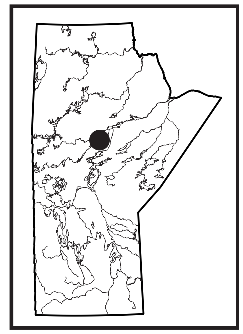
GS-3 Preliminary results from bedrock mapping in the Partridge Crop Lake area, eastern margin of the Thompson nickel belt, central Manitoba (parts of NTS 63P11, 12)

by C.G. Couëslan



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Summary

A project to remap portions of the Archean Pikwitonei granulite domain[1] in central Manitoba, with emphasis on interpretation of protoliths, was extended into the Partridge Crop Lake area in 2013. This area was subjected to relatively uniform, high-grade Neoarchean metamorphism and deformation, and was variably overprinted by high-grade Paleoproterozoic metamorphism and deformation. Exposures in the Partridge Crop Lake area are divided into three main age groups: Archean rocks, rocks of uncertain age and Proterozoic rocks. Archean rocks include mafic gneiss, granodiorite–tonalite gneiss, schollen-bearing tonalite–granodiorite gneiss, and weakly gneissic granodiorite. Rocks of uncertain age include pelite, semipelite, garnet wacke, iron formation, calcsilicate, impure marble, and ultramafic amphibolite. Proterozoic rocks consist of diabase dikes, melasyenite, several granitoid plutons, pegmatitic and aplitic granite dikes, and carbonate rocks of uncertain affinity. A roughly east-trending, subvertical Archean gneissosity is transected at a high angle over much of the area by a subvertical Paleoproterozoic foliation that is axial planar to minor folds. The Paleoproterozoic deformation becomes increasingly intense toward the west where the Archean gneissosity is transposed into the Paleoproterozoic foliation. Archean granulite-facies metamorphic assemblages are progressively overprinted by upper-amphibolite–facies metamorphic assemblages from east to west across the map area.

Sedimentary sequences similar to the Ospwagan group, exposures of sulphidic ultramafic amphibolite, and loose cobbles of serpentinized dunite, suggest the area could be prospective for magmatic nickel deposits. Gossanous zones associated with iron formation and garnetite in mafic gneiss suggest potential for Archean gold and base-metal (volcanogenic massive-sulphide, VMS) mineralization.

Introduction

A project was initiated in 2012 to remap portions of the Pikwitonei granulite domain (PGD, Couëslan et al., 2012). The objective is to re-examine the mafic, intermediate and enderbitic (orthopyroxene-bearing tonalite) gneisses with an eye to protoliths rather than descriptive petrography. Additionally, the information gathered through the course of mapping will provide further insight into the tectonic significance of the PGD (e.g., Weber, 1983) and the mineral potential of the region. Due to the high metamorphic grade and the apparent lack of supracrustal rocks, the PGD has traditionally been considered to have insignificant or lower mineral potential compared to the adjacent, lower grade metamorphic domains.

Five and a half weeks of geological mapping was conducted at 1:20 000 scale on Partridge Crop Lake in July and August of 2013 (Figure GS-3-1; Couëslan, 2013). Water levels were approximately 1 m below normal, which resulted in extensive shoreline exposures. Previous workers recognized that the Partridge Crop–Natawahunan lakes region contains a larger proportion of supracrustal rocks than other portions of the PGD (Dawson, 1952; Weber, 1978), hence, the Partridge Crop Lake area was revisited to better constrain the nature of these supracrustal rocks through the use of petrography, geochemistry and isotopic methods. In addition, Partridge Crop Lake is situated on the eastern margin of the Thompson nickel belt (TNB), so the map area was investigated for potential ultramafic-hosted Ni mineralization and the possible presence of Ospwagan group metasedimentary rocks.

Regional geology

The PGD is a Neoarchean high-grade metamorphic domain along the northwestern margin of the Superior province. It is exposed over a length of approximately 200 km with a maximum width of 75 km in the Split Lake area (Hubregtse, 1980; Böhm et al., 1999). A regional orthopyroxene-in isograd, which is oblique to the generally east-trending fabrics of the Superior province, marks the southeastern boundary of the domain (Hubregtse, 1980; Heaman et al., 2011). The northwestern boundary is defined by Paleoproterozoic Hudsonian (ca. 1.83–1.70 Ga) north-northeast-trending deformational fabrics of the TNB that truncate the east-trending Neoarchean fabrics of the PGD (Hubregtse, 1980; Bleeker, 1990; Heaman et al., 2011; Kuiper et al., 2011; Couëslan et al., 2013).

[1] For the sake of consistency, the Manitoba Geological Survey has opted to make a universal change from capitalized to noncapitalized for the generic part of lithostructural feature names (formal stratigraphic and biostratigraphic nomenclature being the exceptions).

