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Tectonic evolution of the northern Pickle Lake greenstone belt, northwestern Superior Province, Ontario[1]

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Abstract The northern part of the Pickle Lake greenstone belt was previously thought to comprise two volcanic assemblages termed the Northern Pickle (inferred to be ca. 2990 Ma) and the Pickle Crow (ca. 2892 Ma) assemblages. Structural evidence and aeromagnetic patterns suggest that the inferred tectonic boundary between these two assemblages may not be significant and that this part of the belt may belong to a single composite Northern Pickle–Pickle Crow assemblage. Evidence for at least three deformation events is recognized: 1) an early, local planar fabric predating 2860 Ma; 2) the main regional foliation (S_1), bracketed between 2860 Ma and 2742 Ma; and 3) F_2 folds and overprints of the regional foliation associated with the emplacement of plutonic bodies at ca. 2741 Ma. A regional 'Kenoran' fabric of post-Confederation age has not yet been recognized in the northern part of the Pickle Lake belt.

Résumé On pensait auparavant que la partie septentrionale de la ceinture de roches vertes de Pickle Lake comportait deux assemblages volcaniques, soit celui de Northern Pickle (dont l'âge est estimé à 2990 Ma) et celui de Pickle Crow (dont l'âge est d'environ 2892 Ma). Des indices structurales et des configurations aéromagnétiques laissent supposer que la frontière tectonique présumée entre ces deux assemblages ne serait pas importante et que cette partie de la ceinture appartiendrait à un seul assemblage Northern Pickle–Pickle Lake composite. On a mis en évidence au moins trois déformations : 1) une ancienne fabrique planaire locale formée avant 2860 Ma; 2) la principale schistosité régionale (S_1), dont l'âge se situerait entre 2860 et 2742 Ma; et 3) des plis F_2 et des surimpressions de la schistosité régionale associés à la mise en place de corps plutoniques vers 2741 Ma. Une structure régionale «kénoréenne» postérieure à l'assemblage de Confederation n'a pas encore été mise en évidence dans la partie septentrionale de la ceinture de Pickle Lake.

[1] Contribution to Western Superior NATMAP Project

INTRODUCTION

Relationships among lithotectonic assemblages in the Pickle Lake belt (Fig. 1) play a key role in the interpretation that the boundary between the North Caribou terrane and the Uchi subprovince was an accretionary margin prior to its Neoarchean Andean evolution (Stott and Corfu, 1991). Regional deformation, including juxtaposition of ca. 2.89 Ga and 2.99 Ga tectonostratigraphic assemblages and possible gold mineralization, occurred prior to emplacement of 2.74 Ga plutons (Fyon et al., 1992; Corfu and Stott, 1993a). In the adjacent Uchi–Confederation Lake belt, volcanic rocks of the 2.74 Ga Confederation assemblage lie disconformably on older strata (Rogers et al., 2000), whereas further west, in the Red Lake belt, an angular unconformity marks the contact between the Confederation and 2.96 Ga Balmer assemblage (Sanborn-Barrie et al., 2000). The lithotectonic assemblages of the Pickle Lake belt offer a unique window into a ca. 2.8 Ga tectonic history because unlike elsewhere in the Uchi subprovince, deformation prior to the Kenoran Orogeny at ca. 2.7 Ga is preserved belt-wide.

The principal objective of the present project is to establish whether tectonostratigraphic assemblages of the Pickle Lake belt were built on, or accreted against, 3 Ga crust of the North Caribou terrane. Stott (1996) identified four lithotectonic assemblages (Fig. 2): 1) Northern Pickle assemblage, located along the northern margin of the Pickle Lake belt and interpreted to be ca. 2.99 Ga based on stratigraphic correlation with the McGruer assemblage of the North Caribou belt; 2) the Pickle Crow assemblage (>2.86 Ga); the Woman assemblage (ca. 2.836 Ga); and 4) the Confederation assemblage (ca. 2.74 Ga). The 2000 field season focused on understanding the stratigraphy and structure of the two northern assemblages, the Northern Pickle and Pickle Crow, and assessing the nature of their contact.

Specific aims of the project are: 1) to establish the age and affinity of the Northern Pickle assemblage, through U-Pb dating of felsic tuffaceous units, and dating of detrital zircons in associated greywacke units to explore for old crustal sources, and through determination of Nd isotopic compositions of basaltic units, to test hypotheses of continental margin (Stott and Corfu, 1991) versus oceanic origin (Hollings, 1998); 2) to establish the nature of the contact between the Northern Pickle and Pickle Crow assemblages through examination of the discordant boundary zone which has been defined aeromagnetically; 3) to establish stratigraphic order in the Pickle Crow assemblage through determination of younging directions in volcanic and sedimentary units and by U-Pb dating of felsic volcanic units. Clarification of the contact relationships between the tholeiitic and calc-alkaline sequences may help to establish whether the calc-alkaline rocks were built on a previously deformed (accreted) substrate (Hollings, 1998), are conformable, or are in tectonic contact; and 4) to define contact relationships between the Woman, Pickle Crow, and Confederation assemblages.

