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ERRATA NOTICE

In the “Intrusive rocks (units Sp6 and Sp7)” section found on page 17 of GS-1 from the *Report of Activities 2010*, the sentence of:

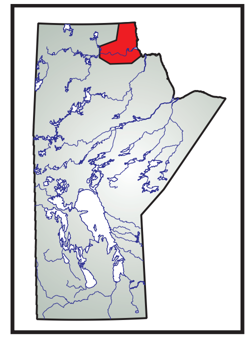
> Peralkaline two-mica granitic rocks are the predominant felsic intrusive rocks in higher-grade (mid- to upper amphibolite) domains in the western portion of the map area where they are found to intrude sedimentary cover rocks of sequences 1, 2 and 3.

was corrected to read as:

> Peraluminous two-mica granitic rocks are the predominant felsic intrusive rocks in higher-grade (mid- to upper amphibolite) domains in the western portion of the map area where they are found to intrude sedimentary cover rocks of sequences 1, 2 and 3.

GS-1 Far North Geomapping Initiative: bedrock geological investigations in the Seal River region, northeastern Manitoba (parts of NTS 54L, M, 64I, P)

by S.D. Anderson, C.O. Böhm and E.C. Syme



Anderson, S.D., Böhm, C.O. and Syme, E.C. 2010: Far North Geomapping Initiative: bedrock geological investigations in the Seal River region, northeastern Manitoba (parts of NTS 54L, M, 64I, P); *in* Report of Activities 2010, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 6–22.

Summary

Bedrock mapping in the Seal River region, supported by sensitive high-resolution ion microprobe (SHRIMP) and isotope dilution–thermal ionization mass spectrometry (ID-TIMS) U-Pb geochronology (Rayner, GS-2, this volume), has fundamentally advanced our understanding of the complex nature, protracted evolution and diverse mineral potential of the southeastern Hearne craton margin, one of the last remaining frontier areas in Manitoba. Of particular importance for regional tectonic correlations as well as mineral exploration is a new chronology of four sedimentary sequences, including U-Au-LREE–mineralized conglomerate now recognized as a Neoarchean molasse sequence that unconformably overlies a Neoarchean greenstone belt with known Au occurrences. The revised stratigraphy and map provide a solid framework for mineral exploration and are key in resolving fundamental questions pertaining to the Precambrian geology and mineral potential of Manitoba's underexplored far northeast.

Introduction

This report summarizes the results of fieldwork completed in 2010 during the second summer of bedrock mapping under the auspices of the Far North Geomapping Initiative — a three-year study of the Hearne craton margin in Manitoba being undertaken by the Manitoba Geological Survey (MGS) in conjunction with the Geological Survey of Canada (GSC) Geo-mapping for Energy and Minerals (GEM) program. The main objective of the Far North Geomapping Initiative is to further the understanding of the nature, evolution and mineral potential of the Hearne craton margin, one of the principal geological building blocks of Manitoba's Precambrian shield. The 2010 map area (Figure GS-1-1) extends south from near the Nunavut boundary to the North Knife River and west from the Hudson Bay coastline to the eastern boundary of Caribou Provincial Park, and thus represents a substantial addition to the map of the Great Island area released in 2009 (Anderson et al., 2009a, b). By extending the new mapping significantly outward into the relatively underexplored and inadequately studied areas northeast and south of Great Island, we were able to gain a much improved understanding of the regional geological context of the principal map units and have acquired a substantial new geoscience dataset to inform land-use planning decisions and guide mineral exploration. New bedrock mapping in far northeastern Manitoba now covers an area of approximately 16 000 km^2.

The MGS launched the Far North Geomapping Initiative in 2008 with reconnaissance mapping and bedrock sampling of the lower Seal and North Knife rivers (Anderson and Böhm, 2008), which was followed up in the fall of 2008 by a GSC-funded aeromagnetic and gamma-ray spectrometric geophysical survey of the Great Island–Seal River area (Fortin et al., 2009). In 2009, supported by the new geophysical data and preliminary geochronology results, the MGS undertook the first summer of detailed bedrock mapping in the Great Island–Seal River area (Anderson et al., 2009a, b). As in 2009, fieldwork in 2010 was helicopter supported and based out of the Sosnowski Lake camp, located 114 km west-northwest of Churchill. Although the 2010 map area was found to contain less than 2% bedrock exposure, with large areas devoid of outcrop, significant upgrades of the existing geological map (Schledewitz, 1986) have been achieved by integrating government and industry aeromagnetic survey data with the results of the bedrock mapping program and ongoing lithogeochemical and geochronological studies. New results from concurrent U-Pb zircon geochronology (Rayner, GS-2, this volume) and surficial geology studies (Trommelen et al., GS-3, this volume) are described elsewhere in this volume.

Regional setting

The southeastern margin of the Hearne craton comprises a heterogeneous basement of Archean orthogneiss, granitoid intrusions and rare supracrustal rocks overlain by scattered erosional remnants of latest Archean and Paleoproterozoic siliciclastic cover sequences, all of which have been variably overprinted by tectonothermal and magmatic activity associated with the Paleoproterozoic Trans-Hudson orogeny. In Manitoba, the southeastern margin of the Hearne craton is divided into the Mudjatik, Wollaston, Seal River, Great Island and Nejanilini domains, which are distinguished by their proportions of cover and possible basement rocks and, to a lesser extent, by their structural trends and metamorphic grade (Schledewitz, 1986). As defined by Schledewitz (1986), the area investigated in 2010 includes the eastern portion of the Nejanilini Domain and parts of the Seal

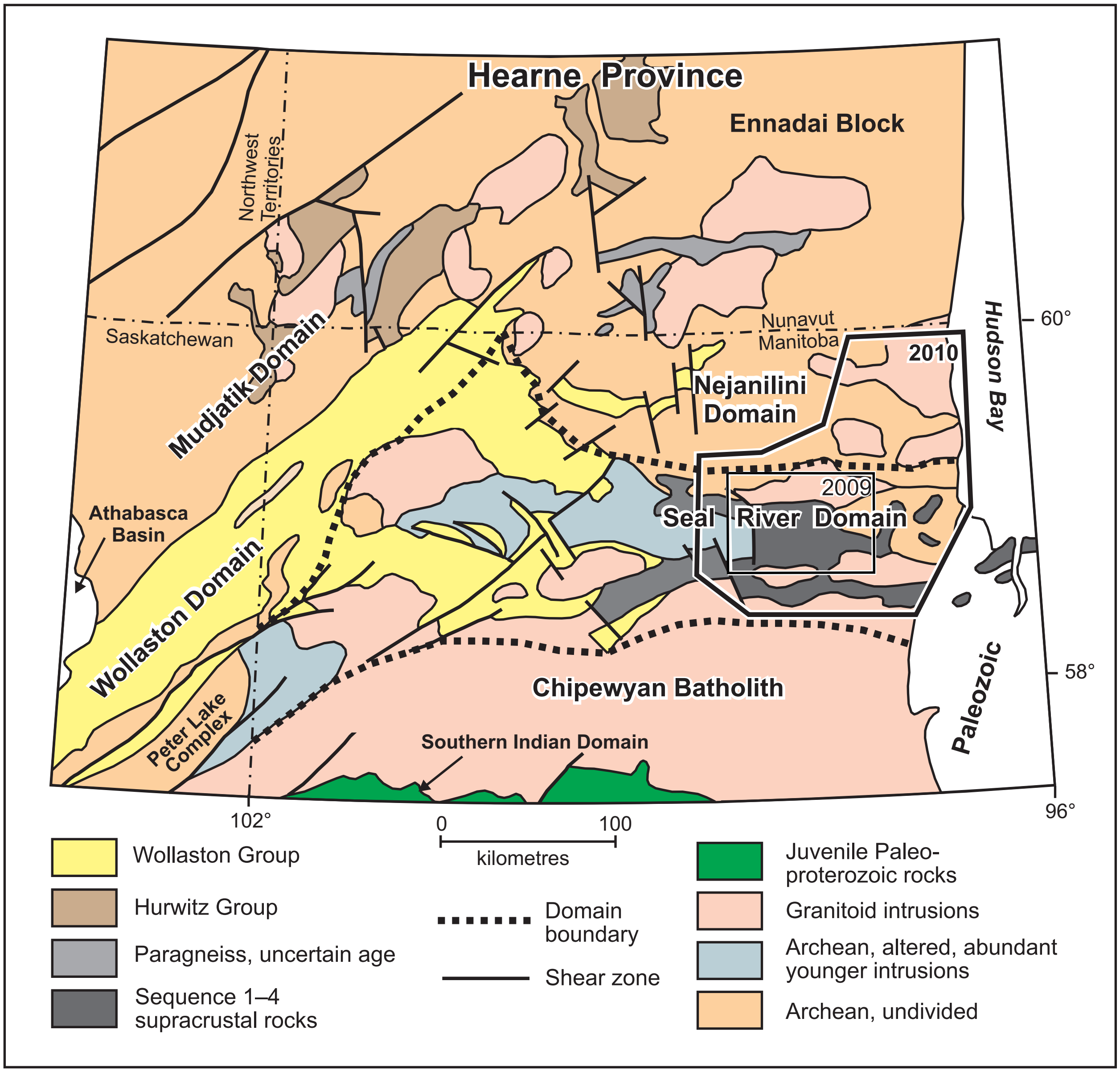


Figure GS-1-1: *Lithotectonic elements and simplified geology of the Hearne craton margin in northern Manitoba and adjacent areas, showing the boundaries of the 2009 and 2010 study areas.*

River and Great Island domains. The Nejanilini Domain is dominated by metaplutonic rocks with minor enclaves of high-grade metasedimentary rocks, and is interpreted to include vestiges of the Archean basement of the Hearne craton (Böhm et al., 2004; Anderson and Böhm, 2005). The Seal River and Great Island domains, which are herein collectively referred to as the Seal River Domain (Figure GS-1-1), are characterized by a dome-and-basin structural geometry, with the 'domes' defined by metaplutonic and metavolcanic rocks of known or inferred Archean age, and the 'basins' defined by synforms of latest Archean and Paleoproterozoic continental and marine siliciclastic rocks. To the south, the Seal River Domain is separated from accreted juvenile Paleoproterozoic terranes in the internides of the Trans-Hudson Orogen by the Wathaman–Chipewyan plutonic complex—a remnant of a vast continental magmatic arc that was emplaced between 1.87 and 1.85 Ga (Meyer et al., 1992). In the southeast corner of the map area, the Precambrian rocks are unconformably overlain by flat-lying Ordovician sandstone, limestone and dolomite at the west margin of the Hudson Bay basin.