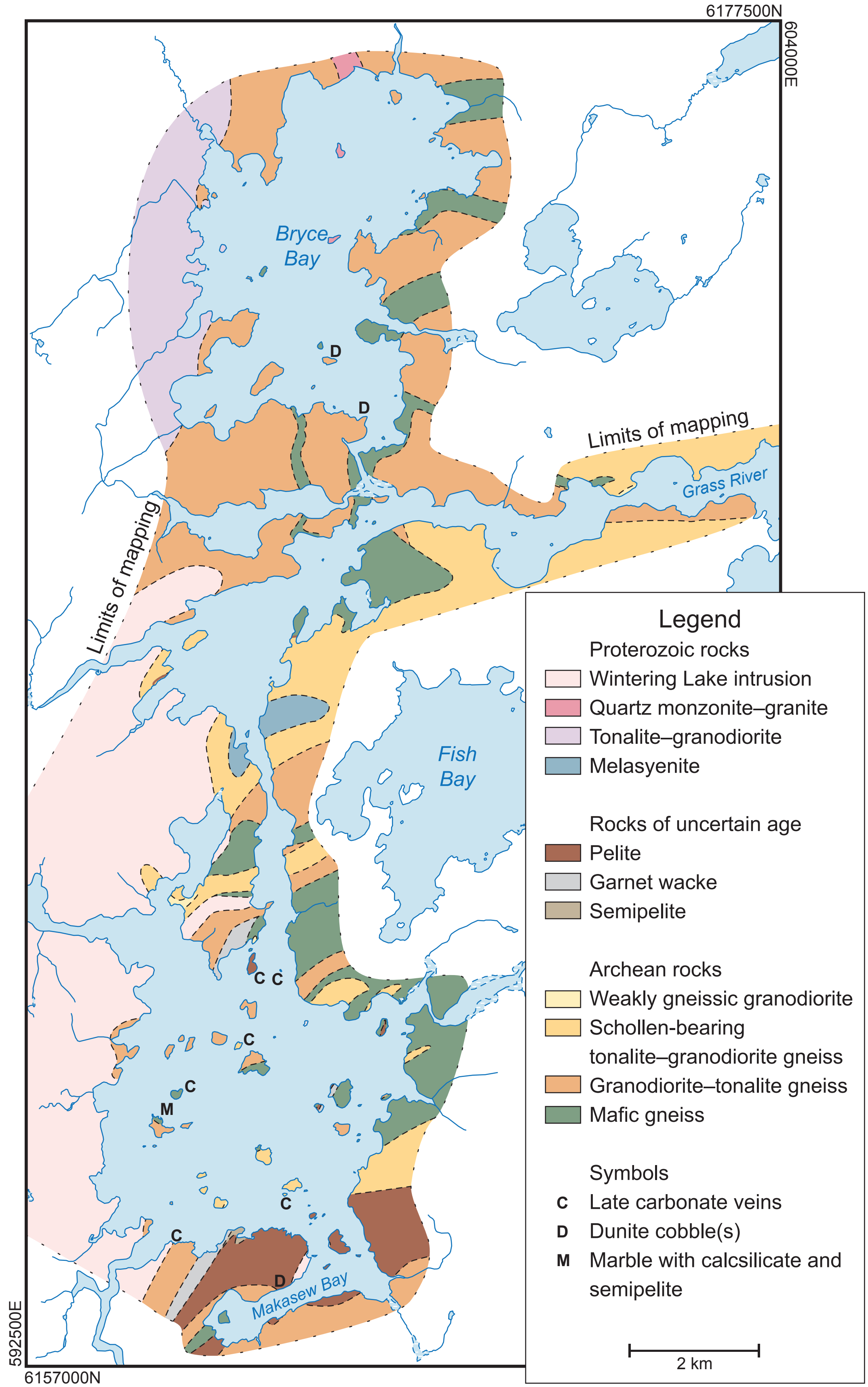

Figure GS-3-1: *Simplified geology of the northern and western Partridge Crop Lake area, central Manitoba (modified after Couëslan, 2013).*

The PGD is underlain by dominantly enderbitic, opdalitic (orthopyroxene-bearing granodiorite) and minor leuconoritic gneiss, and mafic granulites (metagabbro, metapyroxenite and metabasalt; Hubregtse, 1978, 1980; Heaman et al., 2011). Supracrustal rocks are considered to be relatively rare in the PGD. The PGD has experienced two main generations of Archean deformation and metamorphism. The D_1–M_1 generation (ca. 2695 Ma, Heaman et al., 2011) resulted in well-defined, northwest-trending metamorphic banding (S_1) accompanied by isoclinal folding (Hubregtse, 1980). The accompanying M_1 metamorphism is interpreted to have attained amphibolite- to locally lower granulite-facies conditions (Hubregtse, 1978, 1980). This was followed by M_2 metamorphism (ca. 2680 Ma, Heaman et al., 2011), which resulted in pervasive granulite-facies metamorphic conditions throughout the PGD (Hubregtse, 1980; Mezger et al., 1990). Mezger et al. (1990) interpreted the M_2 event to follow a counter-clockwise P-T-t path. The M_2 metamorphism was largely postdated by D_2, which resulted in the development of S_2 fabrics and transposition of S_1 into west-southwest-trending shear folds (Hubregtse, 1980; Heaman et al., 2011; Couëslan, GS-2, this volume).

In the TNB region, the granulitic rocks of the PGD were exhumed and unconformably overlain by the Paleoproterozoic supracrustal rocks of the Ospwagan group (Scoates et al., 1977; Bleeker, 1990; Zwanzig et al., 2007). The Ospwagan group metasedimentary sequence consists of a fining-upward siliciclastic sequence (Manasan formation), grading into calcareous metasedimentary rocks of the Thompson formation. The Thompson formation is overlain by deeper basin siliciclastic and chemical metasedimentary rocks of the Pipe formation, which grade into the Setting formation, a coarsening-upward siliciclastic package. The Setting formation is capped by a thick sequence of mafic to ultramafic metavolcanic rocks of the Bah Lake assemblage (Bleeker, 1990; Zwanzig et al., 2007). Paleoproterozoic detrital zircons have been extracted from the Manasan and Setting formations, yielding maximum ages for deposition of ca. 2.24 Ga and 1.97 Ga, respectively (Bleeker and Hamilton, 2001; Machado et al., 2011a). A minimum age for the Ospwagan group is provided by ultramafic sills, which intruded the Ospwagan group supracrustal rocks at all stratigraphic levels (ca. 1880 Ma) and host the magmatic nickel deposits (Bleeker, 1990; Burnham et al., 2009; Scoates et al., 2010).

The Ospwagan group and underlying gneisses were affected by three main generations of deformation during the Trans-Hudson orogeny (Bleeker, 1990; Burnham et al., 2009). Early deformation (D_1) predates the ca. 1880 Ma mafic magmatism (Molson dikes); however, this early deformation is largely obscured by later deformation. The dominant phase of penetrative deformation (D_2; ca. 1830–1775 Ma, Couëslan et al., 2013) resulted in refolding and tightening of F_1 folds and the development of isoclinal to recumbent F_2 folds (Bleeker, 1990). The recumbent folds are accompanied by regionally pervasive S_2 fabrics. Microstructural observations suggest that peak metamorphic conditions of middle-amphibolite to lower-granulite facies were attained during, and possibly outlasted, D_2 (Couëslan and Pattison, 2012). The D_3 generation of deformation resulted in tight, vertical to steeply southeast-dipping, isoclinal F_3 folds (ca. 1760–1700 Ma; Bleeker, 1990, Burnham et al., 2009; Couëslan et al., 2013). The isoclinal nature of both F_2 and F_3 results in a coplanar relationship between S_2 and S_3 along F_3 fold limbs. Mylonite zones with subvertical stretching lineations parallel many of the regional F_3 folds, and are characterized by retrograde lower amphibolite- to greenschist-facies mineral assemblages (Bleeker, 1990; Burnham et al., 2009). Kinematic indicators in these northeast-striking shear zones commonly indicate southeast-side-up, sinistral movement (Bleeker, 1990; Burnham et al., 2009). The D_3 structures appear to exert a first order control on the present day distribution of metamorphic zones within the belt (Couëslan and Pattison, 2012).

