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Stratigraphy, structure, and petrology of a representative klippe of the Bravo Lake Formation, Piling Group, central Baffin Island, Nunavut

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Abstract: The stratigraphy, structure, metamorphism, and mineral-deposit potential of a prospective type area for the Paleoproterozoic Bravo Lake Formation has been characterized in a well exposed klippe. The klippe is in thrust contact with underlying metaturbidite of the Longstaff Bluff Formation. The Bravo Lake Formation overlies a rusty, strongly sheared metasedimentary basal unit immediately above the thrust contact. The formation in the klippe comprises a lower volcanic unit, pillow basalt, siliciclastic and chemical metasedimentary rocks intruded by ultramafic sills, an upper volcanic unit, and an upper metasedimentary unit containing laminated sulphide pods. Exposures east of the klippe preserve a higher volcanic unit not seen in the klippe. Peak metamorphism (approximately 650°C, 3.0–4.0 kbar) postdates major fabric-forming deformation events. Ultramafic rocks in the klippe could potentially host magmatic sulphide deposits, and some metasedimentary rocks could potentially host exhalative sulphide deposits.

Résumé : Dans une klippe bien exposée, on a caractérisé la stratigraphie, la structure, le métamorphisme et le potentiel minéral d'une zone d'intérêt au sein de la Formation de Bravo Lake du Paléoprotérozoïque. La klippe chevauche des métaturbidites de la Formation de Longstaff Bluff. La Formation de Bravo Lake surmonte une unité basale de roches métasédimentaires rouillées et fortement cisaillées qui se situe juste au-dessus du contact du chevauchement. Dans la klippe, la formation se compose d'une unité inférieure de roches volcaniques; de basaltes en coussins; de roches métasédimentaires silicoclastiques et chimiques envahies par des filons-couches ultramafiques; d'une unité supérieure de roches volcaniques; et d'une unité supérieure de roches métasédimentaires renfermant des lentilles fusiformes de sulfures laminés. Dans des affleurements de la formation situés à l'est de la klippe, on peut observer une autre unité de roches volcaniques située plus haut dans la stratigraphie qui n'a pas été observée dans la klippe. L'atteinte des conditions maximales du métamorphisme (environ 650°C et de 3,0 à 4,0 kbar) est postérieure à d'importants épisodes de déformation qui ont engendré des fabriques. Dans la klippe, les roches ultramafiques pourraient renfermer des gîtes de sulfures magmatiques, et certaines roches métasédimentaires, des gîtes de sulfures exhalatifs.

INTRODUCTION

This report outlines the results of detailed field and petrographic work undertaken over the summers and winter of 2001–2002 in order to describe stratigraphic relationships, structural deformation, metamorphism, and ore-deposit potential of a relatively small (approximately 4 km x 5 km), well exposed klippe of the Bravo Lake Formation at longitude 68°30′N and latitude 72°13′W (NTS map area 37 A).

The Bravo Lake Formation forms part of the Paleoproterozoic Piling Group in the Foxe Fold Belt, central Baffin Island. The Piling Group is a dominantly metasedimentary assemblage flanked to the north by the Archean Rae Province and to the south by the ca. 1.86 to 1.85 Ga Cumberland Batholith. The Bravo Lake Formation is a package of mafic to ultramafic volcanic flows and sills with associated metasedimentary rocks that extends in a discontinuous east-west belt across central Baffin Island, at approximately longitude 68°30′N (Fig. 1). It may represent distal volcanism accompanying rifting in the Piling Group basin. It is mainly preserved in a number of broad, doubly plunging synformal structures and appears to be in tectonic contact with underlying metasedimentary rocks.

The shallow dish shape of the klippe provides good control both on thickness and lateral extent of stratigraphic units, such that the klippe potentially represents a type area for the Bravo Lake Formation. This formation has considerable economic potential, necessitating a thorough understanding of its geology. It contains ultramafic bodies that may be favourable hosts for Ni-Cu-PGE mineralization, as well as some sedimentary rocks that could have the potential for exhalative-type base-metal deposits.

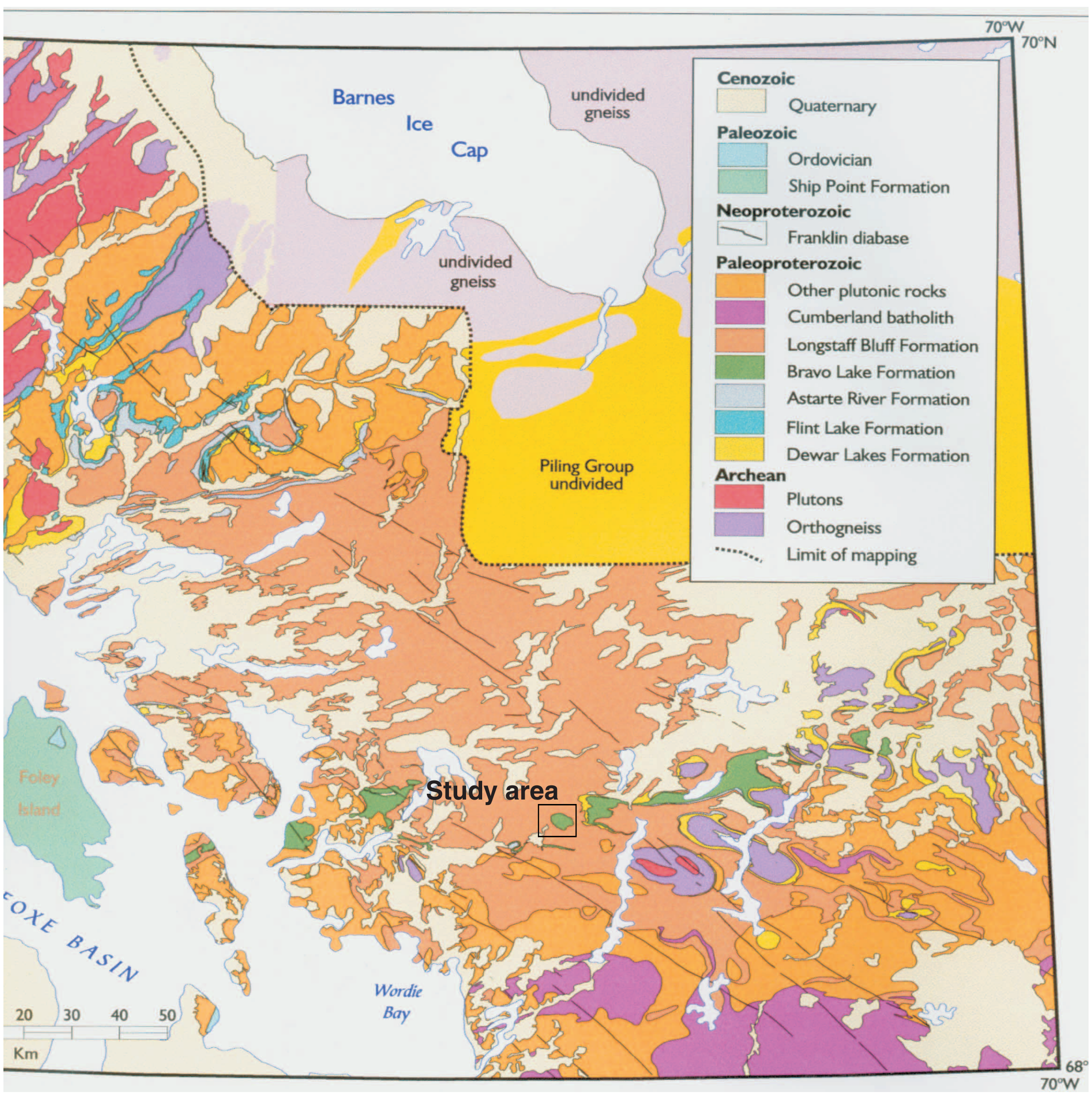

*Figure 1. Simplified regional geology of central Baffin Island. The study klippe is indicated within the belt of Bravo Lake Formation (*after *St-Onge et al., 2002a).*