Description of units

The principal rock units of the Seal River and Nejanilini domains within the 2009–2010 study area are briefly described below, in general order of decreasing known or inferred age of the constituent rocks, with emphasis on new results from the 2010 mapping and ongoing analytical work. Details on the geochronology of a selection of dated rocks (see Table GS-1-1) are discussed separately by Rayner (GS-2, this volume). Unit numbers in this report correspond to those on Preliminary Map PMAP2010-1 (Anderson et al., 2010). Figure GS-1-2 is a simplified version of this map.

Seal River Domain

The Seal River Domain defines the southeastern margin of the Archean Hearne craton in Manitoba and comprises a geologically diverse and complex assembly of rocks that records nearly two billion years of early Earth history (Table GS-1-1; Rayner, GS-2, this volume). The Seal River Domain contains the only known occurrences of volcanic rocks in Manitoba's far north and is characterized by the widespread preservation of siliciclastic cover sequences as relatively intact synforms that unconformably overlie older orthogneiss and volcano-plutonic terranes. Based on the results of the 2010 field program and ongoing U-Pb geochronology, the siliciclastic cover rocks, which were previously referred to as the 'Great Island Group' (Schledewitz, 1986; Anderson et al., 2009a, b), have been subdivided into four distinct sequences (Table GS-1-1). These sequences provide a discontinuous record, spanning at least 700 m.y. of intracratonic sedimentation and basin evolution at the southern margin of the Hearne craton.

Seal River Complex (units Sa1–Sa7)

The Seal River Complex (SRC) is best exposed in extensive shoreline outcrops along the Seal River east of Great Island, which were described in detail by Anderson et al. (2009a). Based on crosscutting relationships, the oldest rock identified in the field is a multicomponent orthogneiss (unit Sa1) that includes layers and sheets of granodiorite, as well as enclaves of amphibolite and metagabbro. A sample of a granodiorite sheet collected in 2009 yielded a U-Pb zircon age of 2901 ±5 Ma (Rayner, GS-2, this volume, sample 96-09-1177), which is interpreted as the crystallization age and thus confirms the presence of Mesoarchean crust at the southern margin of the Hearne craton. The orthogneiss is crosscut by irregular dikes and thick sheets of texturally heterogeneous, light pink biotite±hornblende granite and granodiorite (unit Sa2), which are in turn crosscut by dikes of light grey biotite granodiorite (unit Sa3; Figure GS-1-3a) that yielded a crystallization age of 2860 ±4 Ma, with ca. 3.46 Ga zircon inheritance (Rayner, GS-2, this volume, sample 96-08-43-1). These 'older' components of the complex (units Sa1–Sa3) are crosscut by swarms of northwest-trending hornblende diorite (unit Sa4), feldspar porphyry (unit Sa5) and diabase (unit Sa7) dikes. Thick chilled margins on these dikes indicate relatively high-level emplacement. Brecciated to massive flow-banded rhyolite (unit Sa6) overlaps the intrusive complex to the west (Figure GS-1-2) and was previously included in the Sosnowski Lake assemblage (Anderson et al., 2009a). However, lithogeochemical data from samples collected in 2009 indicate that this rhyolite is similar to the high-level feldspar porphyry dikes (unit Sa5) in the underlying intrusive complex. In addition, a U-Pb zircon age of 2570 ±3 Ma for this rhyolite (Rayner, GS-2, this volume, sample 96-08-40) indicates that it is at least 100 m. y. younger than the probable age of felsic volcanism (ca. 2.68–2.70 Ga) in the adjacent portion of the Sosnowski Lake assemblage (see below). For these reasons, the rhyolite of unit Sa6 is interpreted as an extrusive equivalent to unit Sa5 and is thus included in the SRC (Figure GS-1-2, Table GS-1-1).

Uranium-lead ages from key rock types in the SRC indicate a magmatic history that extends back 3.5 Ga (Rayner, GS-2, this volume). On the basis of these data and the distinctive geological attributes and aeromagnetic signatures, the SRC is interpreted to represent a discrete remnant of ancient crust within the southern margin of the Hearne craton. The older (>2.86 Ga) components of the remnant must have been exhumed from the middle crust prior to emplacement of high-level dike swarms and 2.57 Ga rhyolite flows, perhaps as a consequence of tectonic uplift and accretionary orogenesis at the craton margin. Unconformably overlying low-grade Paleoproterozoic siliciclastic rocks at both the east and west ends of the SRC indicate that it has remained in the upper crust since Neoarchean time.

Sosnowski Lake assemblage (units Sa8–Sa14)

The Sosnowski Lake assemblage, as defined by Anderson et al. (2009a), consists mostly of subaqueous mafic to intermediate lava flows and related intrusions (units Sa8–Sa11), with minor intermediate to felsic volcanic rocks (unit Sa12) and thick successions of volcaniclastic and epiclastic rocks (unit Sa13; Table GS-1-1). The principal components of the assemblage were described in detail by Anderson et al. (2009a) based on mapping in the Great Island area. A thick (>50 m) unit of coarse felsic volcanic sandstone in a section of pillowed and massive basalt flows at the type locality of the assemblage southwest of Sosnowski Lake contains mostly Neoarchean (ca. 2.7 Ga) detrital zircons (Rayner, GS-2, this volume, sample 97-09-280), which is taken to indicate the most likely age of the assemblage as a whole. Subsidiary modes at ca. 2.8, 3.2 and 3.4 Ga suggest at least some of the detritus was derived from extrabasinal sources. Mapping in 2010 was focused on documenting the nature and extents of the assemblage south of Great Island (i.e., the southern extents of the Garlinski Lake greenstone belt; Anderson et al., 2009a) and of a possible correlative volcanic belt exposed ~20 km upstream from the mouth of the Seal River (herein referred to as the Howard Lake greenstone belt).

Table GS-1-1: Principal geological map units, their ages and contact relations in the Seal River region. Abbreviations: bt, biotite; fl, fluorite; fp, feldspar; gt, garnet; hb, hornblende; K-fp, potassium feldspar; ms, muscovite; qz, quartz; ydz, youngest detrital zircon.

POST-TECTONIC DIKES (ca. 1.27 Ga Mackenzie dike swarm)		
Mp1	Gabbro; massive; northwest-trending dikes	intrusive contact
SEAL RIVER DOMAIN		
Sequence 4 (<1.88 Ga)		
Sp13	Quartz arenite with subordinate mudstone	
Sp12	Greywacke-mudstone turbidites; feldspathic	
Sp11	Iron formation; oxide facies	
Sp10	Greywacke-mudstone turbidites; quartzose; 96-08-32, ydz 1.88 Ga	
Sp9	Iron formation; oxide facies	
Sp8	Dolomitic marble and calcsilicate rocks	unconformity
Intrusive rocks		
Sp7	Pegmatite; bt-ms±gt	
Sp6	Bt-ms granite (±gt, fl)	intrusive contact
Sequence 3 (<1.98 Ga)		
Sp5	Mudstone with subordinate arenite interbeds	
Sp4	Dolomitic marble	
Sp3	Quartz arenite with subordinate mudstone interbeds; 96-08-29, ydz 1.98 Ga	
Sp2	Thinly interbedded arenite and mudstone; 96-08-15, ydz 2.05 Ga	
Sp1	Iron formation; silicate facies	unconformity
Sequence 2 (<2.5 Ga)		
Sap5	Basalt	
Sap4	Gabbro; possibly includes east to east-northest–trending gabbro dike swarm	
Sap3	Psammitic and semipelitic paragneiss; 97-09-228, unimodal 2.56 Ga	
Sap2	Mudstone with subordinate arenite	
Sap1	Quartz arenite with subordinate conglomerate and mudstone; 96-08-16, ydz 2.5 Ga	unconformity
Intrusive rocks		
Sa23	Granitic pegmatite; bt	
Sa22	Alaskite	
Sa21	Granite, granodiorite, quartz diorite; 97-09-108, 2550 ±4 Ma	
Sa20	Qz ±fp porphyry; 96-08-28, 2562 ±5 Ma	
Sa19	Syenogranite, quartz syenite; typically fine-grained; 97-09-134, 2570 ±5 Ma	intrusive contact
Sequence 1 (<2.7 Ga, >2.57 Ga)		
Sa18	Quartz arenite with minor mustone and conglomerate	
Sa17	Arenite and polymictic conglomerate; 97-09-89, ydz 2.7 Ga	unconformity
Intrusive rocks		
Sa16	Serpentinite, peridotite, gabbro	
Sa15	Bt ± hb granite, granodiorite, tonalite; gneissic; minor ampholite	fault contact?
Sosnowski Lake assemblage (Garlinski Lake and Howard Lake greenstone belts)		
Sa14	Fp-qz porphyry; 97-09-222, 2679 ±6 Ma	
Sa13	Volcaniclastic and epiclastic rocks; 97-09-280, ydz 2.7 Ga; 96-08-38, ydz 2.61 Ga	
Sa12	Dacite and rhyolite; associated intrusives	
Sa11	Leucodiorite	
Sa10	Andesite	
Sa9	Basalt and basaltic andesite; related gabbro; minor iron formation	
Sa8	Gabbro; local amphibolite along belt margins	fault contact?
Seal River complex		
Sa7	Diabase (dikes); foliated; northwest-trending	
Sa6	Qz and fp-phyric rhyolite; 96-08-40, 2570 ±3 Ma	
Sa5	Fp (±hb, qz) porphyry	
Sa4	Hb diorite (dikes)	
Sa3	Bt granodiorite (dikes); 96-08-43-1, 2860 ±4 Ma, 3.46 Ga inheritance	
Sa2	Bt ± hb granite and granodiorite; heterogeneous	
Sa1	Orthogneiss; includes amphibolite or metagabbro enclaves; 96-09-1177, 2901 ±5 Ma	fault contact?
NEJANILINI DOMAIN		
Late-tectonic dikes (ca. 2.45 Ga Kaminak swarm?)		
Np1	Diabase; north-trending dikes; inferred from magnetic data	intrusive contact
Intrusive and supracrustal rocks		
Na6	Bt granite, leucogranite, granitic pegmatite	
Na5	K-fp porphyritic granite; flow foliation	
Na4	K-fp porphyritic granite; recrystallized	
Na3	Mafic granulite	
Na2	Paragneiss	
Na1	Unseparated bt ±hb granite, granodorite; variably gneissic; 96-08-26, 2527 ±2 Ma	

