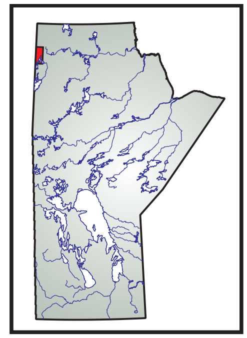
GS-4 Far North Geomapping Initiative: geological mapping in the Misty Lake area, Manitoba (parts of NTS 64K12, 13, 64N4)

by P.D. Kremer, A.R. Carlson and C.G. Couëslan



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Summary

Six weeks of bedrock geological mapping was undertaken in the Misty Lake area of northwestern Manitoba, as part of the Manitoba Geological Survey's Far North Geomapping Initiative. The aim was to examine, document and characterize the southwestern margin of the Hearne craton and its Paleoproterozoic cover sequence(s), in an effort to upgrade the geological knowledge base in this part of the province.

The Misty Lake area occupies the northeastern termination of a structural dome. The dome is cored by foliated to gneissic, biotite±hornblende±orthopyroxene leucotonalite to granite, interpreted to be Archean in age. The core of the dome is bounded to the southeast, northeast and northwest by highly deformed metasedimentary rocks of the Wollaston Supergroup. Outward from the core, the metasedimentary sequence includes variably migmatitic porphyroblastic psammitic to pelitic paragneiss with minor impure quartzite, porphyroblastic arkosic paragneiss with minor calcsilicate, rare marble and calcsilicate rocks, and well-bedded arenite to calcarenite with calcsilicate interlayers. Intrusive rocks, interpreted as Hudsonian in age (ca. 1.83 Ga) on the basis of field relationships with metasedimentary rocks, are widespread, range in composition from tonalite and granodiorite to syenogranite and K-feldspar granite, and vary in texture and grain size, from very fine-grained to pegmatitic and massive to foliated. Areas of moderate to intense alkali metasomatism occur in metasedimentary rocks and granitic rocks and, in one location, cross the contact between the two. The metasomatic zones are characterized by partial to complete replacement of the host rock types by albite–clinopyroxene–amphibole±fluorite±calcite±scapolite. Alkali metasomatism has been documented in association with a variety of intrusion-hosted and metasomatic U, rare earth element (REE) and rare element mineral deposits.

In addition to refining existing geological maps for the area, samples collected for whole rock geochemical, U-Pb geochronological, Sm-Nd tracer isotope and assay analyses, will be used to determine the nature, distribution and age of Archean and Paleoproterozoic rocks at the southeastern Hearne margin, as well as the provenance, age and depositional setting of metasedimentary rocks of the Wollaston Supergroup cover sequence. Furthermore, these data can be compared to, and integrated with, data from the already completed components of the Far North Geomapping Initiative (e.g., Kasmere Lake, Putahow Lake and Nejanilini Lake) for regional correlations across Manitoba's far north.

Introduction

This report summarizes results from six weeks of geological mapping conducted in the Misty Lake area of northwestern Manitoba, during July and August 2010. The Misty Lake area was previously mapped in the mid-1970s (Weber et al., 1975). The current study is part of the Manitoba Geological Survey's Far North Geomapping Initiative, which is a three-year project in collaboration with the Geological Survey of Canada. The purpose of the project is to examine the mineral potential of, and contribute to, the geological mapping and geoscientific knowledge base of Manitoba's far north. The Far North Geomapping Initiative expands on work carried out between 2004 and 2006 (Böhm et al., 2004; Anderson and Böhm, 2005; Matile, 2005; Anderson and Böhm, 2006; Böhm and Anderson, 2006a, b). Recently, the Far North Geomapping Initiative has focused on geological mapping of the Seal River region in northeastern Manitoba (Anderson and Böhm, 2008; Anderson et al., 2009a; Anderson et al., 2009b; Anderson et al., GS-1, this volume). The Wollaston Domain, which forms part of the basement sequence to the Proterozoic Athabasca Basin in northeastern Saskatchewan, locally contains basement-hosted unconformity-related uranium deposits (e.g., Millennium deposit). A number of uranium occurrences in Saskatchewan are associated with particular strata of the Wollaston Supergroup (graphitic pelite of the Daly Lake Group, calcsilicate and calcareous arkose of the Geikie River Group) (Yeo and Delaney, 2007). As a result, the Wollaston Domain in northwestern Manitoba has seen a recent increase in exploration activity. Regional mapping in the Misty Lake area will provide data allowing for comparison and correlation between metasedimentary rocks of the Wollaston Domain in Manitoba with those in Saskatchewan, including known uranium-hosting strata.

Regional setting

The Misty Lake project area lies in the Wollaston Domain of the western Churchill Province in northwestern Manitoba, approximately 230 km north of Lynn Lake and just east of the provincial border between Manitoba and Saskatchewan. The Wollaston Domain comprises Paleoproterozoic rift, passive margin and foreland sedimentary sequences (collectively termed the Wollaston Supergroup), which overlie and contain inliers of Neoarchean basement rocks of the southeast Hearne craton margin (Tran, 2001; Tran et al., 2003; Yeo and Delaney, 2007) (Figure GS-4-1).

In Saskatchewan, inliers of the Hearne craton within the Wollaston Domain are composed of various suites of plutonic rocks including charnockite, monzonite-granite-granodiorite, granodiorite-tonalite, amphibolite, and mixed intrusive and sedimentary rocks (Tran, 2001; Yeo and Delaney, 2007). The majority of ages reported for the southeastern Hearne craton range from 2650 to 2500 Ma (Ray and Wanless, 1980; Annesley et al., 1993; Hamilton and Delaney, 2000; Bickford et al., 2001; Maxeiner et al., 2004; Rayner et al., 2005); however, older ages are documented in the transitional zone between the Wollaston Domain and the adjacent Mudjatik Domain to the northwest (Annesley et al., 1993).