Local geology

The Partridge Crop Lake area is underlain by dominantly granitic gneiss with irregular belts of supracrustal rocks and mafic gneiss (Dawson, 1952; Weber, 1978; Böhm, 1998). Although Dawson (1952) suggested a sedimentary origin for garnet- and quartz-bearing gneisses in the area, Weber (1978) interpreted these rocks to be derived from fumarolic alteration, or granitoid-related metasomatism, of basaltic rocks. Numerous gabbroic, and locally peridotitic, dikes occur throughout the area and typically crosscut the gneissic rocks (Dawson, 1952; Böhm, 1998). The dikes likely correspond to two periods of mafic magmatism related to the Molson dike swarm (ca. 1880 Ma) and an older east-northeast-trending swarm (ca. 2090 Ma; e.g., Cauchon Lake, Gull Rapids, Birthday Rapids; Scoates and Macek, 1978; Heaman et al., 1986; Halls and Heaman, 2000; Heaman et al., 2009). The western part of the Partridge Crop Lake area is underlain by the extensive granitic to granodioritic Wintering Lake intrusion, which has yielded U-Pb ages of 1846 ±8 and 1822 ±5 Ma (Machado et al., 2011a, b).

The Partridge Crop Lake area represents a transition zone approximately 10 km wide, where east-striking Archean granulite-facies rocks of the PGD grade structurally and mineralogically into northeast to north-northeast-trending amphibolite-facies rocks of the TNB (Weber, 1976). East-striking gneisses in the eastern part of the transition zone are folded with axial planes of minor folds striking 010–020°. The deformation intensifies toward the west where the Archean gneissosity becomes transposed into a northeast or north-northeast direction (Weber, 1976). Peak metamorphic conditions during the Archean are estimated to have reached 800–860°C and 8.3–10.7 kbar in the Partridge Crop–Natawahunan lakes area (Paktunc and Baer, 1986; Mezger et al., 1990). Peak metamorphism during the Proterozoic is estimated to have reached upper-amphibolite–facies conditions (Couëslan and Pattison, 2012).

Lithological units

The lithological units identified in the Partridge Crop Lake area are divided into three main age groups: Archean rocks, rocks of uncertain age and Paleoproterozoic rocks. All rocks in the area have been subjected to at least upper-amphibolite–facies metamorphic conditions; however, to improve the readability of the text the 'meta-' prefix has been omitted from rock names.

Archean rocks

Archean rocks in the Partridge Crop Lake area are characterized by a weak to strong gneissosity. Archean granulite-facies metamorphic assemblages and textures are locally preserved. These rocks are presented in approximate order of formation.

Mafic gneiss

Exposures of mafic gneiss occur throughout the map area, but are most abundant along the eastern shore of Bryce Bay, in the Grass River channel immediately south of Bryce Bay, and in the southern basin of the map area (Figure GS-3-1). The mafic gneiss is grey to dark green-grey, coarse grained, foliated, and typically banded on a 2–70 cm scale (Figure GS-3-2a). The composition of the mafic gneiss is heterogeneous with variable proportions of hornblende, garnet, orthopyroxene and clinopyroxene typically accounting for more than 40% of the rock, and plagioclase for the remainder. Garnet is locally preserved with coronas of orthopyroxene±plagioclase (Figure GS-3-2b). Archean textures are locally well preserved with pods and veins of quartz-bearing leucosome ranging from 2 to 20 cm thick. Hudsonian retrogression resulted in the replacement of pyroxene by hornblende, and garnet by plagioclase and hornblende; however, relict garnet is typically present in amphibolitized rocks (Figure GS-3-2c). The leucosome commonly contains blocky hornblende, and rare fibrous anthophyllite, which are likely pseudomorphous after pyroxene.

The mafic gneiss contains local bands of garnetite 20–75 cm thick, which at one location in the southern basin of the map area appears to grade into pelitic sedimentary rocks. Gossanous zones up to 1 m thick are spatially associated with the garnetites at some locations and are typically subparallel to the compositional banding of the gneiss. The mafic gneiss contains local layers and lenses of iron formation that are typically 1–5 m thick and rarely up to 15 m. Garnet wacke and pelite can also be spatially associated with the mafic gneiss. The typical heterogeneity of the mafic gneiss combined with local interbanding and spatial association with sedimentary rocks suggest a mafic volcanic origin for the mafic gneiss; however, some outcrops are relatively homogeneous and could represent (synvolcanic?) intrusions.

Granodiorite–tonalite gneiss

The granodiorite–tonalite gneiss is the most common rock type in the map area (Figure GS-3-1). It is light grey to pinkish grey, medium grained, moderately to strongly foliated, and well banded on a 1–15 cm scale (Figure GS-3-2d). The gneiss varies from tonalitic to granodioritic, locally within the same outcrop. Mafic minerals, consisting of biotite and hornblende, typically make up 5–12% of the rock with biotite usually being dominant. Diffuse coarse-grained pods interpreted as preserved Archean leucosome are locally present. The pods contain aggregate clusters of biotite and hornblende that are likely pseudomorphous after pyroxene. Ten centimetre to two metre thick mafic and locally ultramafic boudins are common. Local banding suggests some boudins may represent rafts of mafic gneiss. Zones of intense deformation are relatively common in the form of straight gneisses, intense isoclinal folding and local rootless folds. Rare sheath folds are also present (Figure GS-3-2e).

Schollen-bearing tonalite–granodiorite gneiss

The schollen-bearing tonalite–granodiorite gneiss occurs throughout the map area, but is most common along the Grass River channel through the central and eastern portions of the map area (Figure GS-3-1). It is likely the amphibolitized equivalent of the schollen enderbite described on Natawahunan Lake (Böhm, 1998) and is texturally similar to the enderbite described from Cauchon Lake (Couëslan, GS-2, this volume). It is white to light grey, coarse grained, moderately to strongly foliated, and weakly banded. The schollen-bearing gneiss is dominantly tonalitic, although it locally contains up to 15% potassium feldspar, and contains 5–15% biotite and/or hornblende. Local patches contain equant hornblende that may be pseudomorphous after orthopyroxene. The gneiss typically contains 5–20% schollen (xenoliths), 3–150 cm long, of dominantly plagioclase amphibolite with lesser calcsilicate and ultramafic rock. Schollen of anorthosite is locally abundant (Figure GS-3-2f).