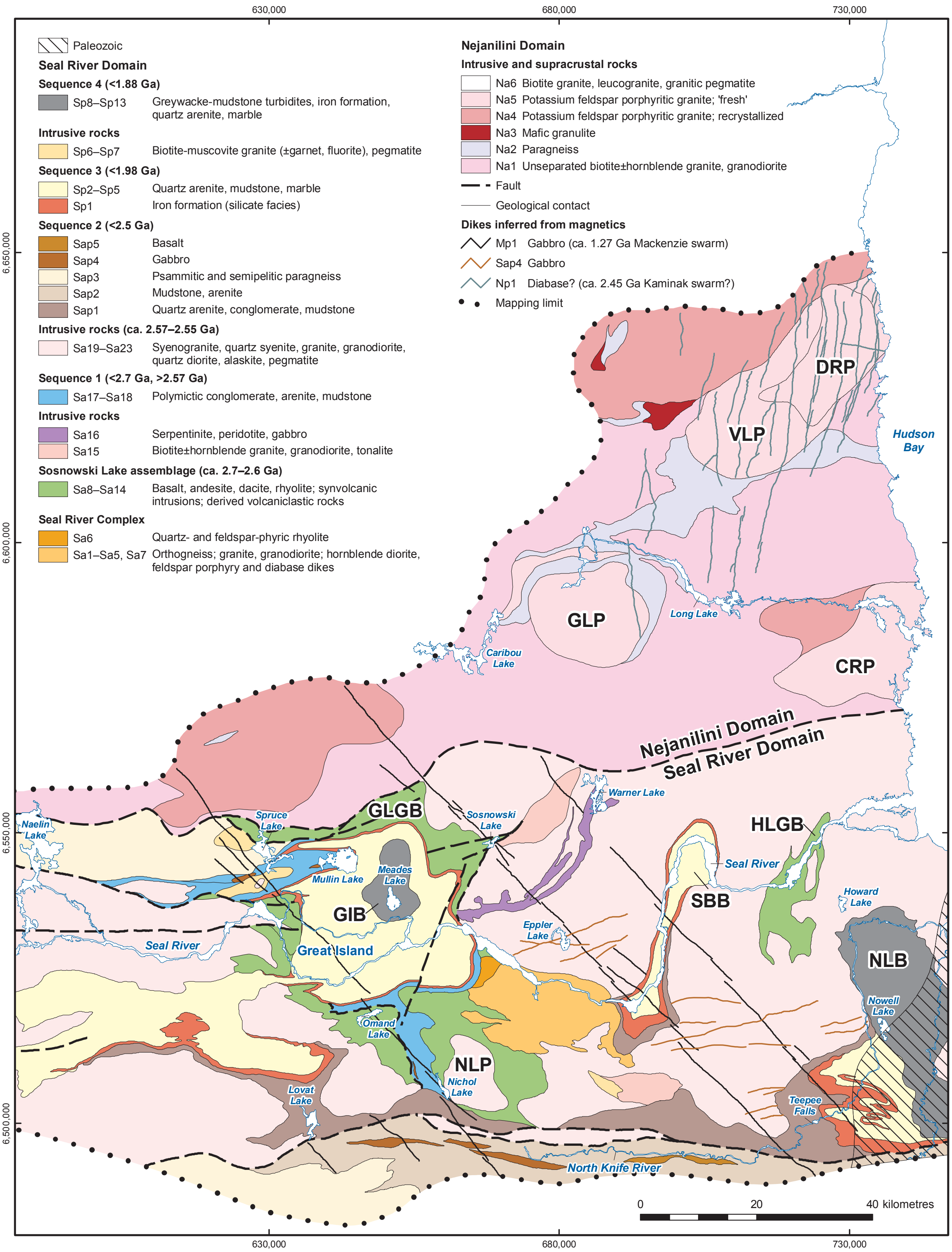


Figure GS-1-2: *Simplified geological map of the Seal River region, showing the locations cited in the text. Abbreviations: CRP, Caribou River pluton; DRP, Dickins River pluton; GIB, Great Island basin; GLGB, Garlinski Lake greenstone belt; GLP, Gross Lake pluton; HLGB, Howard Lake greenstone belt; NLB, Nowell Lake basin; NLP, Nichol Lake pluton; SBB, Seal Bend basin; VLP, Vinsky Lake pluton.*

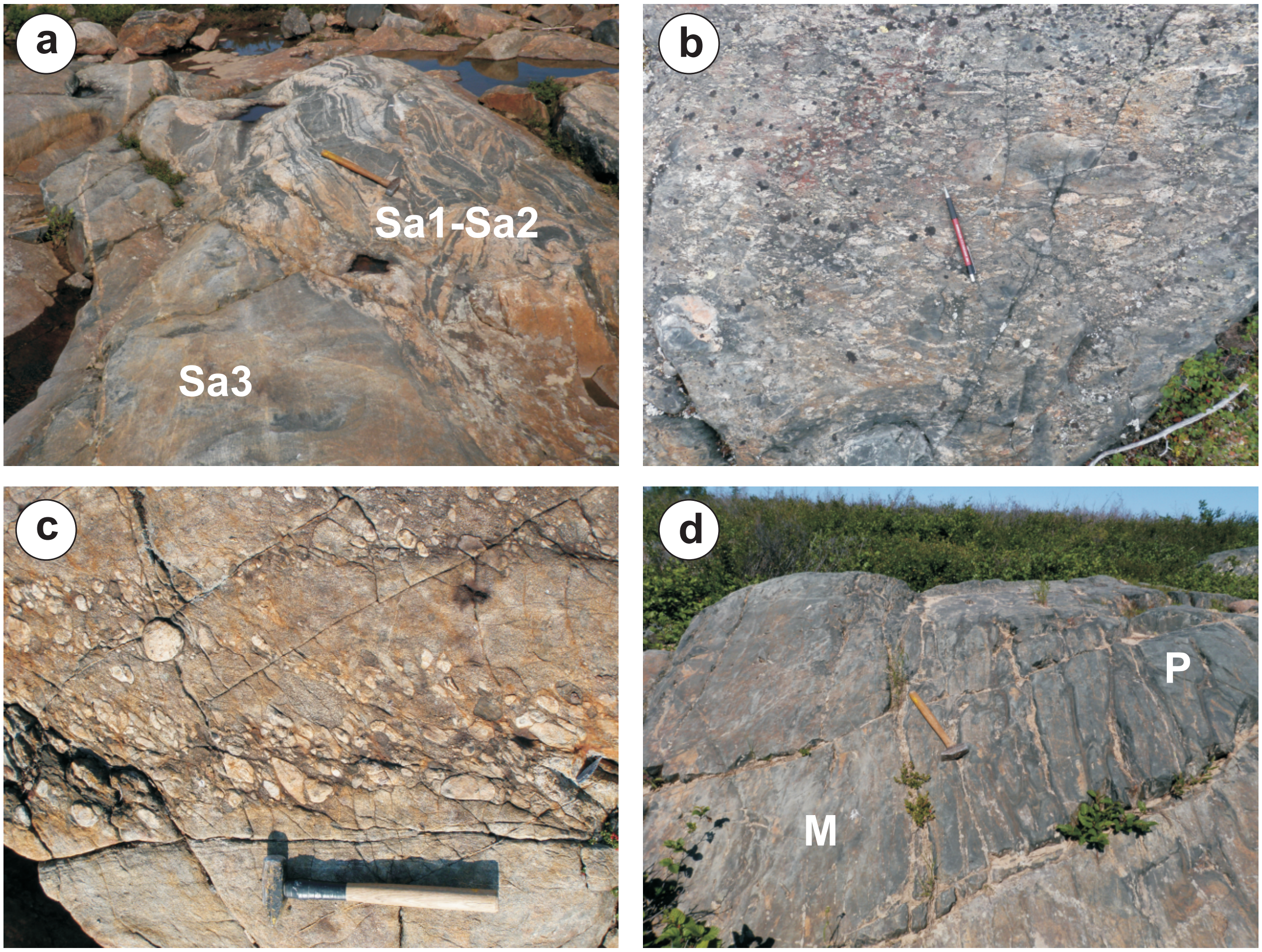


***Figure GS-1-3:** Outcrop photographs of rock types in the Seal River Complex and Sosnowski Lake assemblage: **a)** multi-component orthogneiss (unit Sa1) and heterogeneous granite (unit Sa2) cut by a biotite granodiorite dike (unit Sa3) in the Seal River Complex, east of Great Island; **b)** felsic volcaniclastic rocks (unit Sa13) of the Sosnowski Lake assemblage, southwest of Omand Lake; **c)** polymictic conglomerate and sandstone (unit Sa13) of the Sosnowski Lake assemblage, southeast of Omand Lake; note well-rounded cobbles of 'exotic' quartz arenite; **d)** compound basalt flow (unit Sa9; abbreviations: M, massive; P, pillowed) in the possible outlier of the Sosnowski Lake assemblage, 30 km upstream from the mouth of the Seal River; flows young to the right (east).*

South of Great Island, the Sosnowski Lake assemblage is dominated by coarse volcaniclastic rocks, with minor intercalations of pillowed or massive basalt, quartz-feldspar porphyritic rhyolite, polymictic conglomerate and thin-bedded greywacke-mudstone turbidites. The volcaniclastic rocks (unit Sa13) are heterolithic, matrix-supported, poorly sorted and variably stratified, and contain mostly intermediate to felsic volcanic detritus (Figure GS-1-3b). Included in this unit are several distinctive outcrops of polymictic conglomerate and sandstone southeast of Omand Lake, which are interstratified with intermediate volcaniclastic rocks of apparently local derivation, but contain abundant well-rounded cobbles and boulders of apparently 'exotic' quartzite (Figure GS-1-3c). The detrital zircon population of the sandstone shows distinct peaks at ca. 2.68 and 2.97 Ga (Rayner, GS-2, this volume, sample 96-08-38); the younger peak likely represents locally sourced felsic volcanic detritus (see below), whereas the older peak may be representative of the dominant source of detritus for the sandstone precursor to the exotic quartzite. The youngest detrital zircon in this sample indicates a maximum depositional age of 2613 ±8 Ma (Rayner, GS-2, this volume). A sample of quartz- and feldspar-phyric rhyolite has been submitted for U-Pb geochronological analysis to obtain an absolute age constraint on felsic volcanism in the southern portion of the Sosnowski Lake assemblage.

The basalt flows (unit Sa9) south of Great Island are aphyric and nonamygdaloidal, with minor intercalated flow breccia and iron formation, and appear to increase in abundance toward the east, where they are closely associated with dikes, sills and plutons of fine- to medium-grained gabbro (unit Sa8). Feldspar-quartz porphyry dikes (unit Sa14) are ubiquitous and are possibly related to a small pluton of texturally similar quartz-feldspar porphyry northeast of Omand Lake that yielded a

U-Pb zircon age of 2679 ±6 Ma (Rayner, GS-2, this volume, sample 97-09-222). In conjunction with the maximum depositional age constraint for the polymictic conglomerate southeast of Omand Lake, these data suggest that the Sosnowski Lake assemblage was deposited over a time period of at least 50 m.y. All of these rocks are intruded by 2.57–2.55 Ga granitoid intrusions (units Sa19–Sa21; Rayner, GS-2, this volume), which include the small pluton of biotite granite east of Nichol Lake.