The Wollaston Supergroup has been subdivided into four groups separated by regional unconformities (Yeo and Delaney, 2007), each of which represents a distinct stage in the tectonic and sedimentary evolution of the basin. The Courtenay Lake Group (equivalent to the Needles Falls Group of Ray, 1979 and Tran, 2001), composed of conglomerate and arkosic rocks intercalated with bimodal volcanic rocks, represents the oldest supracrustal rocks in the Wollaston Supergroup and is interpreted as a syn-rift succession. An age of ca. 2.1 Ga for felsic volcanic rocks of the Courtenay Lake Group constrains the age of rifting (Ray, 1979; Ansdell et al., 2000). The Souter

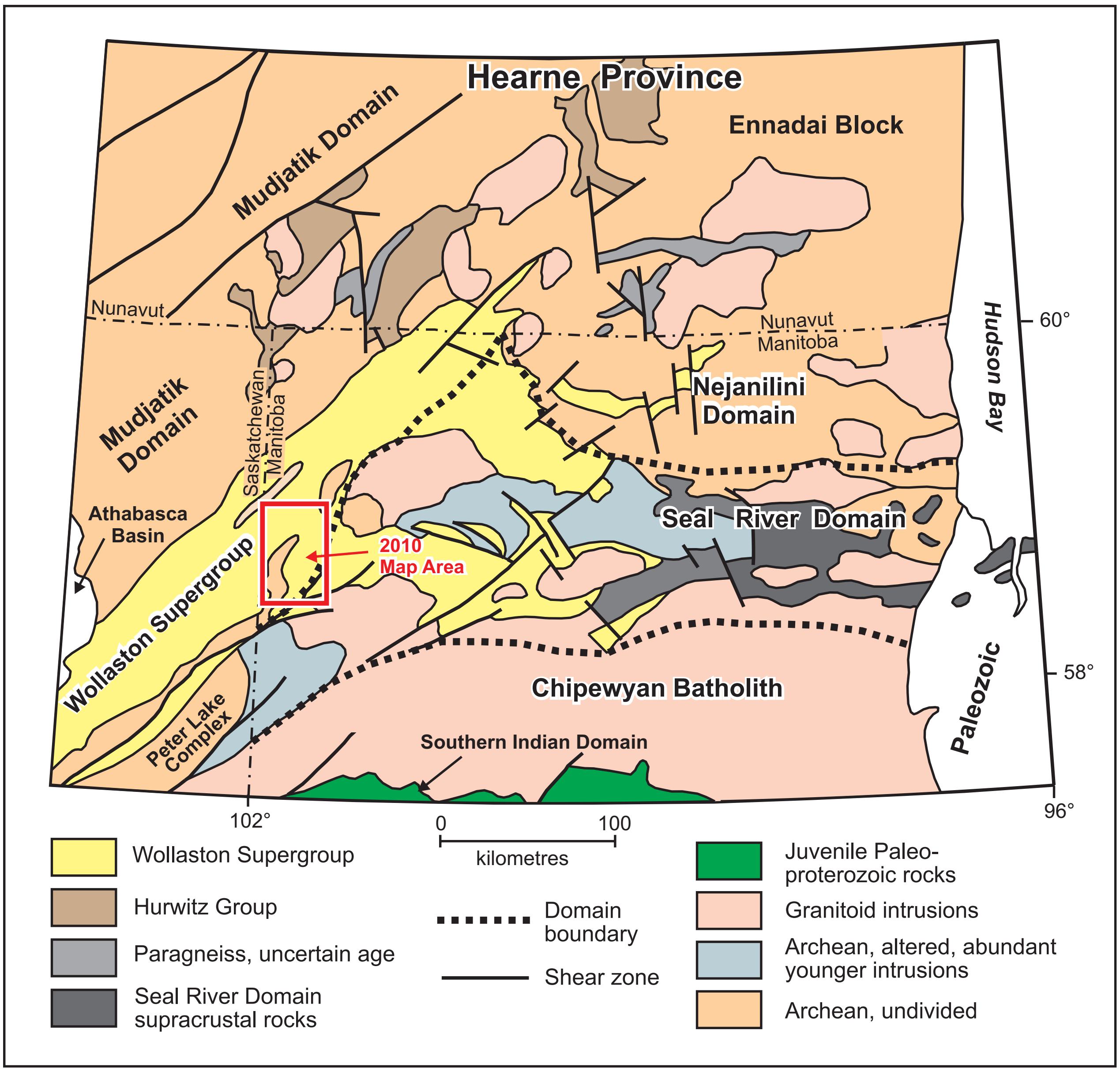

Figure GS-4-1: *General geology of the southeastern Hearne margin, showing the location of the Misty Lake project area.*

Lake Group overlies the Courtenay Lake Group and consists dominantly of quartzitic and psammitic siliciclastic rocks, inferred to form part of a stable platform or passive margin sequence (Yeo and Delaney, 2007). This is in turn overlain by the Daly Lake Group, which consists of various successions of pelite and psammopelite with minor quartzite, calcsilicate rocks and marble, and arkosic to quartzitic rocks that define an upward-coarsening succession. The Daly Lake Group is interpreted to record early stage foreland-basin sedimentation atop the southeastern Hearne margin. Conglomerate, arkose, calcsilicate and marble of the Geikie River Group form the upper succession of the Wollaston Supergroup, which is thought to represent a later stage of foreland-basin infilling. In the Misty Lake area, the exposed metasedimentary rocks appear to be most similar to the early foreland-basin stage (Daly Lake Group) as described by Yeo and Delaney (2007). Similar correlations were made for metasedimentary rocks of the Wollaston Supergroup in the Kasmere and Putahow lakes area in northwestern Manitoba (Böhm and Anderson, 2006b).

Four distinct populations of zircons have been identified from geochronological analyses on various metasedimentary rocks within the Wollaston Domain in Saskatchewan: 1) >2450 Ma, representing detritus eroded from Archean basement rocks of the Hearne craton; 2) ca. 2.1 Ma, thought to correspond to reworking of the underlying Courtenay Lake/Needles Falls Group; 3) 1920–1880 Ma, interpreted as detritus shed from the advancing volcanic terranes of the western Churchill Province (Rottenstone and Southern Indian domains); and 4) 1840–1790 Ma, interpreted as metamorphic zircon growth during peak Hudsonian tectonometamorphism (Ansdell et al., 2000; Hamilton and Delaney, 2000; Tran, 2001; Yeo and Delaney, 2007; Tran et al., 2008). Rocks in the lower successions of the Wollaston Supergroup (Courtenay Lake and Souter Lake groups), contain exclusively Archean to earliest Proterozoic zircons; Paleoproterozoic zircons increase in abundance moving up stratigraphy.

The Wollaston Domain experienced significant tectonothermal reworking during the Trans-Hudson orogeny. Metasedimentary rocks of the Wollaston Supergroup were intensely deformed and interfolded with basement granitic rocks during four episodes of ductile deformation (Lewry and Sibbald, 1980; Yeo and Delaney, 2007). Structural features corresponding to D_1 and D_3 are predominant and correspond to two generations of metamorphism and anatexis (Yeo and Delaney, 2007).

