Potential source variation in Munro komatiites: Fred's and Theo's Flows, Ontario, Canada

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Munro-type komatiites, also called Al-undepleted komatiites, are volcanic ultramafic rocks characterized by a high MgO content (>18 wt%), and near-chondritic ratios of Al_20_3/TiO_2 and $(Gd/Yb)_n$.

We present new data of trace element concentrations, measured in two thick, differentiated flows, both Archean (2.7Ga) in age, located in the Munro Township in the Abitibi greenstone belt. Fred's Flow has komatiitic affinity. It differentiated from a parental magma with about 20% MgO into a series of upper spinifex lavas, a central gabbroic unit and lower olivine-dominated cumulates. Theo's flow has an Fe-rich tholeiitic affinity. It differentiated from a less-magnesian picritic parental magma into a central gabbro and underlying pyroxene-rich cumulates. The goal of this geochemical study is to better understand the petrogenetic relationship of those two flows.

The results reveal notable differences in REE pattern between the samples. Eight Fred's Flow units are characterized by moderate to strong depletion in LREE $(0.55 \leq (La/Sm)_n \leq 0.99)$ and relatively flat HREE patterns $(0.88 \leq (Gd/Yb)_n \leq 1.20)$, whereas seven Theo's Flow units have a convex pattern with $(0.83 \leq (La/Sm)_n \leq 1.24)$ and $(1.34 \leq (Gd/Yb)_n \leq 1.63)$. Elements such as Ba, Cs, Sr and Eu were mobile during metamorphism and/or hydrothermal alteration.

As a whole Theo's Flow is more enriched in trace elements than Fred's Flow and its HREE are depleted, indicating that garnet was residual during partial melting. Together with the Fe-rich composition, this may reflect a lower degree of melting and/or a more enriched source, perhaps one with a high eclogite component. Fred's Flow magmas probably formed by fractional melting of a hotter peridotitic source.

Multiscale melt extraction in the lower crust and upper mantle

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The dynamics associated with melt extraction, including both the movement of melt and the much slower deformation of the solid residue, involves motion on a range of scales. Ultimately melt separation occurs on the crystal scale, while consequent solid deformation occurs on scales of 10s to 100s of kilometers. In order to examine both the solid-state instabilities and melt extraction in detail, we have adopted a multi-scale modeling approach. Crystal scale melt extraction under different amounts of mantle anisotropy is calculated using a lattice Boltzmann method, and a parameterized permeability based on numerous calculations is then incorporated into a multiphase thermal and dynamic model to study the location, timing and flux of melt separating from the crystalline solid. We apply this approach to examine the residence time and extraction rates of melt in lower crustal MASH zones and examine the consequences of foundering of dense crustal roots.

The foundering of dense, mafic residual material from the base of the crust and lithosphere into the underlying mantle has been proposed to explain the long-term chemical evolution of continental crust. Such density instabilities generate solid-state dynamics in the upper mantle surrounding the downwelling material and the return flow of the surrounding mantle. Upwelling regions may generate melting and perturb the flux of magma reaching the base of the crust. We find that large-scale mantle stresses create anisotropy in the permeability structure of the mantle that focuses melt in roughly annular regions surrounding downwelling material. The extent of melting is a function of the degree hydration of the mantle, with the most hydrated conditions resulting in a factor of 3-4 times estimates of background arc melt flux. When the presence of a slab is considered, melt flux is focused preferentially several kilometers toward the backarc region, leaving a magmatic shadow immediately below the downwelling flow.