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Redox equilibria within eclogite assemblages as function of pressure and temperature: implications for the deep carbon cycle

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The knowledge of the oxygen fugacity within metamorphic assemblages is needed to understand the speciation of volatiles and their role in fluid-rock equilibria. Eclogites, in particular, are of importance as their stability to deep portions of the Earth can affect the chemical heterogeneity of the mantle and its refertilization over the geological time scale. Although redox conditions are likely buffered by heterogeneous mineral equilibria involving ferric iron bearing phases similarly to peridotitic assemblages, to date no oxy-thermobarometry has been available for eclogite rocks. In particular, determining the relationship between the oxygen fugacity and the Fe3+/Fe2+ changes in carbonated eclogitic systems can yield insight not only into the formation mechanism of diamonds but also the production of carbonate rich magmas in the mantle such as carbonatitic or kimberlitic melts.
In this study, we conducted experiments to determine the oxygen fugacity at which carbon (graphite or diamond) coexists with carbonate minerals and melts in synthetic eclogites representative of a carbonated oceanic crust. Experiments were performed at both above and below the solidus of a carbonated eclogite in the Na-Ca-Mg-Al-Si-Fe-O-C system at pressures between 2.5 and 22 GPa and temperature of 800-1600 °C using multianvil and piston cylinder devices. The oxygen fugacity at each run was experimentally determined using noble metals (iridium) acting as redox sensor. Further experiments were performed using monomineralic layers of synthetic omphacite and garnet sandwiched between buffering layers of carbonated eclogite and their ferric iron content was measured using Mössbauer spectroscopy.

Preliminary results of this study are here used to show the ferric iron content in both garnet and omphacitic clinopyroxene as a function of pressure and temperature. Simultaneously, our data show ferric iron contents of garnet and omphacite when coexisting with carbon bearing phases and this allows a comparison with available data about ferric iron contents of silicate inclusions in natural diamonds.

Results from this study aim to improve our knowledge regarding possible redox equilibria involving ferric/ferrous iron and carbon/carbonate bearing minerals within high pressure metamorphic assemblages. More interestingly, our results will be used to develop an oxy-thermobarometer for eclogitic rocks to better understand the fate of carbon when subducted back into the mantle and the speciation of fluids in the C-O-H system.