The geology of the Foxe Fold Belt was first examined at a reconnaissance level in the early 1970s and is currently the focus of a 1:100 000 scale bedrock and surficial mapping initiative by the Geological Survey of Canada, the Canada-Nunavut Geoscience Office, and the Polar Continental Shelf Project (Corrigan et al., 2001, and references therein; St-Onge et al., 2001a, b, c, d, 2002a, b, c; Scott et al., 2002; de Kemp et al., 2002; Wodicka et al., 2002; Dredge, 2002). The results presented herein are from a detailed study of the Bravo Lake Formation that was undertaken as part of the regional project and that forms part of a M.Sc. thesis at the University of Calgary.

REGIONAL GEOLOGY

The Foxe Fold Belt has been correlated with the Rinkian Belt of Greenland (Taylor, 1982; Hoffman, 1988). In central Baffin Island, it is bordered to the north by Archean rocks of the Rae Province and to the south by the ca. 1.85 Ga Cumberland Batholith (Corrigan et al., 2001, and references therein). Its main tectonostratigraphic unit is the Piling Group, which unconformably overlies the Rae Craton (Fig. 2). The lowermost two units of the Piling Group consist of quartzite of the Dewar Lakes Formation and marble of the Flint Lake Formation, both of which overlie Rae basement in the northern part of the Foxe Fold Belt (Fig. 1). Basement-cored structural domes southeast of the klippe are also mantled by Dewar Lakes Formation quartzite. The Dewar Lake and Flint Lake formations contain micaceous schist and minor iron-formation and are interpreted to represent a platformal depositional environment (Corrigan et al., 2001). Overlying the Flint Lake Formation in the north is graphitic ferruginous pelite of the 'Astarte River Formation'. In the southern part of the Foxe Fold Belt, the Bravo Lake Formation overlies quartzite and rusty pelite attributed to the upper Dewar Lakes Formation (Scott et al., 2002; de Kemp et al., 2002).

North of this study area, the Astarte River Formation is overlain by the Longstaff Bluff Formation, a thick package of wacke and psammitic turbidite interpreted as foredeep flysch (Corrigan et al., 2001, and references therein). It is the highest stratigraphic unit exposed in central Baffin Island. Southeast of the study area, Longstaff Bluff Formation turbidite has been observed in conformable stratigraphic contact with underlying mafic volcanic rocks of the Bravo Lake Formation, suggesting that the turbidite blanketed the entire basin following cessation of volcanic activity (Scott et al., 2002).

Although the Bravo Lake Formation may have been deposited originally at the same stratigraphic level as the Flint Lake Formation (Fig. 2), it is now exposed as a thrust package structurally emplaced on top of the Longstaff Bluff Formation. The basis for proposing a thrust contact is primarily a stratigraphic one: metasedimentary rocks correlated with the Dewar Lakes Formation are found in structural contact with underlying recognizable metaturbidite of the Longstaff Bluff Formation and are in turn overlain by mafic units of the Bravo Lake Formation. Strongly sheared hanging-wall metasedimentary rocks (Dewar Lakes Formation) corroborate what is essentially a stratigraphic juxtaposition argument.

Regional deformation in the central Baffin area involves an early Archean event (D_{1A}), accompanied by amphibolite-facies metamorphism (Corrigan et al., 2001). This was followed by three phases of Proterozoic deformation that affected the Piling Group and, at least in part, the Archean basement (Corrigan et al., 2001; Scott et al., 2002; de Kemp et al., 2002). A roughly east-trending D_{1P} event, related to convergence, resulted in thin-skinned thrust stacking of the Piling Group onto the Rae Craton and imbrication of lower sequence quartzite and marble. D_{1P} deformation is likely associated with the north- to northwest-directed overthrusting of Bravo Lake Formation rocks onto the Longstaff Bluff Formation.

The second Proterozoic deformation event (D_{2P}) is characterized by more thick-skinned folding involving both the supracrustal Piling Group and the Archean basement. D_{2P} produced large-scale, roughly east-northeast-trending, tight to isoclinal, upright to north-vergent folds, which appear to be largely coaxial with D_{1P}. The dominant foliation in the region is ascribed to D_{2P}. The final regional deformation event (D_{3P}) reflects orogen-perpendicular folding, resulting in large-

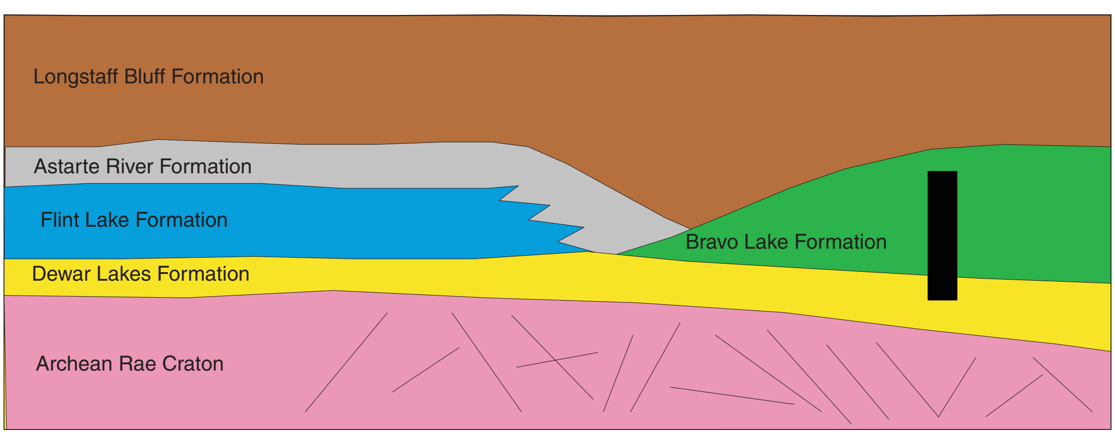

Figure 2. *Predeformational geometry of the Piling Group. The black bar represents the portion of the Bravo Lake Formation exposed in the study klippe (*modified from *Scott et al., 2002).*

wavelength, northwest- to northeast-trending, upright, open folds that interfered with D_{2P} to produce the dome-and-basin structures observed throughout the Foxe Fold Belt on Baffin Island.

Metamorphic mineral assemblages in the Piling Group, in particular the Longstaff Bluff Formation, indicate a regional low-pressure (i.e. Buchan) sequence (Tippett, 1980, 1985; Corrigan et al., 2001; Scott et al., 2002). The klippe studied lies within the sillimanite+K-feldspar+melt zone. Peak metamorphic conditions postdate D_{1P} and may be synchronous with, or postdate, D_{2P}, as evidenced by the growth of porphyroblasts across the dominant (D_{2P}) foliation in the rocks (Tippett, 1980, 1985; Corrigan et al., 2001; Allan and Pattison, 2003).