Felsic intrusive rocks in the western Churchill Province range from small plugs and sills to large batholiths. The ca. 1.86 Ga Chipewyan (Wathaman) Batholith, which intrudes the Wollaston Domain, represents continental-arc magmatism along the southern Hearne margin (Corrigan et al., 2000). The Hudson granite suite was emplaced during terminal collision of the Trans-Hudson orogeny. The granitic suite ranges in age from 1.84 to 1.79 Ga with a main plutonic phase ca. 1.83 Ga (van Breemen et al., 2005).

Geology of the Misty Lake area

The following section provides preliminary field descriptions, an overview of contact relationships between rock types and interpretations of the overall geology, based on six weeks of mapping, conducted in the Misty Lake area during the summer of 2010 (Kremer et al., 2010). Geochemical and geochronological laboratory analyses are pending.

Possible basement rocks

Variably foliated to locally gneissic leucotonalite to granodiorite forms the core of a large structural dome in central Misty Lake that extends southwest towards Waspison Lake (Figure GS-4-2). Leucotonalite to granodiorite is medium- to coarse-grained, weathers buff pink to white and has locally developed pale orange patches. It is generally massive and homogeneous, to locally gneissic in individual outcrops (Figure GS-4-3), but shows minor variations from exposure to exposure. The principal minerals found are plagioclase (50–60%), quartz (30%), K-feldspar (5–15%) and biotite (~5%) ±hornblende ±orthopyroxene, with varying amounts of accessory magnetite, titanite and allanite. Southwest of Asinneewakamow Island, granodiorite locally contains up to 2% titanite and allanite.

Leucotonalite to granodiorite contains a moderately- to well-developed foliation, defined by parallel alignment of biotite±hornblende, which occurs in discontinuous wisps <2 mm thick and approximately 5 cm long (Figure GS-4-3a). Although the contact with surrounding metasedimentary rocks is well constrained by mapping, the nature of the contact relationships is unclear, mainly due to structural and recrystallization overprint. Based on field relationships, Weber et al. (1975) interpreted leucotonalite and granodiorite to be Archean, which is in accordance with the apparent absence of tonalite or granodiorite dikes in the flanking metasedimentary rocks, or metasedimentary xenoliths in the leucotonalite and granodiorite. Together, these observations suggest that the intrusive suite could be older (basement?) than the metasedimentary rocks. A sample of this unit was collected for U-Pb geochronological analysis to test this interpretation.

Metasedimentary rocks

Psammitic to pelitic paragneiss

Psammitic to pelitic gneiss forms a continuous sequence that extends from the Cochrane River, northwest of Misty Lake, to the northwestern corner of Lac Brochet. In map pattern, it defines a macroscopic fold cored by foliated leucotonalite to granodiorite (Figure GS-4-2). Layering of paragneiss units, visible in outcrop as

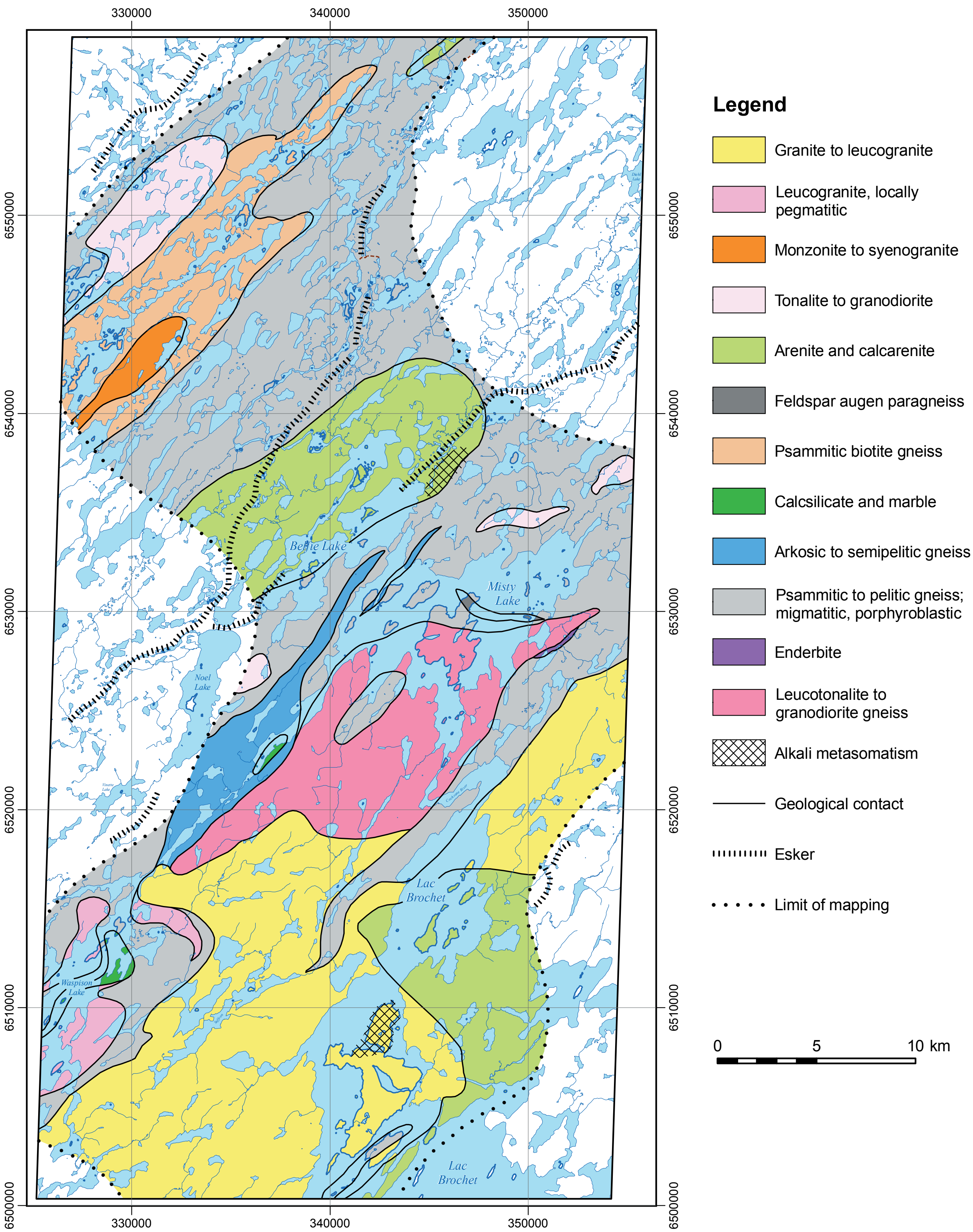

Figure GS-4-2: *Simplified geological map of the Misty Lake area, northwestern Manitoba.*

