great Island basin, three outcrops were found to consist of heterolithic volcanic conglomerate, pillowed andesite and massive to fragmental dacite. The conglomerate is matrix supported, poorly sorted and appears unstratified on the scale of the examined outcrop (Figure GS-13-3a). The clasts range up to 50 cm across (typically <20 cm) and consist mainly of grey-green, variably feldspar-phyric andesite and basalt, with subordinate gabbro. Pillowed andesite flows are exposed south of the conglomerate, just below the northern margin of the Great Island basin. The andesite is light grey to green and contains up to 5% plagioclase phenocrysts (1–5 mm) and up to 5% round quartz amygdules (2–10 mm across; Figure GS-13-3b). The pillows are bun-shaped to amoeboid and range up to 4 m or more in maximum dimension, with 1–2 cm thick selvages and locally thick (20 cm) hyaloclastite-filled interstices. These rocks have

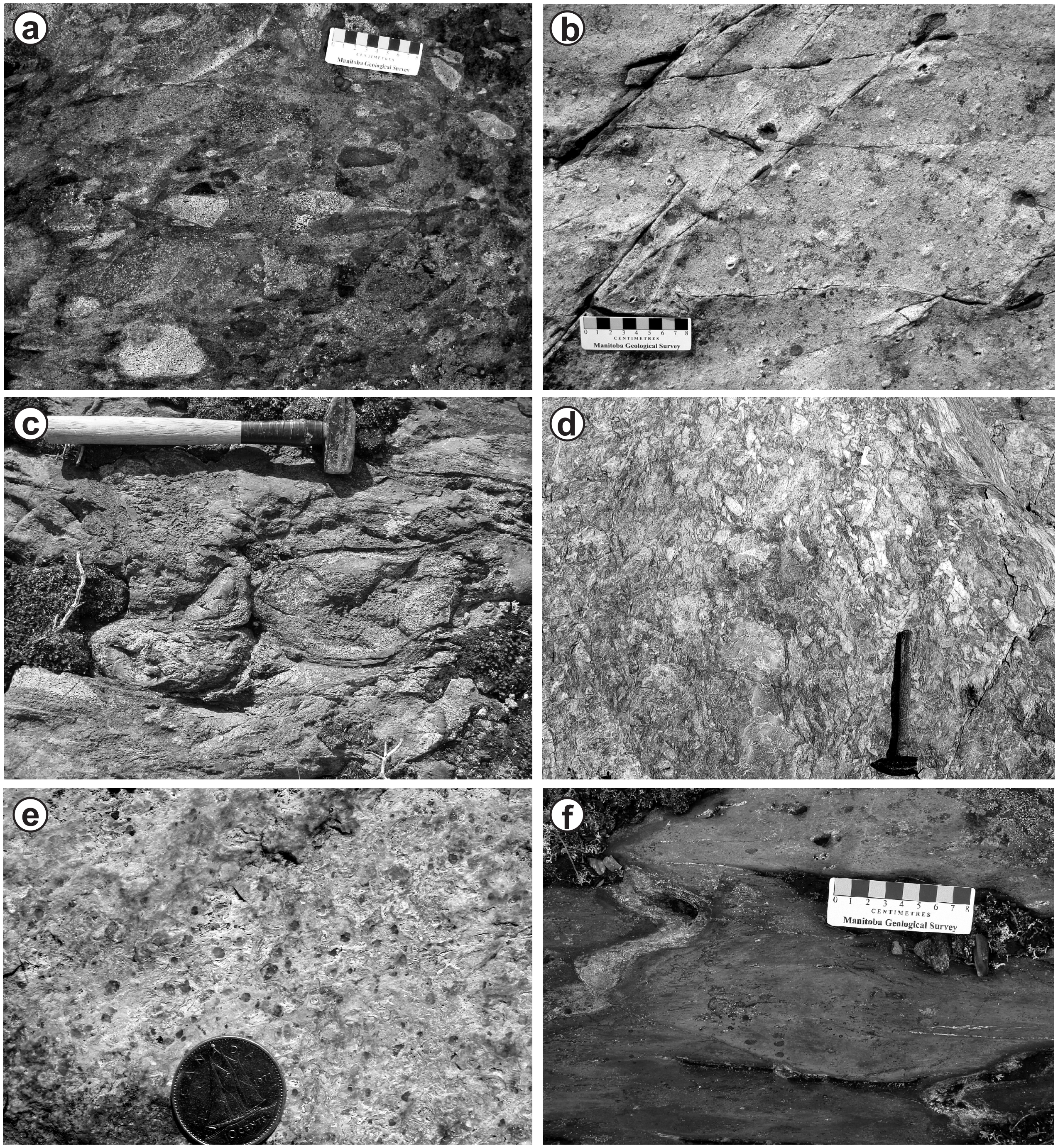

Figure GS-13-3: *Outcrop photographs of metavolcanic rocks in the Great Island Domain:* ***a)*** *heterolithic volcanic conglomerate (UTM Zone 14, 653606E, 6554261N, NAD 83,);* ***b)*** *feldspar-phyric, amygdaloidal andesite (UTM 651698E, 6551981N);* ***c)*** *pillowed aphyric andesite (UTM 668744E/6544014N);* ***d)*** *brecciated aphyric rhyolite (UTM 662727E, 6538910N);* ***e)*** *quartz-feldspar phyric rhyolite (UTM 666814E, 6525052N);* ***f)*** *pillowed aphyric andesite (UTM 722880E, 6547895N).*

been reported to host several high-grade gold occurrences, which are associated with disseminated arsenopyrite and quartz veins near the southern margin of the andesite flows (Assessment File 93289), although the authors did not observe this in the examined location. Farther to the west, these rocks give way to rocks of more felsic composition consisting of massive to fragmental dacite. The dacite weathers light grey to green and ranges from aphanitic to sparsely feldspar-phyric. The fragmental rocks are monolithic, poorly sorted and matrix supported, and contain angular to subround clasts of grey aphyric dacite in a chloritic tuff matrix.

