Redox state of deeply subducted altered oceanic crust: Experimental study and evidence from natural samples

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Eclogitic xenoliths from kimberlites, regularly diamond-bearing, are often interpreted as having an origin as subducted oceanic crust [1]. The existence of diamonds in these rocks constrains equilibrium temperatures and pressures of some eclogites to the upper mantle. However the additional critical parameter controlling the stabilty of diamonds, oxygen fugacity (fO_2), is unknown in eclogitic assemblages.

A series of piston-cylinder experiments were conducted using model carbonate and kyanite bearing eclogite assemblages to determine the fO_2 of the limiting reaction for graphite vs. diamond:

$CaMg(CO_3)_2 + 2SiO_2 = CaMgSi_2O_6 + 2C + 2O_2$ [2]

as a function of pressure (P=3.5-6 GPa) and temperature (T=900-1300ºC).

The oxygen fugacity in experiments was determined using Fe-Ir alloy fO_2 sensors [3] and a newly developed Fe-Pd-based redox sensor [4]. The experimental data allowed calibration of two redox reactions (involving garnet-clinopyroxene [5] and garnet-kyanite) as oxybarometers to determine fO_2 of eclogitic assemblies. The accuracy of the fO_2 thus calculated is highly dependant on precision of the garnet $Fe^{3+}/\Sigma Fe$ measurements, which were obtained using the flank method [6] and the synchrotron based Fe K-edge XANES method [7].

Both reactions were calibrated and used to estimate fO_2 of kyanite and coesite bearing eclogite xenoliths from Udachnaya kimberlite pipe, Yakutia, Russia.

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