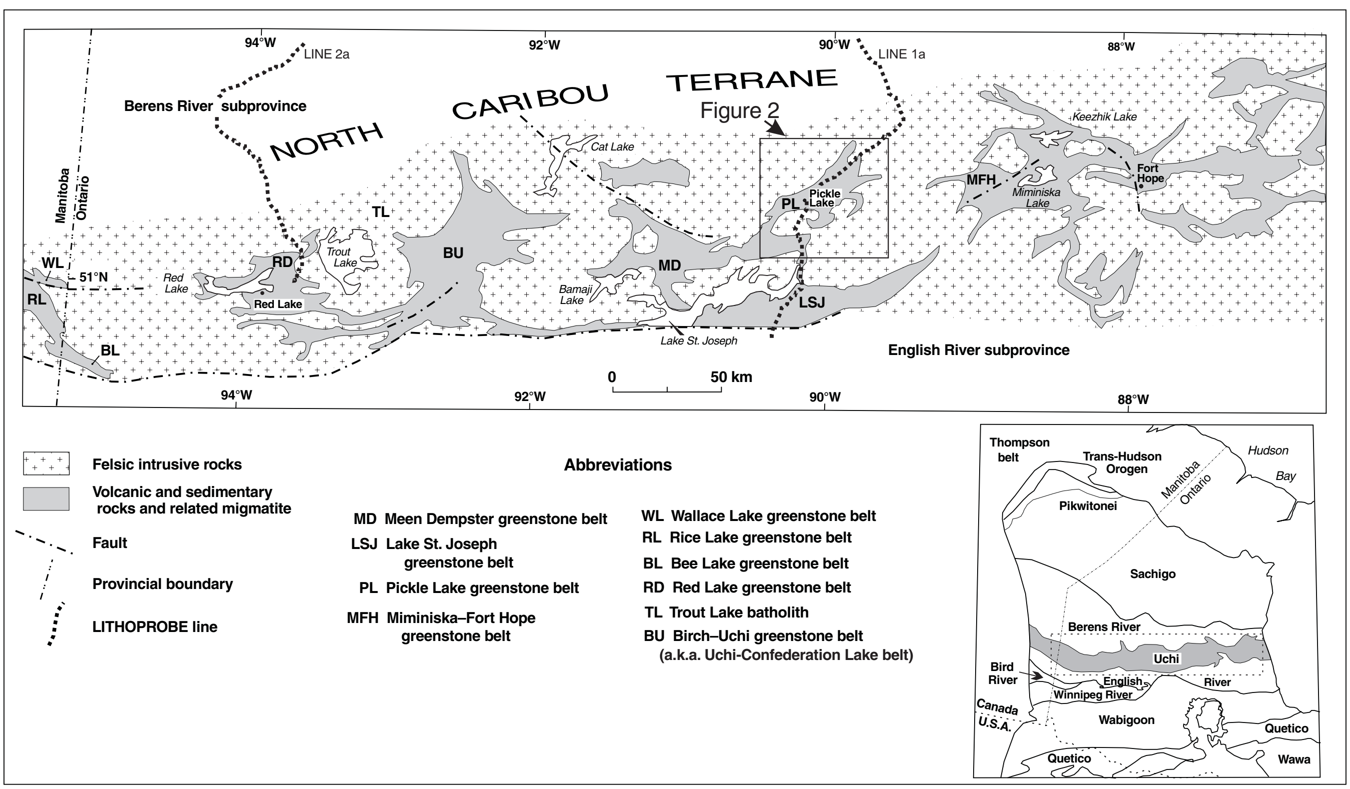

Figure 1. Greenstone belts and granitic batholiths of the Uchi subprovince (after Stott and Corfu, 1991).

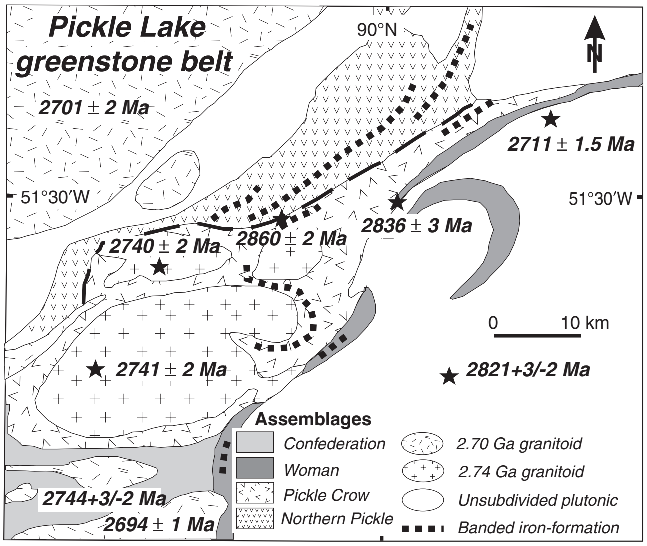

Figure 2. *Tectonic assemblage map of the Pickle Lake greenstone belt showing U-Pb zircon ages.*

