Mantle redox evolution inferred from eclogites: Implications for volatile-rich magma generation

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Kimberlite-borne eclogite xenoliths with Archaean and Proterozoic ages have complex histories that can be unravelled using their major- and trace-element relationships. Low-pressure protoliths are identified by flat HREE and positively correlated Y-TiO_2, sometimes accompanied by Eu anomalies. Incompatible element abundances relate to melt fraction during protolith generation, revealing a similarity to basalts or picrites. The melt fraction lost from rutile eclogite that induced low LREE/HREE upon metamorphism in some samples can be approximated by modelling. Excluding metasomatised samples and accounting for the effects of eclogitisation, these rocks can be employed together with orogenic eclogites and (meta)basalts from allochtonous greenstone belts to constrain some characteristics of the convecting mantle sources from which their protoliths were ultimately derived.

We use the V/Sc of eclogites that only fractionated olivine ± plagioclase and that have low-pressure protoliths which separated from a garnet-free peridotite source to unravel the redox history of the convecting mantle [1] [2]. Because of higher mantle potential temperatures in the Archaean, low V/Sc results in part from deeper average melting pressures and decreasing f_{O2} with depth. After accounting for this effect, Archaean convecting mantle can be shown to have been more reducing than its modern equivalent, as previously suggested [3], with ΔFMQ as low as -1.5 and Fe^{3+}# of 0.08±0.04. This has several consequences for the carbon cycle, including (1) the locus of the peridotite solidus and the composition of fluids/melts that can be generated along the mantle adiabat; (2) the viability of redox melting in decompressing mantle as a precursor to continental rifting in the presence of thick cratonic lithospheric keels, and (3) the stability of graphite/diamond vs CO_2-bearing melts upon recycling of reducing Archaean oceanic crust [4].

[1] Canil (1997) *Nature* **389,** 842-845. [2] Lee *et al*. (2005) *JPet* **46,** 2313-2336. [3] Foley (2011) *JPet* **52**, 1363-1391. [4] Stagno *et al*. (2015) *CMP* **169**, 16.