Possible correlatives to the Sosnowski Lake assemblage crop out along the Seal River approximately 20 km upstream from the Hudson Bay coastline (the Howard Lake greenstone belt; Figure GS-1-2). The greenstone belt in this location ranges up to 8 km wide over a strike length of 20 km, and is intruded along the margins by younger granitoid plutons. This succession consists of strongly deformed, pillowed, massive and brecciated basalt flows with minor interflow iron formation (observed only in drillcore) and potentially cogenetic gabbro intrusions, which are locally well layered. The flows are generally aphyric, nonamygdaloidal and composed of strongly flattened, bun-shaped to amoeboid pillows up to 1.5 m in maximum dimension. Some pillows contain up to 5% quartz amygdules (<1.5 cm) concentrated along their upper margins. Interpillow hyaloclastite and carbonate typically account for less than 5% of individual flows. Younging criteria in three locations (compound flows, pillow cusps and vesicular pillow tops) indicate tops to the east (Figure GS-1-3d). Most flows contain patchy to pervasive zones of epidotization and silicification, and are variably sulphidized; some of these rocks are described as rhyolite and rhyodacite on the map of Schledewitz (1986). Preliminary lithogeochemical results indicate that the basalt and gabbro are transitional between typical mid-ocean ridge and arc-like tholeiitic basalt, and are chemically similar to basalt flows southwest of Sosnowski Lake, in the type locality of the assemblage.

Intrusive rocks (units Sa15 and Sa16)

Intrusive rocks of units Sa15 and Sa16 are not observed cutting the siliciclastic cover sequences in the Seal River Domain (and are therefore interpreted to be of Archean age), but show ambiguous age relationships to the Neoarchean volcanic rocks of the Sosnowski Lake assemblage. Unit Sa15 consists of unseparated biotite (±hornblende) granite, granodiorite and tonalite that characteristically exhibit a weak to moderate foliation and variably developed gneissosity (Figure GS-1-4a), and commonly contain inclusions, rafts or screens of amphibolite. These rocks crop out in the east-central portion of the map area and appear to represent an older component within the voluminous granitoid intrusions of unit Sa21. Although large areas of the Seal River Domain may be underlain by these rocks, mappable intrusions are delineated on the basis of distinctive magnetic signatures in only two locations (Figure GS-1-2; Anderson et al., 2010). In these respects, some of these rocks are similar to orthogneiss of the SRC; however, none display the intrusive complexity and distinctive magnetic signature of the type locality of the SRC. Nevertheless, preliminary U-Pb zircon analyses from a sample of gneissic granitoid collected north of the SRC indicates that at least some of these rocks also include Mesoarchean components (N. Rayner, pers. comm., 2010).

Based on limited drillhole and outcrop data, unit Sa16 is interpreted to consist of variably serpentinized peridotite and gabbro. This unit is clearly delineated by a prominent series of arcuate and branching linear aeromagnetic anomalies and is interpreted to represent a sill-like layered intrusion that extends southwest from Warner Lake for a total strike length of 33 km. To the west, this intrusion is abruptly truncated at the faulted eastern contact of the Garlinski Lake greenstone belt. The northeastern termination is somewhat less distinct, perhaps indicating a primary pinch-out of gabbroic (as opposed to peridotitic) composition, or a more diffuse structural truncation within the zone of ductile deformation that marks the north margin of the Seal River Domain. Peridotite of unit Sa16 is thought to represent the most likely source of the strongly enriched Cr (up to several thousand parts per million) in fuchsitic conglomerate (unit Sa17) of sequence 1; hence, the minimum depositional age of sequence 1 (2.57 Ga; see below) is also interpreted to represent the minimum age of unit Sa16.

Sequence 1 (units Sa17 and Sa18)

Sedimentary rocks of sequence 1 are exposed in a 3–5 km wide half-graben that trends in a northerly direction through Nichol Lake to the southern margin of the Great Island basin, where it is folded and appears to be truncated by the unconformity at the base of sequence 3 (Figure GS-1-2). To the south, this graben appears to also be truncated at the base of sequence 2. The graben fill is interpreted to unconformably overlie felsic volcanic and volcaniclastic rocks of the Sosnowski Lake assemblage to the east, whereas the western margin appears to represent a high-angle fault. Possible correlative rocks are also exposed in the area south of Spruce Lake, where they are crosscut by a variety of intrusive rocks that are not observed in the overlying rocks of sequence 3, likewise indicating an unconformable contact relationship. In both of these areas, sequence 1 was previously referred to as the ‘Omand Lake assemblage’ (Anderson et al., 2009a).

Sequence 1 consists of a lower unit of interstratified arenite and polymictic conglomerate (unit Sa17) and an upper unit of quartz arenite, with minor interbeds of conglomerate and mudstone (unit Sa18). Both units are up to several hundreds of metres thick locally. Conglomerate beds in unit Sa17 are typically matrix supported, poorly sorted and massive to normal graded, and are locally up to at least 20 m thick. Well-rounded and highly spherical

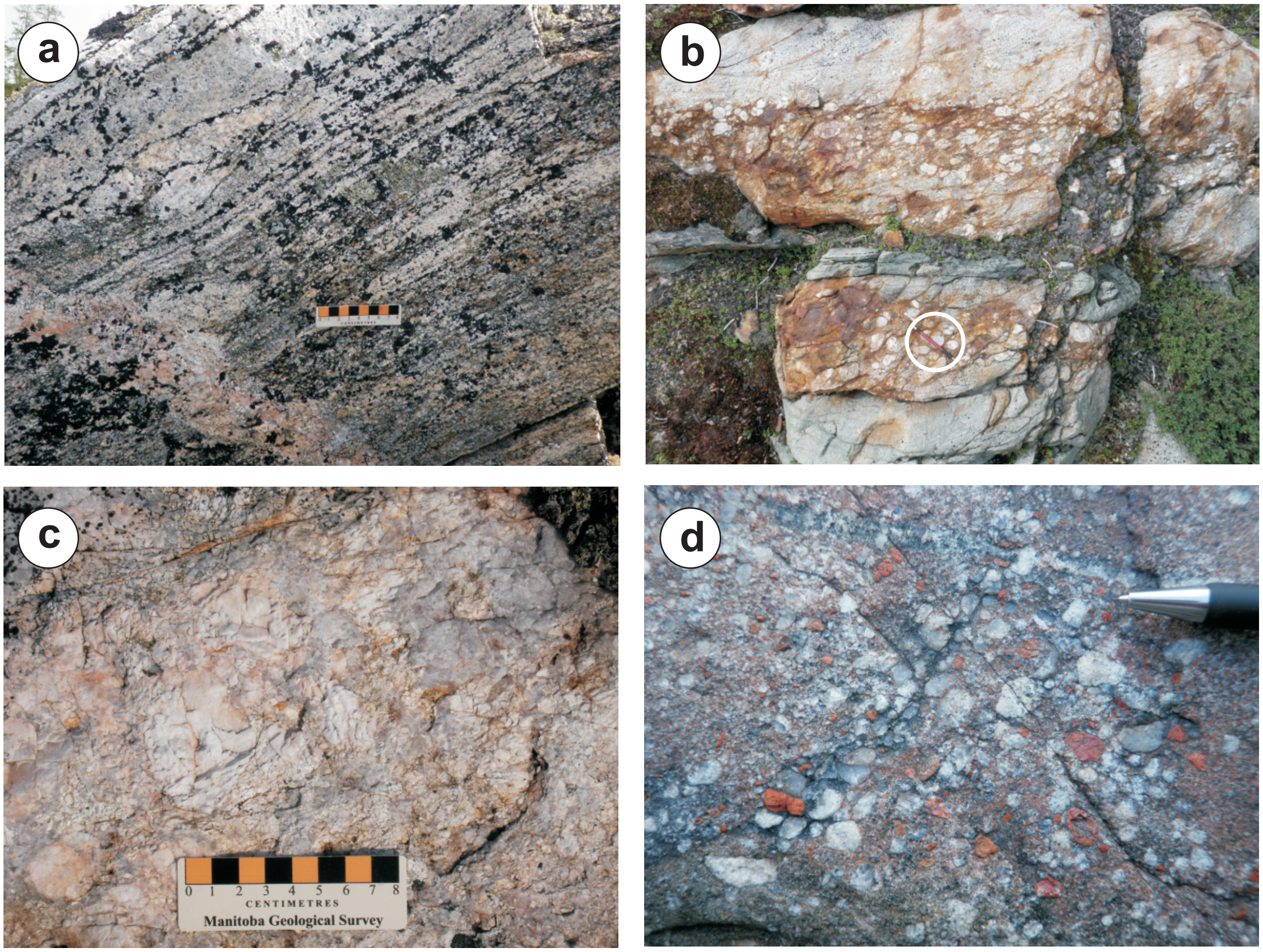


Figure GS-1-4: *Outcrop photographs of key rock types southeast of Great Island between the Seal and North Knife rivers:* ***a)*** *gneissic granitoid (unit Sa15), northeast of Eppler Lake;* ***b)*** *interstratified arenite and gossanous quartz pebble conglomerate (unit Sa17) near the base of sequence 1, east of Omand Lake; pencil for scale (circled);* ***c)*** *coarse-grained to pegmatitic alaskite (unit Sa22), northwest of Nowell Lake;* ***d)*** *quartz, feldspar and lithic pebbles in a thin conglomerate layer in quartz arenite (unit Sap1) near the base of sequence 2, approximately 2 km upstream from Teepee Falls on the North Knife River.*

clasts account for a significant proportion of the clast population, a feature consistent with significant subaerial transport; this material likely represents channel deposits in a braided fluvial-alluvial system. South of Great Island, the dominant clast types are vein quartz and quartzite, with subordinate granitoid rocks, intermediate to felsic volcanic rocks, gabbro and altered mafic or ultramafic rocks of unknown precursor; conglomerate in the Spruce Lake area is less quartz-rich. In both locations, interbeds of medium- to coarse-grained pebbly arenite vary from massive to normal graded to crossbedded, and range up to 2 m thick.

Unit Sa17 south of Great Island contains quartz pebble conglomerate as diffuse lags at the base of crossbed sets and as closely packed lenticular beds up to 75 cm thick that are interstratified with crossbedded arenite (Figure GS-1-4b). This conglomerate is characterized by patchy to pervasive hematite-sericite alteration of the matrix and locally contains anomalous concentrations of Au, U and LREE. The associated arenite also contains patchy hematite-sericite alteration, and characteristically contains fuchsite along bedding surfaces or disseminated throughout beds. Uranium-lead ages of detrital zircons from fuchsitic quartz pebble conglomerate northeast of Omand Lake indicate that it is almost exclusively derived from ancient sources, with two prominent detrital zircon modes at ca. 3.39 and 3.47 Ga, and a significant number of grains older than 3.6 Ga (Rayner, GS-2, this volume, sample 97-09-89). The youngest detrital zircon yielded an age of 2695 ±8 Ma (Rayner, GS-2, this volume), which indicates the maximum age of deposition.

