

## Evolution of SCLM beneath the Renard Kimberlites, SE Superior Craton: An integrated study of diamonds, xenoliths and xenocrysts

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The diamondiferous Renard kimberlites are located in the eastern portion of the Superior Province, in the northern Otish Mountains of Quebec. To better constrain the cratonic lithospheric mantle beneath Renard, 116 microxenoliths and xenocrysts, and 56 diamonds were collected.

Based on the single clinopyroxene geothermobarometer [1] a cold 'Slave-type' geotherm was present during Neoproterozoic kimberlite emplacement. Common Pb dating of clinopyroxene xenocrysts indicates an age of ~2.7 Ga for the underlying lithospheric mantle, broadly coinciding with a major phase of global continental crust generation.

Compositionally, garnet xenocrysts mainly fall in the on craton lherzolite field (G9A of [2]). Considerable variability in the chondrite normalized trace element patterns of the peridotitic garnets is observed and three principal patterns have been identified: sinusoidal, humped, and sloped. Sinusoidal patterns follow the fluid metasomatism trend of [3] whilst garnets with humped patterns fall on a melt metasomatic trend. Sloped patterns fall along a trend of increasing Y with little to no associated increase in Zr, a trend not observed in the Kaapvaal samples of [3].

Calculated REE<sub>N</sub> patterns of the metasomatising agents indicate that sinusoidal patterns likely reflect metasomatism by a highly fractionated fluid. The agent associated with sloped patterns is similar to typical mantle melts. Evolution of this melt through interaction with garnet peridotite wall rocks produced the metasomatic agent reflected by humped garnet patterns.

Renard diamonds have nitrogen contents and aggregation states similar to worldwide data. Two distinct inclusion assemblages have been determined: A peridotitic (olivine, Mg-chromite and a G10 garnet), and an SiO<sub>2</sub> assemblage. The latter may represent an eclogitic silica rich source or a peridotitic source with SiO<sub>2</sub> forming during localised carbonation reactions along veins.

[1] Nimis & Taylor (2000). *Contrib. Mineral. Petrol.* **139**, 541-554. [2] Grütter *et al.* (2004)., *Lithos* **77**, 841-857. [3] Griffin & Ryan (1995), *J. Geochem. Explor.* **53**, 311-337.

## Fe-redox, aridification, and acidic surface waters on early Mars

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Observations from planetary orbiters and *in situ* experiments have shown that the sedimentary rocks at Meridiani Planum, Mars were formed in the presence of acidic surface waters [1, 2]. The water was thought to be brought to the surface by groundwater upwelling [3], and may represent the last vestiges of the widespread occurrence of liquid water on Mars. However, it is unclear why the surface waters were acidic. Here we use geochemical calculations, constrained by chemical and mineralogical data from the Mars Exploration Rover *Opportunity*, to show that Fe-oxidation and the precipitation of Fe<sup>3+</sup>-minerals generate excess acid with respect to the amount of base anions available in the rocks present in outcrop. We suggest that subsurface waters of near neutral pH and rich in Fe<sup>2+</sup> were rapidly acidified as iron was oxidized at the martian surface [4].

Our analysis permits estimates of the volume of water required to form the Meridiani Planum succession, and indicates that temporal variation in surface acidity may have been controlled by the availability of liquid water. For instance, we calculate that 95 liters of H<sub>2</sub>O/kg outcrop is required to dissolve the H<sup>+</sup> remaining after Fe<sup>3+</sup>-mineral precipitation and acid titration and generate a pH=2 fluid. If we perform the same calculation for a pH=4 fluid, the required water volume estimates increase to 2x10<sup>4</sup>L H<sub>2</sub>O/kg. These pH values bound the stability range of jarosite, a ferric sulfate mineral present in Meridiani outcrop. This substantial volume increase highlights the important role water plays in diluting the acid produced by Fe-redox. We will further explore the interdependence between fluid pH and total water availability and their implications for the evolution of the martian hydrosphere.

[1] Grotzinger, J.P., *et al.* (2005) *EPSL* **240**, 11-72. [2] Squyres, S.W., *et al.* (2009) *Science* **324**, 1058-1061. [3] Andrews-Hanna, J.C., *et al.* (in press) *JGR* doi:10.1029/2009JE003485. [4] Hurowitz, J.A., *et al.* (in press) *Nat. Geosci.*