Three outcrops examined on the eastern margin of the Great Island basin were found to consist of pillowed andesite, aphyric rhyolite breccia and felsic tuff, and quartz-phyric flow-banded rhyolite. The pillowed andesite forms a prominent outcrop ridge that extends toward the southwest from Sosnowski Lake for a distance of more than 4 km. In the examined location, the section ranges up to 300 m thick and is remarkably homogeneous. The andesite is dark green and aphyric, with up to 20% round calcite and epidote amygdules that range up to 5 mm across. The andesite forms moderately flattened bun-shaped pillows up to 1.5 m in maximum dimension, which exhibit 1–3 cm thick chloritized selvages (Figure GS-13-3c). Most outcrops contain 5% interpillow hyaloclastite. Rare dikes of texturally similar andesite in this location range up to 2 m thick. Pillow tops in two locations indicate that the flows young toward the northwest.

Farther to the south (down-section?), felsic volcaniclastic rocks are exposed in a large isolated outcrop just east of the eastern margin of the Great Island basin and north of the Seal River. This outcrop exposes a 300 m thick section of alternating breccia and tuff. The breccia is clast supported, unsorted and monolithic, and is composed of very angular to subangular clasts of highly siliceous, white to pale green, aphyric rhyolite that range up to 50 cm across (Figure GS-13-3d). Moderate to strong and pervasive sericite-fuchsite alteration in the matrix and patchy gossan provide evidence of hydrothermal circulation. Breccia ranges up to 160 m thick in the central portion of the outcrop and is bounded on both sides by massive, light grey to green, felsic tuff that contains up to 5% quartz and feldspar phenocrysts. The contacts trend west-northwest at a high angle to bedding in the adjacent sedimentary rocks of the Great Island basin, perhaps indicating the presence of a pronounced angular unconformity in this location. Rhyolite was also examined in a large outcrop south of the Seal River. Here, the rhyolite is massive and pinkish grey to green, and contains evenly distributed blue quartz (1–5%; up to 4 mm) and pink-white feldspar (1–2%; up to 2 mm) phenocrysts in an aphanitic siliceous matrix (Figure GS-13-3e). Local preservation of fine-scale compositional banding, interpreted to represent flow-banding, indicates an extrusive origin. A sample of quartz-feldspar-phyric, flow-banded rhyolite was collected for U-Pb zircon geochronological analysis.