GEOLOGICAL SETTING

The Pickle Lake belt has been the subject of active gold exploration and mining since the 1920s. Early geological investigations took advantage of widespread outcrop stripping, drill core analyses, and mine workings to construct detailed maps of the central part of the belt (Thomson, 1939; Ferguson, 1966; Pye, 1976). Systematic reconnaissance mapping placed the belt in a regional context (Sage and Breaks, 1982), and topical stratigraphic, structural, and geochronological studies, summarized in Stott (1996), defined tectonostratigraphic assemblages. Stott and Corfu (1991) concluded that the Pickle Lake greenstone belt may be one of the few parts of the Uchi subprovince where exotic oceanic crustal blocks have been accreted to the margin of the 3 Ga North Caribou terrane. Recently, Hollings (1998) provided interpretations of the geodynamic setting of volcanism based on geochemical data, and this is discussed later in the context of each assemblage. From an analysis of deep reflections on seismic profile 1a of the Western Superior LITHOPROBE Transect, Hynes (1999) suggested that the Uchi subprovince represents a broad, gently east-plunging synform at the regional scale. Like most upper crust of the western Superior Province, the Pickle Lake area is characterized by a shallow, seismically transparent zone (D. White, pers. comm., 1999).

NORTHERN PICKLE ASSEMBLAGE

This assemblage occurs at the northern margin of the Pickle Lake belt (Fig. 2). Although no direct or indirect ages have been determined, Stott and Corfu (1991) proposed that this assemblage could be correlative with 3.0–2.9 Ga supracrustal rocks of the North Caribou terrane based on the northeast-trending aeromagnetic patterns and similarities in stratigraphic sequences. The assemblage consists mainly of massive and pillowed basalt flows, with interbeds of carbonate-chert-magnetite banded iron-formation, sill-like mafic intrusive sheets, and very minor clastic metasedimentary interbeds associated with the iron-formation. No felsic volcanic rocks were observed in the field, but dacitic to rhyolitic tuff beds are reported from drill core (Stott et al., 1989a, b).

Pillowed and massive basalt flows near the southeastern margin of the assemblage are characterized by pink weathering, possibly due to low-temperature hydrothermal alteration or fault-related alteration. In contrast, the basalt in the central and western parts of the assemblage typically weathers green. More intermediate, pillowed to massive flows are also preserved in the southeast, closely associated with the pink-weathered basalt. Near the Thierry mine site (Fig. 3), altered pillow basalt consisting of hornblende-epidote-albite assemblages predominate, along with mafic-ultramafic sills. On the basis of trace-element geochemistry, Hollings (1998) recognized both Mg- to Fe-tholeiitic basalt, interpreted as an oceanic plateau sequence, and alkalic basalt inferred to represent an ocean-island environment; however, as a result of limited exposure, the geochemical database of Hollings (1998) is limited to a strike-parallel section in the central part of the assemblage along Highway 808 (Fig. 3). Without cross-strike geochemical control, subdivision of lithological packages is difficult.

The carbonate-chert iron-formation is characterized by laminated carbonate-rich chert beds interbedded with thin, magnetite-rich layers. It is exposed in only a few localities but can be traced aeromagnetically through the eastern part of the assemblage. East of Highway 808, a thin (20 cm thick) clastic unit occurs adjacent to the iron-formation. It grades from medium-grained quartz-rich sandstone to fine-grained siltstone and shale, in which grading indicates younging to the northwest. This overall stratigraphic younging direction was recorded at approximately 20 localities where pillow tops indicate northwest younging (Fig. 4), although Stott (1996) reported inconsistent younging indicators.

In the far northeastern corner of the belt, the Northern Pickle assemblage is intruded by the July Falls mafic stock consisting of phases ranging from quartz diorite to gabbro (Fig. 3; Stott, 1996). The elongate shape of the stock is parallel to the regional northeast strike of foliation, and the stock is internally foliated. Near the Thierry mine, the tonalitic Pickle Lake Stock imposes a strong flattening fabric in its contact strain aureole.

PICKLE CROW ASSEMBLAGE

The Pickle Crow assemblage is composed mainly of massive to pillowed basaltic flows and lesser dacitic to rhyolitic pyroclastic flows, carbonate-chert and magnetite-chert banded iron-formation interbeds, and minor clastic sedimentary units. On Kapkichi Lake, the amphibolitic basalt flows are composed of acicular hornblende, plagioclase, and pods and veinlets of epidote-quartz. Lithologically, these rocks resemble those of the western part of the Northern Pickle