LOCAL GEOLOGY, STRATIGRAPHY, AND PETROGRAPHY OF THE KLIPPE

The klippe has been divided into several mappable units, which are described below. A geological map and stratigraphic column of the klippe and surrounding rocks is presented in Figure 3. Two cross-sections through the area are shown in Figure 4. An aerial overview of the western end of the klippe, showing the cliff-forming nature of its lower stratigraphic units and the approximate location of the basal thrust fault, is presented in Figure 5.

Footwall rocks

Metasedimentary rocks underlying the base of the klippe belong to the Longstaff Bluff Formation and consist of metamorphosed turbidite intruded by garnet+muscovite+biotite syenogranite pegmatite sills (Fig. 6a). The dominant foliation in the metasedimentary rocks generally wraps around pegmatitic bodies. Strain in the Longstaff Bluff Formation appears to increase progressively toward the base of the klippe. Metapelitic layers in the turbidite contain sillimanite+K-feldspar+biotite+muscovite and are locally migmatitic (Fig. 6b). Leucosomes contain plagioclase+quartz+K-feldspar+tourmaline. The pegmatite bodies show no chilling at their margins and the amount of leucosome in the migmatite increases in proximity to the pegmatite bodies.

Hanging-wall rocks

Basal quartzite and semipelite

The basal unit of the klippe (possibly Dewar Lakes Formation) is on average approximately 50 m thick and characterized by its rusty colour (Fig. 7a) and high strain, the latter manifested in a pronounced platy fabric and rare recumbent isoclinal folds. The platy fabric is a strong, bedding-parallel planar foliation that causes the unit to weather as thin plates (approximately 1 cm thick). The unit comprises rusty quartzite, locally interlayered with mafic metasedimentary rocks and pelitic beds hosting sillimanite+muscovite+quartz knots (*faserkiesel*). A decrease in the abundance of quartzite occurs upward toward unit 1 of the Bravo Lake Formation, with a corresponding increase in amphibole-bearing mafic metasedimentary rocks and semipelite. The overall sulphide content of the unit also increases upward in proximity to unit 1 of the Bravo Lake Formation. Randomly oriented metamorphic amphibole grains grow across the penetrative platy fabric, indicating that peak metamorphism postdated the major fabric-forming event (Fig. 7b). The fault separating the klippe from the Longstaff Bluff Formation metaturbidite is nowhere exposed, although it can be constrained to a few metres in places.

Unit 1 of the Bravo Lake Formation

The lowermost unit (lower mafic unit) of the Bravo Lake Formation is up to approximately 200 m thick and forms prominent, black, 20 to 30 m high cliffs on the western side of the klippe (Fig. 5). The base of the formation is defined by the first occurrence of mafic igneous layers and has been termed the ‘Bravo Lake Formation basal surface’ by de Kemp et al. (2002). In the klippe, a sharp contact generally separates the basal metasedimentary unit and overlying mafic volcanic flows and sills of unit 1. Mafic rocks near the Bravo Lake Formation basal surface are foliated, although not as highly as the underlying rusty metasedimentary rock, and contain abundant calc-silicate stringers (Fig. 8). Strain decreases upward within the unit, allowing some primary volcanic features, such as flow-top breccia, to be recognized.

Mafic to ultramafic flows and sills are the most common rock type, with minor intercalated mafic metasedimentary rocks, iron-formation, psammite, and more rarely, pelite. Sills, which are coarser grained than flows, intrude the metasedimentary rocks between the flows and may represent intrusive equivalents to the volcanic rocks. The unit thins toward the eastern side of the klippe and appears to pinch out near the easternmost fold closure (Fig. 3, 4).

In thin section, the mafic volcanic rocks are dominated by randomly oriented calcic amphibole, biotite, plagioclase, and relict clinopyroxene. Ultramafic sills contain radiating clusters of calcic amphibole. Heavily serpentinized ultramafic rocks (up to ~50% serpentine) are spinel-bearing, with relict olivine visible in thin section. Most sills, however, appear to be formed of metapyroxenite, with some large, optically continuous patches of relict clinopyroxene suggesting original grain sizes greater than 10 mm. Mafic metasedimentary rocks are finer grained and contain abundant radiating brown to black amphibole, garnet, and biotite. Some rocks of this unit, including garnetite, garnet-quartz rocks (coticule), and garnet-cummingtonite rocks, may represent the metamorphic products of subaqueous hydrothermal activity accompanying volcanism (e.g. Spry et al., 2000). Rare metapelite contains sillimanite and K-feldspar, but unlike footwall metapelite, it does not contain leucosome.

Unit 2 of the Bravo Lake Formation

Unit 1 is overlain by a distinctive package of deformed and metamorphosed pillow basalt (unit 2). This unit is discontinuous within the klippe, but in places reaches up to approximately