The northeast-trending belt of metavolcanic rocks mapped by Schledewitz (1986) along the lower Seal River, 20–30 km west of Hudson Bay, was examined in three locations, each of which was found to consist of pillowed andesite flows. The andesite is dark green, aphyric and nonamygdaloidal and forms strongly flattened, bun-shaped to amoeboid pillows (Figure GS-13-3f). Interpillow hyaloclastite is locally well preserved and accounts for not more than 5% of individual flows. Most outcrops contain patchy, weak epidotization, with trace to 2% disseminated pyrrhotite (±chalcopyrite). Flattened pillows define a moderate to strong planar fabric that trends north-northeast. Included in the examined outcrops was a large outcrop field near the southern extent of the metavolcanic belt, which was mapped by Schledewitz (1986, unit 7d) as “rhyolite to rhyodacite”. Although clearly pillowed throughout, some of these outcrops exhibit moderate to strong patchy silicification that locally imparts a light grey colour to weathered surfaces, which may have been taken to indicate rocks of felsic primary composition. Core from the 1988 drilling program of Homestake Mineral Development Co. on the Polar Gold project was also examined. The drillcore was found to consist mainly of fine- to medium-grained gabbro and pillowed andesite, with minor intervals of oxide- and silicate-facies iron formation. Grab samples of pillowed andesite and massive gabbro were collected for lithogeochemical analysis.

A distinctive unit of felsic volcaniclastic rocks was examined in a large clean outcrop on the southern bank of the Seal River, 30 km east of the eastern end of Great Island, within an area identified by Schledewitz (1986) as including intermediate tuff and lapilli tuff. The examined outcrop consists of heterolithic lapilli tuff, crosscut by diabase dikes. The lapilli tuff weathers dark grey to brown and is matrix-supported, unsorted and apparently unstratified. Aphanitic, siliceous, black-grey lapilli predominate and, although strongly flattened, appear to have been very angular to subangular. Some of these clasts have ragged, wispy terminations that are suggestive of collapsed pumice or scoria (Figure GS-13-4a). The clasts account for less than 10% of the rock and are supported in an aphanitic to fine-grained, siliceous tuff matrix that contains 1–2% quartz (<2 mm) and feldspar (<4 mm) phenocrysts. Other clast types, which range up to 20 cm across and are typically equant and angular to subangular, include medium-grained granodiorite and very coarse-grained leucogabbro. Some of these clasts are mantled by aphanitic, black-grey, siliceous material that appears similar to the dominant lapilli type, and are thus interpreted to represent accidental fragments within a primary pyroclastic deposit. Similar rocks are also present 8.5 km farther to the east as inclusions in a complex intrusion

