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Partial Melting of Hydrous Carbonated Fertile Peridotite at 3 GPa: Influence of Water and CO2 in the Formation of Picrites and Komatiites

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Komatiites and picrites are ultramafic volcanic rocks characterized by high magnesium oxide content (15 – 32 wt.%) that mostly erupted throughout the Archean and Proterozoic eras globally. Their production is a contentious topic, with models proposing extensive volatile-free partial melting of mantle peridotite and the melting of hydrous mantle as potential mechanisms. Additionally, numerous investigations have identified CO2 in the melt inclusions of these rocks. These volatiles substantially lower the melting point of peridotite in the upper mantle by several hundred degrees. Nonetheless, the limitations on the influence of H2O–CO2 fluids on the formation of picrites and komatiites are restricted. This work presents two sets of piston-cylinder experiments conducted at controlled and static temperatures on a fertile peridotite composition (MixKLB-1; XMg = 0.89) with 1 wt.% CO2 and XH2O values of 0.86 and 0.92. Given that these volatiles exhibit significant solubility in silicate melts at pressures above 2 GPa, all experiments were performed at 3 GPa and within a temperature range of 1200 to 1575℃ to simulate upper mantle conditions from the Archean to Proterozoic eras. In the controlled heating experiments (1350-1575℃), the temperature was initially elevated to 75–200 ℃ above the target run temperature and maintained for 10 minutes to 3 hours to facilitate the development of big crystals (>35 μm). Subsequently, the temperature was reduced to the end run temperature at consistent ramp rates ranging from 19.8 to 51℃/h and maintained at the target temperature for a duration of 6 to 16 hours. The static experiments were conducted at constant temperatures ranging from 1200 to 1300℃ for durations of 30 to 120 hours. A broad spectrum of melt proportions (<5 – 61 wt.%) was detected in equilibrium with olivine + orthopyroxene ± clinopyroxene throughout every experiment. As the degree of melting increases, the composition of the partial melt, excluding volatiles, transitions from picritic to komatiitic, characterized by 14.5–34 wt.% MgO, 38–51 wt.% SiO2, and an Al/Ti ratio of 5.5–12.9. The analogous major element concentrations of hydrous carbonated partial melts (4.1 - 11.2 wt.% Al2O3, 7.2 – 14.8 wt.% FeO, and CaO/Al2O3 ratios of 1-3.5) with natural picrites and komatiites indicates the presence of both CO2 and H2O in the source of these ultramafic rocks.

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