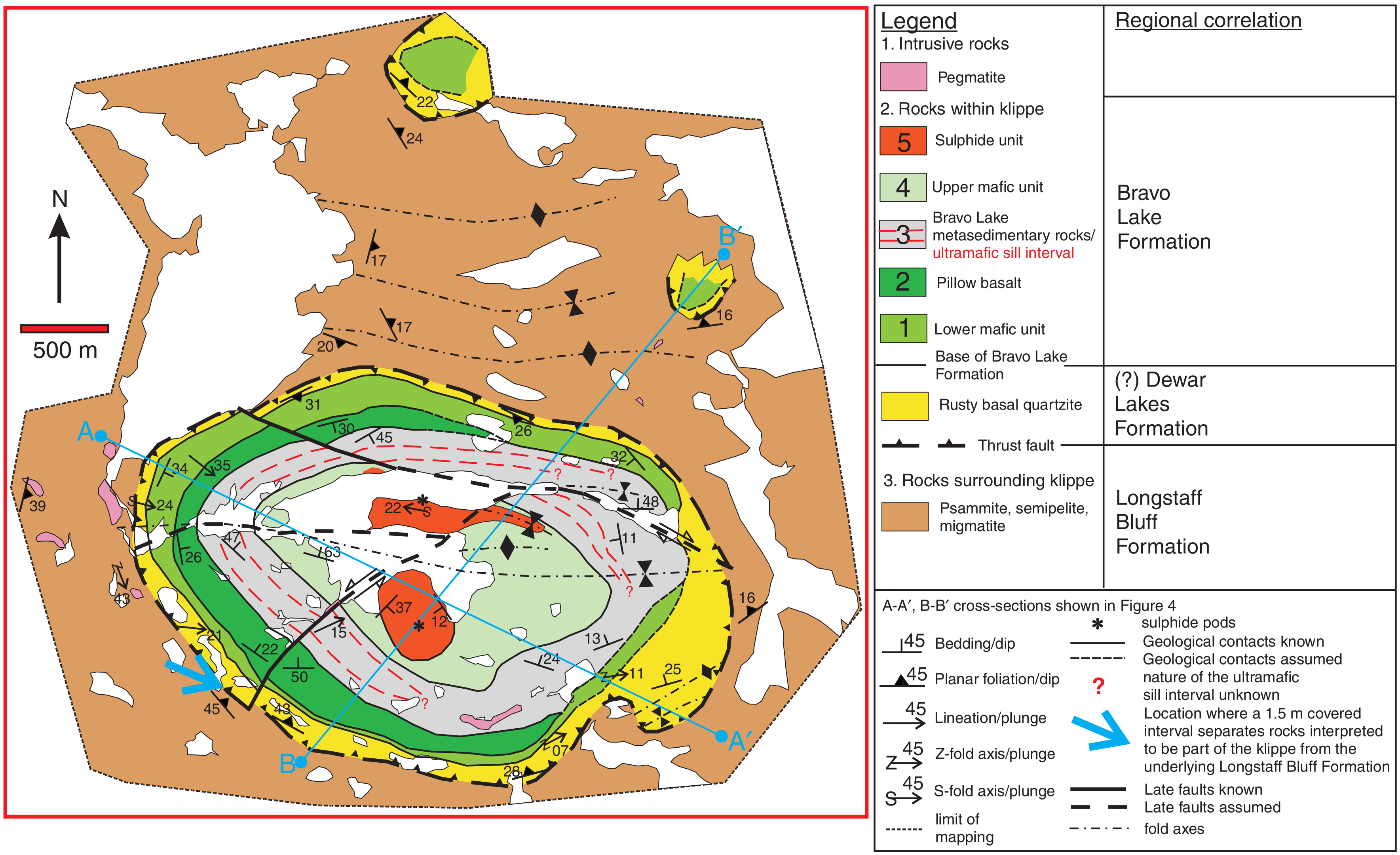

Figure 3. Geological map of the study klippe and surrounding rocks.

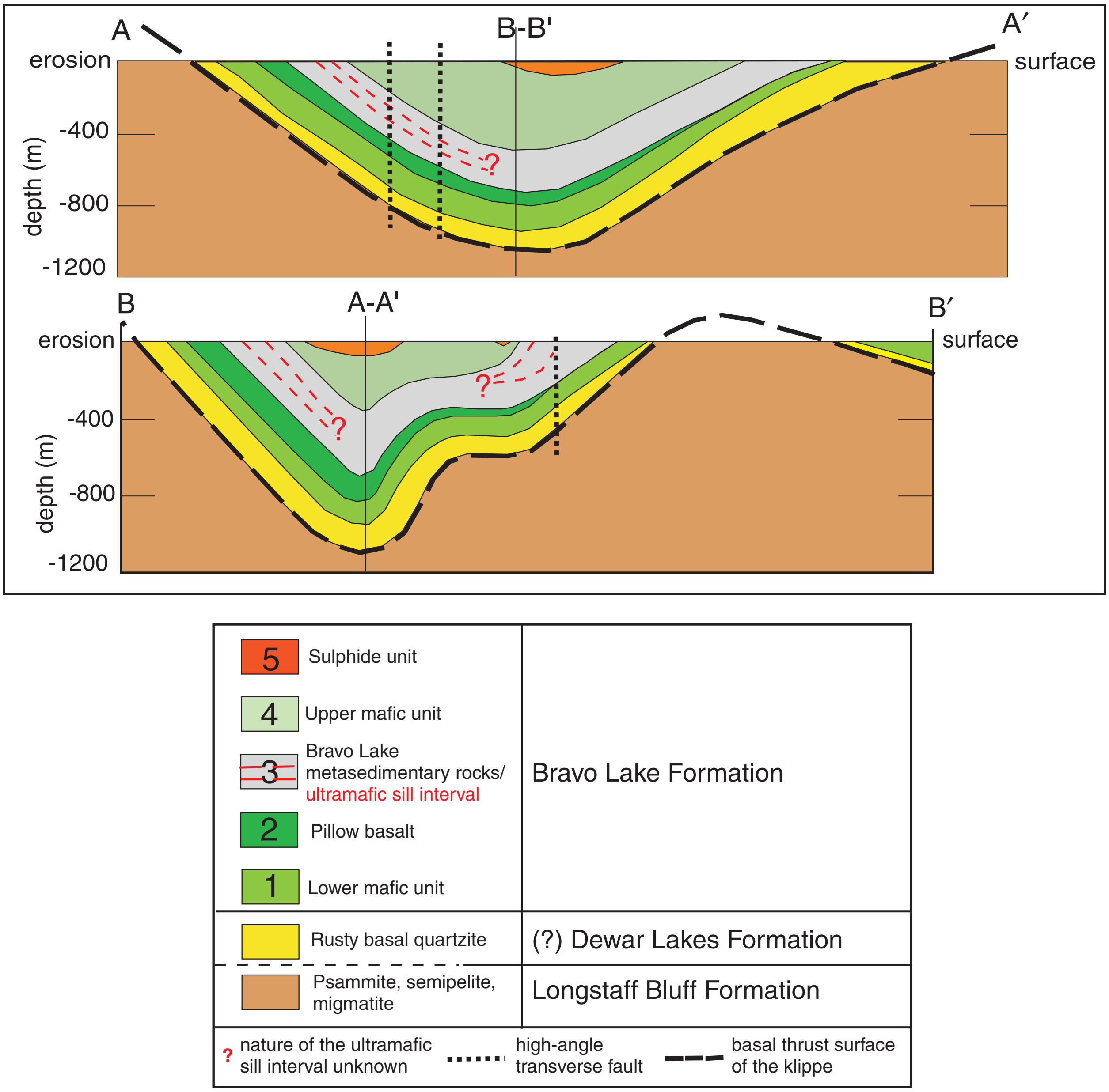

Figure 4. *Geological cross-sections of the study area. Note the discontinuous nature of the pillow unit.*

200 m in thickness (*see* cross-section B-B'; Fig. 4). Outcrop surfaces display a bulbous texture produced by rounded pillow tops (Fig. 9). Pillow keels, visible in cross-section, consistently indicate stratigraphic younging toward the structural centre of the klippe. Individual pillows preserve selvedges and interpillow space is locally filled with calcite+diopside+garnet. In thin section, the pillow interiors reveal relict phenocrysts of concentrically zoned plagioclase and clinopyroxene in a fine-grained groundmass of randomly oriented calcic amphibole, plagioclase, and minor carbonate.

Unit 3 of the Bravo Lake Formation

Unit 3 is a gossanous metasedimentary package up to approximately 300 m thick, locally intruded by ultramafic sills. Its lower part consists of rusty, schistose, amphibole+biotite+garnet mafic metasedimentary rocks with minor quartzite and interlayered garnet+orthoamphibole rocks interpreted to be metamorphosed silicate-facies iron-formation. Sulphides, including pyrrhotite and pyrite, are abundant throughout this unit. Ultramafic sills increase in abundance toward the middle of the unit. The main sill interval is shown in Figure 3. Individual sills are usually less than 10 m thick and appear to be lens shaped, although it is unclear whether this shape is primary or the result of deformation. The most common metamorphic mineral in the ultramafic sills is calcic amphibole with minor biotite. The sills locally preserve a relict cumulate texture, although the original minerals have been largely replaced by metamorphic minerals. Relict igneous clinopyroxene is visible in thin section.

The metasedimentary rocks in the upper part of unit 3 are similar to those in the lower part, but reflect a change in composition from predominantly mafic to more siliceous rocks (quartzite) with abundant silicate- and sulphide-facies iron-formation. The upper part of unit 3 is extremely rusty, reflecting a high sulphide content, and is locally rich in orthoamphibole, garnet, and quartz. Thin layers of stratiform sulphides (mainly pyrrhotite) are visible in outcrop (Fig. 10).

