Geochemistry and Radiogenic Isotope Characteristics of the Fort Hope Greenstone Belt, Northwestern Ontario: Development of a Continental arc on the Margins of a Proto-Continent

Pete Hollings
Department of Geology
Lakehead University
955 Oliver Road
Thunder Bay, Ontario
P7B 5E1
Canada
peter.hollings@lakeheadu.ca

Greg Stott
Ontario Geological Survey
Precambrian Geoscience Section
933 Ramsey Lake Road
Sudbury, Ontario
P3E 6B5
Canada
greg.stott@ontario.ca

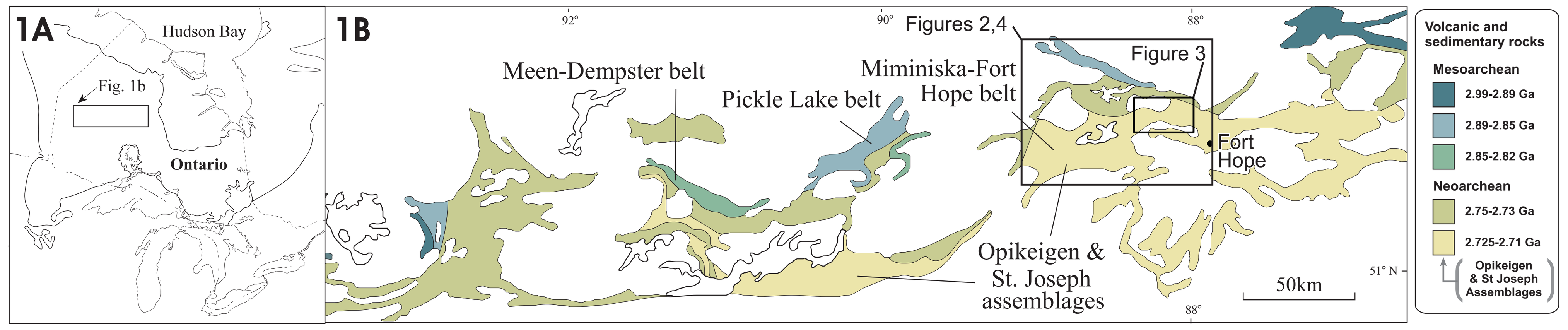
Introduction

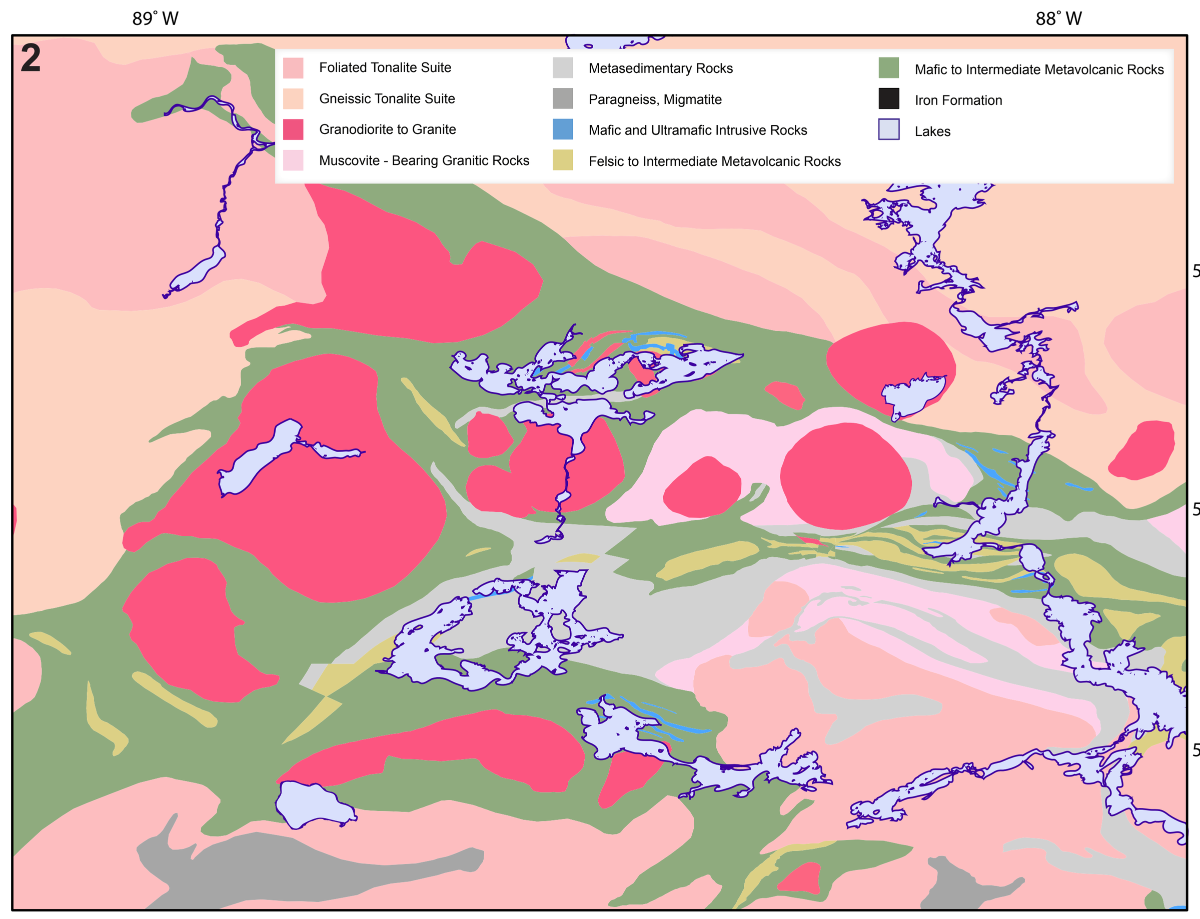
The Uchi subprovince of the Superior Province (Figure 1) is unusual in that it incorporates over 300 million years of discontinuous volcanic activity. It forms a long, linear domain, well over 600 km, along the southern margin of a Mesoarchean terrane. In general the older sequences have been interpreted as the result of rifting of passive margins of an older cratonic nucleus (c.f., Davis et al., 1988; Tomlinson et al., 1996), likely related to the impingement of a mantle plume on the continental lithosphere (e.g., Hollings et al. 1999) and are included within the North Caribou terrane of Thurston et al. (1991). In contrast, the younger assemblages of the Uchi comprise a mix of allochthonous and autochthonous volcanic sequences (Stott and Corfu, 1991; Hollings and Kerrich, 2006).

