Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.17879

The importance of carbon to the formation and composition of silicates during mantle metasomatism

MICHELE RINALDI[1], SAMI MIKHAIL[1], DIMITRI A. SVERJENSKY[2] AND JOANNA KALITA[1]

[1]University of St Andrews

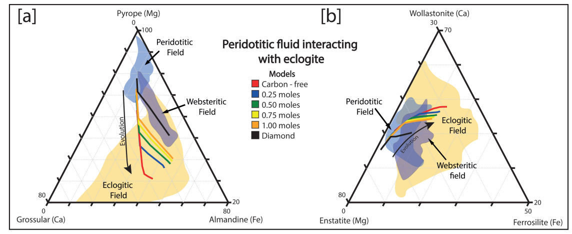
[2]Johns Hopkins University

Presenting Author: mr267@st-andrews.ac.uk

Mineral and fluid inclusions in mantle diamonds provide otherwise inaccessible information concerning the nature of mantle metasomatism and the role of fluids in the mass transfer of material through the Earth's interior. We explore the role of the carbon concentrations during fluid-rock metasomatism in generating garnet and clinopyroxene compositions observed in diamonds from the sub-continental lithospheric mantle. We use the Deep Earth Water model to predict the results of metasomatism between silicic, carbonatitic and peridotitic fluids with mantle rocks (peridotites, eclogites and pyroxenites) at 5 GPa, 1000 ºC, across a range of redox conditions (logfO_2 = -2 to -4 ΔFMQ), and a range of initial carbon concentrations in the metasomatic fluids. Our results show that the predicted compositions of metasomatic garnets and clinopyroxenes are controlled by the initial composition of the fluids and the rocks, with subsequent mineral-specific geochemical evolution following definable reaction pathways.

Model carbon-rich, diamond-forming metasomatic fluids (initial carbon content > 5.0 m) result in Mg-rich garnets and clinopyroxenes typical of peridotitic, eclogitic, and websteritic inclusions in diamonds. However, model carbon-poor, metasomatic fluids that do not form diamond can result in Mg-poor, Ca-rich garnets and clinopyroxenes. Such garnets and clinopyroxenes can nevertheless occur as inclusions in diamonds. In our models, the abundance of carbon in the fluids controls the behaviour of the bivalent ions through the formation of aqueous Mg–Ca–Fe–C complexes which directly govern the composition of garnets and clinopyroxenes precipitated during the metasomatic processes. As the C-rich initial fluids can form the higher Mg-eclogitic, peridotitic, and websteritic inclusions in diamonds, these inclusions can be syngenetic (metasomatic) or possibly protogenetic. However, in our models, the relatively Mg-poor, Ca- and Fe-rich eclogitic garnet and clinopyroxene inclusions found in mantle diamonds formed from C-poor fluids that do not form diamonds. These inclusions most likely reflect a metasomatic event prior to being incorporated into their host diamonds, or they could represent protolith-based protogenetic geochemistry.

Therefore, the paragenetic groups used to classify diamonds should not be considered a genetic classification, as the role of the fluid/melt appears to be more relevant than the one played by the host rock.



Results for models with variable carbon contents. Garnets (a) and clinopyroxenes (b) chemical composition resulting from the interaction between peridotitic fluids with an eclogite at 1000 ºC, 5 GPa and -3 ΔFMQ. The amount of carbon varies from carbon-free to those in equilibrium with diamond.