Unit 4 of the Bravo Lake Formation

The rusty metasedimentary rocks of unit 3 are overlain by unit 4 (upper mafic unit), a distinctive green metavolcanic unit up to 300 m thick. It is readily recognizable by its pea-green colour in outcrop and by the abundance of fine-grained, interlocking crystals of green amphibole, which make it very hard. The lower part of unit 4 consists of massive volcanic flows with local flow-top breccia (Fig. 11). At higher stratigraphic levels, the flows are intercalated with possibly locally derived mafic metasedimentary rocks of similar mineralogy, which locally contain rare angular basaltic clasts. In thin section, the metavolcanic rocks reveal large (~15 mm) patches of granular, optically continuous relict clinopyroxene in a groundmass of fine-grained calcic amphibole and plagioclase. Unit 4 is locally strongly magnetic.

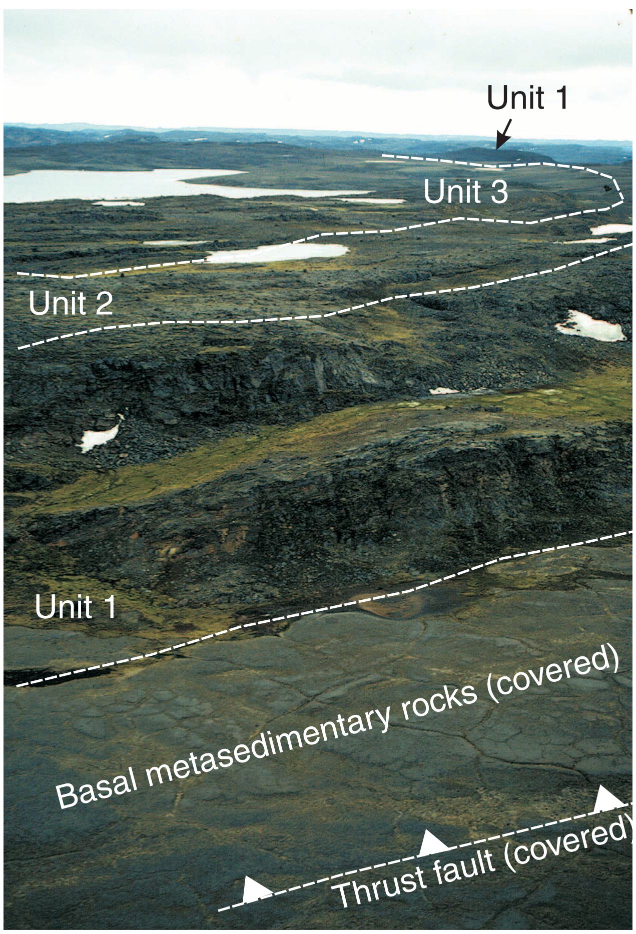

Figure 5. *Aerial photograph illustrating the cliff-forming nature of the lower part of the klippe. The cliffs in the background are continuous with those in the foreground and curve around outside the frame as shown. Units 1 to 3 are of the Bravo Lake Formation and are discussed in the text.*

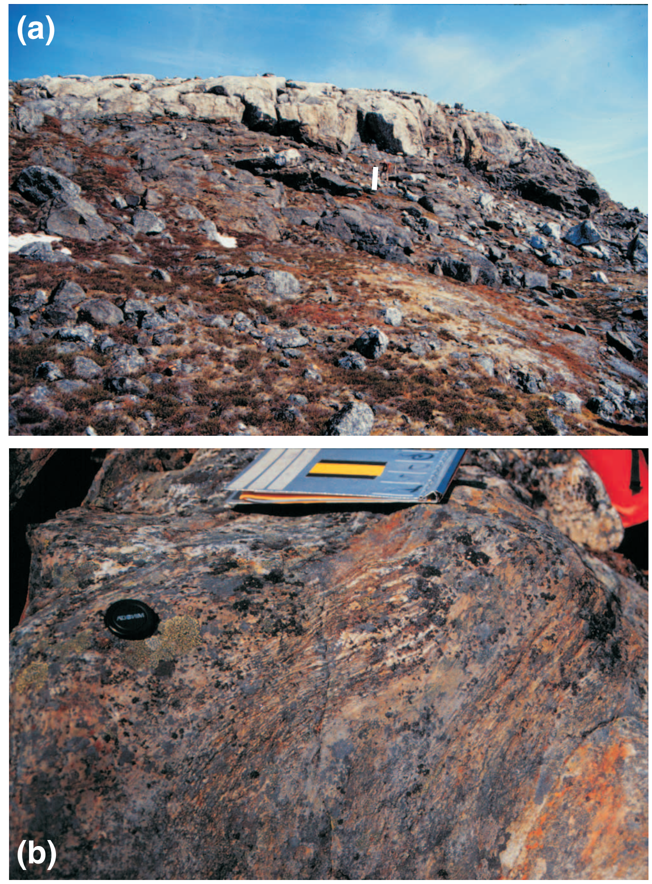

Figure 6. ***a****) Pegmatite sill (light-coloured) emplaced in footwall metasedimentary rocks (Longstaff Bluff Formation). The white bar is 2 m high.* ***b****) Leucosome development in footwall metapelite (light coloured). The clipboard is 30 cm long.*

Unit 5 of the Bravo Lake Formation

The highest stratigraphic unit (sulphide unit) in the klippe is approximately 75 m thick and extremely gossanous where exposed. Its lower part comprises rusty biotite-bearing psammite and crystalline siliceous rock containing fine-grained disseminated sulphides. The middle part is intruded by minor ultramafic sills, but much of it is covered by Quaternary sediments, obscuring the primary stratigraphy.

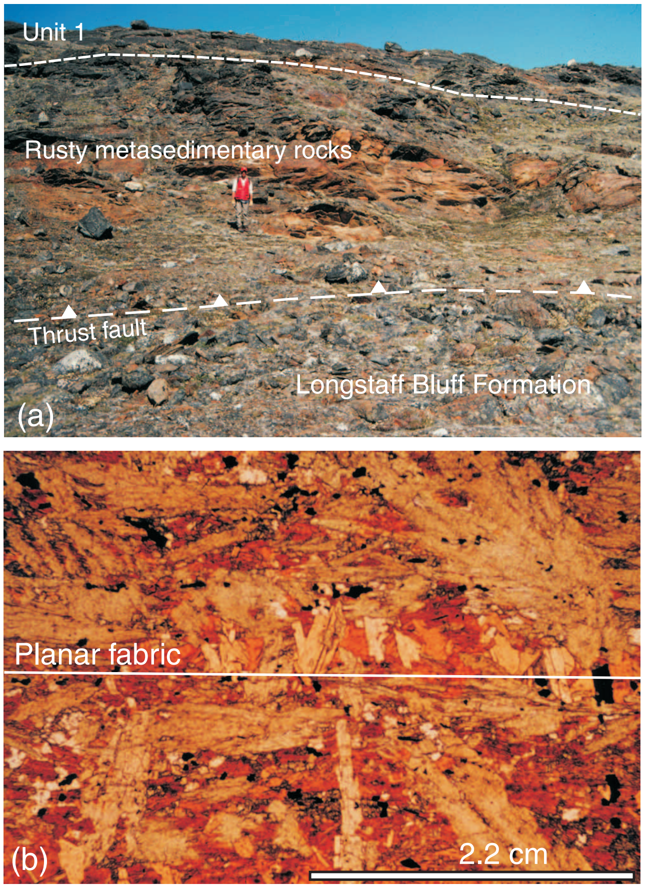

***Figure 7. a**) Rusty, highly strained basal metasedimentary rocks above the thrust fault with the Longstaff Bluff Formation, overlain by the lower mafic unit (unit 1). The possible location of the thrust fault is indicated where the rubble changes colour. The person is about 2 m tall. **b**) Photomicrograph showing post-tectonic amphibole grains crosscutting platy fabric in basal metasedimentary rocks.*