Weakly gneissic granodiorite

Isolated exposures of weakly gneissic granodiorite occur scattered in the southern basin of the map area (Figure GS-3-1). The weakly gneissic granodiorite is light grey to pink, medium to coarse grained, and relatively homogeneous. It displays a weak, discontinuous gneissosity that is defined by the attenuation of schlieren and diffuse, coarse-grained patches that are interpreted as Archean leucosome. The weakly gneissic granodiorite typically contains 5–7% biotite.

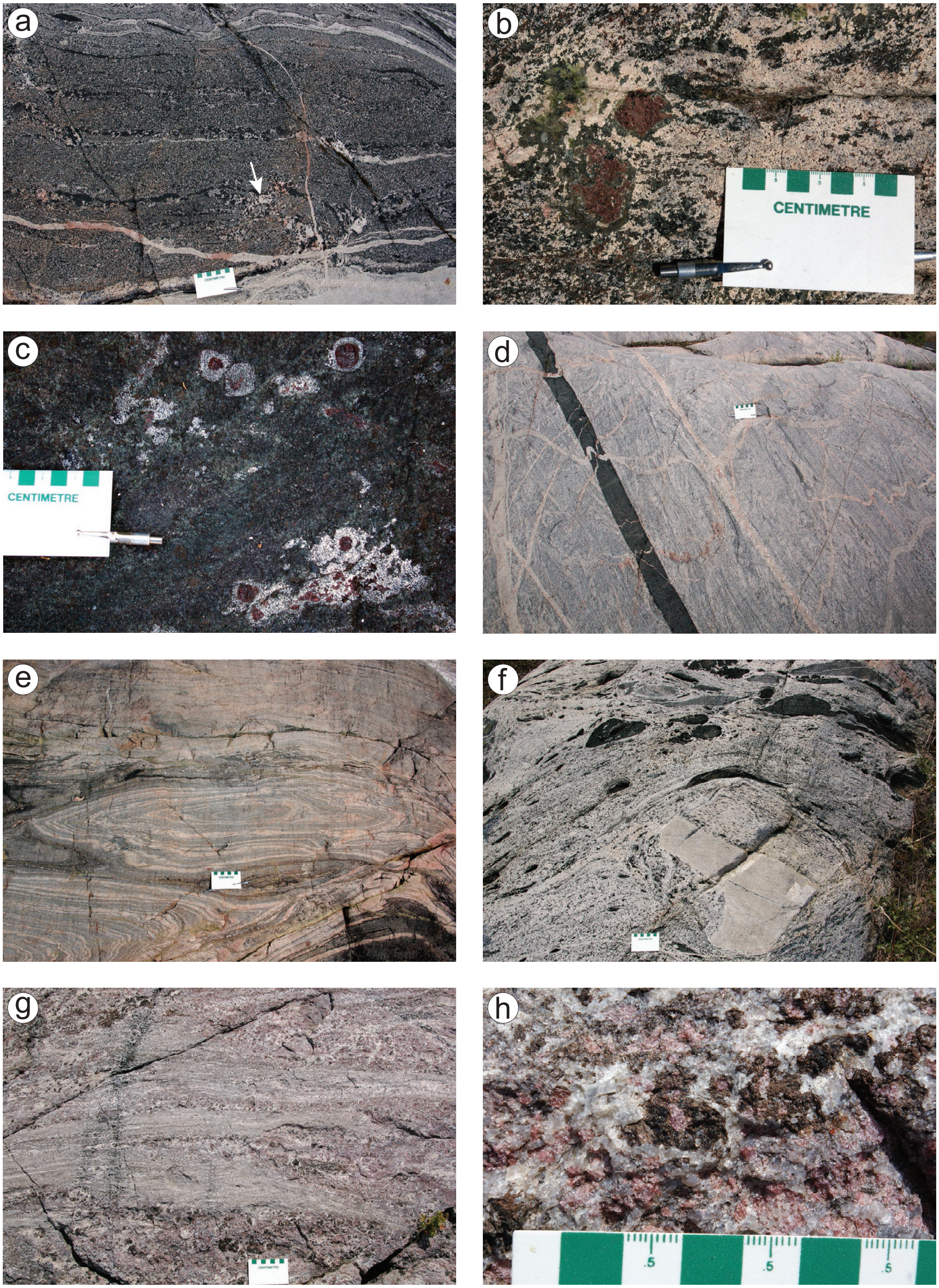

Figure GS-3-2: *Outcrop photographs from the Partridge Crop Lake area, central Manitoba:* ***a)*** *amphibolitized mafic gneiss with texturally preserved Archean leucosome (arrow);* ***b)*** *garnet with orthopyroxene coronas in mafic gneiss;* ***c)*** *garnet with plagioclase coronas in partially amphibolitized mafic gneiss;* ***d)*** *amphibolitized diabase dike transecting granodiorite gneiss;* ***e)*** *sheath folds in granodiorite gneiss;* ***f)*** *schollen-bearing tonalite gneiss, a raft of anorthosite is to the right of the scale card;* ***g)*** *pelite diatexite containing granulite-facies mineral assemblages;* ***h)*** *garnet rimmed by orthopyroxene (centre of photo) in pelite diatexite.*

Rocks of uncertain age

These rocks are largely sedimentary in origin. Preserved granulite-facies metamorphic assemblages in some units strongly suggest they are Archean; however, scattered exposures of sedimentary rocks with upper-amphibolite–facies peak metamorphic assemblages could suggest that a Paleoproterozoic sedimentary sequence(s) is also present. The stratigraphic order of these units is not known.

