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

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Mineral and fluid inclusions in mantle diamonds provide essential information concerning the history of Earth's otherwise inaccessible interior and the nature of the deep carbon cycle over the past 3.6 billion years. The geochemical and petrological diversity of diamond inclusions either reflects [i] pre-metasomatic heterogeneity in the subcontinental lithospheric mantle (preserving primary compositions) and/or [ii] metasomatism coeval with diamond formation (recording secondary processes). These options are not mutually exclusive, but misinterpreting the petrogenesis of these mineral inclusions will generate inaccurate geodynamic models.

We use the Deep Earth Water model to predict the results of metasomatism between silicic, carbonatitic and peridotitic fluids with common mantle rocks (peridotites, eclogites and pyroxenites). We have explored the role mineralogy and geochemistry on the outcome of fluid rock metasomatism at 5 GPa, 1000 ºC, across a range of redox conditions ($\log fO_2$ = -2 to -4 ΔFMQ) [1]. Our models predict that the compositions of metasomatic garnets and clinopyroxenes are controlled by the initial geochemistry of the fluids and rocks, with subsequent mineral-specific geochemical evolution following definable reaction pathways. Moreover, 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 [2]. In summary, the paragenetic groups used to classify diamonds should not be considered a genetic classification because the role of the fluid metasomatism appears to be more important than the one played by host rock mineralogy.

References cited:

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