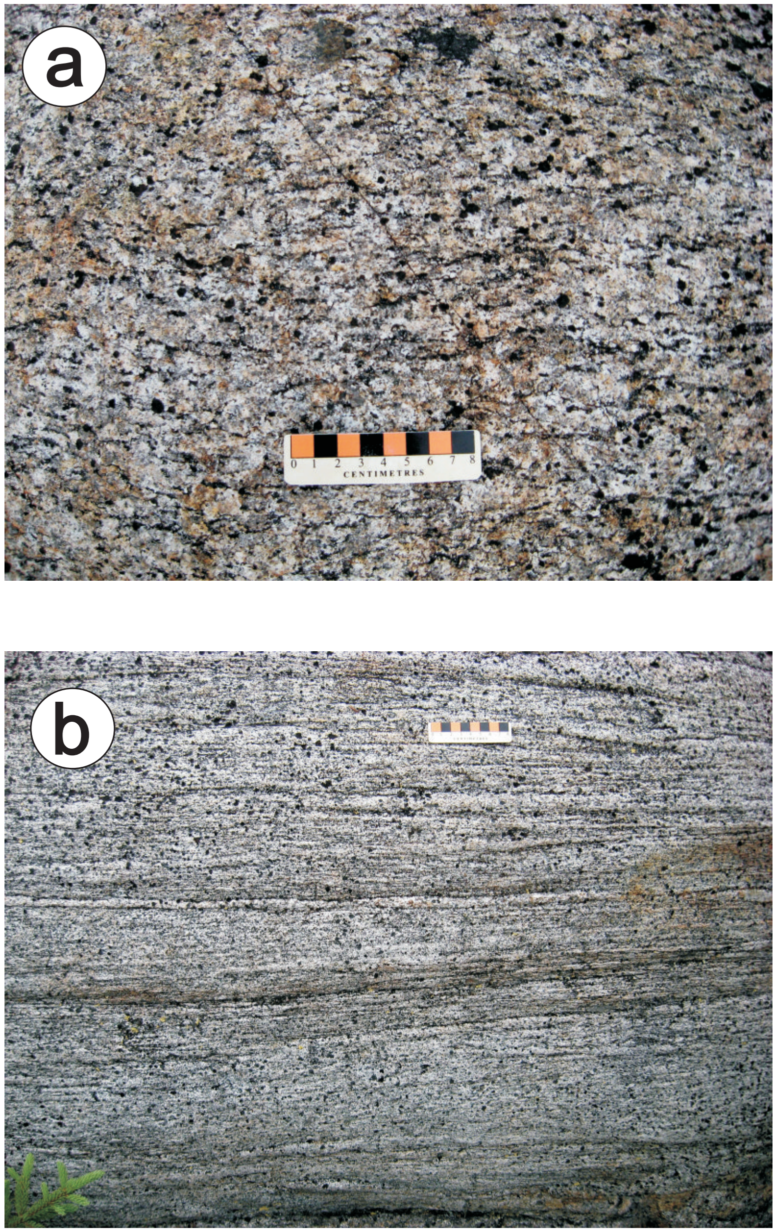

Figure GS-4-3: *Outcrop photographs of leucotonalite to granodiorite at Misty Lake:* ***a)*** *moderately foliated hornblende-biotite granodiorite;* ***b)*** *straight gneiss.*

centimetre- to metre-scale compositional banding, is interpreted as primary sedimentary bedding. Psammitic layers weather buff to white and are composed of quartz (40–60%), plagioclase (30–40%) and biotite (<10%) ±cordierite and magnetite. Psammite is interlayered at outcrop scale with semipelitic to pelitic layers that range from <1 cm to approximately 5 m thick. Semipelitic to pelitic gneiss is composed of up to 70% biotite, 10–20% quartz, 10–20% feldspar, and up to 30% garnet and cordierite (Figure GS-4-4a). At one location in southwestern Lac Brochet, semipelitic to pelitic paragneiss contains assemblages of up to 70% cordierite-sillimanite Figure GS-4-4b). Rare beds of buff white protoquartzite were observed at a few locations across the map area, but could not be traced along strike. All exposures of paragneiss contain a well-developed layer-parallel foliation defined by aligned biotite. This foliation varies from planar to slightly anastomosed.

The scarcity of outcrop in large parts of the Misty Lake area precludes internal subdivision of these paragneiss units. Northeast of Misty Lake, near the nose of the structural dome, paragneiss becomes more psammitic toward the north, perhaps suggesting a coarsening up sequence; however, the same relationship is not apparent on the eastern limb at Lac Brochet.

Paragneiss is variably migmatitic across the map area, containing in situ anatectic melt pods with irregular boundaries and/or abundant anatectic dike injection