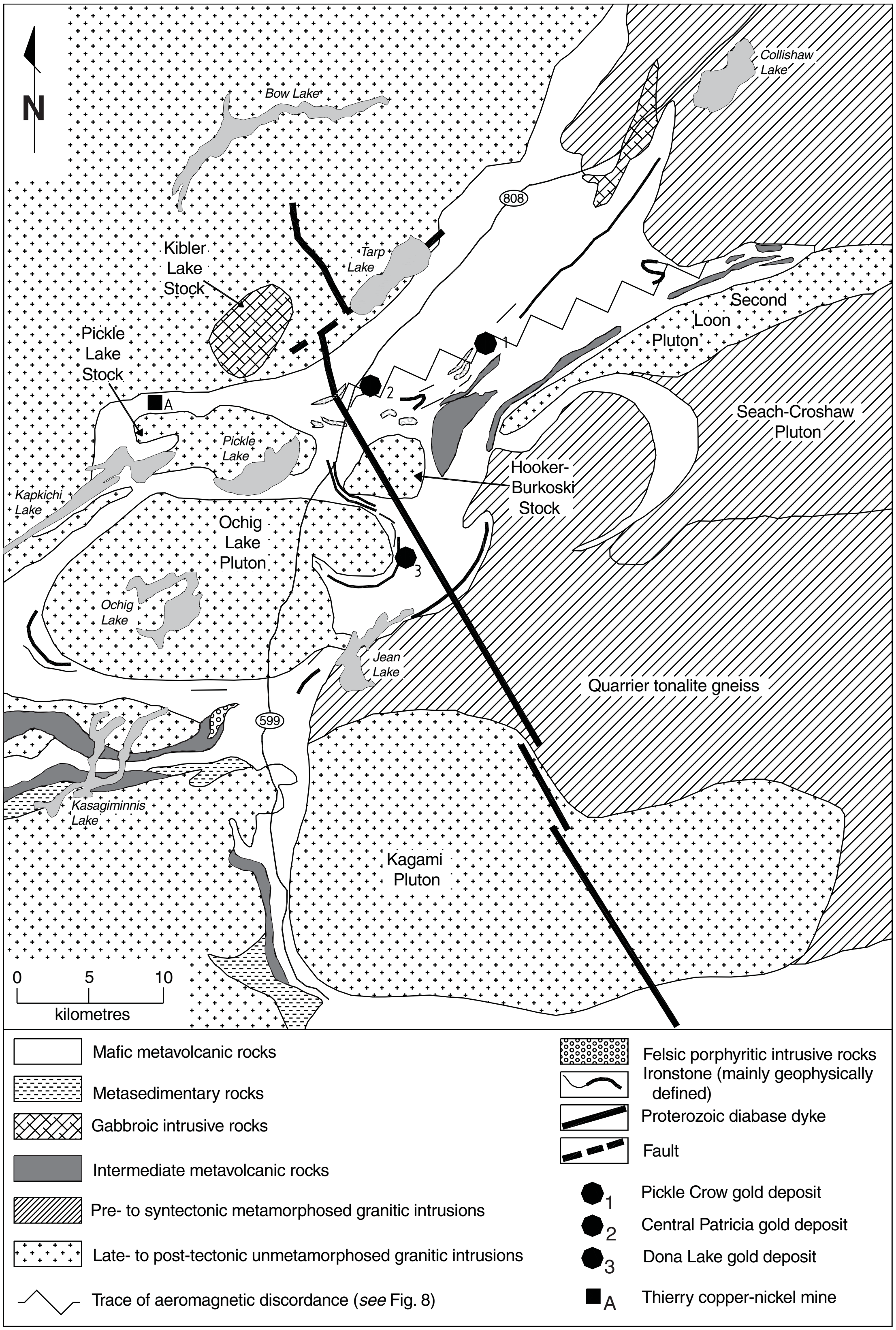

Figure 3. *Geology of the Pickle Lake greenstone belt (*after *Stott et al., 1989a, b).*

assemblage, and based purely on lithology, the contact between the assemblages is not easily defined in the western part of the belt. The Pickle Crow area is characterized by extensive carbonate alteration of strongly deformed, typically pillowed, basaltic flows. Hollings (1998) identified tholeiitic basalt to basaltic andesite and minor komatiite and inferred an oceanic plateau setting.

A unit of intermediate tuff, lapilli tuff, and tuff breccia southeast of the Pickle Crow mine area is characterized by felsic fragments in a more mafic matrix (Fig. 5). Geochemical data from the Pickle Crow assemblage provide conflicting interpretations. Hollings (1998) interpreted these calc-alkaline rocks to have continental arc affinities, and inferred that they postdated an accretion event. In contrast, Henry et al. (2000) found depleted mantle values (ε_{Nd}=+2.4) in ca. 2860 Ma rocks, which indicates no interaction with older evolved crust.

Iron-formation in the Pickle Crow mine area is of the carbonate-chert-magnetite type, whereas the iron-formation west of the Hooker-Burkoski Stock and in the Dona Lake area is of the magnetite-chert type (Fig. 6). The different types of iron-formation suggest either deposition in two different basins or lateral facies variation within the same basin. It is also

