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Modelling the formation of diamond inclusions during fluid-rock metasomatism

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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. Recent work has provided a simple mechanistic explanation for the occurrence of disequilibrium inclusion assemblages, such as diamonds hosting inclusions of mixed silicate parageneses ([1]). Using the same approach, we have expanded this work and modelled the interaction between the three empirical fluid-endmembers (silicic, carbonatitic and peridotitic; [2]) with common mantle rocks (peridotites, eclogites and pyroxenites) at 5 GPa, 1000ºC, and across a range of redox conditions ($logfO_2$ = -2 to -4 ΔFMQ). Both carbon-rich and carbon-free fluids have been modelled to constrain the role played by carbon during fluid metasomatism. Our results show how the chemical gradient can serve as a strong enough driving force for the chemical evolution of silicates, connecting different paragenetic groups during a single isobaric and isothermal metasomatic event. Compositional differences between fluid and rock control the initial garnet and clinopyroxene composition and their subsequent evolution following definable reaction pathways. We find that peridotitic and silicic fluids reacting with peridotites, eclogites or pyroxenites results in chemical compositions which fit natural diamond inclusion datasets. Carbon-free metasomatism results in the formation of Ca-rich garnets and clinopyroxenes, where the system progresses across the eclogitic field towards extremely Mg-poor compositions observed in some diamond inclusions. However, regardless of the host rock mineralogy (peridotite, eclogite, or pyroxenite), the presence of carbon in the fluid alters the behaviour of the bivalent ions through the formation of the aqueous Mg–Ca–Fe–C complexes in our models and favours the formation of Mg-rich mineral phases.

References Cited

[1] A genetic link between eclogitic and peridotitic diamond inclusions; Mikhail, S., Rinaldi, M., Mare, E.R., Sverjensky, D.A. (2021); Geochemical Perspectives Letters

[2] Fluid Inclusions in Fibrous Diamonds; Weiss, Y., Czas, J., Navon, O. (2022); Reviews in Mineralogy & Geochemistry