VARIATIONS IN THE TRACE ELEMENT SYSTEMATICS OF THE MAFIC ROCKS FROM THE ARCHEAN BELLETERRE-ANGLIERS GREENSTONE BELT, SE SUPERIOR PROVINCE, CANADA: A PRODUCT OF CONTAMINATION, SOURCE VARIATION, OR BOTH?

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The Belleterre – Angliers greenstone belt (BAGB) is located near the southern margin of the Archean-aged Pontiac Subprovince and is one of the southernmost greenstone belts of the Superior Province. It is located north of the Grenville Front, and south of the Abitibi Subprovince within the Timiskaming region of Québec. Previous investigations have suggested that the BAGB represents a tectonically-juxtaposed arc and oceanic plateau environment that was rifted as it passed over a mantle plume (Barnes et al., 1993). Subsequently the BAGB is interpreted to have been emplaced as a thrust sheet above a midcrustal-level duplex consisting of tonalites and metasediments of the Pontiac Group (Sawyer and Barnes, 1994). U-Pb (zircon) geochronological investigations of the volcanic rocks within the BAGB have returned ages ranging from 2712 –2682 Ma (Mortensen and Card, 1994, this study).

Lithogeochemical analysis of the tholeiitic mafic volcanic rocks from the BAGB reveals that they can be divided into two distinct populations based on their trace element concentrations: those which are characterized by an enrichment in the light Rare Earth Elements (REE) as well as pronounced negative Nb and Zr anomalies when plotted on primitive mantle-normalized diagrams (LREE population), and those which possess flat REE patterns with weakly negative to positive Nb anomalies (FREE population). The mafic intrusive rocks of the BAGB can be similarly classified into these two populations based on the same lithogeochemical criteria. The mafic lavas and mafic intrusions of the respective populations are interpreted to be consanguinous equivalents based on their similar degrees of alteration, metamorphism, and structural deformation, as well as lithogeochemical and geochronological similarities. Spatially, these two lithogeochemical populations of mafic rocks occur in close proximity to one another and thus two broad questions are raised: 1) What process(es) led to the formation of these distinctly different magmas? and 2) What mechanism allowed for them to be intruded and erupted in such close proximity to one another?

Field evidence from the study area suggests that the FREE (N-MORB-like) mafic magmatism preceeded the LREE magmatism and that the LREE magmatism is spatially associated with a large unit of felsic, quartz and feldspar-phyric sediments and flows. Thus it is possible that the LREE magmas may have been formed via contamination of the FREE magma through assimilation of this felsic unit. However, simple mixing models using these two components does not accurately reproduce the composition of the LREE magma, particularly the pronounced negative Nb and Zr anomalies. Therefore if the LREE magmas were formed by contamination, it does not appear as though the contaminant is exposed at the present crustal level. The distinct trace element nature of the LREE magmas, however, may be a source characteristic rather than a function of crustal contamination. For instance, Zr, Hf, and HREE may have become fractionated from the LREE if majorite garnet was present in the mantle residue from which these magmas were derived (Xie et al., 1993). Furthermore, mantle metasomatism within a sub-arc mantle wedge can produce island arc-type lithogeochemical signatures which are similar to those of the LREE magmas. Further work is required in order to evaluate which of the processes described above or a combination there of contributed to the formation of the LREE magmas.

The mechanism which is invoked for the emplacement of the two populations of magma will be largely dependent on the process by which they are inferred to have formed, thus a number of scenarios are possible. Similar spatial relationships between N-MORB and island arc-type mafic lavas have been documented in the Hemlo-Schreiber greenstone belt of the Superior Province by Polat et al. (1998). There the association is attributed to the accretion of ocean plateau fragments with N-MORB geochemical signatures to an arc causing arc-trench migration of the magmatic activity through the accretionary wedge (Kusky and Polat, 1999). This would allow for the intrusion and eruption of island arc-type mafic magmas proximal to the accreted ocean plateau. The impingement of a plume on an island arc offers another

possible explanation for the spatial association of these two magmas (Kerrich et al., 1999, Barnes et al., 1993).

Significant questions remain regarding both the possible role of contamination and source variation in the formation of the two magma populations and the mechanism by which these magmas were emplaced into the crust. However, the identification of their lithogeochemical variations represents an economically significant observation in that Ni-Cu-PGE sulphide deposits have been identified in a number of the mafic intrusions belonging to the LREE population whereas the FREE intrusions appear to be devoid of mineralization.

References:

Barnes, S.-J, Couture, J.-F., Sawyer, E.W., and Bouchaib, C., 1993, Nickel-Copper Occurrences in the Belleterre-Angliers Belt of the Pontiac Subprovince and the Use of Cu-Pd Ratios in Interpreting Platinum-Group Element Distributions: Econ. Geol., v. 88, p. 1403.

Kerrich, R., Polat, A., Wyman, D., and Hollings, P., 1999, Trace element systematics of Mg-, to Fe-tholeiitic basalt suites of the Superior Province: implications for Archean mantle reservoirs and greenstone belt genesis: Lithos, v. 46, p. 163.

Kusky, T.M., and Polat, A., 1999, Growth of granite-greenstone terranes at convergent margins, and stabilization of Archean cratons: Tectonophysics, v. 305, p. 43.

Polat, A., Kerrich, R., and Wyman, D.A., 1998, The late Archean Schreiber-Hemlo and White River-Dayohessarah greenstone belts, Superior Province: collages of oceanic plateaus, oceanic arcs, and subduction-accretion complexes, Tectonophysics, v. 289, p. 295.

Mortensen, J.K., and Card, K.D, 1993, U-Pb age constraints for the magmatic and tectonic evolution of the Pontiac Subprovince, Quebec: Can. J. Earth Sci., v. 30, p. 1970.

Sawyer, E.W., and Barnes, S.-J., 1994, Thrusting, magmatic intraplating, and metamorphic core complex development in the Archaen Belleterre-Angliers Greenstone Belt, Superior Province, Quebec, Canada: Precam. Res., v. 68, p. 183.

Xie, Q., Kerrich, R., and Fan, J., 1993, HFSE/REE fractionations recorded in three komatiite-basalt sequences, Archean Abitibi greenstone belt: Implications for multiple plume sources and depths: Geochim. Cosmo., v. 57, p. 4111.