Sulfur 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 SiO_2-rich compositions. Whereas the solubility of sulfur for mafic silicate melts has been extensively studied, equivalent data for carbonate-rich compositions has not been obtained. This research looks to determine sulfur solubility in molten carbonate to assess the potential for such melts as a mass transfer agent for sulfur, 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 sulfur at sulfide saturation in molten carbonate will be measured as function of several variables, including melt composition and pressure to assess the sulfur 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. We use a synthetic carbonate melt modeled after experiments that produced in the phase equilibrium experiments with a mantle peridotite assemblage. This material is mixed with a similar mass of FeS, doped with 1 wt% each of Ni and Cu, then loaded, along with ~5 wt% H_2O, into a graphite-lined Pt capsule. Capsules are placed into a pressure cell comprised of crushable MgO, with an outer graphite furnace and $BaCO_3$ sleeve. To date, one experiment has been done, at 1.0 GPa and 1100°C for 24 hours. Runproducts consist of a crystalline pyrrhotite coexisting with quenched carbonate melt, represented by a fine-grained intergrowth of carbonate phases. Melt FeO concentrations are <1 wt%, and analyses reveal sulfur concentrations of ~700 ppm. This is in comparison to previous solubility measurements at similar conditions on silicate melt with ~10 wt% FeO containing ~1000 ppm sulfur or less. Results thus far suggest similar solubilities for carbonate versus silicate melts, although the FeO contents are significantly different. Additional experiments to test the effect of melt FeO content are in progress. Future experiments will be doped with Au, Ag, and platinum group elements in order to measure carbonatite-sulfide partitioning of precious metals. Further results from this study will provide a better understanding of sulfur solubility mechanisms, and the role of molten carbonate to dissolve and transport sulfur, as well as precious metals, which is currently unknown.

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