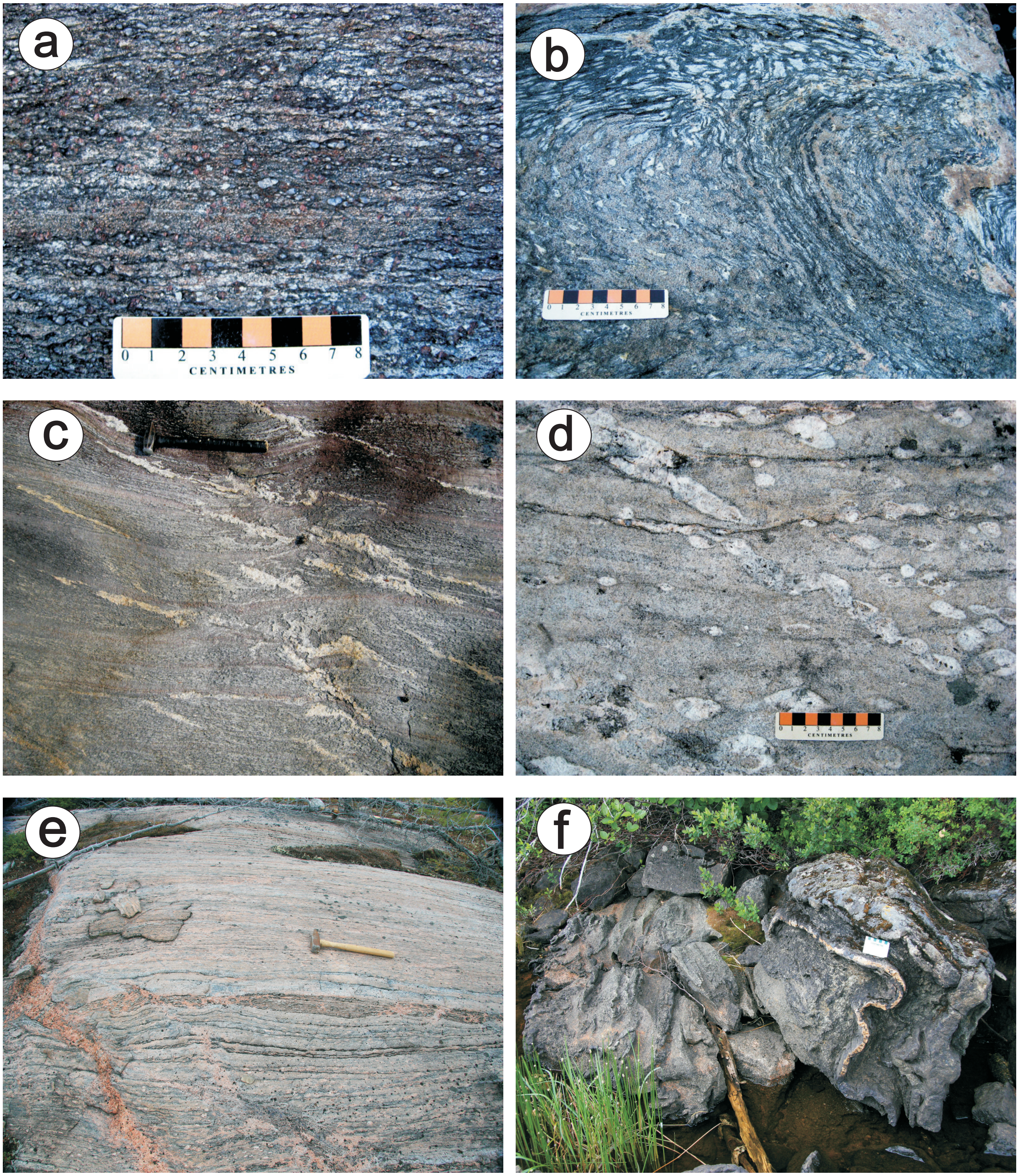

Figure GS-4-4: *Outcrop photographs of metasedimentary rocks in the Misty Lake area:* ***a)*** *garnet-cordierite semipelitic paragneiss, northern Misty Lake;* ***b)*** *cordierite-sillimanite-bearing pelitic paragneiss, western Lac Brochet;* ***c)*** *leucosome oriented oblique to bedding, western Lac Brochet;* ***d)*** *boudinaged quartzofeldspathic dikes in interlayered psammitic and pelitic paragneiss, east of Belfie Lake;* ***e)*** *compositional layering in arkosic paragneiss with cordierite-bearing syenogranitic dikes, western Misty Lake;* ***f)*** *folded marble and interlayered calcsilicate, southwestern Misty Lake.*

locally composing >70% of the outcrop. Leucosome is tonalitic to granodioritic in composition and, in many instances, includes the metamorphic assemblage found in the country-rock (e.g., cordierite±garnet). Leucosome occurs along compositional layering in paragneiss, as well as parallel to the axial planes of minor F_2 folds. Near the nose of F_2 folds, leucosome is at a high angle to compositional layering and delineates a weakly to moderately developed axial planar fabric (S_2). Along the limbs of F_2 folds, compositional layering is subparallel to S_2, and leucosome veins are at a small angle or subparallel to S_1 (Figure GS-4-4c). These observations suggest that peak metamorphic conditions were coeval with D_2 deformation (see *Structural and metamorphic geology* for more details).

Psammitic paragneiss generally contains abundant knots of coarse-grained quartz and feldspar up to 3 cm in diameter. These knots are round to lensoid, commonly rimmed by fine-grained biotite, and are locally cored by cordierite. Previous interpretations suggested that they are recrystallized feldspar porphyroblasts (Weber et al., 1975); however, in some exposures they appear to be boudinaged dikelets of leucosome (Figure GS-4-4d).

Arkosic paragneiss

Psammitic to pelitic paragneiss is interlayered at map-scale with arkosic to semipelitic paragneiss along the western shore of Misty Lake. Arkosic gneiss is marked by a significant increase in K-feldspar with respect to plagioclase relative to psammitic to pelitic paragneiss. This is also reflected in the anatectic melt associated with arkosic gneiss, which contains a more potassic mineral assemblage (monzo- to syenogranite; Figure GS-4-4e). Arkosic paragneiss contains up to 5% cordierite porphyroblasts, 5–10 mm in size. Boudins and rare beds of calcsilicate rock (<10 cm thick) are locally interlayered with arkosic to semipelitic paragneiss. Contacts between psammitic and arkosic paragneiss are gradational. An approximately 40 m thick unit of marble and calcsilicate is present within arkosic to semipelitic gneiss, in the southwestern arm of Misty Lake (Figure GS-4-4f). Marble layers are highly recessive owing to the abundance of weathered-out carbonate, and are complexly folded together with more resistant calcsilicate layers up to 3 m thick. The marble is grey to pink and composed of carbonate (60–70%), clinopyroxene (20–30%), hornblende (5–7%) and phlogopite (3–5%). The enclosing calcsilicate is pale green and consists of variable proportions of clinopyroxene and plagioclase with minor hornblende and titanite. The clinopyroxene typically forms medium-grained aggregates, angular single crystals and bands varying from <1 cm to a few metres thick, within a groundmass of plagioclase. These layers are much more resistant to weathering and deformation and locally form large boudins within marble and semipelitic gneiss.

