

Metasomatic effects of sulphur-bearing carbonated melts on the lithospheric mantle

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Sulphur and carbon are key volatiles in tracing petrogenetic processes within the Earth's mantle. Carbon-bearing melt/fluid metasomatism has been linked to various mantle lithosphere-scale enrichment and destruction processes, such as diamond formation and ultramafic alkaline magmatism. Sulphide minerals are key hosts of mantle S and platinum group element budgets, and sulphide stability during mantle melting controls the movement of these economically important metals. We present a case study of eclogite metasomatism by S±C-bearing fluids/melts, integrating new experimental work with investigations of sulphide-bearing eclogite xenoliths from five kimberlite occurrences on the Kaapvaal craton, South Africa.

Experiments at continental lithospheric mantle conditions (2 – 3.5 GPa and 1050 – 1300 °C) on S±C-bearing MORB-like eclogite demonstrate that S mobility is controlled by the degree of partial melting and the resulting melt composition. Sulphur can be mobilised as either sulphide melt pools within CO₂-free basaltic-andestitic melts or as elemental S within hybrid silicate-carbonate melts, but not in pure carbonatitic melts. Comparative investigations of eclogite xenoliths show that sulphide occurrence and their IPGE/PPGE compositions are intimately linked to eclogite redox state and the compositional character of the metasomatic melt/fluid. Importantly, these variables are linked to eclogite depth residence within the Kaapvaal lithospheric mantle. Relatively PPGE enriched sulphides occur in mid-lithospheric eclogites with redox compositions comparable to ambient mantle. These 'shallow' sulphides bear the metasomatic effects of basaltic-type melts. In contrast, PGE-poor sulphides reside in deeper eclogites with relatively oxidized compositions near the base of the lithospheric mantle. They record interaction with an oxidising, silica-undersaturated metasomatic agent that infiltrated the craton base. These results show that sulphide geochemistry adds to the knowledge of lithospheric mantle overprinting, which is commonly viewed from a silicate mineral perspective with a focus on lithophile elements.