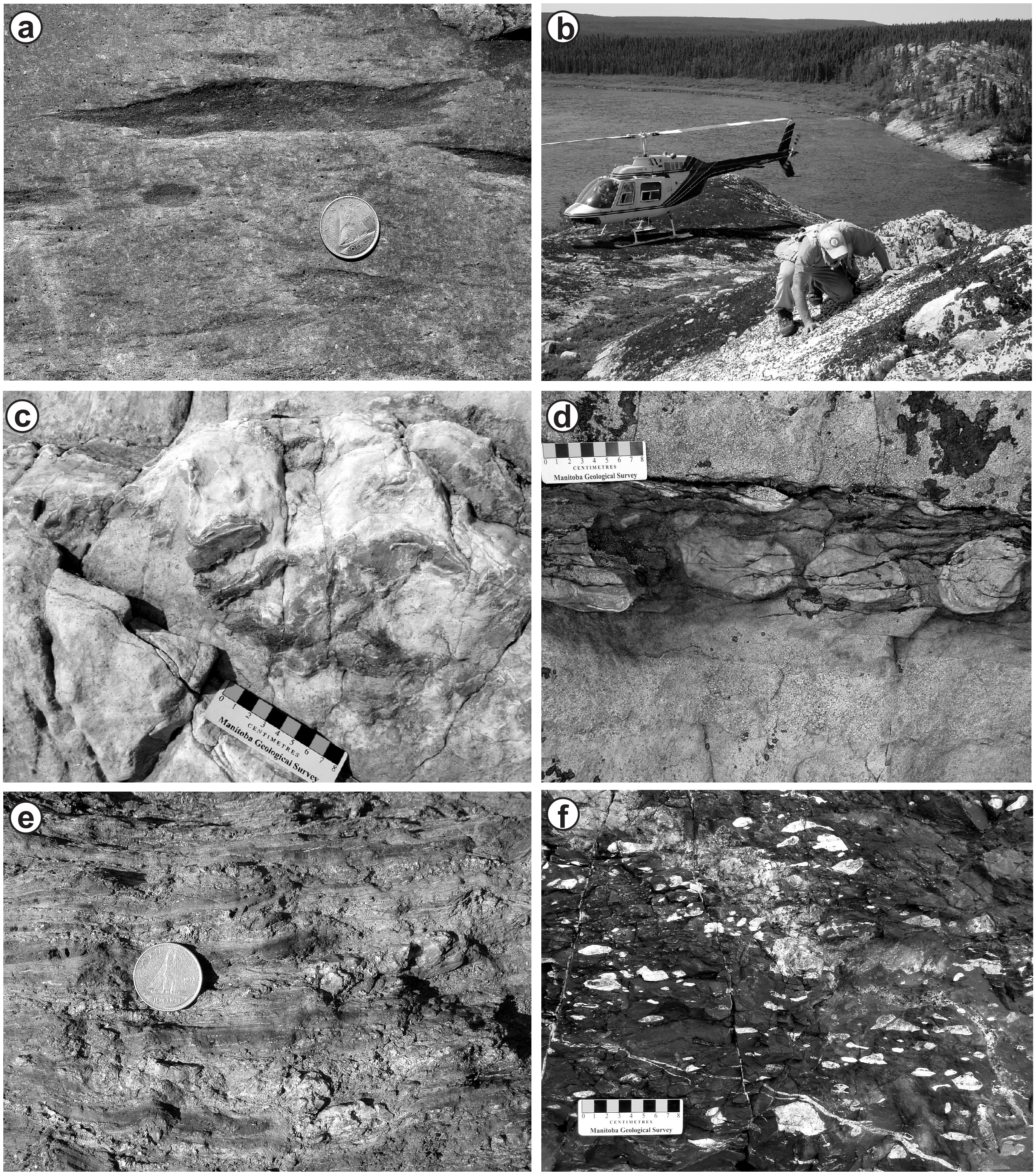

***Figure GS-13-4:** Outcrop photographs of metavolcanic and metasedimentary rocks in the Great Island Domain: **a)** heterolithic lapilli tuff (UTM, Zone 14, 679531E, 6524546N, NAD 83); **b)** prominent quartzite ridge on the northern channel of the Seal River (UTM 638695E, 6533416N); **c)** dolomitic marble with disrupted siliceous argillite layers (UTM 650549E, 6534775N); **d)** ball structures in greywacke-mudstone turbidite (UTM 653786E, 6542568N); **e)** dark grey to black argillite with coarse disseminated pyrite and transposed quartz-pyrite veinlets (UTM 692490E, 6495124N); **f)** amygdaloidal basalt flow (UTM 701750E,6494486N).*

breccia along the southern margin of a large granodioritic pluton that separates the Great Island and Grand Bend basins. It is uncertain how, or even if, these rocks are related to the metavolcanic rocks farther to the west and east along the Seal River.

Metasedimentary rocks

Metasedimentary rocks were examined in the Great Island, Grand Bend and Nowell Lake basins, as well as along the lower North Knife River. Of these, the Great Island basin is the largest and best preserved locality, and thus appears to offer the most complete stratigraphic section. Similarities in rock types and regional geophysical expression suggest that the Grand Bend and Nowell Lake basins preserve only the lower most section of the sedimentary succession present in the Great Island basin. As described by Schledewitz (1986), the basal section of this sedimentary succession consists of interlayered quartzite and phyllite. However, due to differential weathering and erosion, quartzite outcrops typically dominate in any given location in the study area (Figure GS-13-4b). This rock type was examined at two localities at the western end of the Great Island basin, as well as at two localities in each of the Nowell Lake and Grand Bend basins. The quartzite weathers buff to white to pale green-grey and is typically fine to medium grained and well bedded. Individual beds generally range up to 50 cm thick and are separated by thin seams of darker grey or green phyllite. Most outcrops include both planar and crossbedded intervals. Tabular-planar and trough crosssets are defined by pebble lags or heavy-mineral seams, with co-sets separated by scoured mudstone interbeds up to several centimetres thick. Beds of massive medium- to coarse-grained quartzite range up to several metres thick in the western part of the Great Island basin. The intervening phyllite was examined near the centre of the Grand Bend basin and, in this location, appears to be derived from thin-bedded greywacke-mudstone turbidite.