Pelite

A large exposure of pelite occurs along the southern shore of the map area and forms a belt almost 1.5 km wide (Figure GS-3-1). The pelite varies from purplish grey to brown grey, it is coarse grained, foliated, and compositionally banded on a 1–50 cm scale (Figure GS-3-2g). The pelite is typically retrogressed, but zones containing granulite-facies mineral assemblages are locally preserved. In these zones the composition of the pelite varies from 5–7% cordierite, 7–10% sillimanite, 7–10% biotite, 10–20% orthopyroxene, 20–30% quartz, and approximately equal proportions of potassium and plagioclase feldspar; to 5–7% sillimanite, 10–20% biotite, 10–20% orthopyroxene, 20–30% garnet, 30–40% quartz, and approximately equal proportions of potassium and plagioclase feldspar. Where present together, orthopyroxene locally forms coronas around garnet grains (Figure GS-3-2h). Much of the compositional variation of this unit could be the result of migmatization and differentiation into restite-rich and melt-rich bands. In most exposures, the pelite is retrogressed with orthopyroxene, cordierite, sillimanite and garnet that is replaced, or partially replaced, by combinations of biotite and chlorite. Orthopyroxene is also locally replaced by amphibole. Retrogressed zones are commonly strongly foliated to locally mylonitic. The pelite commonly contains discontinuous bands and boudins of calcsilicate and mafic rock from 15 to 100 cm thick. Local layers of garnet wacke, iron formation and garnetite up to 30 cm thick are also present, along with rare boudins of massive anthophyllite up to 70 cm across. This unit was interpreted by Weber (1978) as derived from hydrothermal alteration of the mafic gneiss; however, no direct evidence was observed to support this interpretation. Samples have been submitted for bulk-rock geochemistry to compare the trace-element signatures of the mafic gneiss and pelite.

Scattered exposures of pelite also occur throughout the southern and central portions of the map area where they are typically spatially associated with exposures of mafic gneiss, although isolated exposures of pelite, and pelite interbedded with garnet wacke, also occur. These scattered exposures are typically medium grained, and contain 7–10% garnet, 10–20% sillimanite and 20–40% biotite. Although these scattered exposures are migmatitic, the degree of partial melting and differentiation appears less than the main exposure of pelite described above (Figure GS-3-3a). A narrow band (3–5 m wide) of graphitic and sulphide-rich pelite, containing up to 20% semimassive pyrrhotite, is present in the central portion of the map area (Figure GS-3-1). The sulphide-rich pelite grades into garnet wacke and appears to be relatively continuous over at least 2 km.

Semipelite

Exposures of semipelite are scattered, but restricted to the southern basin of the map area where it typically occurs in association with garnet wacke and locally mafic gneiss. The semipelite is grey to pinkish grey, coarse grained, and strongly foliated to mylonitic. It typically contains 10–15% muscovite, 20–30% biotite, and roughly equal proportions of quartz, plagioclase and potassium feldspar. Garnet is locally present in trace amounts. Potassium feldspar–rich leucosome is ubiquitous and migmatization has typically disrupted all primary compositional banding (i.e., diatexite, Figure GS-3-3b). The muscovite occurs as aggregates of randomly oriented grains that are pseudomorphous after knots of sillimanite. At one location the semipelite occurs as a 1–1.5 m wide band in contact with calcsilicate grading into impure marble, and spatially associated with silicate-facies iron formation and sulphide-bearing ultramafic amphibolite.

Garnet wacke

The garnet wacke occurs as scattered exposures in the southern and central portions of the map area (Figure GS-3-1). It is usually associated with pelite and semipelite, but locally occurs interbanded/infolded with mafic gneiss. The garnet wacke is grey to purplish grey, medium grained, strongly foliated, and banded on a 1–15 cm scale. It typically contains 3–7% garnet, 20–30% biotite, and roughly equal proportions of quartz and plagioclase. Veins and pods of leucosome locally contain equant aggregates of anthophyllite, likely pseudomorphous after orthopyroxene. Discontinuous bands and boudins of iron formation, plagioclase amphibolite and calcsilicate, typically less than 30 cm thick, are common. Where it is associated with sulphide-rich pelite, the garnet wacke contains disseminated sulphide and a light, but pervasive, gossan stain.

Iron formation

Iron formation occurs throughout the map area, typically as bands and lenses in mafic gneiss, pelite and garnet wacke. Bands are typically <1 m thick, but on one island, in central Bryce Bay, iron formation occurs interbanded with mafic gneiss on a scale of metres to tens of metres (Figure GS-3-1). The majority of iron formation occurrences consist of silicate-facies iron formation, with oxide-facies iron formation being relatively rare. The iron formation is typically dark green to rusty brown, medium