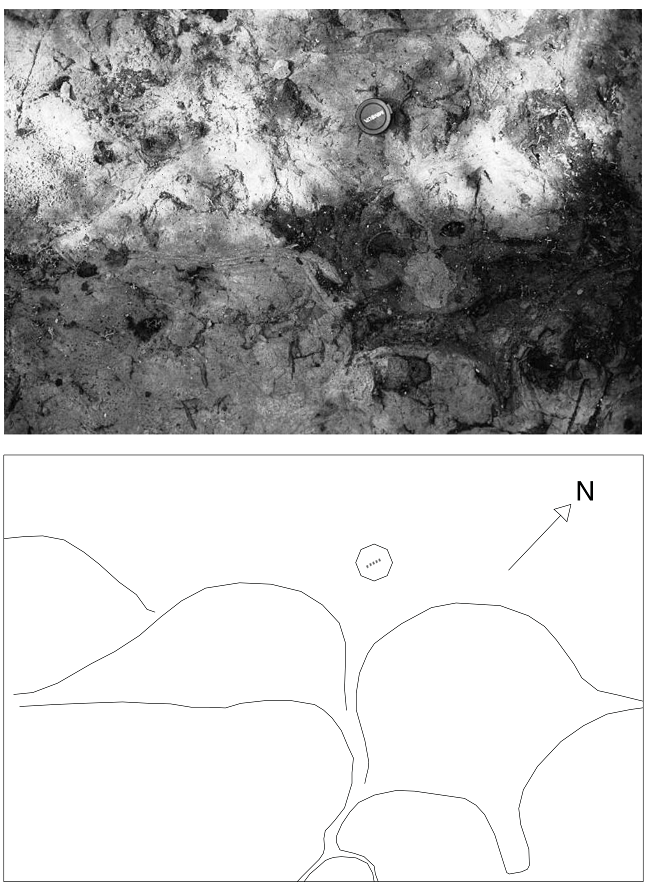

Figure 4. *Photograph and sketch of a pillowed flow from the Northern Pickle assemblage showing younging to the northwest.*

possible that the carbonate is a product of synvolcanic, low-temperature, hydrothermal alteration of iron-formation (Chown et al., 2000). The carbonate-chert-magnetite iron-formation of the Pickle Crow area is petrographically similar to that of the Northern Pickle assemblage and is apparently contiguous across the boundary identified by Stott (1996) (*see* 'Discussion'). A locally derived polymictic conglomerate shows grading on the bed and outcrop scale, suggesting a northwest younging direction (Fig. 7); however, because the Pickle Crow area is isoclinally folded (Ferguson,

Figure 5. *Tuff breccia from the southeastern part of the Pickle Crow assemblage.*

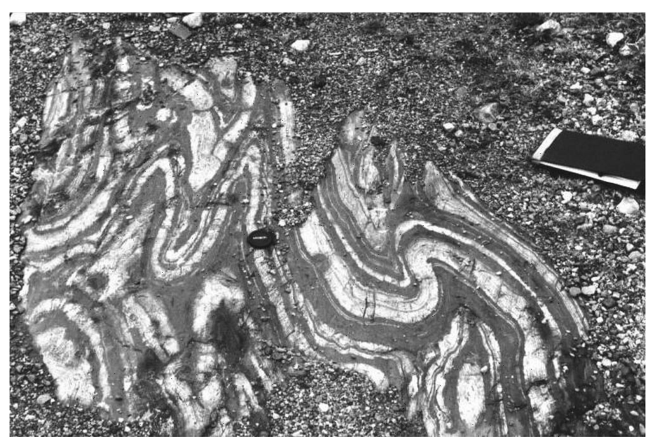

Figure 6. *Carbonate-chert-magnetite iron-formation from the Pickle Crow assemblage. Similar iron-formation occurs in the Northern Pickle assemblage.*

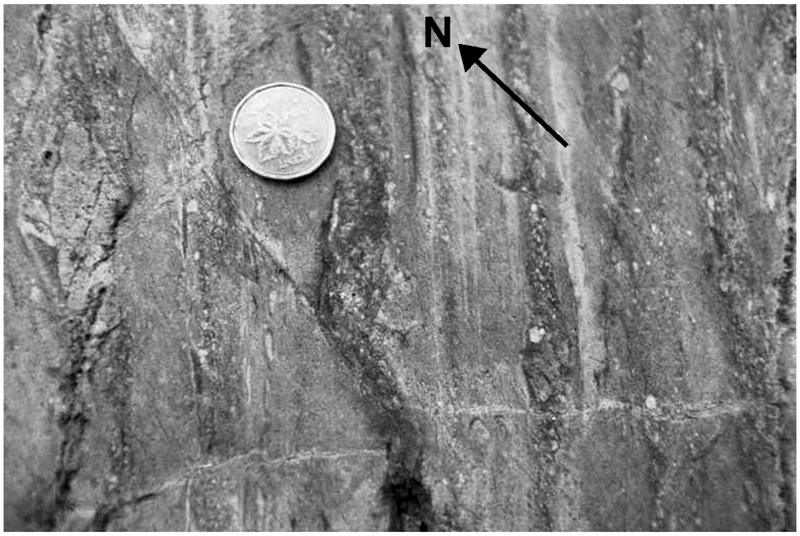

Figure 7.

Interbedded sandstone and locally derived polymictic conglomerate of the Pickle Crow assemblage, showing normal grading to the northwest.

1966; Sage and Breaks, 1982), local younging directions may not be representative. Therefore, the overall stratigraphic younging direction remains unconstrained.

The Pickle Crow assemblage is intruded by several tonalitic bodies. A suite of lenticular, quartz porphyry sills intruded the assemblage in the Pickle Crow mine region, and the Pickle Crow porphyry yielded an igneous zircon age of 2860 ± 2 Ma, with inherited grains of 2892+5/-2 Ma, inferred to date the host volcanic pile (Corfu and Stott, 1993b). Zircon dates for the Pickle Lake Stock and the Ochig Lake Pluton are 2740 ± 2 and 2741 ± 2 Ma, respectively. The Hooker-Burkoski Stock has yielded a titanite age of ca. 2736 Ma and was inferred to be part of the ca. 2740 Ma granitoid intrusive suite (Corfu and Stott, 1993a).

