

Sulphur solubility of carbonatites, with implications for mass transfer in Earth's mantle*

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Carbonatites are rare, mantle-derived igneous rocks with >50 wt.% carbon, compared to more typical SiO₂-rich compositions. Whereas the solubility of sulphur for mafic silicate melts has been extensively studied, equivalent data for carbonate-rich compositions has not been obtained. This research looks to determine sulphur solubility in molten carbonate to assess the potential for such melts as a mass transfer agent for sulphur, along with precious metals, in the mantle. The goal is to determine the importance of carbonatite metasomatism to establish precious-metal-rich source regions for magmatic ore deposits. The concentration of sulphur at sulphide saturation (SCSS) in molten carbonate will be measured as a function of several variables, including melt composition and pressure, to assess the sulphur solubility mechanism. Experiments are done using piston cylinder apparatus at the Dalhousie Laboratory for High Pressure Geological Research. Run products are analyzed using the electron microprobe analyzer using wavelength dispersive spectroscopy. A synthetic carbonate melt determined to be in equilibrium with a mantle peridotite assemblage is used. This material is mixed with a similar mass of FeS, doped with 1 wt.% each of Ni and Cu and additional Fe₂O₃, and then loaded, along with ~ 5 wt.% H₂O, into a graphite-lined Pt capsule. Capsules are placed into a pressure cell comprised of crushable MgO, with an outer graphite furnace, pyrex sleeve, and NaCl sleeve. Run products consist of a crystalline pyrrhotite or quenched sulphide liquid, coexisting with quenched carbonate melt, as represented by a fine-grained intergrowth of carbonate phases. An initial experiment at 1 GPa, 1100°C, FeO <1%, done for 24 hours yields a SCSS of ~700 ppm. Results thus far suggest similar solubilities for carbonate versus silicate melts. Experiments done with up to 30 wt.% added Fe₂O₃ contain ~ 4 wt.% FeO in the carbonate melt, as well as excess Fe-oxide crystals, suggesting primary carbonate melts will be FeO-poor, with limited formation of dissolved FeS complexes, in contrast to silicate melt. Additional experiments to test the effect of pressure and runs doped with platinum group elements in order to measure carbonatite-sulphide partitioning of precious metals are in progress. Further results from this study will provide a better understanding of sulphur solubility mechanisms, and the role of molten carbonate to dissolve and transport sulphur, as well as precious metals, which is currently unknown.

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