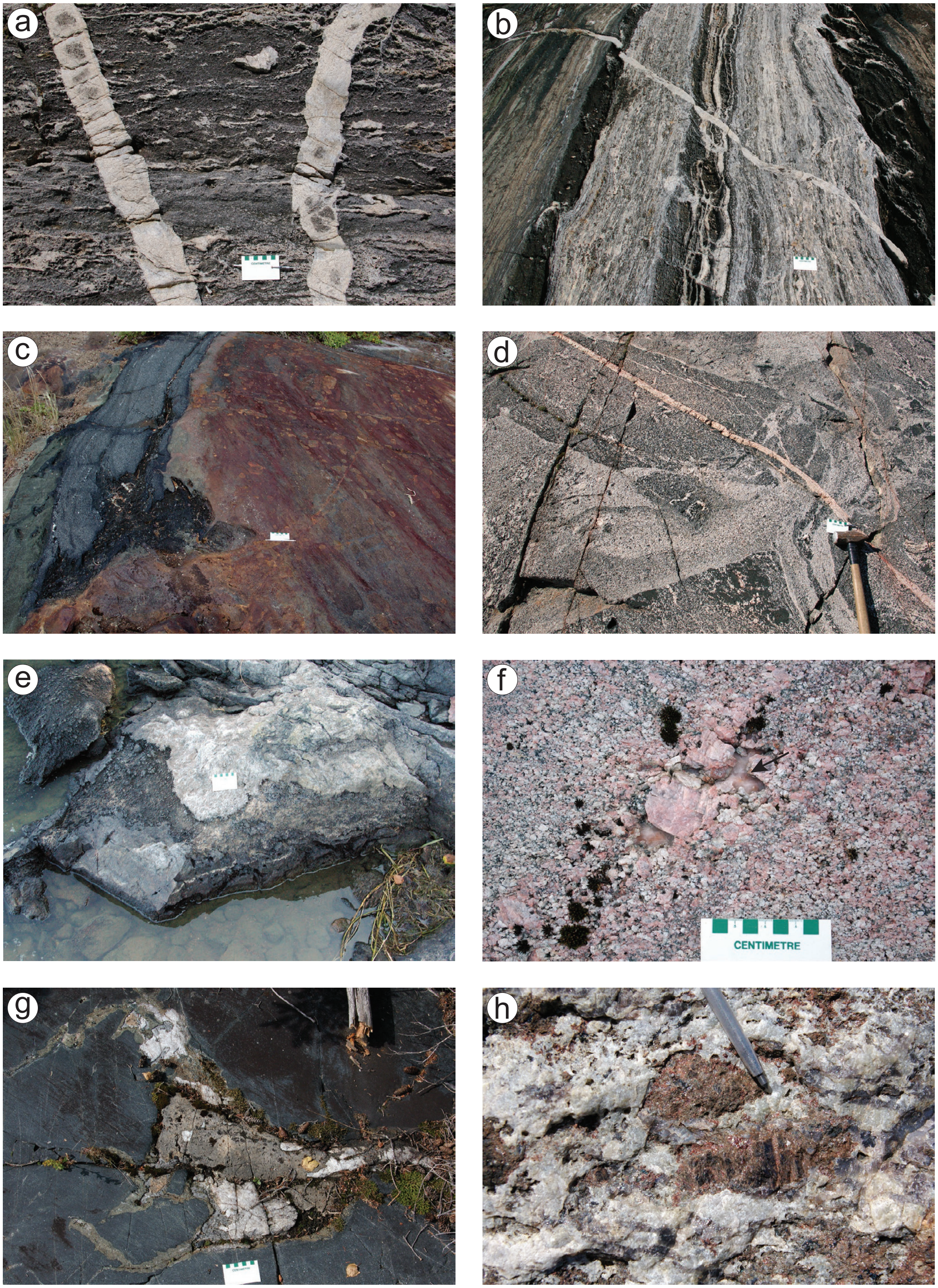

Figure GS-3-3: *Outcrop photographs from the Partridge Crop Lake area, central Manitoba:* ***a)*** *pelite containing upper-amphibolite–facies mineral assemblages;* ***b)*** *semipelite diatexite (centre) grading in both directions to calcsilicate;* ***c)*** *gossanous ultramafic amphibolite containing disseminated and stringer sulphide;* ***d)*** *syenitic intrusive breccia dominated by melasyenite;* ***e)*** *carbonatite-like band with irregular margins (recessive weathering below and left of scale card);* ***f)*** *carbonate blebs (arrow) in Wintering Lake intrusion in vicinity of carbonatite-like bands;* ***g)*** *late carbonate vein in amphibolitized diabase;* ***h)*** *leucosome in pelitic granulite with orthopyroxene rimmed by fine-grained aggregates of garnet and magnetite.*

to coarse grained, foliated, and strongly magnetic. The composition is variable and typically consists of ferruginous layers with varying proportions of Fe-orthopyroxene, garnet, magnetite and pyrrhotite separated by chert layers 2–20 mm thick. Local, discontinuous garnetite bands may be up to 10 cm thick.

Calcsilicate and impure marble

The calcsilicate is green-grey to green, medium to coarse grained, and massive to locally banded on a 1–10 cm scale (Figure GS-3-3b). The composition typically consists of massive diopside with variable but minor amounts of hornblende, biotite, plagioclase, and quartz or carbonate. The calcsilicate rarely forms bands up to 2 m thick. Calcsilicate typically occurs as bands and boudins in pelite and garnet wacke; however, it also occurs at one locality in the southern basin of the map area, in contact with semipelite and grading into impure marble (Figure GS-3-1). The impure marble is grey to pinkish grey, coarse grained and foliated. It contains 10–20% phlogopite, 30–40% olivine and carbonate.

Ultramafic amphibolite

The ultramafic amphibolite occurs as rare bands and boudins throughout the map area. It occurs as isolated rafts in granite, and as bands in mafic gneiss up to 2 m wide. The ultramafic amphibolite consists dominantly of green amphibole with varying amounts of hornblende, anthophyllite and biotite. At one location in the southern basin of the map area, the ultramafic amphibolite is gossanous and contains 10–15% sulphide as stringers and disseminated grains (Figure GS-3-3c). Chalcopyrite was tentatively identified in some stringers. The sulphidic ultramafic amphibolite is spatially associated with mafic gneiss and a supracrustal sequence that includes semipelite in contact with calcsilicate grading into impure marble, and silicate-facies iron formation.

Proterozoic rocks

Proterozoic rocks in the Partridge Crop Lake area consist of dominantly igneous intrusive rocks. No contacts were observed between the units to constrain the relative ages.

Diabase dikes

Diabase dikes occur throughout the map area and range from 1 cm to 15 m thick; however, the largest dikes (>10 m) are most common in the Bryce Bay area (Figure GS-3-1). The majority of dikes trend 012–017° with occasional dikes trending 041–043°, and rarely 303–335°. The three orientations are compatible with dikes of the Molson, Cauchon and Mackenzie swarms, respectively (LeCheminant and Heaman, 1989; Halls and Heaman, 2000). In the eastern portion of the map area and at Bryce Bay, larger dikes typically retain igneous mineral assemblages and textures, with local zones of hydration accompanied by the development of a foliation. Throughout the remainder of the map area, the dikes occur as bands of plagioclase amphibolite that are typically foliated and discordant to the gneissosity (Figure GS-3-2d). Increasing deformation can result in the boudinage of dikes.

Pristine diabase is typically grey-brown and medium grained. It contains 30–50% plagioclase, variable amounts of clinopyroxene and orthopyroxene, and 2–3% ilmenite. Local quartz- and hornblende-bearing pegmatitic segregations are typically <20 cm across. Amphibolitized dikes are typically dark greenish grey, fine to medium grained and foliated. They consist of plagioclase and >50% hornblende. Layering is locally present in amphibolitized dikes and is interpreted as igneous.

Melasyenite

An intrusion of melasyenite is present in the central portion of the map area and forms a body of at least 200 by 800 m (Figure GS-3-1). The melasyenite is pinkish green, coarse grained and foliated. It contains 20–30% dark green amphibole, and potassium feldspar. The amphibole occurs as polycrystalline aggregates that may be pseudomorphous after clinopyroxene. The melasyenite forms the dominant phase of an intrusion breccia (Figure GS-3-3d) that locally contains angular blocks of older hornblendite/metaclinopyroxenite up to 45 by 75 cm and is intruded by a stockwork of at least two phases of mesocratic to leucocratic syenite. The melasyenite contains a fabric that is disrupted by the stockwork of later syenite phases.