STRUCTURAL GEOLOGY

The volcanic rocks of both assemblages are steeply north-dipping panels that trend southwest. Penetrative strain is generally moderate to strong, so that primary features are generally poorly preserved. The inference that the Northern Pickle and Pickle Crow assemblages are in tectonic contact is based on structural evidence. Stott (1996) inferred that an aeromagnetic discordance (Fig. 8) marks the accretionary boundary between the assemblages and that foliation in the Pickle Crow assemblage is subparallel to this discordance, whereas the trend of foliation in the Northern Pickle assemblage is at an angle to both the discordance and foliation in the Pickle Crow. Beyond the angular difference in foliation across the inferred boundary, no field evidence supporting a tectonic boundary has been documented.

Planar fabric elements

A regionally penetrative, southwest-striking bedding-parallel foliation, termed S_1 (*see also* Stott et al., 1989a, b), is pervasive throughout the two northern assemblages. Folding (F_1) is restricted to the Pickle Crow mine area and is generally tight, with subvertical S_1 forming an axial planar foliation (Fig. 8). The folds are steeply plunging, but facing directions around them are not well understood. In the Pickle Crow area, S_1 locally crenulates an earlier, moderately developed fabric (Fig. 9). This zone of pre-S_1 fabric coincides with a broad zone of extensive iron-carbonate alteration and F_1 folding. Folding may be restricted to this zone because D_1 strain may have been focused along this zone of previously deformed rock. This zone extends east-northeast from the Central Patricia mine area, south of and roughly parallel to the aeromagnetic discordance inferred to be the Northern Pickle–Pickle Crow assemblage boundary (cf. Fig. 8). The early fabric is cut by the Albany porphyry inferred to be the same age as the Pickle Crow porphyry, and only S_1 is well developed in the Albany porphyry. The pre-S_1 fabrics may have been more common, but were elsewhere possibly transposed parallel to S_1.

Adjacent to and within the margins of the ca. 2740 Ma granitoid bodies, a strong S_2 strain aureole flattening fabric is developed that overprints S_1 (Stott et al., 1989a, b). Within the strain aureoles, the strike of S_2 follows the trend of the intrusive margin. In the Dona Lake area, the iron-formation and S_1 are transposed and folded around the eastern lobe of the Ochig Lake Pluton.

The regional S_1 foliation strikes consistently southwest in both assemblages, with no apparent angular discordance across the assemblage boundary as reported by Stott (1996). The aeromagnetic discordance inferred to represent the accretionary boundary (Stott, 1996) is at an angle (25–30° clockwise) to S_1 and bedding. The aeromagnetic discordance is spatially related to the domainal pre-D_1 fabric, however, a clear genetic relationship has not been determined.

Timing of deformation events

The pre-S_1 fabric is cut by the quartz porphyry sills, indicating that its minimum age is ca. 2860 Ma. The regional S_1 foliation is strongly developed in the Albany porphyry, but is cut by younger granitoid bodies, and thus S_1 is bracketed