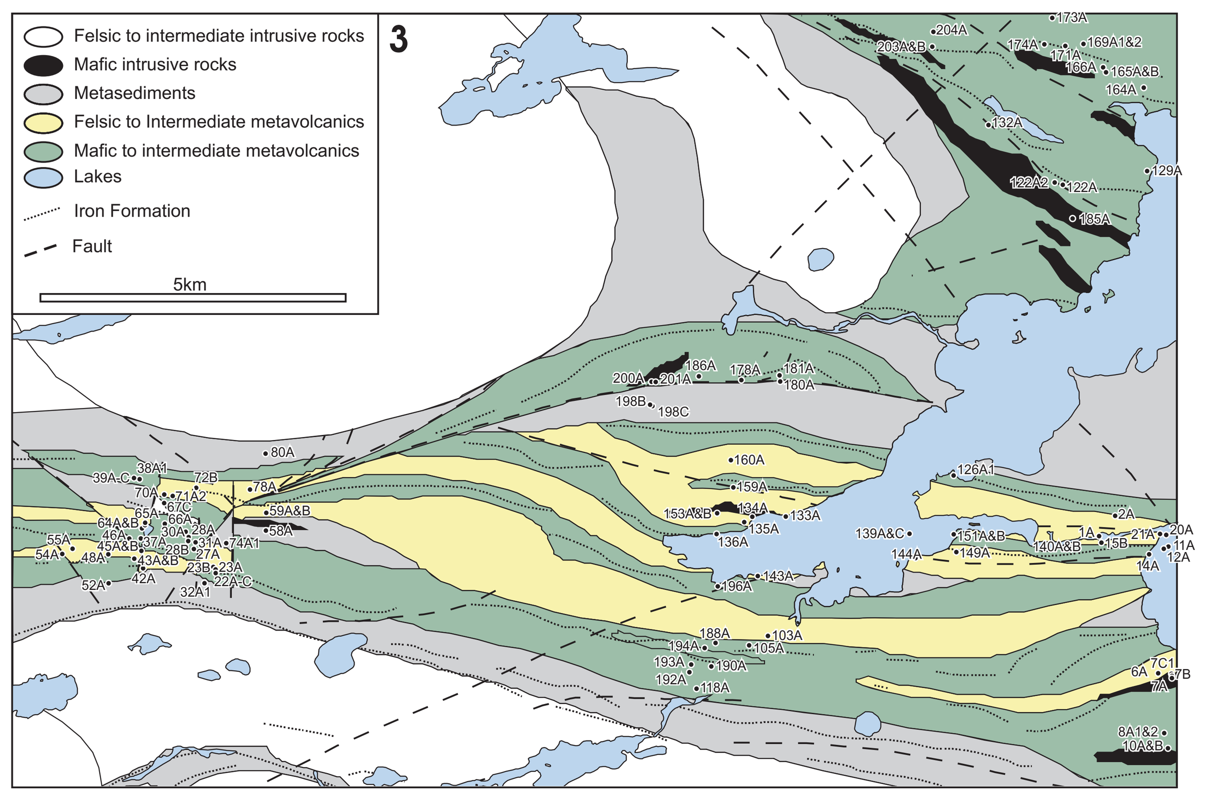
Regional Geology

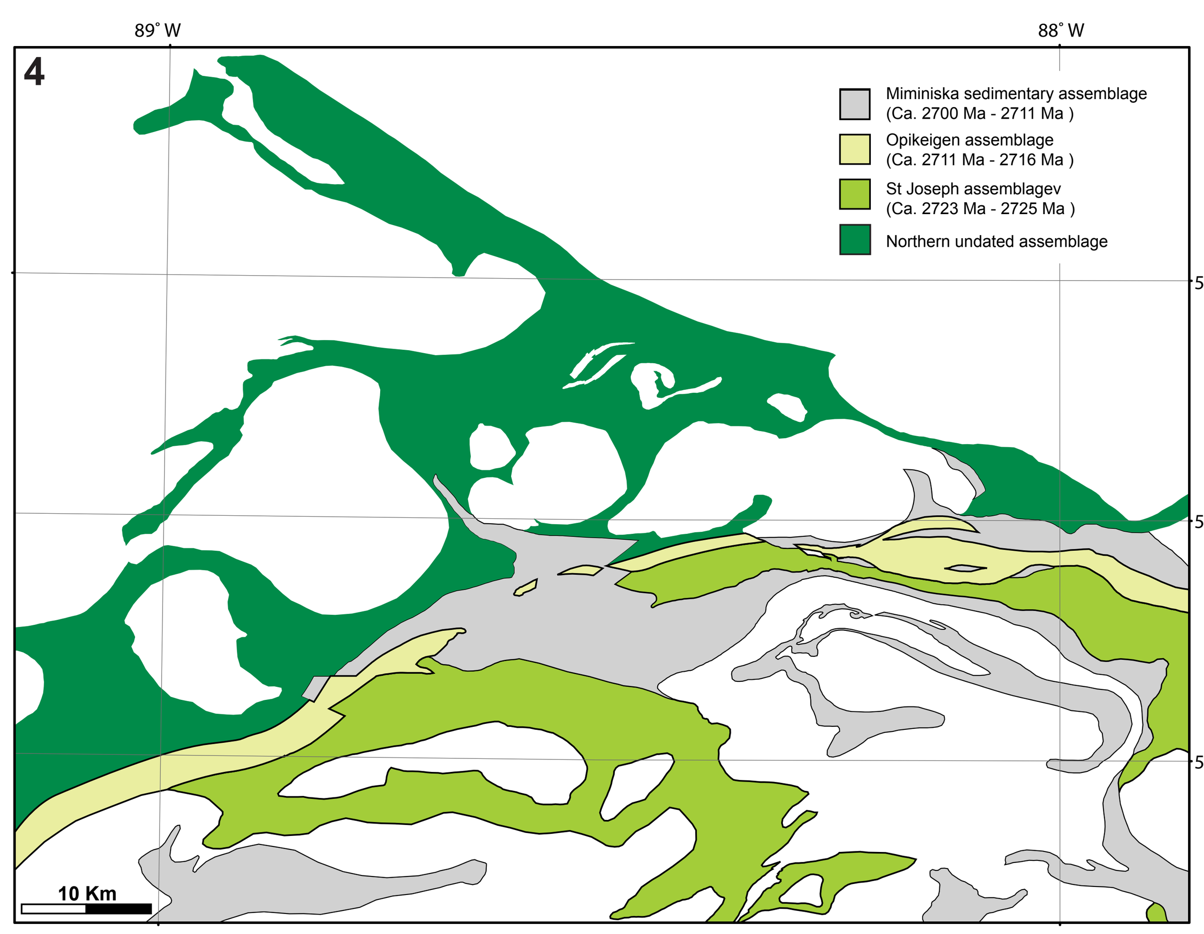
The Miminiska-Fort Hope greenstone belt is located towards the eastern end of the Uchi subprovince and has been the subject of relatively little detailed mapping or other geological studies. Detailed geological mapping was undertaken by Wallace (1978, 1981a, b) in the south of the belt and by Prest (1944) in the northern portion. Based primarily on U/Pb zircon age determinations and regional correlations with the central Uchi and the Pickle Lake belt (Young 2006), we tentatively identify one portion of the northern part of the belt that could be correlated with the (~2.89 to 2.86 Ga) Pickle Crow assemblage of the Pickle Lake belt. The older assemblages comprise predominantly tholeiitic pillow basalts with rare felsic pyroclastic flows. In contrast, the southern portion of the Fort Hope belt includes felsic pyroclastic rocks with ages of 2723-2716 Ma (Corfu and Stott 1993) and younger clastic sediments. Based on the reported ages and the presence of tholeiitic and calc-alkaline basalt flows overlain by intermediate to felsic pyroclastic units, Stott and Corfu (1991) proposed that this assemblage was an extension of the St Joseph assemblage of the Lake St Joseph greenstone belt. Subsequent dating of rocks (see Madon et al. 2009) and geochemistry in the Opikeigen Lake area confirm that the original St Joseph assemblage can be subdivided into two assemblages: ca. 2724Ma St Jospeh assemblage and ca. 2711-2716 Ma Opikeigen assemblage.