Tonalite–granodiorite

A pluton grading from tonalitic to granodioritic occurs along the western shore of Bryce Bay over a length of at least 2.5 km (Figure GS-3-1). It is light grey to pinkish grey, medium grained and foliated. It typically contains 3–10% biotite and 7–10% potassium feldspar, although up to 20% potassium feldspar is locally present. The intrusion locally contains xenoliths of mafic gneiss and granodiorite–tonalite gneiss, from 20 cm to 5 m across. Dikes of granodiorite up to 7 m thick intrude adjacent outcrops of granodiorite–tonalite gneiss.

Wintering Lake intrusion

A portion of the Wintering Lake intrusion is exposed along the western shore of the southern basin of the map area, where it forms outcrops of relatively homogeneous granite. The granite is pink to pinkish grey, coarse grained and foliated. It typically contains 3–7% biotite, and rare grains of garnet and allanite. Potassium feldspar forms phenocryst up to 2.5 cm. The granite locally contains blocks of gneiss and plagioclase amphibolite up to 30 m across. Related granitic dikes increase in abundance toward, and form an irregular stockwork adjacent to, the main intrusion.

Quartz monzonite–granite

An intrusion of quartz monzonite occurs through the central islands of Bryce Bay and grades into granite toward the northern shore of the bay (Figure GS-3-1). The total length of the intrusion is at least 2.5 km, but the width is uncertain because of poor exposure. It is light pink, coarse grained, and foliated to mylonitic. It typically contains 3–7% hornblende and/or biotite, and trace amounts of allanite. Potassium feldspar forms phenocryst up to 5 cm across that are locally zoned and twinned. This unit appears to be part of a larger intrusion that extends along the TNB-PGD boundary to Apussigamasi Lake. Its textural and mineralogical similarity to the Wintering Lake intrusion could suggest a comagmatic relationship. Samples have been submitted for bulk-rock geochemistry to investigate this possibility.

Pegmatite–aplite

Dikes and irregular pods of pegmatite and aplite are ubiquitous in the Partridge Crop Lake area and are present in the majority of outcrops. Dikes are typically from 2 to 200 cm in width, but locally exceed 10 m. They typically contain <5% biotite and vary from granodioritic to granitic. Dikes vary from discordant to concordant in relation to regional gneissosity and foliations, and likely represent a range of intrusive ages.

Carbonate rocks of uncertain affinity

Two varieties of carbonate rock of uncertain affinity were observed in the Partridge Crop Lake area. An exposure of foliated carbonatite-like bands were discovered west of the map area, and small, undeformed carbonate-bearing veins were observed at several locations in the southern basin of the map area.

Carbonatite-like bands

Carbonatite-like bands were identified at one locality just west of the map area near the Hudson Bay Railway bridge over the Grass River. Seven to eight individual bands, 10–50 cm thick and several metres long, occur along a 30 m stretch of shoreline. Most exposures appear to be about 30–60 cm below normal water levels. There are at least two varieties. The more common variety is pinkish grey, medium grained, and massive to foliated. It contains trace amounts of apatite and scapolite, 1–2% titanite, 3–5% clinopyroxene, 10–20% green amphibole, 10–20% epidote, and carbonate. The other, less common variety, is light grey, medium grained, massive to foliated, and magnetic. It contains 1–2% magnetite, 5–7% chlorite, 7–10% clinopyroxene, 20–30% serpentinized olivine, 20–30% white carbonate and grey carbonate. The bands contain up to 20% xenolithic/xenocrystic material derived from the wallrock, which gives the carbonatite-like bands a knobby weathered surface. The bands vary from relatively irregular, convoluted forms, to folded but relatively continuous bands with irregular margins (Figure GS-3-3e). The folding varies from tight to open. Folded and foliated pegmatite and aplite dikes locally cut across the bands. Lichen and algae make identification of the hostrock difficult. Rock in contact with the carbonatite-like bands typically consists of variable proportions of epidote, green amphibole, and potassium feldspar. Nearby exposures of the Wintering Lake intrusion locally contain vuggy-weathering carbonate blebs (Figure GS-3-3f).

Late carbonate veins

Late, unfoliated carbonate veins are present at several locations in the southern basin of the map area (Figure GS-3-1). They range from small centimetre-scale blebs to irregular veins from one to several centimetres thick and several metres long. The veins consist of yellow-orange– to white–weathering carbonate, euhedral epidote and amphibole grains up to 1 cm across, and local white quartz (Figure GS-3-3g). Rare apatite occurs as small green to blue prisms. The late carbonate veins are hosted in mafic gneiss, diabase dikes, pelite, and granodiorite–tonalite gneiss, and typically have selvages of varying proportions of epidote and amphibole.

Structural geology

The earliest structure recognized in the Partridge Crop area consists of a roughly east-trending, subvertical Archean gneissosity (S_A). Over much of the map area, the gneissosity is intersected at a high angle by a subvertical Paleoproterozoic foliation (S_P) that typically trends 010–040°. The S_A fabric is locally transposed subparallel to S_P, this relationship becomes increasingly common toward the western portion of the map area. The S_P fabric is axial planar to minor folds that generally have steeply northeast or southwest plunging fold axes; however, other fold axis orientations are present. Zones of intense isoclinal folding, local rootless folds, and rare sheath folds in the granodiorite–tonalite gneiss are typically axial planar to S_P (Figure GS-3-2e). Rodding structures display a similar range of orientations as the minor fold axes. Fabric asymmetry around potassium feldspar phenocrysts in the Wintering Lake intrusion indicates a sinistral shear component associated with the S_P foliation. Local mylonite zones subparallel to S_P also contain sinistral shear sense indicators. Both sinistral and dextral brittle-ductile shears are recognized overprinting S_P. Brittle-ductile shears are steeply dipping and typically trend northeast, but east-trending shear zones were also recognized. Rare, late dextral brittle faults are southwest trending. Fractures and epidote-filled veins associated with brittle-ductile and brittle structures typically have selvages of K-Fe alteration.

Metamorphic geology

Archean granulite-facies assemblages are locally preserved throughout the map area, but are most common in the eastern Bryce Bay area. Preserved granulite-facies mineral assemblages in the mafic gneiss contain varying proportions of orthopyroxene, clinopyroxene, garnet, hornblende and plagioclase. Locally preserved garnet with coronas of orthopyroxene±plagioclase (Figure GS-3-2b) indicate isothermal decompression and suggest that the Archean metamorphism evolved along a clockwise P-T-t path, contrary to the findings of Mezger et al. (1990) for the Pikwitonei granulite domain.