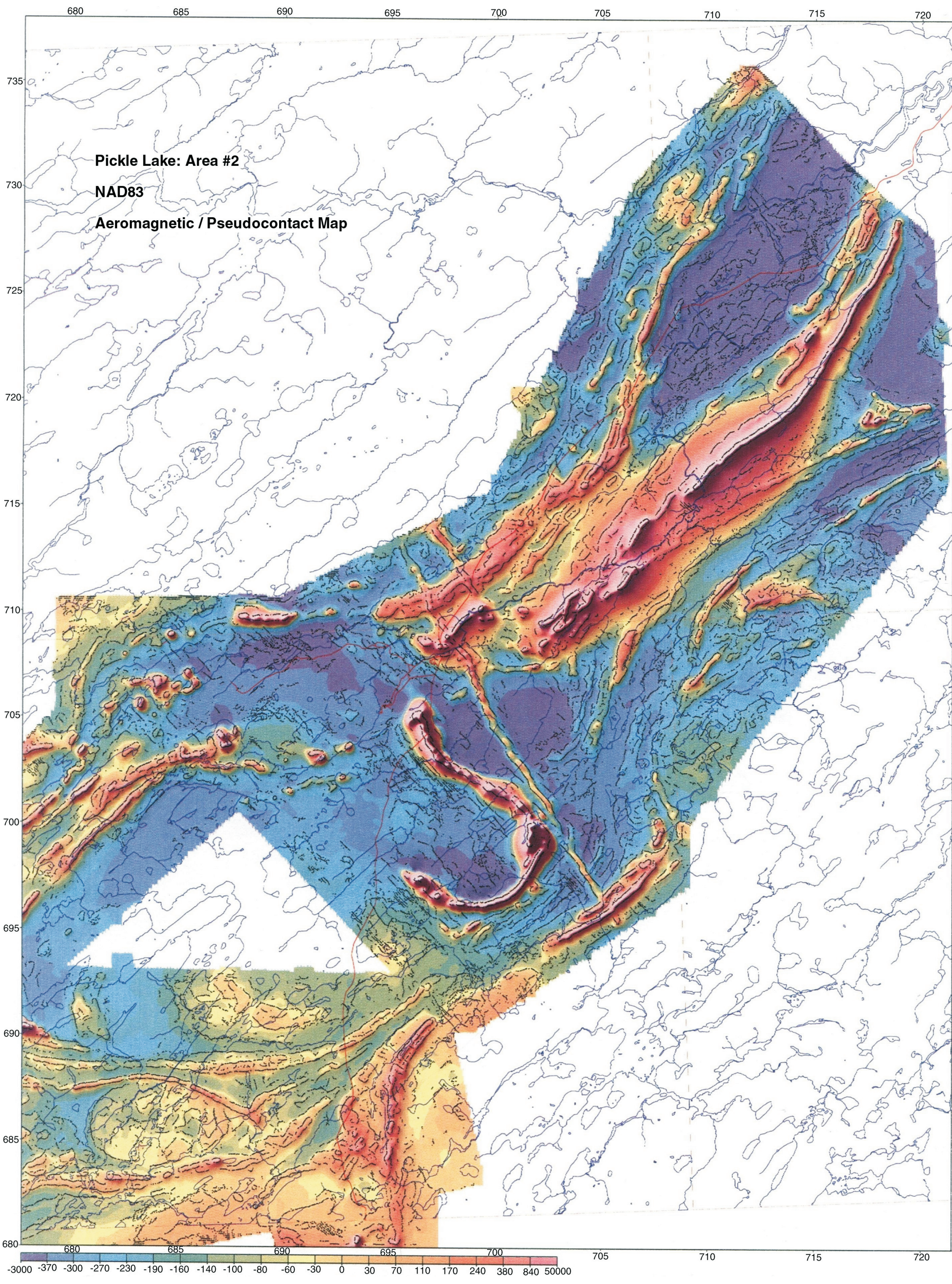

Figure 8. *Aeromagnetic map of the Pickle Lake belt showing stratigraphic continuity of the iron-formation (low magnetic susceptibility).*

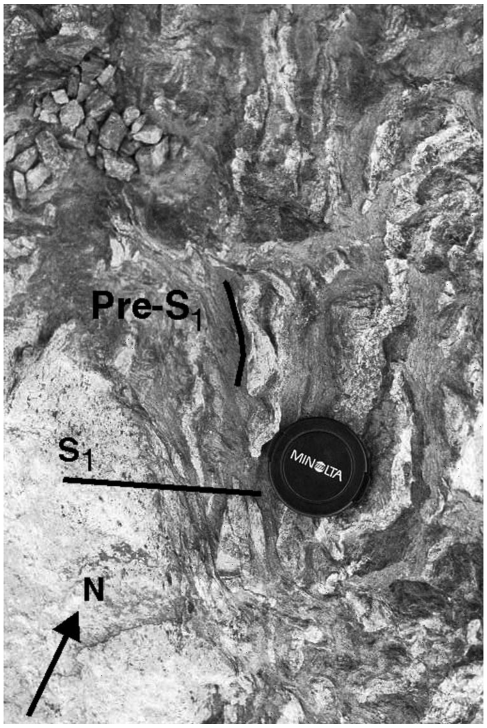

Figure 9. *Pre-S_1 fabric crenulated by S_1 in the Pickle Crow mine area. Light-coloured rock in the upper right corner is the Albany porphyry inferred to be correlative with the 2860 Ma Pickle Crow porphyry.*

between ca. 2860 Ma and ca. 2741 Ma (Stott, 1996). The contact strain aureoles (D_2) are synchronous with the emplacement of the ca. 2740 Ma granitoid plutons.

DISCUSSION

The inferred tectonic boundary between the Northern Pickle and Pickle Crow assemblages is defined mainly by indirect evidence (Stott, 1996):

1. The northern margin of the Pickle Lake belt (Northern Pickle assemblage) was inferred to be stratigraphically correlative with the southeast younging McGruer assemblage of the North Caribou terrane, implying an age of ca. 2990 Ma. The Pickle Crow assemblage is interpreted to be ca. 2892 Ma based on inherited zircons in the Pickle Crow porphyry, which was emplaced at 2860 Ma.
2. Stott (1996) reported an angular (15–300°) discordance between the strike of foliation in the Northern Pickle and Pickle Crow assemblages, defining two apparently different tectonic trends.
3. The interface across which the strike of foliation changes is marked by an aeromagnetic discordance. The foliation in the Pickle Crow assemblage was inferred to parallel the aeromagnetic discordance.

Based on these lines of evidence, Stott (1996) suggested that the Pickle Crow assemblage was tectonically juxtaposed against the southern margin of the Northern Pickle assemblage, which was inferred to be part of the North Caribou terrane.

On the basis of our preliminary work, and in light of recent geochemical studies, we question the significance of the Northern Pickle–Pickle Crow boundary for the following reasons.

1. The geochemical data of Hollings (1998) suggests that the Northern Pickle assemblage is of oceanic origin, rather than being of continental margin affinity. In addition, facing indicators in the Northern Pickle assemblage suggest northwest younging rather than southeast as required by the correlation with the North Caribou terrane (Stott, 1996).
2. Regional foliation is more or less parallel throughout both northern assemblages and at an angle to the aeromagnetic discordance. This angular relationship suggests that the regional foliation is not related to the structure represented by the aeromagnetic discordance.
3. The lithological similarities across the previously inferred boundary in the western part of the belt, and the continuity of the carbonate-chert-magnetite iron-formation across this boundary do not support a distinction of separate assemblages.