Unit Sa18 consists of relatively 'clean' quartz arenite, with only minor interbeds of pebble conglomerate and mudstone. The quartz arenite beds range up to several metres thick and are massive or crossbedded, with the latter including tabular-planar or trough cross-sets. Most outcrops contain subordinate (<10%) beds of sericitic mudstone less than 5 cm thick. In the areas west of

Mullin Lake and west of Nichol Lake, these rocks contain thick sill-like intrusions of medium-grained, equigranular gabbro, which may be related to gabbro sills and basalt flows in the overlying siliciclastic rocks of sequence 2 (see below).

Coupled with the available age constraints (<2.7 Ga, >2.57 Ga; see below), the above attributes suggest that sequence 1 may be broadly correlative to the Montgomery Group (<2.69 Ga; Rainbird et al., 2002) in the central portion of the Hearne craton. The Montgomery Group is dominated by coarse siliciclastic rocks composed of locally derived Archean detritus and is interpreted to have been deposited in fault-controlled alluvial basins that unconformably overlie Archean basement (e.g., Aspler et al., 2000). These rocks are unconformably overlain by Paleoproterozoic siliciclastic rocks of the lower Hurwitz Group and are thought to represent either a late Neoarchean molasse succession or a Paleoproterozoic precursor to the Hurwitz Group (Aspler et al., 2000; Rainbird et al., 2002). The available age constraints on sequence 1 in the Seal River Domain support the former hypothesis and suggest an analogy to late molasse basins found in many Neoarchean and Paleoproterozoic greenstone belts.

Intrusive rocks (units Sa19–Sa23)

Units Sa19–Sa23 consist of a variety of granitoid intrusive rocks that are known or inferred to intrude supracrustal rocks of the Sosnowski Lake assemblage and sequence 1, but are not observed to cut the unconformably overlying rocks of sequences 2–4.

Syenogranite and quartz syenite of unit Sa19 are best exposed in large clean outcrops along the Seal River upstream from the west end of Great Island, within an area characterized by a strong anisotropy and generally high response on regional aeromagnetic maps. These rocks weather beige or pink and are generally homogeneous, with a fine- to medium-grained equigranular texture defined by variably recrystallized feldspar laths. Most specimens contain 5–10% fine-grained biotite and characteristically contain 2–5% magnetite as finely disseminated grains or (rarely) equant porphyroblasts up to 5 mm in diameter; some specimens also contain sparse (<10%) K-feldspar phenocrysts up to 5 mm. Individual outcrops vary from massive to penetratively foliated, the latter of which also locally contain weak gneissosity. A sample of this rock type from an outcrop on the Seal River yielded a U-Pb zircon crystallization age of 2570 ±5 Ma (Rayner, GS-2, this volume, sample 97-09-134). Rafts and inclusions of arenite derived from sequence 1 are locally observed along the north margin of this pluton, which indicates a minimum depositional age of 2.57 Ga for sequence 1. Toward the east, these rocks intruded mafic volcanic and felsic volcaniclastic rocks of the Sosnowski Lake assemblage.

Quartz porphyry of unit Sa20 is exposed in several large outcrops near the south end of Spruce Lake and, in one location, forms dikes up to at least 200 m thick that discordantly cut interlayered arenite and polymictic conglomerate of sequence 1 (unit Sa17). These dikes are massive, weather light pink and contain up to 10% anhedral to subhedral quartz phenocrysts (1–3 mm) in a very fine grained matrix of feldspar, quartz and biotite (~5%). A sample from a similar, though weakly foliated, quartz porphyry exposed in a large outcrop 2.4 km to the south of the above locality yielded a zircon crystallization age of 2562 ±5 Ma (Rayner, GS-2, this volume, sample 96-08-28) that overlaps, within error, the crystallization age of the syenogranite intrusion to the south (unit Sa19) and thus confirms the ca. 2.57 Ga minimum depositional age for sequence 1.

Granite, granodiorite and lesser quartz diorite plutons of unit Sa21 intrude the Sosnowski Lake assemblage and, at least locally, define the margins of both the Garlinski Lake and Howard Lake greenstone belts. These plutons also appear to be extensive beyond the margins of these belts, where they may include significantly older components (e.g., unit Sa15). These rocks are generally leucocratic and consist of varying proportions of medium- to coarse-grained plagioclase, quartz and K-feldspar, with minor (<15%) biotite and magnetite, and local hornblende. Some plutons of this suite contain abundant blue quartz. Aside from minor aplite or granitic pegmatite dikes, these rocks are generally homogeneous on the scale of individual outcrops, although from one outcrop to the next, the texture varies from equigranular to feldspar porphyritic. Most outcrops are massive or show a weak foliation defined by aligned mafic minerals. Zones of quartz-ribbon mylonite up to 2.0 m thick form anastomosed arrays in some outcrops. A sample of this rock type from northeast of Sosnowski Lake, close to the boundary zone with the Nejanilini Domain, yielded a U-Pb zircon crystallization age of 2550 ±4 Ma (Rayner, GS-2, this volume, sample 97-09-108). Included in this unit is the discrete biotite granite pluton within the Sosnowski Lake assemblage east of Nichol Lake (referred to as the Nichol Lake pluton), which locally contains gabbroic rafts that appear to be locally derived.

In the area southwest of the Seal River delta, thick sheets of alaskite (unit Sa22) discordantly cut granitoid rocks of units Sa15 and Sa21, as well as mafic volcanic and intrusive rocks of the adjacent Howard Lake greenstone belt (units Sa8 and Sa9). The alaskite weathers white or pink and is typically heterogeneous, with a medium-grained to pegmatitic texture defined by graphic K-feldspar phenocrysts up to 15 cm in diameter in a quartz (30–40%) and biotite (<5%) matrix (Figure GS-1-4c). These rocks are unconformably overlain by low-grade Paleoproterozoic siliciclastic rocks at the north end of the Nowell Lake basin. Narrow dikes and sheets of granitic pegmatite (unit Sa23), which are possibly related to the alaskite, are a common, though minor, constituent of units Sa15 and Sa21.

Sequence 2 (units Sap1–Sap5)

Sequence 2 is best exposed in the laterally extensive cutbanks along the deeply incised section of the North Knife River that extends for 50 km upstream from Teepee Falls (Figure GS-1-2). Although strongly transposed, this section is considered the type locality. Here, the sequence consists of quartz arenite (with minor pebble conglomerate and mudstone; unit Sap1), thick intervals of varicoloured mudstone (with minor quartz arenite and greywacke; unit Sap2), gabbro sills and dikes (unit Sap4), and rare flows of amygdaloidal basalt (unit Sap5). Toward the south, these rocks transition into andalusite-bearing paragneiss and schist (unit Sap3) that contain minor enclaves of amphibolite and are intruded by synmetamorphic biotite–muscovite–garnet±fluorite granite (unit Sp6) and related pegmatite (unit Sp7). To the north, quartz arenite of unit Sap1 appears to lie unconformably on a Neoarchean (≥2.55 Ga) basement composed of orthogneiss, granitoid intrusions, volcanoplutonic rocks and fluvial-alluvial rocks of sequence 1. Sequence 2 is distinguished from sequence 1 by the absence of coarse polymictic conglomerate, and from sequence 3 by the absence of basal iron formation. Sequence 2 also contains mafic flows and intrusions and generally exhibits a more intense structural overprint. Based on these criteria, sequence 2 is also thought to include the strongly transposed psammitic and semipelitic paragneiss exposed between Spruce Lake and Naelin Lake, which was provisionally considered part of the Omand Lake assemblage by Anderson et al. (2009a).

Unit Sap1 is most extensive to the north of the North Knife River, where it appears to define the base of sequence 2. The characteristic rock type is a light grey, medium-grained quartz arenite, which forms units up to 80 m thick that vary from massive to planar-bedded to trough crossbedded and contain only minor interlayers of light brown, sericitic mudstone from 1 to 5 cm thick. Some arenite beds have normal-graded tops and basal scours filled with coarse-grained pebbly arenite. Rare beds of clast-supported, moderately sorted pebble conglomerate are up to 50 cm thick and consist of well-rounded to angular clasts of quartz and feldspar (Figure GS-1-4d), with locally abundant mudstone rip-ups. A sample of pebbly arenite from a large outcrop at Teepee Falls contains mostly Neoarchean (ca. 2.87–2.65 Ga) detritus and yielded a youngest detrital zircon age of 2504 ±25 Ma (Rayner, GS-2, this volume, sample 96-08-16). Though much less abundant, the distribution of Meso- and Paleoarchean detritus in this sample is similar to that obtained from the fuchsitic quartz pebble conglomerate of sequence 1. Another sample of quartz arenite from near the base of sequence 2 at Lovat Lake (collected in 2004) also contains mostly Neoarchean detritus, with significant modes at ca. 2.7 and 2.57 Ga, but lacks any detrital zircons older than ca. 3.0 Ga (Böhm and Anderson, unpublished data, 2004).

Most of the outcrops along the deeply incised section of the North Knife River upstream from Teepee Falls consist of thinly bedded to laminated, varicoloured (black, grey, green or maroon) mudstone and derived phyllite (unit Sap2), which contain only minor interlayers of quartz arenite and greywacke. Abundant younging reversals and evidence from fabric overprinting for two generations of tight to isoclinal, upright, doubly plunging folds indicate that this section is intensely transposed. In several locations, unit Sap2 also contains sill-like bodies of dark green homogeneous gabbro (unit Sap4) that range up to 40 m thick in outcrop. This rock has a medium-grained subophitic texture and locally contains large rafts of the sedimentary country rock. The gabbro bodies contain 1–3% disseminated pyrrhotite and are thus clearly delineated on total-field aeromagnetic maps. Sill-like gabbro bodies within sequence 1 in the Nichol Lake area and at the west end of Mullin Lake are provisionally included in unit Sap4 (see Anderson et al., 2010).