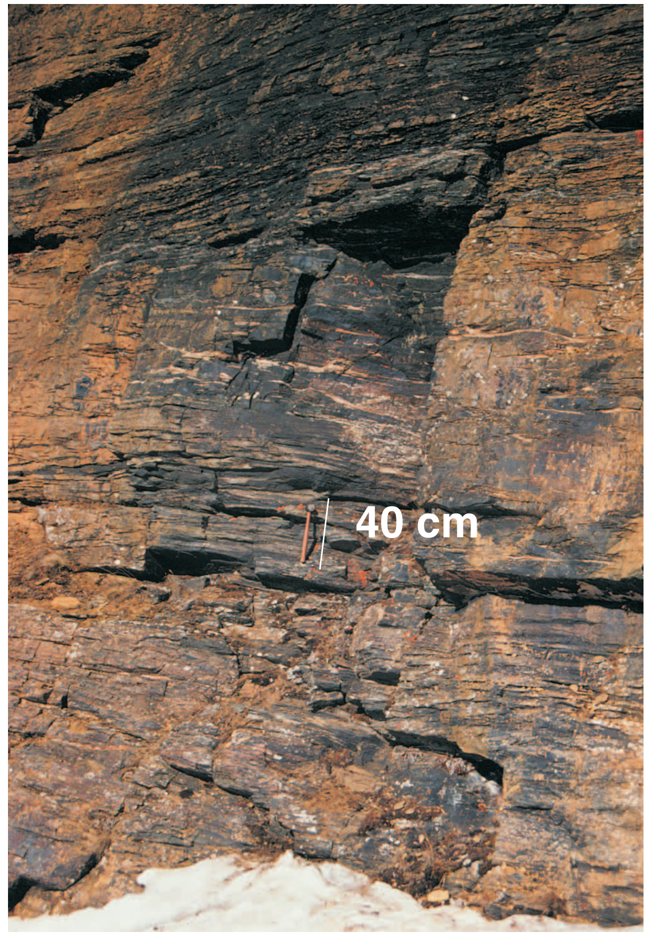

***Figure 8.** Highly strained mafic rocks of the lower mafic unit (unit 1) with calc-silicate stringers (light-coloured). The hammer is 40 cm long.*

The upper 20 m of the unit are strongly gossanous and contain two repeated sedimentary sequences separated by an ultramafic sill. In the lowermost sequence, a lower, possibly psammitic layer (largely covered) is succeeded by a laminated pyrite layer up to about 1 m thick (Fig. 12). The laminated pyrite layer is overlain by up to 1.5 m of strongly magnetic, sulphide-rich rocks. The sequence is capped by up to 2 m of siliceous rocks with coarse (~2 cm) pyrite and finer grained pyrrhotite. The sequence is similar above the ultramafic sill, except that the laminated pyrite layer is capped directly by siliceous rocks containing coarse sulphide domains. Outcrops showing the same association of sulphides and siliceous rocks are exposed at several locations in the unit (*see* Fig. 1). The uppermost part of the sulphide unit is capped by ultramafic rock.

The sulphide bodies are finely bedded and were likely deposited as continuous layers. However, they are now exposed as pods with highly convoluted bedding, possibly as a result of boudinage during deformation. Mineralogically, the massive sulphides are simple, being composed primarily

***Figure 9.** Bulbous outcrop surfaces of pillow basalt of unit 2. The hammer is 40 cm long.*

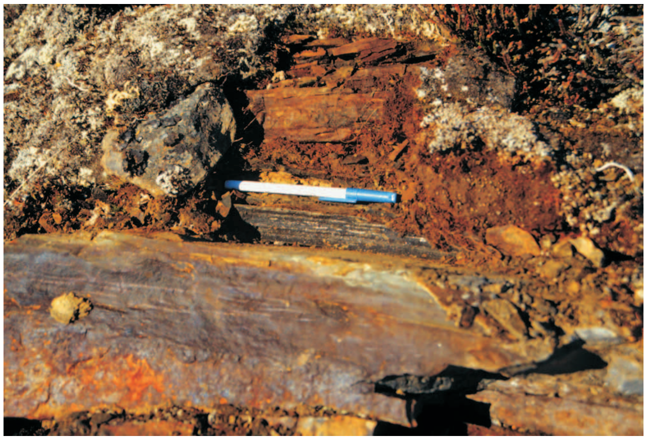

__Figure 10.__ Closeup of a thin layer of stratiform pyrrhotite (below the pen) from the upper part of unit 3 (Bravo Lake metasedimentary rocks).

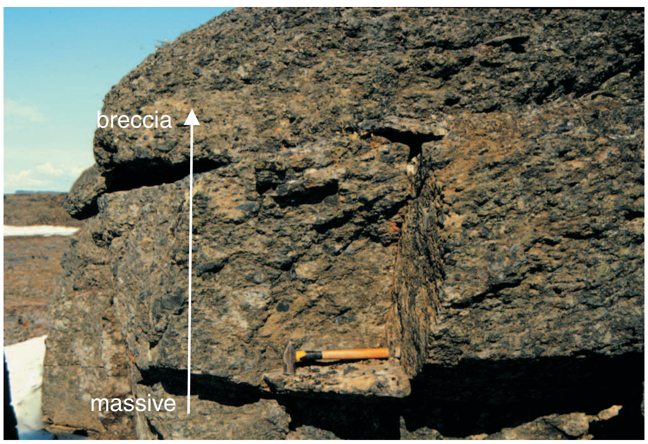

__Figure 11.__ Rubbly flow-top breccia from unit 4 (upper mafic unit). The arrow indicates grading from the massive flow into its brecciated top. The hammer is 40 cm long.

of pyrite and pyrrhotite, with minor quartz and sphalerite. Aside from the sphalerite, the sulphide appears barren of any economic minerals, although assays are needed to confirm this.

Silica-rich rocks capping the layered sulphides are composed mainly of medium-grained, recrystallized quartz with minor biotite and graphite, fine-grained disseminated pyrrhotite, and coarse (1–3 cm) pyrite cubes and aggregates. Ultramafic sills are composed almost entirely of coarse, radiating bundles of amphibole and biotite with minor pyrrhotite.

Intrusive rocks in the klippe

The youngest rocks inside the klippe are rare muscovite+biotite syenogranite pegmatite bodies (Fig. 3), which occur as either semiconcordant sills subparallel to primary layering, or tabular dykes locally adjacent to high-angle transverse faults. The pegmatite bodies are compositionally similar to those in the footwall, but lack garnet.

