S-bearing metasomatism of mantle eclogites: constraints from the Kaapvaal craton and experiments

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Mantle metasomatism by C-O-H-S fluids has resulted in isotopic heterogeneities and the addition of new minerals such as diamond since the Archean [1]. While the influence of C-bearing fluids on the lithospheric mantle is under continuous investigation, the activity of S-bearing fluids and their role in diamond formation is less well constrained. Here we present a case study of eclogite metasomatism by S±C-rich fluids in the Kaapvaal craton mantle lithosphere. We combine experimental work and the analysis of sulphide-bearing eclogite xenoliths from key kimberlite occurrences such as Roberts Victor and Jagersfontein. Most eclogite xenoliths in this suite have subducted oceanic basalt or gabbroic protoliths, based on Mg#, REE patterns, Eu*, and oxygen isotope compositions. We report the highest garnet $\delta^{18}O$ value of 10.4‰ ever measured for mantle-derived eclogites. Sulphides in these eclogites form discrete polyphase assemblages (e.g. Po+Pn+Cp) that occur as inclusions in clinopyroxene and as interstitial grains. The sulphides are enriched in PGEs and are similar in composition to sulphides present in mantle eclogites and eclogite-type diamond inclusions [2]. Moreover, eclogite melting experiments at upper mantle conditions in the presence of S±C-rich fluids produced silicate residua plus S- and/or Si±C-rich melts, along with mss. The experimentally produced sulphides are similar in composition to the natural eclogitic sulphides. Furthermore, the C-bearing melt compositions are comparable to various inclusions found in fibrous diamonds [3]. Consequently, the S+C-rich mantle metasomatism studied here has the potential to facilitate eclogitic diamond formation.

[1] Griffin et al. (2003). Prec Res 127. 19–41.

[2] Gréau et al. (2013). Chem Geol 354. 73-92.

[3] Schrauder and Navon (1993). GCA 58. 761-771.