Also provisionally included in unit Sap4 are east-trending gabbro dikes that discordantly cut foliated granite of unit Sa21 north of Eppler Lake and northwest of Howard Lake. These dikes range up to 7 m thick and likely belong to a swarm indicated by east- to east-north-east–trending magnetic linears in the area underlain by Archean granitoid rocks of units Sa15 and Sa21 between the Seal and North Knife rivers and in the Eppler Lake area (Figure GS-1-2). The gabbro weathers greenish grey to brown and is dark green on fresh surfaces, with a fine- to medium-grained equigranular texture defined by recrystallized plagioclase (20–40%) and mafic minerals (60–80%). Sharp, planar and parallel external contacts and well-developed chilled margins 10–40 cm thick are indicative of relatively high-level emplacement. Lithogeochemical analyses of samples collected in 2009 and 2010 indicate a chemical affinity to calcalkaline arc basalt; these dikes might represent feeders to the overlying calcalkaline basalt flows of unit Sap5 (see below).

The basalt flows of unit Sap5 are exposed in three locations along the North Knife River upstream from Teepee Falls. The basalt weathers greenish grey to brown and is dark green on fresh surfaces, with a very fine grained subophitic texture defined by 30–40% plagioclase laths in a chlorite-actinolite matrix. In one outcrop, the basalt is strongly recrystallized and contains hornblende porphyroblasts up to 5 mm long (30–40%) that overgrow an early penetrative foliation. Individual flows range from 1 to 3 m thick and are defined by variations in the size and abundance of quartz amygdules (Figure GS-1-5a). Flow tops contain round to amoeboid amygdules up to 7 cm across that account for up to 20% of the rock, whereas the flow bottoms contain only sparse round amygdules or are non-amygdaloidal. Thin lenses of monolithic closed-framework flow-breccia composed of angular clasts (<30 cm) of variably amygdaloidal basalt also locally define flow contacts. The cumulative thickness of the flows in one location is at least 50 m. Preliminary lithogeochemical results indicate an affinity to calcalkaline arc basalt. Given the basinal-marine eruptive setting, the apparent absence of pillowed flows is taken to indicate very high effusion rates and close proximity to the discharge site(s).

Toward the south, unit Sap2 transitions into psammitic to semipelitic, biotite-muscovite-andalusite paragneiss and schist (unit Sap3; Figure GS-1-5b) that are intruded by irregular dikes and thick sheets of biotite–muscovite–garnet±fluorite granite (unit Sp6) and pegmatite (unit Sp7). Possible correlative paragneiss in the area between Spruce Lake and Naelin Lake is likewise intruded by voluminous two-mica pegmatite and granite, but typically contain a higher-pressure metamorphic assemblage (biotite–sillimanite±garnet±cordierite). Planar bedforms are locally well preserved, which suggests that most of the paragneiss is derived from thinly interbedded arenite and mudstone. A sample of psammitic paragneiss, collected approximately 2 km west of the location where interbedded arenite and conglomerate of sequence 1 are discordantly cut by dikes of 2.56 Ga quartz porphyry, returned a unimodal population of ca. 2.56 Ga detrital zircons (Rayner, GS-2, this volume, sample 97-09-228), suggesting a very local source for sequence 2 and a depositional contact relationship with sequence 1.

The available age constraint on sequence 2 in the Seal River Domain (<2.5 Ga) suggests a possible correlation with the lower Hurwitz Group in Nunavut (<2.45 Ga, >2.11 Ga; see Aspler and Chiarenzelli, 1997), which is likewise dominated by locally derived Archean detritus (Davis et al., 2005) and contains coeval mafic volcanic rocks. Sequence 2 laps onto Archean basement of the Hearne craton to the north and includes basalt flows that are chemically similar to discordant gabbro dikes in the basement, which appear to be part of an east-trending swarm that roughly parallels the craton margin. Based on

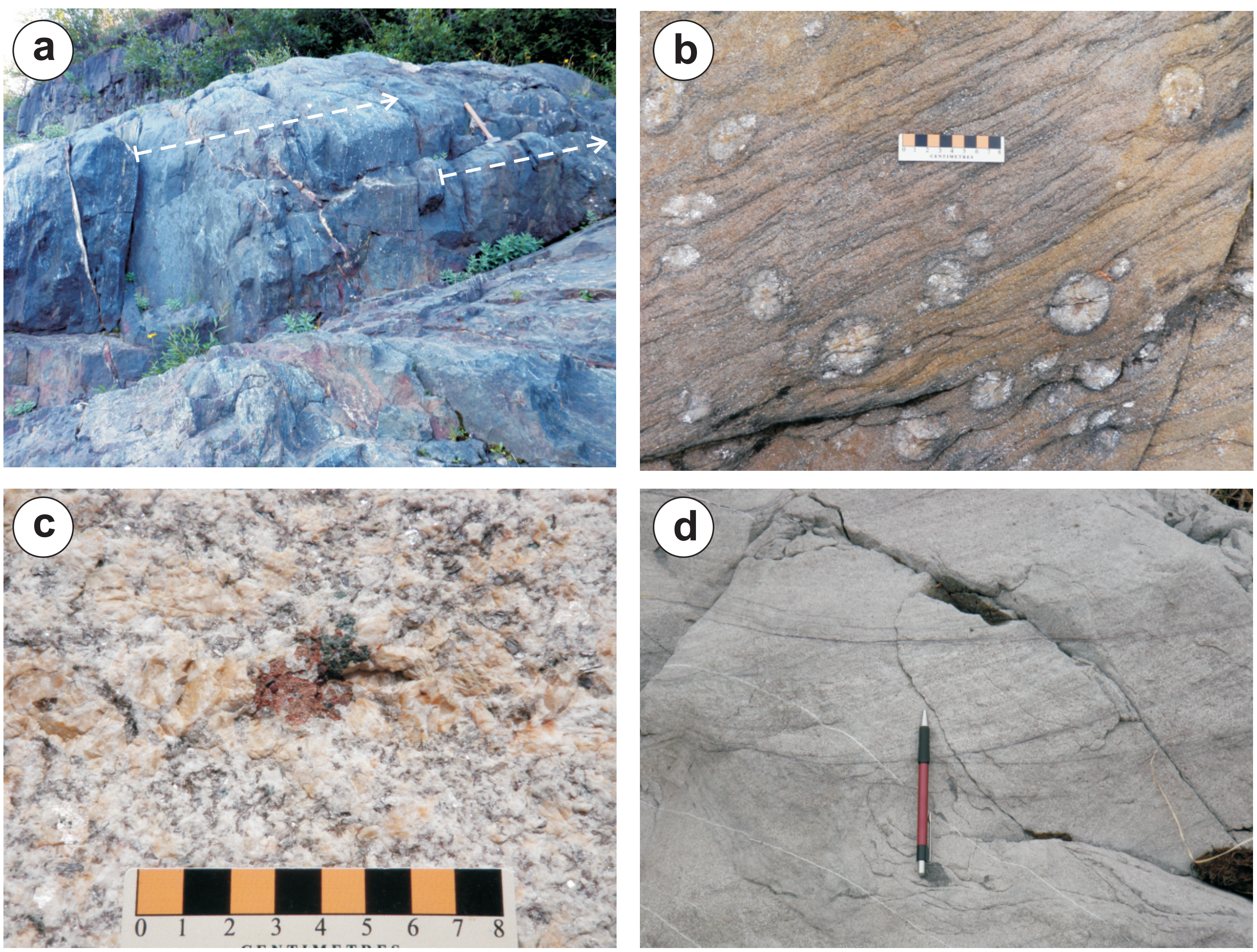


Figure GS-1-5: *Outcrop photographs of key rock types along the North Knife River:* ***a)*** *a series of 1.5–2.0 m thick massive basalt flows in sequence 2 (unit Sap5) defined by variations in quartz amygdule content, approximately 20 km upstream from Teepee Falls (flow contacts and younging direction indicated by dashed arrows);* ***b)*** *andalusite porphyroblastic psammitic schist of sequence 2 (unit Sap3), southwest of Lovat Lake on the North Knife River;* ***c)*** *muscovite-biotite-garnet-fluorite granite (unit Sp6) that intrudes sequence 2, south of Great Island on the North Knife River;* ***d)*** *trough cross-bedded quartz arenite (unit Sp13) at the top of sequence 4 in the central portion of the Nowell Lake basin, northeast of Nowell Lake.*

these relationships, sequence 2 is provisionally thought to record Paleoproterozoic crustal extension and perhaps rifting of the Hearne craton.

Sequence 3 (units Sp1–Sp5)

Sequence 3 sedimentary rocks define the very prominent synclinal basins that are the defining characteristic of the Seal River Domain and the southern margin of the Hearne craton in Manitoba. Of these, the Great Island basin (Schledewitz, 1986) is the most extensive and can be traced continuously to the southwest for more than 50 km as a series of smaller sub-basins. To the east, two other intact basins are defined by aeromagnetic patterns and sparse outcrop in the Seal Bend area (the Seal Bend basin) and at Nowell Lake (the Nowell Lake basin; Figure GS-1-2).

The constituent rock types of sequence 3 were described in detail by Anderson et al. (2009a) and are thought to record deposition in a marine-deltaic setting. The base of the sequence is defined by a thick, laterally extensive silicate facies iron formation (unit Sp1) that is clearly delineated by a formational aeromagnetic anomaly and indicates that basin infilling was preceded by relatively quiescent deposition in a marine setting. Most exposures of sequence 3 rocks consist of thinly interbedded arenite and mudstone (unit Sp2) or thick-bedded quartz arenite, with only minor mudstone interbeds (unit Sp3). As described by Anderson et al. (2009a), the latter unit may represent distributary sand deposits in a marine-deltaic system, whereas the former may represent interdistributary or delta-slope deposits. Mudstone with subordinate arenite (unit Sp5) is only extensively exposed in sections along the Seal River at Great Island, but might nevertheless be the dominant rock type in sequence 3, since it is likely under-represented in outcrop due to differential weathering and erosion. This unit consists of thick successions of laminated to thin-bedded mudstone, with only subordinate, and typically thin, planar interbeds of fine- to medium-grained quartz arenite. Sediment fluidization structures are common and completely disrupt bedding in places. In a marine-deltaic system, such features would be consistent with distal prodelta deposits. Dolomitic marble of unit Sp4 is found in small isolated outcrops in four locations.

The detrital zircon population of a sample of quartz arenite from unit Sp2 near the base of sequence 3, which was collected downstream from Teepee Falls on the North Knife River, shows distinct peaks at ca. 2.56 and 2.69 Ga, and indicates a maximum depositional age of 2049 ±19 Ma (Rayner, GS-2, this volume, sample 96-08-15). Higher up in the stratigraphy, a sample of quartz arenite from unit Sp3 collected on the north channel of the Seal River at Great Island contains a generally younger detrital zircon population that defines a broad peak between ca. 2.5 and 2.3 Ga, and indicates a slightly younger maximum depositional age of 1984 ±14 Ma (Rayner, GS-2, this volume, sample 96-08-29). These age constraints (<2.05 Ga and <1.98 Ga) suggest that sequence 3 in the Seal River Domain may be broadly correlative to sequence 3 of the upper Hurwitz Group in Nunavut (<1.96 Ga; Davis et al., 2005), as well as the ca. 2.1–1.9 Ga Wollaston Group (Tran et al., 2008) in Saskatchewan.