The upper section of the sedimentary succession was examined in the core of the Great Island basin and, from base to top, consists of dolomitic marble, ferruginous argillite and iron formation, and greywacke-mudstone turbidite (e.g., Schledewitz, 1986). The dolomitic marble weathers pink to white and contains disrupted layers of siliceous argillite up to 1 cm thick (Figure GS-13-4c). The overlying ferruginous argillite includes bright red (hematitic) and dark grey (pyritic) varieties. Sharp contacts between these rock types appear to record abrupt changes in redox conditions during, or subsequent to, deposition. The iron formation was described by Schledewitz (1986) and is apparent in the regional aeromagnetic data, but was not observed by the authors in the examined locality. The greywacke-mudstone turbidite was examined southeast of Wolochatiuk Lake, on the eastern flank of the Great Island basin. Greywacke predominates at the base of this unit and is typically buff to light grey and medium grained and forms massive to normally graded beds up to 1.5 m thick. Some beds contain abundant mudstone rip-up clasts. The mudstone is dark grey and forms thin-bedded to laminated layers up to 15 cm thick, which locally display slump folds and ball structures (dislocated slump folds or load structures; Figure GS-13-4d). Farther up section, the greywacke beds are thinner and subordinate to mudstone. The overall stratigraphy of the Great Island basin suggests deposition in a prograding marine-fan setting.

Similar rocks, albeit strongly transposed, are exposed along the deeply incised valley of the North Knife River. Thin- to thick- bedded quartzite and phyllite appear to predominate in the east, in the area where the course of the river changes from east to north, whereas thin-bedded red, grey and black argillites predominate in the west. The variously coloured argillites typically exhibit evidence of intense transposition in the form of abundant rootless and isoclinal folds and are interleaved on the scale of several metres or tens of metres. The black argillite is locally highly sulphidic, with up to 25% pyrite (Figure GS-13-4e). In one location, these rocks contain a distinctive unit of amygdaloidal basalt, which was described as “black meta-argillite, with quartz pebbles” by Schledewitz (1986). This rock weathers dark grey to black, is dark green-black on fresh surfaces and has a very fine grained diabasic texture. Quartz amygdules account for up to 20% of the rock and vary from round to tubular to highly irregular (Figure GS-13-4f). Variations in the size and abundance of the amygdules, and the presence of discontinuous layers of brecciated basalt up to 1.5 m thick, point toward a series of 1–5 m thick lava flows, rather than a high-level intrusion. Hence, basin infilling must have been accompanied, at least locally, by mafic magmatism and associated high heat-flows, which thus indicates potential for exhalative or magmatic mineral deposits.

Economic considerations

Previous exploration in the Great Island Domain has demonstrated the potential for several types of mineral deposits, including iron formation Au, quartz-carbonate vein Au, disseminated replacement Au and volcanic-hosted Cu-Pb-Zn sulphides. In addition, the diverse geology and apparently protracted tectonic evolution of the Great Island Domain indicate that conceptual potential exists for several additional types of mineral deposit, including magmatic Ni-Cu-PGE sulphides, sediment-hosted Zn-Pb-Ag sulphides (SEDEX), high-grade unconformity U, low-grade granitoid U, paleoplacer U-Au, metasomatic U-Au-REE, kimberlite-hosted diamonds, carbonatite Nb-P-REE and iron-oxide Cu-Au (IOCG). One of the principal goals of the Far North Mapping Initiative is to bridge the gap between conceptual and demonstrated exploration potential in Manitoba’s far north, by acquiring state-of-the-art geoscientific data that will facilitate well-constrained predictive models for ongoing and future exploration activity.

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