Wallace (1978) conducted the first detailed mapping of the Opikeigen Lake area (Figure 2). He reported the presence of abundant massive and pillowed lavas and flow breccias in east-trending belts throughout the area. Algoma-type iron formation occurs as minor bands intercalated with the mafic volcanics (Wallace, 1978). Mafic tuffs between 0.3 and 1.5 m thick are intercalated throughout the volcanic pile as are felsic to intermediate pyroclastic tuffs, massive flows and autobreccias (Wallace, 1978). More recently the Norton Lake area was subject to detailed mapping as part of a Master's thesis by Johnson (2005) whereas the Opikeigen Lake area was mapped in detail by Hall (2005) with more recent compilation by Madon et al. (2009).









Results

The volcanic rocks of the Fort Hope belt range in composition from basalts to rhyolites. We have tentatively subdivided the volcanic strata in the Opikeigen Lake area into three mafic assemblages: a "northern", undated, largely mafic assemblage, the ca. 2711-2716 Ma Opikeigen assemblage and the ca 2724 Ma St Joseph assemblage (Figures 3 and 4) both composed of mafic and felsic rocks. We argue that the southern mafic successions correspond in age to the ca. 2723-2725 Ma felsic volcanics and are part of the St. Joseph assemblage. The significantly younger volcanic felsic volcanic succession, ca. 2711-2716 Ma, referred to here as the Opikeigen assemblage, can be found along the length of the southern shores of Lake St Joseph, at Miminiska Lake, where it appears to be unconformably overlain by the Miminiska metasedimentary assemblage, and across southern Opikeigen Lake (Figures 1B and 4).

The "northern" assemblage (northwest Opikeigen Lake) consists of mafic flows and gabbros with flat to slightly depleted LREE and minor negative Nb anomalies (Fig. 5A). These are comparable to oceanic plateau basalts that have been widely documented in older terranes of the Uchi subprovince. The absence of felsic rocks within this sequence is consistent with this interpretation.