Psammitic biotite paragneiss

Psammitic biotite gneiss occurs at Spencer Lake, northwest of Misty Lake, where it forms a southwesterly trending sequence that extends into Allnutt Lake in Saskatchewan. Psammitic biotite gneiss is fine- to medium-grained and composed of biotite (60%), quartz (25%) and feldspar (15%). All exposures of psammitic biotite gneiss are non-magnetic and non-porphyroblastic. Compositional layering (1–20 cm thick) is generally well preserved and is characterized by a subtle increase or decrease in biotite content, which is often accentuated by symmetrical boudins of granitic and pegmatitic injection (Figure GS-4-5a). Lenses of massive to crudely bedded arkosic wacke and rare feldspar augen gneiss occur in association with psammitic biotite gneiss, but cannot be traced along strike.

Arenite to calcarenite

Well-bedded, medium-grained arenite to calcarenite with minor calcsilicate, occurs at Belfie Lake, in northwestern Lac Brochet, east of Spencer Lake and on Waspison Lake. Bedding ranges from 2 to 30 cm in thickness and alternates between white and light pink layers (Figure GS-4-5b). White layers are composed of quartz and feldspar with minor biotite and magnetite, whereas light pink layers are composed dominantly of quartz and K-feldspar. Fine to coarse grains of diopside and hornblende occur locally and impart a spotted appearance to some of the beds. Arenite is interlayered with calcsilicate rocks composed of diopside, plagioclase and minor quartz. Near metasomatic zones (see below), patchy to intense alteration has overprinted primary features and arenite has a mottled 'bleached' appearance (Figure GS-4-5c). Bedding is locally crosscut by veins of blocky, coarse-grained feldspar and clinopyroxene±amphibole (<10cm) and clinopyroxenite up to 1 m thick (Figure GS-4-5d). The veins locally contain up to 7% titanite, which locally forms rims on ilmenite.

Alkali metasomatites

Discrete zones of moderate to intense alkali metasomatism were identified throughout the map area. On an island in the northern channel of Lac Brochet, fine- to medium-grained, magnetite-bearing alkali feldspar granite is completely replaced by a coarse-grained assemblage of albite, clinopyroxene, amphibole, fluorite and a mineral tentatively identified as scapolite. Clinopyroxene occurs as large, dark green masses up to 30 cm long by 10 cm thick that are commonly rimmed by black amphibole and contain inclusions of biotite and purple fluorite up to 1 cm in size (Figure GS-4-6a). Radial fractures surround local clusters of a black, equant to prismatic accessory mineral. The mineral has a pitchy to resinous lustre and appears to be metamict. At one location, a 50 cm knot of massive very coarse-grained biotite is surrounded by coarse

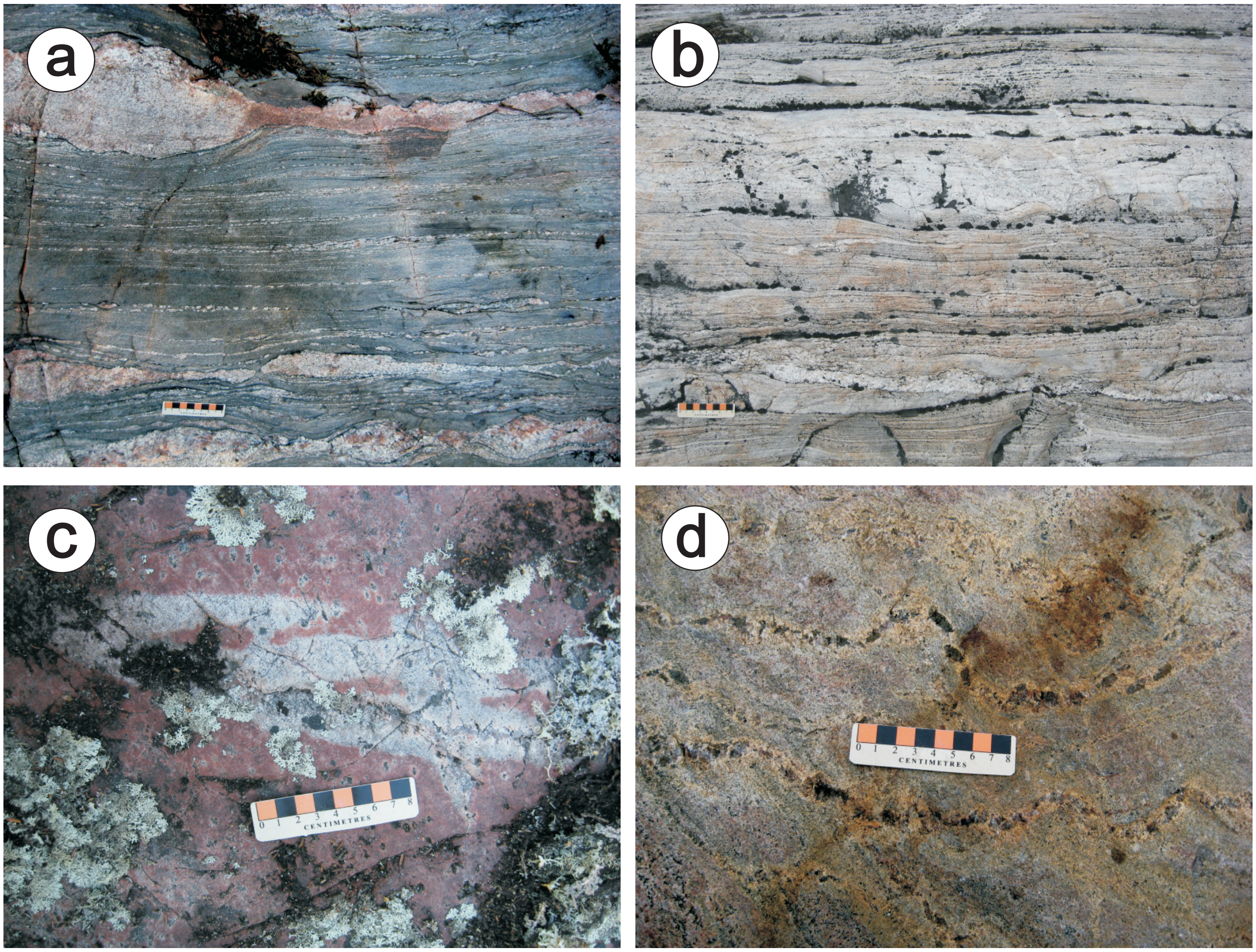

*Figure GS-4-5: Outcrop photographs of psammitic biotite paragneiss and arenite to calcarenite: **a)** psammitic biotite paragneiss with boudinaged granitic lits injected parallel to compositional banding, western Spencer Lake; **b)** well-bedded arenite, east of Spencer Lake; **c)** patchy alteration in arenite has obliterated primary sedimentary features, north of Belfie Lake; **d)** feldspar-clinopyroxene veins crosscutting calcarenite, northern Lac Brochet.*

grained scapolite. The contact between unaltered granite and intensely metasomatized granite is gradational across 1–2 metres and shows a progression from alkali feldspar granite, to a fine-grained, sugary-textured aplitic zone, into a 'bleached' feldspar zone marked by the progressive disappearance of quartz towards the core of the metasomatic zone. This zone extends to the southwest, where it crosses the geological contact between alkali feldspar granite and arenite. At this location, the contact is sharp and accentuated by en échelon gash veins (Figure GS-4-6-b).