The origin of the two tectonic events prior to emplacement of granitoid intrusions at ca. 2740 Ma is not well understood. The pre-2860 Ma, pre-S_1 domainal fabric is an expression of an early event. The origin of the pre-2740 Ma regional fabric also remains unresolved, but it could represent an accretionary event remote from the North Caribou terrane margin or alternatively, accretion of a composite Northern Pickle–Pickle Crow assemblage onto the southern margin of the North Caribou terrane. The aeromagnetic discordance may represent a late brittle fault with little observable offset.

The interpretations drawn here are preliminary and will be tested through radiometric dating of felsic to intermediate volcanic units and felsic intrusive bodies. As exposure and access are major obstacles in understanding the belt, trace-element geochemistry will be used to test whether geochemical distinction between assemblages is possible. A second field season is planned to study the relationships between the Confederation and Woman assemblages and the northern assemblage. Exposure in the Confederation and Woman assemblages is similar to that of the composite Northern Pickle–Pickle Crow assemblage, and access is more difficult necessitating fly-in camps.

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REFERENCES

Chown, E.H., N'dah, E., and Mueller, W.U.
2000: The relation between iron-formation and low temperature hydrothermal alteration in an Archean volcanic environment; Precambrian Research, v. 101, p. 263–275.

Corfu, F. and Stott, G.M.
1993a: Age and petrogenesis of two late Archean magmatic suites, northwestern Superior Province, Canada: zircon U-Pb and Lu-Hf isotopic relations; Journal of Petrology, v. 34, p. 817–838.
1993b: U-Pb geochronology of the central Uchi Subprovince, Superior Province; Canadian Journal of Earth Sciences, v. 30, p. 1179–1196.

Ferguson, S.A.
1966: Geology of Pickle Crow Gold Mines Limited and Central Patricia Gold Mines Limited, No. 2 Operation; Ontario Department of Mines, Miscellaneous Paper 4, 97 p.

Fyon, J.A., Breaks, F.W., Heather, K.B., Jackson, S.L., Muir, T.L., Stott, G.M., and Thurston, P.C.
1992: Metallogeny of metallic mineral deposits in the Superior Province of Ontario; *in* Geology of Ontario; Ontario Geological Survey, Special Volume 4, pt. 2, p. 1091–1174.

Henry, P., Stevenson, R., Larbi, Y., and Gariépy, C.
2000: Nd isotopic evidence for Early to Late Archean (3.4-2.7 Ga) crustal growth in the Western Superior Province (Ontario, Canada); Tectonophysics, v. 322, p. 135–151.

Hollings, P.
1998: Geochemistry of the Uchi Subprovince, northern Superior Province: an evaluation of the geodynamic evolution of the northern margin of the Superior Province ocean basin; Ph.D. thesis, University of Saskatchewan, Saskatoon, Saskatchewan, 229 p.

Hynes, A.
1999: Seismic reflections and the gravity field: Indications of the dep structure of the Uchi, English River and Winnipeg River subprovinces; *in* 1999 Western Superior Transect Fifth Annual Workshop; (ed.) R.M. Harrap and H.H. Helmstaedt; LITHOPROBE Report 70, LITHOPROBE Secretariat, University of British Columbia, p. 80–89.

Pye, E.G.
1976: Geology of the Crow River area, District of Kenora (Patricia Portion); Ontario Department of Mines, Open File Report 5152, 264 p.

Rogers, N., McNicoll, V., van Staal, C.R., and Tomlinson, K.Y.
2000: Lithogeochemical studies in the Uchi-Confederation greenstone belt, northwestern Ontario: implications for Archean tectonics; Geological Survey of Canada, Current Research 2000-C16, 11 p. (online; http://www.nrcan.gc.ca/gsc/bookstore)

Sage, R.P. and Breaks, F.W.
1982: Geology of the Cat Lake-Pickle Lake area, Districts of Kenora and Thunder Bay; Ontario Geological Survey, Report 207, 238 p.

Sanborn-Barrie, M., Skulski, T., Parker, J., and Dubé, B.
2000: Integrated regional analysis of the Red Lake greenstone belt and its mineral deposits, western Superior Province, Ontario; Geological Survey of Canada, Current Research 2000-C18, 16 p. (online; http://www.nrcan.gc.ca/gsc/bookstore)

Stott, G.M.
1996: The geology and tectonic history of the central Uchi Subprovince; Ontario Geological Survey, Report 5952, 178 p.

Stott, G.M. and Corfu, F.
1991: Uchi Subprovince; *in* Geology of Ontario, Ontario Geological Survey, Special Volume 4, pt. 1, p. 145–236.

Stott, G.M., Brown, G.H., Coleman, V.J., Green, G.M., and Reilly, B.A.
1989a: Precambrian geology of the Pickle Lake area, western part; Ontario Geological Survey, Preliminary Map P.3056, scale 1:50 000.
1989b: Precambrian geology of the Pickle Lake area, eastern part; Ontario Geological Survey, Preliminary Map P.3057, scale 1:50 000.

Thomson, J.E.
1939: The Crow River area; Ontario Department of Mines, Annual Report, v. 47, pt. 3, p. 49–62.

Geological Survey of Canada Project 970014