Geophysical Research Abstracts
Vol. 20, EGU2018-9934, 2018
EGU General Assembly 2018

A mantle source of water in the Late Neoproterozoic appinitic Greendale Complex, Nova Scotia: An O and H isotopic study on amphiboles provides evidence of asthenospheric upwelling

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Appinites are plutonic rocks that typically form in convergent to collisional tectonic settings. Appinite contains abundant amphibole, a mineral that uniquely records magma chamber conditions through the incorporation of mantle, crustal and or meteoric water during crystallisation. Isotopic ratios of D/H and $^{18}O/^{16}O$ in the amphibole provide independent tracers on the source of water in cooling appinitic magma thus informing on magma transport, storage and evolution in the crust.

Two generations of amphiboles in the ca. 607 Ma Greendale Complex appinites are identified: one generation returns $\delta^{18}O$ data in the range of 4.8 - 6.8 ‰ these are interpreted as mantle derived and were likely transported to supracrustal zones where they underwent low T water-rock interactions; the second generation returns $\delta^{18}O$ data from 0.9 to 4.7 ‰ these are interpreted as likely having a crustal origin and experienced high T-hydrothermal interaction with meteoric waters in sub-volcanic magma chambers and/or by assimilation of previously hydrothermally altered units. The δD isotopic signatures show increasingly D-enriched signatures from -135 to -64 ‰ which are interpreted to be the result of mixing between a region of mantle upwelling and a subducting slab, allowing for hydration of the magma during ascent through the slab window into the overlying mantle wedge.

Appinites have been widely interpreted to be the result of asthenospheric upwelling either by generation of a slab window or slab breakoff. Previous models for evolution of the Avalonian-Cadomian belt propose the end of arc magmatism with the generation of a transform system. Our δD and $\delta^{18}O$ data support this model with the generation of a slab window behind the transform system through which the asthenosphere could upwell and intrude into the crust. Our isotopic data provides firm evidence in support of the importance of asthenospheric upwelling in contributing the origin of appinites and suggests that appinitic complexes may be a tracer of such processes.