Intrusive rocks (units Sp6 and Sp7)

Peraluminous two-mica granitic rocks are the predominant felsic intrusive rocks in higher-grade (mid- to upper amphibolite) domains in the western portion of the map area where they are found to intrude sedimentary cover rocks of sequences 1, 2 and 3.

Two-mica granite (unit Sp6) forms mappable plutons in the Spruce Lake area, where it is hosted by sillimanite-grade sedimentary rocks of sequences 1 and 2. The granite weathers white to light grey and has a fine- to medium-grained equigranular texture defined by feldspar and subordinate quartz. Biotite (3–5%) and muscovite (1–2%) are the characteristic minor phases, although some specimens also contain appreciable garnet, cordierite or fluorite (Figure GS-1-5c). Individual outcrops are homogeneous or heterogeneous, the latter of which are characterized by irregular pegmatitic segregations and inclusions or screens of paragneiss or quartz arenite. These features are indicative of 'S-type' granite produced through anatexis of the adjacent metasedimentary rocks. Narrow, generally late-tectonic dikes of biotite–muscovite±garnet granitic pegmatite (unit Sp7) appear to be comagmatic with the two-mica granite plutons. A sample of the two-mica granite collected from an outcrop on the North Knife River in the southwest corner of the map area has been submitted for U-Pb geochronology.

Sequence 4 (units Sp8–Sp13)

Sedimentary rocks of sequence 4 are the youngest supracrustal rocks identified to date in the Seal River region. The sequence has been identified on the basis of distinctive aeromagnetic patterns and scattered outcrops in the stratigraphically highest sections of the Great Island and Nowell Lake basins (Figure GS-1-2), and may also be present in the northern portion of the Seal Bend basin. With the exception of the stratigraphically highest unit (unit Sp13), the constituent rock types of sequence 4 were described in detail by Anderson et al. (2009a), and were provisionally interpreted to record deposition in a basinal-marine setting. An abrupt decrease in the amplitude of upright folds across the contact of sequences 3–4, coupled with local angular discordance, indicates an angular unconformity; this relationship is particularly evident in the southern portion of the Nowell Lake basin (Figure GS-1-2).

In the Great Island basin, the base of sequence 4 is clearly delineated by a formational magnetic feature on regional aeromagnetic maps, which coincides with scattered outcrops of dolomitic marble and calcsilicate rocks (unit Sp8) and oxide-facies iron formation (unit Sp9). In the core of the Nowell Lake basin, a similar formational magnetic feature is interpreted to mark the base of sequence 4, but is not exposed. The upper portion of sequence 4 in the Great Island basin includes two distinct units of greywacke-mudstone turbidites that are distinguished by the thickness and composition of the constituent greywacke beds. Unit Sp10 is characterized by relatively thick (generally >30 cm; up to 1.5 m) beds of light grey fine- to coarse-grained greywacke that contains coarse detrital quartz, plagioclase and lithic fragments, whereas unit Sp12 is characterized by relatively thin (generally <10 cm; up to 40 cm) beds of light grey to brown, fine- to medium-grained feldspathic greywacke, which are generally subordinate to mudstone and lack the coarse detrital components. These units are separated by thin oxide facies iron formation (unit Sp11). The detrital zircon population of a sample of coarse lithic greywacke from near the base of unit Sp10 east of Meades Lake shows a distinct peak at ca. 2.53 Ga, and indicates a maximum depositional age of 1879 ±19 Ma (Rayner, GS-2, this volume, sample 96-08-32). These age constraints (<1.88 Ga) suggest that sequence 4 in the Seal River Domain might be broadly correlative to sequence 4 of the upper Hurwitz Group (<1.91 Ga; Davis et al., 2005).

Crossbedded quartz arenite (Figure GS-1-5d) with minor mudstone interbeds is exposed in the stratigraphically highest portion of the Nowell Lake basin and has been assigned to unit Sp13 (the equivalent stratigraphic level in the Great Island basin is occupied by Meades Lake and is thus unexposed; Figure GS-1-2). These rocks are thought to represent possibly the youngest supracrustal rocks in the entire Seal River region; a sample of this arenite has been submitted for detrital zircon U-Pb geochronology.

Nejanilini Domain

In the 2010 map area, the Nejanilini Domain consists mainly of unseparated granitoid orthogneiss (unit Na1) that contains enclaves of migmatized supracrustal rocks (units Na2 and Na3) and is intruded by strongly recrystallized (unit Na4) and comparatively fresh (unit Na5) porphyritic granite plutons, late granitoid sheets and dikes (unit Na6), and an interpreted swarm of discordant mafic dikes (unit Np1; Table GS-1-1). Clark and Schledewitz (1988) referred to the high-grade portions of this complex as the 'Nejanilini granulite massif' and interpreted a sample of monzocharnockite to be Archean in age based on a Rb-Sr age of 2577 ±42 Ma, with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7057. Granulite-grade biotite tonalite gneiss from the western portion of the massif in the Nejanilini Lake area yielded a U-Pb zircon crystallization age of ca. 2.70 Ga (Böhm and Anderson, unpublished data, 2006), which confirms the Archean age.

In the 2010 study area, the southern margin of the Nejanilini Domain is marked by a zone of greenschist-facies mylonite that is up to several kilometres wide and marks the northern limit of the relatively intact basins of supracrustal rocks that characterize the Seal River Domain.

Archean intrusive rocks (unit Na1)

Unseparated granite and granodiorite of unit Na1 are the dominant rock types in the eastern portion of the Nejanilini Domain. The characteristic feature of this unit is its marked heterogeneity from outcrop to outcrop. The precursor rock types are variably feldspar-porphyritic granite and granodiorite, with minor quartz diorite and tonalite. Weathered surfaces are generally light grey or pink. Fresh surfaces commonly have a waxy green to deep brown colour, suggestive of granulite-grade granitoid rocks elsewhere in the Nejanilini Domain; identification of the diagnostic metamorphic minerals awaits detailed petrographic examination. Most specimens contain accessory biotite (<15%) and some also contain up to 10% hornblende and/or orthopyroxene. Individual exposures vary from massive to strongly foliated and most contain a variably developed gneissic layering that is commonly flat-lying and thus difficult to recognize in the subhorizontal outcrop surfaces that typify the map area, although frost-heaved blocks of bedrock locally provide three-dimensional exposures. Widely scattered inclusions of paragneiss and mafic granulite are locally of sufficient size to define map units (units Na2 and Na3).

A sample of 'charnockitic gneiss' (field term) collected from the western portion of this unit for U-Pb zircon geochronology was found to contain a fairly complex zircon population that includes four distinct morphologies. Analyses of single-grain fractions of each morphology yielded variably discordant results and a best-estimate crystallization age (2526.5 ±1.3 Ma; Rayner, GS-2, this volume, sample 96-08-26) that is difficult to reconcile with the local field relationships and the available U-Pb zircon age constraints from elsewhere in the Nejanilini Domain. Hence, the significance of this result is currently unclear. To resolve this problem, an additional sample of orthogneiss from the southern margin of the Nejanilini Domain has been submitted for U-Pb geochronology.

Paragneiss (unit Na2)

Paragneiss of unit Na2 is interpreted to underlie the extensive magnetic low that trends in a northeastern direction from Caribou Lake to the Hudson Bay coast. Within this low, the largest exposures of paragneiss are found in the Long Lake area (Figure GS-1-2; Anderson et al., 2010). Paragneiss is also found in several isolated outcrops outside of this magnetic low along the northwest boundary of the map area. These rocks weather light grey to buff to rusty brown and are dark grey or 'waxy' green or brown on fresh surfaces, with a fine- to medium-grained granoblastic texture. Most outcrops contain a well-developed gneissosity or migmatitic layering and at least one generation of penetrative foliation. Individual outcrops vary from homogeneous to markedly heterogeneous, and several compositional varieties of paragneiss are recognized in the map area. These include grey garnet-biotite psammite, light grey biotite quartzite, brown-grey biotite–sillimanite±garnet±cordierite semipelite (Figure GS-1-6a), dark grey or brown biotite-sillimanite pelite and pyroxene skarn/calcsilicate. Patches and veins of migmatitic leucosome (quartz–feldspar–biotite±garnet±cordierite±sillimanite±hornblende) locally account for up to 40% of some outcrops. Patchy gossan on some outcrops is caused by finely disseminated pyrrhotite and pyrite. Strongly recrystallized dikes of equigranular or coarsely porphyritic K-feldspar granite and granitic pegmatite are a minor component of most outcrops.

In the western portion of the Nejanilini Domain at Nejanilini Lake, a sequence of superficially similar paragneiss includes Archean-sourced quartzite with a maximum depositional age of ca. 2.5 Ga and semipelitic gneiss with detrital zircons as young as 1.9 Ga (Anderson et al., 2005; Böhm and Anderson, unpublished data, 2006), indicating a possible correlation to Paleoproterozoic supracrustal rocks of sequences 2 and 4, respectively, in the Seal River Domain. In contrast, the available age constraints on paragneiss in the eastern portion of the Nejanilini Domain suggest an Archean depositional age. In particular, the prominent magnetic lows associated with paragneiss exposures in the Long Lake area are clearly crosscut by north-trending magnetic linears that are presumed to represent mafic dikes of the ca. 2.45 Ga (Heaman, 1994) Kaminak swarm, which are widespread farther north in the central portion of the Hearne craton. If valid, this hypothesis would indicate an Archean