The central, Opikeigen assemblage, includes both mafic and felsic volcanic rocks (Fig. 5B1-3) as well as a sedimentary unit thought to be ca. 2711 Ma in age. Geochemically the mafic rocks comprise a mix of LREE depleted basalts and arc like basalts (Fig. 5B1-2). The LREE depleted basalts are MORB-like and lack the weak Nb anomalies seen in the "northern" assemblage basalts.

The southerly, St Joseph assemblage comprises mafic and felsic volcanic rocks and gabbros that are thought to be ca. 2723 Ma in age. The assemblage comprises a mix of LREE depleted MORB-like rocks intercalated with LREE-enriched supra-subduction zone felsic rocks Fig. 5c). The MORB-like package is distinguished from the similar rocks of the Opikeigen assemblage by large negative Nb anomalies.

$\varepsilon Nd_{(T=2700Ma)}$ values for the rocks of the Fort Hope belt are consistently positive (0.29-3.03) and show no consistent trend, within groups, between groups or with indices of contamination (Nb/Nb* or La/Sm_n; Fig. 6).

Interpretation

The presumably older but undated "northern" assemblage of the Fort Hope belt comprises plateau-like rocks similar to older assemblages of the Uchi subprovince (e.g., Hollings et al., 1999). It is proposed that this assemblage was accreted to the margins of the proto-continental North Caribou Terrane early in the history of the subprovince. The ~2724 Ma St Joseph assemblage displays a complexity of the mafic rock chemistry that is consistent with a back arc origin, upon which was constructed the largely pyroclastic calc-alkalic volcanic successions observed along the length of the southern edge of the Uchi domain. The younger, Opikeigen assemblage represents a second arc sequence accreted to the margins of the Uchi subprovince. The absence of negative Nb anomalies indicative of contamination by older continental crust suggests that these volcanic successions all formed as intraoceanic sequences distal to the margins of the North Caribou proto-continent.

