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Water in omphacite and garnet from unmetasomatised xenolithic eclogite: T-X-fO_2 controls, and implications for conductivity and the deep H_2O cycle

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Eclogite xenoliths - widely interpreted as having oceanic crustal protoliths - contain some 50 wt.% omphacitic clinopyroxene, which can accommodate 100s to 1000s wt.ppm H_2O. This lithology has thus been interpreted as an important carrier of water into deep Earth, with consequences for mantle rheology and melting behaviour. We determined, by Fourier Transform Infrared Spectroscopy, structural OH contents in clinopyroxene (oriented crystals in polarised mode) and garnet from 15 relatively pristine (unmetasomatised), well-characterised Archaean and Palaeoproterozoic eclogite xenoliths from the Udachnaya kimberlite (Siberian craton) and the Diavik kimberlite (Slave craton), respectively.

Calculated total c(H_2O) range from only 50 to 300 wt.ppm for reconstructed bulk eclogites, suggesting limited transport of water into the deep mantle in ancient subduction zones. Garnet delta^{18}O ranges from +5.0‰ (mantle-like) to +7.3‰ (similar to low-temperature seawater-altered oceanic crust). Temperature- and H_2O-dependent electrical conductivity ranges from $10^{-4.0}$ to $10^{-1.0}$ S/m using the calibration for eclogite minerals of Liu et al. (2019), and is mostly higher than that derived either from magnetotelluric studies or calculated for peridotite in cratons (Garber et al. 2018), thereby placing upper limits on the volume of eclogite present in the cratonic lithosphere. Both H_2O content and electrical conductivity in bulk eclogites increase with depth.

The orientation of the OH dipole in clinopyroxene, captured as the ratio of gamma- over alpha-polarised component (though not c(H_2O)) is positively correlated with Fe^{3+}/Fe^{total} and temperature, suggesting OH redistribution among crystal defects that may be a useful tool to estimate iron valence state if the temperature effect is accounted for. Clinopyroxene-garnet H_2O distribution coefficients range from 2.2 to 75 and decrease with increasing temperature and garnet grossular component, similar to other incompatible components in eclogite minerals. The two samples with the lowest total HREE abundances and garnet delta^{18}O, indicative of a deep oceanic cumulate protolith unaffected by seawater alteration, have the highest bulk c(H_2O). This signature may indicate interaction of subducted oceanic crust with serpentinite-derived fluids having mantle-like delta^{18}O.

Liu et al. (2019) Contributions to Mineralogy and Petrology 174

Garber et al. (2018) G-Cubed 19