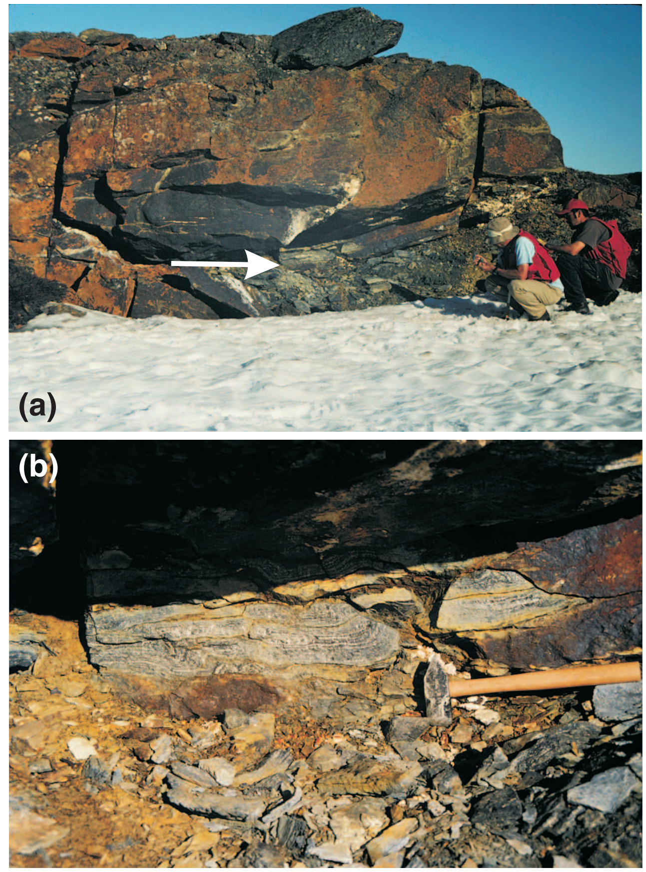

__Figure 12. a__) Upper sulphide unit. The arrow points to a recessive-weathering sulphide pod. __b__) Detail of millimetre-scale layering in the sulphide pod.

RELATIONSHIP OF KLIPPE UNITS TO REGIONAL STRATIGRAPHY

The approximate position of the klippe in the context of regional stratigraphy is shown in Figure 2. The full Bravo Lake Formation is not represented in the klippe. In other exposures of the formation farther east, another metavolcanic unit is seen above the sulphide unit (S. Modeland, pers. comm., 2002). The base of this third magmatic event may be represented in the klippe by the ultramafic sills at the top of the sulphide unit. Elsewhere, this uppermost volcanic unit is overlain by metaturbidite of the Longstaff Bluff Formation.

The stratigraphy of the Bravo Lake Formation belt appears to vary along strike. To the east of this study area, the volume of Bravo Lake metasedimentary rocks and ultramafic sills is greater relative to mafic volcanic rocks (Scott et al., 2002). To the west, the lower mafic unit (unit 1) thickens substantially and the thickness of pillow basalt (unit 2) also increases whereas that of the metasedimentary units decreases (e.g. unit 3).

STRUCTURE

Figure 3 shows representative bedding, foliation, and lineation measurements in the klippe and surrounding rocks. Fabrics in the Longstaff Bluff Formation beneath the klippe are folded in broad dome-and-basin style. With the exception of massive mafic units and pegmatite, most rock types in the klippe display a strong planar fabric parallel to bedding. Planar fabrics dip inward at a moderate angle toward the central part of the klippe, although minor folds cause local reversals in dip directions. The rare lineations observed plunge to the east or southeast, consistent with D_{1P} thrusting in a northerly to westerly direction such as is observed regionally (Corrigan et al., 2001). In the first several metres above the base of the Bravo Lake Formation, a platy fabric is seen that is similar to the one observed in the basal quartzite; it decreases in intensity upward. We interpret this to mark the upper limits of strain associated with emplacement of the klippe. Stretched pillows plunge to the southeast on the western side of the klippe (Fig. 3).

At one locality, a 1.5 m covered interval (Fig. 3) separates highly sheared migmatitic psammite of the Longstaff Bluff Formation from platy quartzite characteristic of the Dewar Lakes Formation. It provides the narrowest constraint on the location of the basal thrust fault in the study area. The strong platy fabric is the most prominent structural feature above the thrust fault, although local east- to northeast-plunging recumbent isoclinal folds were also observed. Shear-sense indicators are rare and equivocal and recognition of shear lineations is complicated by randomly oriented post-tectonic mineral growth.

D_{2P} deformation resulted in roughly east-trending folds, whereas D_{3P} created roughly north-trending fold axes (Corrigan et al., 2001; Scott et al., 2002); their interference resulted in the bowl shape of the klippe. Northeast of the klippe, the basal thrust fault intersects the erosion surface, forming two small exposures of the basal metasedimentary rocks and unit 1 of the Bravo Lake Formation (Fig. 3). The doubly plunging syncline structure is shown in cross-sections A-A' and B-B' (Fig. 4). A comparison of the two cross-sections shows how east-trending D_{2P} folding (B-B') is tighter than north-trending D_{3P} crossfolding (A-A').

Three high-angle transverse faults cut through the klippe, creating a wedge-shaped structure on the western end (Fig. 3). Some rocks immediately adjacent to faults are highly sheared, most notably on the central peninsula, and bedding in metasedimentary units may be locally deflected toward the fault trace.

METAMORPHISM

Peak metamorphism was reached after the main fabric-forming deformation events. Metamorphic amphibole grains in the basal metasedimentary rocks of the klippe randomly crosscut deformation fabrics related to D_{1P}. In one sample of mafic metasedimenary rock from unit 3, planar fabrics (possibly D_{1P}) are crenulated (possibly by D_{2P}) and overgrown by large garnets, indicating late syn- to post-D_{2P} garnet growth. Mafic and ultramafic rocks inside the klippe consistently show randomly oriented metamorphic amphibole grains, suggesting peak metamorphism under relatively static conditions following D_{2P}.

Rare pelitic rocks within the klippe contain fibrous sillimanite and small (<1 mm) poikiloblastic K-feldspar porphyroblasts. These rocks contain no leucocratic segregations. These features suggest progress of the subsolidus reaction muscovite + quartz + plagioclase = sillimanite + K-feldspar + vapour.

In the footwall, however, Longstaff Bluff Formation turbidite with the same mineral assemblage is locally migmatitic, with layer-parallel plagioclase+quartz+K-feldspar+tourmaline leucosomes suggestive of localized partial melting. As noted above, the amount of leucosome in Longstaff Bluff Formation metasedimentary rocks increases with proximity to the pegmatite bodies, suggesting a link between the timing of peak metamorphism and pegmatite emplacement. The fact that the footwall contains melt and the hanging wall does not suggests that pressure-temperature conditions were close to the pseudo-invariant point generated by the intersection of the reaction muscovite + quartz + plagioclase = sillimanite + K-feldspar + vapour and the granite melting curve (Fig. 13).