Locally preserved granulite-facies assemblages in pelite along the southern shore of the map area strongly suggest the pelite is Archean. These rocks consist of varying proportions of garnet, orthopyroxene, sillimanite, biotite, potassium feldspar, quartz and plagioclase with minor rutile; and cordierite, orthopyroxene, sillimanite, biotite, quartz, potassium feldspar, plagioclase and minor rutile. These assemblages are similar to those observed on Sipiwesk Lake (Couëslan et al., 2012), and suggest metamorphic conditions in the range of 800–900°C and >7 kbar. Garnet with orthopyroxene coronas are also locally observed in pelitic bulk compositions (Figure GS-3-2h), which supports a clockwise P-T-t path for the metamorphic evolution of these rocks.

Mineral assemblage observed in scattered pelite exposures contrasts greatly with the pelite observed along the southern shore of the southern basin of the map area. These exposures are medium grained, migmatitic and contain assemblages of biotite, garnet, sillimanite, quartz and plagioclase, which suggest upper-amphibolite–facies metamorphic conditions. This is further supported by apparently lower degrees of partial melting and migmatitic differentiation (Figure GS-3-3a). This contrast in metamorphic grade could indicate the presence of a younger metasedimentary sequence that was only affected by Hudsonian amphibolite-facies metamorphism. However, this interpretation warrants caution. These scattered pelite exposures are commonly associated with occurrences of Archean mafic gneiss, and different mineral assemblages could be the product of bulk compositional differences. Moreover, early granulite-facies mineral assemblages could have been completely replaced during Hudsonian metamorphism; however, this would have required high strain rates to erase prior evidence for granulite-facies mineral assemblages and metamorphic/migmatitic differentiation.

Hudsonian metamorphism of Paleoproterozoic mafic dikes, and hydrous retrogression of Archean mafic gneiss, produced amphibolite-facies assemblages of hornblende and plagioclase. Garnet typically remains as a relict phase in amphibolitized mafic gneiss, but is locally rimmed by coronas of plagioclase±hornblende (Figure GS-3-2c), and is rarely completely replaced, which can give the rock a mottled texture. Rare examples of anhydrous retrogression occur in both mafic gneiss and pelitic granulite, where granulite-facies mafic minerals are rimmed by fine-grained aggregates of garnet and magnetite (Figure GS-3-3h). Exposures of pelite with strong Hudsonian fabrics are migmatitic and contain biotite-, garnet- and sillimanite-bearing assemblages that suggest upper-amphibolite–facies metamorphic conditions in the range of 650–750°C and 4–8 kbar.

Extensive zones of lower grade retrogression occur in the southern basin of the map area and in the east-west channel of the Grass River. In the southern basin of the map area, mafic minerals in exposures of mafic gneiss, granodiorite–tonalite gneiss, schollen-bearing gneiss, garnet wacke and pelite are replaced, or partially replaced, by aggregates of chlorite, actinolite and magnetite. The retrogression can be pervasive or in irregular diffuse zones, and locally appears to be accompanied by silicification. The retrogression occurred in high-strain zones, and also under apparently static conditions, such that actinolite and chlorite form felted masses after pyroxene and amphibole. Retrogression in the Grass River channel east of Bryce Bay overprinted mafic gneiss, weakly gneissic granodiorite, and granodiorite–tonalite gneiss. Feldspars are bleached, chalky white, and mafic minerals are replaced by chlorite. Veins of epidote and quartz±albite and carbonate are common.

Economic considerations

A sedimentary sequence in the southern basin, consisting of semipelite grading into calcsilicate and impure marble, is similar to the progression from the Manasan formation to the Thompson formation of the Ospwagan group. This similarity is enhanced by adjacent exposures of iron formation, which could potentially be correlated to the Pipe formation of the Ospwagan group. Exposures of sulphidic, ultramafic amphibolite are also present within several metres of the semipelite and marble. Unfortunately, this sequence has been partially disrupted by granitic stockwork from the nearby Wintering Lake intrusion. The sedimentary sequence is also closely associated with exposures of mafic gneiss, which suggests it could be Archean. The semipelite and marble were sampled for bulk-rock geochemistry, and the semipelite will be submitted for Sm-Nd isotopic analysis to ascertain its possible relationship to the Ospwagan group, using the methodology set out by Böhm et al. (2007). The sulphidic ultramafic amphibolite was sampled for assay.

A narrow band (approximately 5 m wide) of sulphidic and graphitic pelite is present in the central portion of the map area. Rocks of this type in the Pipe formation of the Ospwagan group are considered to have been the main source of sulphur for nickel sulphide deposits hosted by ultramafic intrusions of the Thompson nickel belt. Although the pelite is of uncertain age, it is continuous over a couple of kilometres and could have supplied sulphur to any intersecting ultramafic magmas. A sample of sulphidic and graphitic pelite was selected for bulk-rock geochemistry.

Glacially deposited cobbles of serpentinized dunite were observed at two locations in southeast Bryce Bay and at one location in Makasew Bay. The cobbles are subangular suggesting limited transport. Two generations of glacial striations were tentatively identified in the Partridge Crop area: an older set trending approximately 200°, and a younger set trending 260°. Therefore, an ultramafic body, similar to those that generated the nickel deposits of the Thompson nickel belt, may lie to the east and north of Bryce Bay.

Gossanous zones up to one metre thick are locally present within the mafic gneiss. These zones are typically subconcordant to the gneissosity and spatially associated with bands of silicate- and oxide-facies iron formation, and garnetite. The presence of exhalative sedimentary rocks suggests that these sections of mafic gneiss likely represent mafic volcanic rocks, and the gossanous zones in association with exhalative sedimentary rocks suggest a potential for both gold and base metal (VMS) mineralization. Samples of sulphide-bearing iron formation and mafic gneiss were collected for assay.

Samples of the carbonatite-like bands from outside the map area, and the carbonate veins from the southern basin of the map area, were collected for geochemical and petrographic analyses. Carbonatites are important sources for a variety of rare metals (REE, Y, Nb), and if the carbonate rocks from the Partridge Crop area are found to be of carbonatitic affinity then additional mapping toward the south and west is warranted.

Although some anorthositic rocks are known from eastern Partridge Crop Lake (Weber and Malyon, 1978), the presence of anorthosite fragments within the schollen-bearing tonalite–granodiorite gneiss could indicate that it is more widespread than previously recognized, which may in turn indicate potential for anorthosite-hosted Ti-Fe-V-P deposits.

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