Northwest of Misty Lake, a variably textured suite of rocks including fine-grained to pegmatitic feldspar-scapolite-clinopyroxene rock, large masses of coarse-grained clinopyroxenite and sugary-textured aplitic albitite is exposed on an isolated ridge (Figure GS-4-6c–f). Textural and compositional phases observed are gradational with one another. Albitite contains veins and large knots of dark green to black clinopyroxene±hornblende that are rimmed by K-feldspar and scapolite and contain up to 5% fine-grained accessory minerals. It is unclear whether these rocks were derived from metasomatism of sedimentary rocks of the Wollaston Supergroup or whether they form part of a metasomatized alkali intrusive rock (represented by the coarse-grained to pegmatitic feldspar-scapolite-clinopyroxene phase). Similar rocks elsewhere in northwestern Manitoba, were interpreted by Weber et al. (1975) to be derived from metamorphism of sodium-rich sedimentary rocks (evaporite deposits). In the Misty Lake area, however, these zones are discordant to stratigraphy and affect both sedimentary and intrusive rocks, and therefore a metasomatic origin is suggested.

Intrusive rocks

Intrusive rocks occur throughout the metasedimentary rocks of the Wollaston Supergroup, ranging from small plugs to large batholithic bodies. Mineralogically, intrusive rocks range from leucotonalite to syenogranite and vary in texture from fine-grained to pegmatitic. Abundant dikes of leucotonalite intrude psammitic to pelitic,

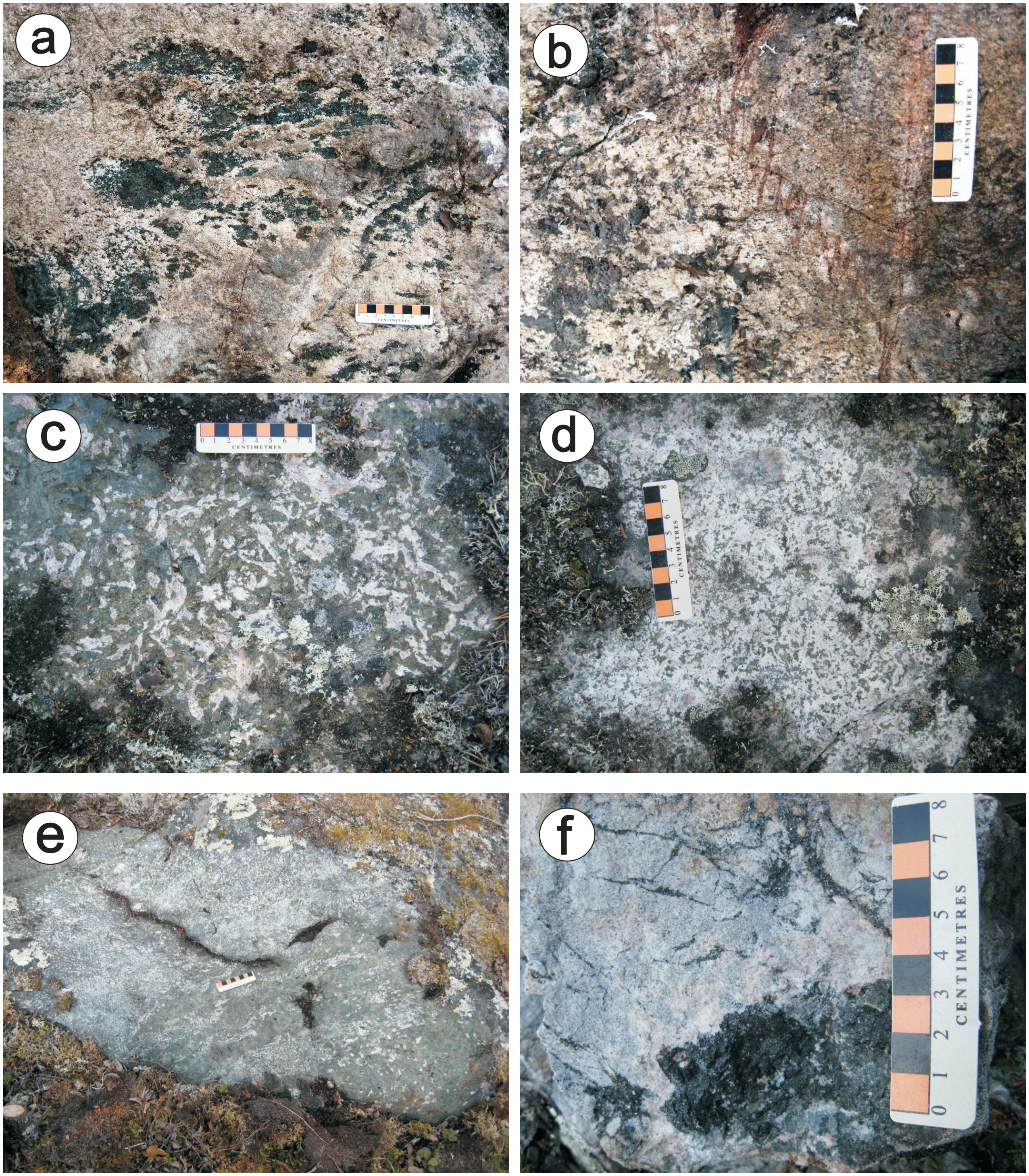

Figure GS-4-6: *Outcrop photographs of alkali metasomatic zones:* ***a)*** *albite-clinopyroxene-amphibole-fluorite metasomatism in alkali feldspar granite, northern Lac Brochet;* ***b)*** *contact between albite-clinopyroxene-amphibole metasomatism and arenite, northern Lac Brochet;* ***c)*** *pegmatitic feldspar- scapolite-clinopyroxene rock northeast of Belfie Lake;* ***d)*** *leucocratic feldspar-scapolite-clinopyroxene rock, northeast of Belfie Lake;* ***e)*** *variably-textured scapolite-clinopyroxene rock, northeast of Belfie Lake;* ***f)*** *sugary-textured albitite with veins and masses of black pyroxene and amphibole rimmed by fine-grained feldspar and scapolite, northeast of Belfie Lake.*