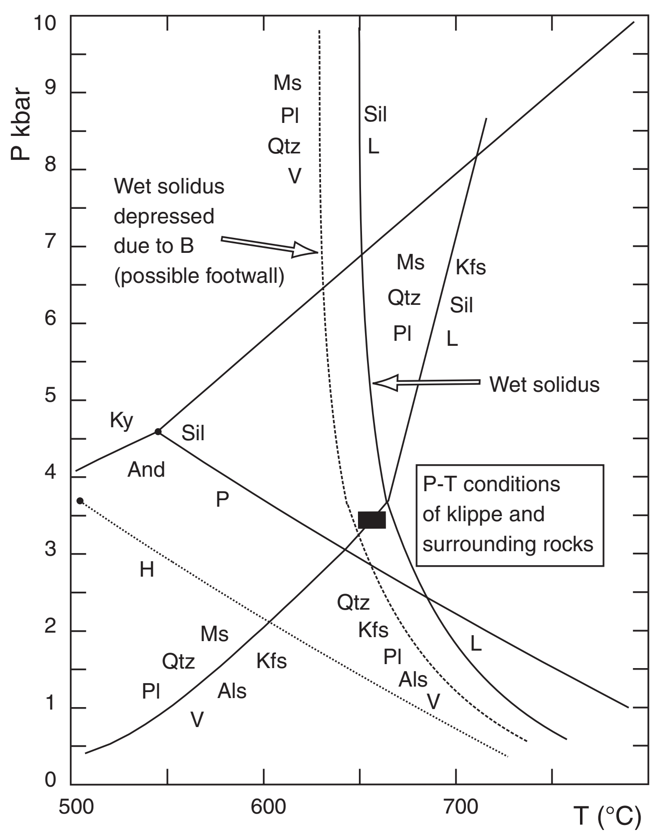

Figure 13. *Simplified P-T diagram illustrating how partial melting may be promoted in metapelite by depression of the melting curve due to boron released from pegmatite. Hanging-wall conditions are represented by the solid black melting curve and footwall conditions, by the dashed line. See text for discussion. Als, Al_2SiO_5 mineral; And, andalusite; Kfs, K-feldspar; Ky, kyanite; Ms, muscovite; Pl, plagioclase; Qtz, quartz; Sil, sillimanite; H, And=Sil curve of Holdaway (1971); L, silicate liquid; P, And=Sil curve of Pattison (1992); V, vapour*

The vertical distance between hanging-wall and footwall assemblages is 300 to 400 m, which amounts to a pressure difference of about 0.1 kbar. Although this small pressure difference could contribute to the contrast in melt development above and below the fault, a more likely explanation may be that the granite solidus was locally depressed in the footwall due to the influence of boron and perhaps other incompatible elements in the fluids released by the pegmatite (e.g. Pattison, 1992, Fig. 13). Peak P-T conditions in the vicinity of the klippe can therefore be constrained to approximately 650°C and 3.0 to 4.0 kbar.

EXPLORATION POTENTIAL

The most favourable mineral exploration targets would appear to be the ultramafic sills and metasedimentary rocks in units 3 and 5 of the Bravo Lake Formation. The cumulate-textured ultramafic sills are mineralized with pyrrhotite, holding the potential for magmatic sulphide deposits. The abundance of iron-formation and stratiform sulphide layers may signify the potential for exhalative-type base-metal sulphide deposits. Although the klippe itself may or may not hold significant ore mineralization, the stratigraphic control on prospective mineralization established in this study may apply to other exposures of the Bravo Lake Formation in the central Baffin Island area.

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REFERENCES

Allan, M.M. and Pattison, D.R.M.
2003: Deformation history and metamorphism of a synformal depression, Longstaff Bluff Formation metaturbidite, central Baffin Island, Nunavut; Geological Survey of Canada, Current Research 2003-C15.

Corrigan, D., Scott, D.J., and St-Onge, M.R.
2001: Geology of the northern margin of the Trans-Hudson Orogen (Foxe Fold Belt), central Baffin Island, Nunavut; Geological Survey of Canada, Current Research 2001-C23, 27 p.

de Kemp, E.A., Sherwin, T., Ryder, I., Davies, A., and Snyder, D.
2002: Detailed stratigraphic, structural, and three-dimensional mapping of the basal surface of the Paleoproterozoic Bravo Lake Formation, Nadluardjuk Lake area, central Baffin Island, Nunavut; Geological Survey of Canada, Current Research 2002-C18, 10 p.

Dredge, L.A.
2002: Surficial materials, central Baffin Island; Geological Survey of Canada, Current Research 2002-C20, 6 p.

Hoffman, P.F.
1988: United plates of America, the birth of a craton: Early Proterozoic assembly and growth of Laurentia; Annual Reviews of Earth and Planetary Sciences, v. 16, p. 543–603.

Holdaway, M.J.
1971: Stability of andalusite and aluminum silicate phase diagram; American Journal of Science, v. 271, p. 97–131.

Pattison, D.R.M.
1992: Stability of andalusite and sillimanite and the Al_2SiO_5 triple point; constraints from the Ballachulish aureole, Scotland; Journal of Geology, v. 100, no. 4, p. 423–446.

Scott, D.J., St-Onge, M.R., and Corrigan, D.
2002: Geology of the Paleoproterozoic Piling Group and underlying Archean gneiss, central Baffin Island, Nunavut; Geological Survey of Canada, Current Research 2002-C17, 10 p.

Spry, P.G., Peter, J.M., and Slack, J.F.
2000: Meta-exhalites as exploration guides to ore; *in* Metamorphosed and Metamorphogenic Ore Deposits; Reviews in Economic Geology, v. 11, p. 163–201.

St-Onge, M.R., Scott, D.J., and Corrigan, D.
2001a: Geology, MacDonald River, Nunavut; Geological Survey of Canada, Open File 3958, scale 1:100 000.
2001b: Geology, Flint Lake, Nunavut; Geological Survey of Canada, Open File 3959, scale 1:100 000.
2001c: Geology, Nadluardjuk Lake, Nunavut; Geological Survey of Canada, Open File 3960, scale 1:100 000.
2001d: Geology, Wordie Bay, Nunavut; Geological Survey of Canada, Open File 3961, scale 1:100 000.
2002a: Geology, North Tweedsmuir Island, Nunavut; Geological Survey of Canada, Open File 4199, scale 1:100 000.
2002b: Geology, Straits Bay, Nunavut; Geological Survey of Canada, Open File 4200, scale 1:100 000.
2002c: Geology, Dewar Lakes, Nunavut; Geological Survey of Canada, Open File 4201, scale 1:100 000.

Taylor, F.C.
1982: Precambrian geology of the Canadian North Borderlands; *in* Geology of the North Atlantic Borderlands, (ed.) J.W. Kerr, A.J. Ferguson, and L.C. Machan; Canadian Society of Petroleum Geologists, Memoir 7, p. 11–30.

Tippett, C.R.
1980: A geological cross-section through the southern margin of the Foxe Fold Belt, Baffin Island, Arctic Canada, and its relevance to the tectonic evolution of the northeastern Churchill Province; Ph.D. thesis, Queen's University, Kingston, Ontario, 409 p.
1985: Geology of a transect through the southern margin of the Foxe Fold Belt, Central Baffin Island, District of Franklin; Geological Survey of Canada, Open File 1110, 77 p.

Wodicka, N., St-Onge, M.R., Scott, D.J., and Corrigan, D.
2002: Preliminary report on the U-Pb geochronology of the northern margin of the Trans-Hudson Orogen, central Baffin Island; Geological Survey of Canada, Current Research 2002-F7; Radiogenic Age and Isotopic Studies: Report 15, 12 p.

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