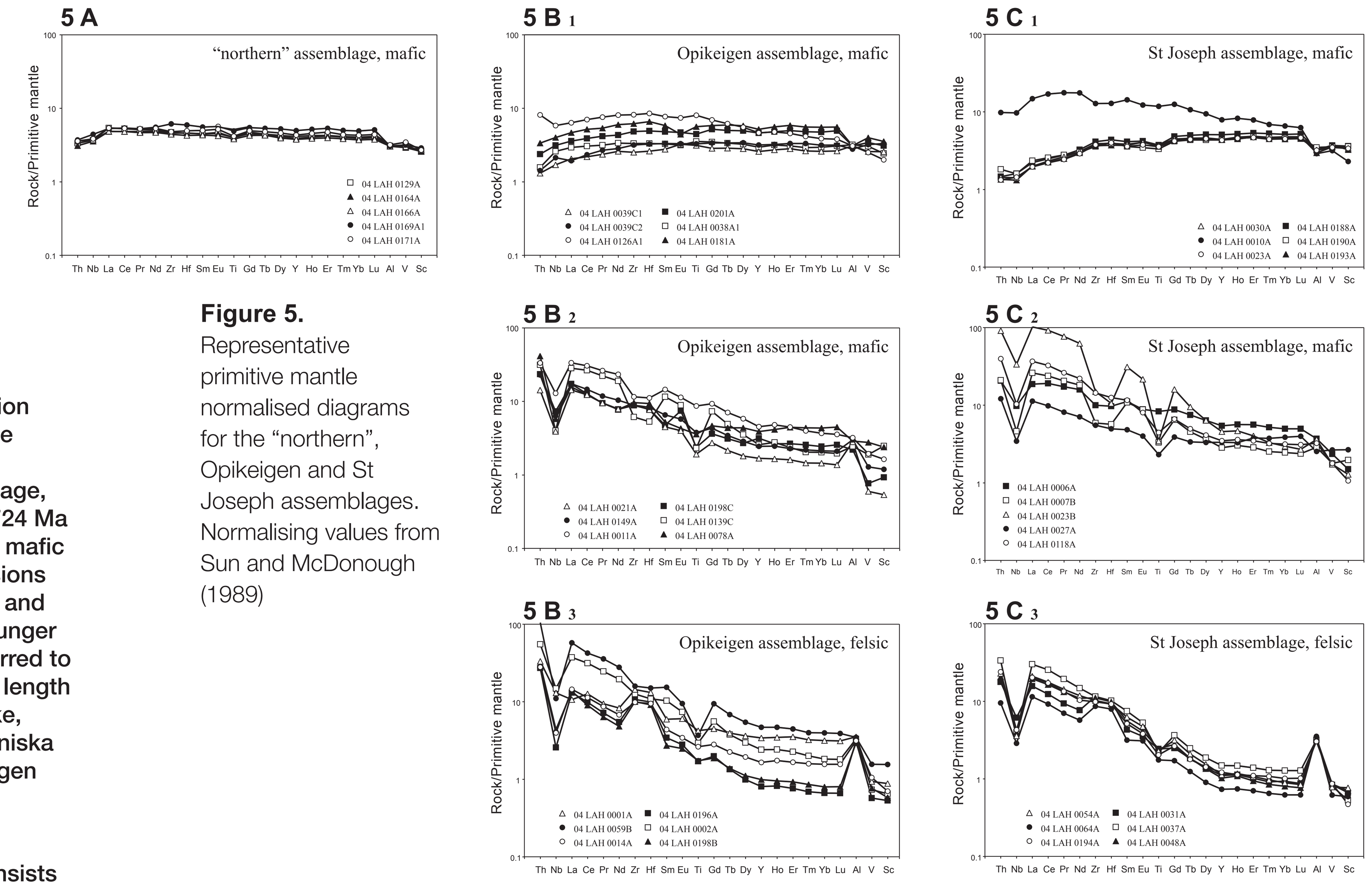


Figure 5. Representative primitive mantle normalised diagrams for the "northern", Opikeigen and St Joseph assemblages. Normalising values from Sun and McDonough (1989)