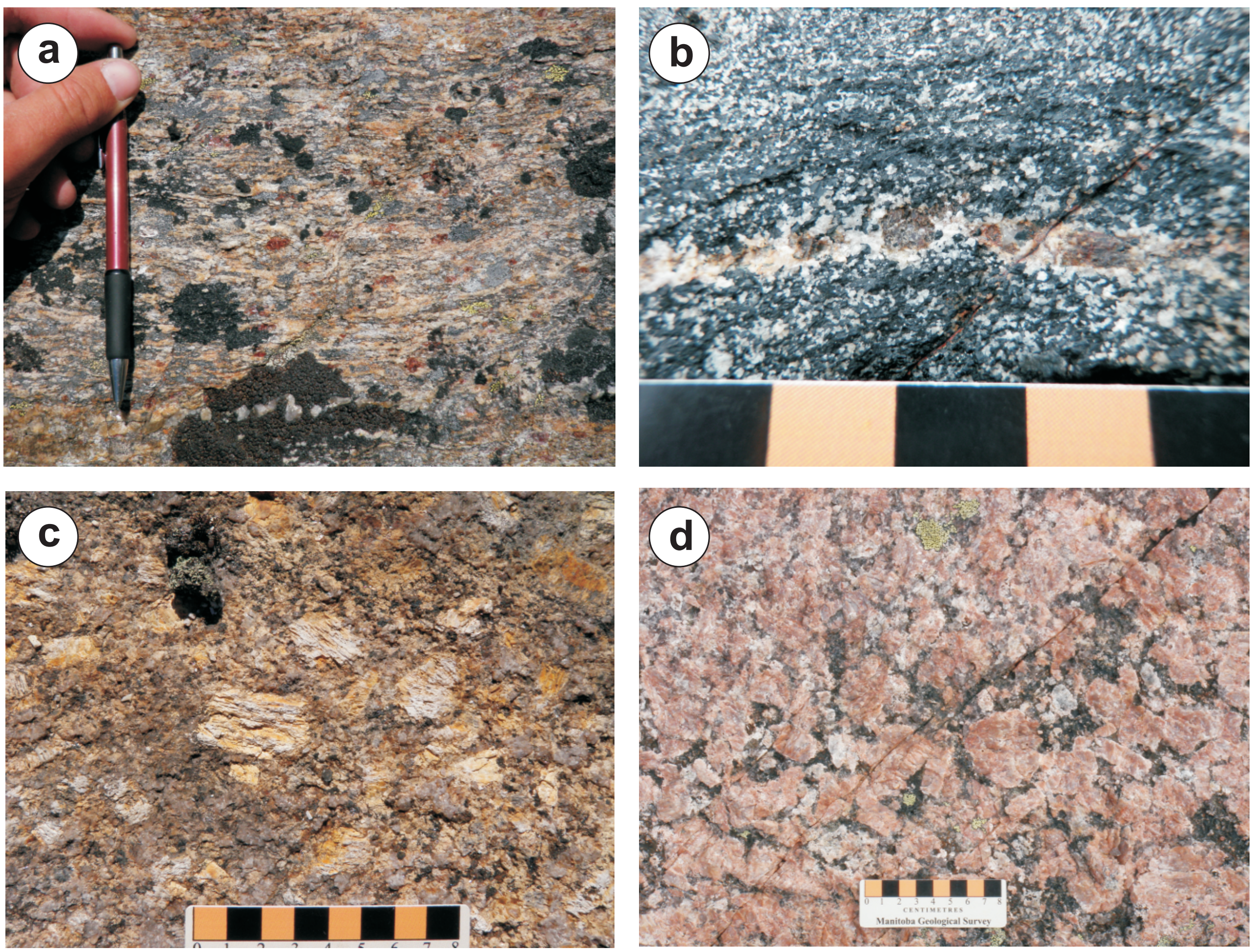


Figure GS-1-6: *Outcrop photographs of key rock types in the Nejanilini Domain:* ***a)*** *strongly foliated biotite-sillimanite-garnet-cordierite semipelitic paragneiss (unit Na2) northwest of Long Lake;* ***b)*** *quartz-plagioclase-hypersthene leucosome in granoblastic mafic granulite (unit Na3) from the large body located approximately 20 km north of Long Lake;* ***c)*** *strongly recrystallized K-feldspar porphyritic granite (unit Na4) from the large pluton at the northernmost extent of the map area;* ***d)*** *relatively fresh K-feldspar porphyritic granite (unit Na5) in the central portion of the Vinsky Lake pluton, 25 km northeast of Long Lake.*

depositional age for the precursor sedimentary rocks. A sample of psammitic paragneiss from the Long Lake area has been submitted for detrital zircon U-Pb geochronology to test this hypothesis.

Mafic granulite (unit Na3)

Mafic granulite (unit Na3) is associated with outcrops of paragneiss in two locations in the far northwest corner of the map area. These rocks weather light grey to green with dark grey-green fresh surfaces and are characterized by a fine- to medium-grained equigranular texture defined by granoblastic plagioclase, hornblende, orthopyroxene, garnet and biotite. Some specimens contain porphyroblastic garnet (up to 30%) or pyroxene (up to 15%), or contain patches and wispy layers of quartz-plagioclase-hornblende-orthopyroxene leucosome (Figure GS-1-6b). Both outcrops contain a well-developed gneissosity that obscures evidence of the protolith.

K-feldspar porphyritic granite (unit Na4)

Porphyritic granite of unit Na4 forms large plutons along the northwest edge of the map area, as well as thick sheets within areas underlain by older granitoid gneiss (unit Na1) and paragneiss (unit Na2). This rock weathers pale pink to buff and is a distinctive rusty brown to waxy green on fresh surfaces. Outcrop surfaces are deeply weathered and are locally sculpted or hummocky due to preferential weathering and erosion along joint surfaces. Most specimens contain 20–40% tabular K-feldspar phenocrysts up to 4 cm long that have been variably recrystallized (Figure GS-1-6c) and, in some outcrops, are only apparent as relict aggregates of granoblastic K-feldspar and quartz. The medium- to coarse-grained matrix consists of granoblastic K-feldspar and quartz, with minor (<10%) biotite, hornblende, orthopyroxene or garnet. This rock varies from massive to weakly foliated, but tends to be very homogeneous on the scale of individual outcrops. In some otherwise massive outcrops, the recrystallized phenocrysts show a distinct preferred orientation that is suggestive of a precursor magmatic fabric. Several outcrops include large rafts of paragneiss. Although similar in most respects to the porphyritic granite of unit Na5 (see below), these units are clearly distinguished in the field by the differences in weathering, colour, texture and apparent metamorphic grade.

K-feldspar porphyritic granite (unit Na5)

Porphyritic granite plutons of unit Na5 are clearly delineated by prominent elliptical features on regional aeromagnetic maps and include the Gross Lake, Caribou River, Vinsky Lake and Dickins River plutons. Porphyritic granite also forms dikes and sheets of highly variable thickness within units Na1–Na4. This rock weathers buff to pink and is mottled pink and grey on fresh surfaces. Individual outcrops are typically homogeneous and exhibit a seriate porphyritic texture defined by tabular pink K-feldspar phenocrysts (0.5–5 cm) in a matrix of medium- to coarse-grained quartz, K-feldspar and plagioclase (Figure GS-1-6d). The phenocryst content varies from 10 to 50% and most specimens also contain 10–15% biotite and 1–2% magnetite. The Dickins River pluton appears to be nested within the Vinsky Lake pluton, which locally contains 5–10% hornblende and shows a slightly more muted magnetic signature than the other plutons of the suite. In outcrop, the porphyritic granite varies from massive to weakly foliated and, in most instances, shows a prominent preferred alignment of phenocrysts that appears to have originated by magmatic flow. A texturally similar pluton of K-feldspar porphyritic granite in the Nejanilini Lake area yielded a poorly constrained U-Pb zircon crystallization age of ca. 2.6 Ga (Böhm and Anderson, unpublished data, 2006). A sample of porphyritic granite from the Dickins River pluton has been submitted for U-Pb geochronology to determine the crystallization age. This sample will also provide a minimum depositional age for the precursor sedimentary rocks to the paragneiss of unit Na2.

Granite (unit Na6)

Unit Na6 comprises unseparated leucogranite and granitic pegmatite dikes and sheets that are observed to cut map units Na1–Na5. These rocks weather pink or white and are light grey-pink on fresh surfaces. The leucogranite is medium grained and equigranular, and consists of subequal amounts of quartz, K-feldspar and plagioclase with <10% biotite. Pegmatitic varieties have a similar mineralogy, but locally contain accessory garnet. Most of these intrusions are massive to very weakly foliated.

Late-tectonic dikes (unit Np1)

Prominent magnetic linears in the northeast portion of the map are presumed to represent a swarm of north-trending mafic dikes (unit Np1), although no dikes of this orientation were observed in outcrop. The postulated dikes are particularly abundant in a northeast-trending corridor through the Long Lake area, which mostly coincides with exposures of paragneiss (unit Na2) and porphyritic granite plutons (unit Na5; Figure GS-1-2). Solely on the basis of orientation, these dikes are provisionally thought to be part of the ca. 2.45 Ga (Heaman, 1994) Kaminak dike swarm, which is widespread in the central portion of the Hearne craton and predates the Paleoproterozoic cover rocks of the Hurwitz Group (e.g., Aspler and Chiarenzelli, 1997).

Post-tectonic dikes (unit Mp1)

As described by Anderson et al. (2009a), prominent magnetic linears that transect the Great Island area from northwest to southeast were found to coincide with exposures of massive gabbro (unit Mp1) in five locations. The gabbro weathers a distinctive reddish brown to green and has a medium-grained diabasic texture defined by plagioclase laths (50–60%, 1–2 mm), interstitial pyroxene (30–35%) and magnetite (5–15%). Most outcrops are homogeneous, although one locality on the southern channel of the Seal River at Great Island is faintly layered, likely as a result of compound emplacement. Lithogeochemical analyses of samples collected in 2009 indicate that these dikes are tholeiitic, with a chemical affinity to continental or enriched mid-ocean–ridge basalt. Both the orientation and chemistry of these dikes are indicative of post-tectonic dikes of the Mackenzie swarm (see Baragar et al., 1996), which were emplaced at 1.27 Ga (LeCheminant and Heaman, 1989).

Economic considerations

The southeastern margin of the Archean Hearne craton in Manitoba comprises a geologically diverse and complex assembly of rocks that records nearly two billion years of early Earth history. In the Seal River Domain, vestiges of Paleo- and Mesoarchean crust, Neoarchean (ca. 2.7–2.6 Ga) volcanic belts and fault-controlled fluvial-alluvial basins (<2.70 Ga) are intruded by voluminous Neoarchean (2.57–2.55 Ga) granitoid intrusions. Subaqueous volcanic rocks within this heterogeneous basement terrane exhibit good potential for several types of mineral deposits, including exhalative base-metal sulphides, shear-hosted (quartz-carbonate vein) Au and iron formation Au. Quartz pebble conglomerate horizons in the Archean fluvial-alluvial basins (sequence 1) are being actively explored for paleoplacer Au-U deposits. Widespread erosional remnants of siliciclastic cover rocks in the Seal River Domain provide a discontinuous record of intracratonic sedimentation and basin evolution spanning at least 700 m.y. and show evidence of additional mineral potential. For example, horizons of supermature quartz pebble conglomerate near the base of sequence 2 are considered to have good potential to host paleoplacer Au-U deposits, whereas coeval basalt flows higher up in the sequence indicate the possibility of high-heat flows during sedimentation and thus potential for sedimentary exhalative sulphide (SEDEX) deposits. Furthermore, the protracted depositional history recorded by these rocks indicates the presence of long-term stable (i.e., thick) crust of the type considered favourable for kimberlite-hosted diamond deposits.

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