variably migmatitic porphyroblastic paragneiss, and form >70% of some outcrops. Leucotonalite is medium-grained to pegmatitic, consisting of plagioclase (60–70%), quartz (25%), K-feldspar (5%) and biotite (<5%), and locally contains up to 5% garnet and cordierite. Syenogranite occurs in abundance between Misty and Belfie Lakes, where it intrudes and contains abundant rafts of arkosic to semipelitic paragneiss. Syenogranite to monzogranite is medium-grained to pegmatitic and contains ubiquitous rafts of metasedimentary rocks and, locally, zones with abundant magnetite (up to 60% in a 1 by 0.5 m area). A large pluton of medium- to coarse-grained alkali feldspar granite to monzogranite occurs along the western shore of Lac Brochet, where it intrudes well-bedded arenite to calcarenite. In north-central Lac Brochet, xenoliths of clinopyroxenite identical to those identified in metasomatic zones, are entrained in alkali feldspar granite near the contact with arenite units. Contacts between metasedimentary and intrusive rocks are commonly gradational and marked by a systematic increase in the size and abundance of granitic dikes found in the sedimentary units. Many of the granitic dikes contain partially digested xenoliths of metasedimentary country rock. In situ anatectic melt pods in metasedimentary rocks are mineralogically similar to nearby intrusive phases, and in some instances form part of an interconnected network of granitic dike injection. These observations suggest that granitic rocks, at least in part, may be derived from melting of the metasedimentary sequence. Smaller occurrences of medium-grained enderbite (granulite-grade metamorphic tonalite) and fine-grained intermediate intrusive rocks occur locally throughout the area, and may represent relic Archean intrusive rocks.

Structural and metamorphic geology

Metasedimentary rocks of the Wollaston Supergroup invariably contain a penetrative foliation that is parallel to compositional banding. The S_1 foliation is interpreted to record an early folding/transposition event. F_1 folds are rarely preserved, and were only documented in a few locations. Where exposed, they consist of small-scale isoclinal closures, the limbs of which are transposed into the S_1 foliation. The S_1 foliation is overprinted by a moderately-developed northeast-trending, moderately to steeply dipping S_2 foliation, which is axial planar to outcrop-scale and regional-scale F_2 folds. The S_2 foliation is often accentuated by injections of anatectic mobilizate which are boudinaged along the S_2 plane, indicating that migmatization and anatexis is coeval with D_2 deformation. F_2 folds are tight to isoclinal, plunge shallowly to moderately to the northeast and southwest, and are responsible for the transposition of the Wollaston Supergroup into its regional northeasterly trend. Owing to the high metamorphic grade of the sedimentary sequence and the strong effects of deformation, primary sedimentary features in the vast majority of outcrops have been obliterated. Recognition of map-scale F_2 folds, based on consistent stratigraphic mapping, is rendered difficult. However, local reversals in S_0-S_1/S_2 vergence across certain areas and unit repetition, allow for confident identification of F_2 folds in some cases. At the nose of F_2 folds, or where outcrop-scale parasitic F_2 folds exist, the S_2 foliation is at a moderate to high angle with respect to S_1. On limbs of F_2 folds, the S_2 foliation is subparallel to S_1 and the structural fabric in the majority of outcrops is a composite S_0-S_1-S_2 foliation.

The abundance of migmatitic rocks, sillimanite–cordierite–biotite–leucosome and cordierite–garnet–biotite–leucosome assemblages in metasedimentary rocks are suggestive of metamorphic grades transitional between upper amphibolite and granulite facies. The widespread occurrence of cordierite in psammitic to semipelitic gneiss is also indicative of relatively low pressures during regional metamorphism.

Economic considerations

The Misty Lake area has seen an increase in exploration activity in the last few years. To the southwest in Saskatchewan, the Archean and Paleoproterozoic rocks underlying the Athabasca Basin locally host basement uranium deposits. In the Misty Lake area of Manitoba, these same rocks are exposed at surface. Anomalous REE and uranium mineralization (<7.2% U_3O_8) have been documented in boulders and boulder trains scattered throughout northwestern Manitoba (Assessment File 74359, Manitoba Innovation, Energy and Mines, Winnipeg). In the Misty Lake area, LREE enrichment up to 10% (including 4.39% Ce, 2.91% La, and 1.53% Nd) has been reported (CanAlaska Uranium Ltd., 2009). Zones of intense alkali±fluorine metasomatism in the area are indicative of widespread hydrothermal activity. Alkali metasomatism has been documented in association with a variety of mineral deposit types, including intrusion-hosted or metasomatic U, REE and rare element deposits (U, skarn, carbonatite-related REE-Nb-F, LCT-type pegmatites (Černý, 1991) and peralkaline granitoid-related Zr-Nb-Y-REE-F). Although detailed thin section and geochemical laboratory analyses of these poorly exposed zones are currently pending, these features are suggestive of significant potential for high-grade U and REE deposits in the Misty Lake area. Pelitic gneissic rocks in the Misty Lake area are tentatively correlated to metasedimentary rocks of the Daly Lake Group in Saskatchewan, where they contain fracture- and pegmatite-hosted uranium mineralization (Yeo and Delaney, 2007). A calcsilicate (albite-clinopyroxene) outcrop on a small island near the centre of Waspison Lake is laden with clinopyroxenite veins, one of which contains trace sulphide mineralization. The sulphide mineral found is coarse grained, with a good cleavage, dark grey to blue in colour and exhibits a slight iridescence that most resembles stibnite or galena. The presence of base-metal sulphides in a metasomatic host-rock such as this indicates that sulphur saturation was attained at some point during the system's history, making the area a potential target for skarn mineralization. In addition, two previously reported (Weber et al., 1975) sulphide occurrences (pyrite, pyrrhotite, chalcopyrite), in the southwest corner of Lac Brochet, were visited and sampled. Both occurrences are hosted by paragneiss and contain from trace to 2% finely disseminated and fracture-controlled pyrite and pyrrhotite. Proximal to one of these occurrences is a covellite-bearing plagioclase-porphyritic granite.

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