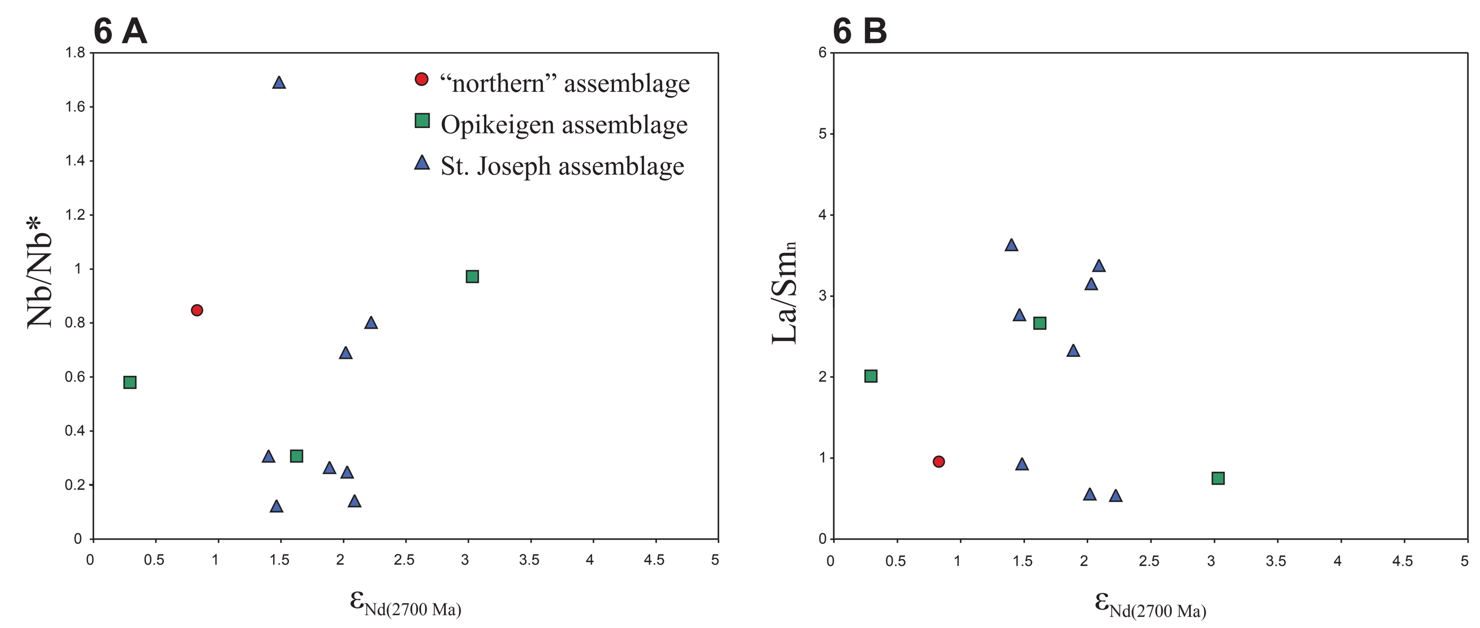


Figure 6. Plots of Nb/Nb* and La/Sm_n versus $\varepsilon Nd_{(2700\ Ma)}$ for the "northern", Opikeigen and St Joseph assemblages of the Fort Hope greenstone belt.

References

Corfu, F. and Stott, G.M. 1993, U-Pb geochronology of the central Uchi Subprovince, Superior Province, Can. J. Earth Sciences, 30, 1179-1196.

Davis, D.W., Sutcliffe, R.H. and Trowell, N.F., 1988, Geochronological constraints on the tectonic evolution of a late Archaean greenstone belt, Wabigoon subprovince, Northwest Ontario, Canada, Precambrian Research, 39, 171-191.

Hall, L.A.F., 2005, Precambrian geology, Opikeigen Lake area, Ontario Geological Survey, Preliminary Map P.3269, scale 1:20,000.

Hollings, P., Wyman, D. and Kerrich, R., 1999, Komatiite - basalt - rhyolite volcanic associations in Northern Superior Province greenstone belts: Significance of plume-arc interaction in the generation of the proto continental Superior Province, Lithos, 46, 137-161.

Hollings, P. and Kerrich, R., 2006, Light rare earth element depleted to enriched basaltic flows from 2.8-2.7 Ga greenstone belts of the Uchi Subprovince, Ontario, Canada, Chemical Geology, 227, 133-153.

Johnson, J., 2005. Mineralization and tectonic setting of the Norton lake region, Uchi subprovince. Unpublished MSc thesis, Lakehead University, 171p.

Madon, Z.B., McIlraith, S.J. and Stott, G.M. 2009, Geological compilation of the Miminiska Lake – Fort Hope area, eastern Uchi domain, Ontario Geological Survey, Preliminary Map P.3611, scale 1:250 000.

Prest, V.K., 1944, Geology of the Fort Hope area, Ontario Department of Mines, Annual Report, 1942, v.51, pt.3, 1-28.

Stott, G.M. and Corfu, F., 1991, Uchi Subprovince, in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, 145-236.

Sun, S.-s., and McDonough, W.F., 1989, Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes: in Saunders, A.D., and Norry, M.J., eds., Magmatism in the ocean basins, Geological Society, Special Publication No.42, p. 313-345.

Thurston, P.C., Osmani, I.A and Stone, D., 1991, Northwestern Superior Province: Review and terrane analysis, in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, 81-144.

Tomlinson, K.Y., Thurston, P.C., Hughes, D.J. and Keays, R.R., 1996, The central Wabigoon region: Petrogenesis of mafic-ultramafic rocks in the Steep Rock, Lumby Lake and Obonga greenstone belts (Continental rifting and rifting in the Archean), in 1996 Western Superior Transect Second Annual Workshop, Harrap, R.M. and Helmstaedt, H. eds., Lithoprobe Report 53, 65-73.

Wallace, H., 1978, Geology of the Opikeigen Lake area, Ontario Geological Survey, Report 185, 58p.

Wallace, H., 1981a, Geology of the Minimiska Lake area, Ontario Geological Survey, Report 214, 96p.

Wallace, H., 1981b, Geology of the Attwood Lake area. Ontario Geological Survey, Report 203, 49p.

Young, M.D., McNicoll, V., Helmstaedt, H., Skulski, T. and Percival, J.A. 2006, Pickle Lake revisited: New structural, geochronological and geochemical constraints on greenstone belt assembly, western Superior Province, Canada, Can. J. Earth Sciences, 43, 821-847

Lakehead UNIVERSITY

Ontario