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Partial melting of Pyroxenite-H₂O-CO₂ at 3 GPa and genesis of primitive arc magmas

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Subduction zones link the mass transfer, element cycling and magma differentiation processes in which the release of C-O-H fluids from the slab plays a key role. Geochemical characteristics of basaltic magmas suggest that olivine-poor lithologies like pyroxenites may be produced from the reaction between subducting slab and ambient mantle peridotite in conjunction with variable additions of a hydrous slab component. Numerous experimental data on water solubility in nominally anhydrous minerals (NAMs) are available for hydrous peridotitic and basaltic systems. However, the extent of H migration to the sub-arc mantle wedge from the subducting crust and storage of water in the NAMs present in pyroxenites in presence of both H₂O and CO₂ are not available. Here we report new partial melting experiments of hydrous carbonated secondary pyroxenite and discuss the partial melt compositions with respect to the genesis of primitive tholeiitic basalts to calc-alkaline basalts.

High-pressure experiments were performed using a Piston-cylinder apparatus and Platinum/Graphite capsule at 3 GPa and 1350 to 1525°C. A silica-deficient pyroxenite (SPX-15-1) with varying XCO₂ [=molar CO₂/(H₂O+CO₂)] from 0.08 to 0.29 were used as the starting material. To facilitate the growth of single crystals for FTIR analyses, temperature was increased by ~200 °C above the final desired run temperature for 0.5 to 2 hrs to reduce the number of nuclei available for grain growth and finally lower the temperature at 0.4 to 1 °C/min to the final run temperature. Clinopyroxene, orthopyroxene and hydrous carbonated silicate melts (> 30 wt.%) were present in all the experiments in the presence or absence of garnet. Hydrogen incorporation in clinopyroxenes and orthopyroxenes decreases with an increase in the XH₂O of pyroxenites and a decrease in Al content in their structure, which suggest Al³⁺ + H⁺ substitution. With the increased degree of melting, the partial melt compositions, on volatile-free basis, formed tholeiitic arc basalts to calc-alkaline basalts (45.17 to 51.81 wt.% SiO₂, 8.42 to 10.75 wt.% CaO). Comparison of the major element compositions of hydrous carbonated silicate melts (14.85-22.69 wt.% Al₂O₃, 10.77-15.02 wt.% MgO, CaO/Al₂O₃ of 0.45-0.67) with natural arc magmas suggest that hydrous carbonated-fluxed melting of secondary pyroxenite over 90 km depth can produce partial melts similar to primitive tholeiitic basalts from Japanese, Sunda and Lesser Antilles arc magmatism.

Primary authors: Dr RAY, Dwijesh (PRL Ahmedabad); Mr DASH, Jitendra Kumar (IIT Kharagpur); GHOSH, Sujoy (IIT Kharagpur)

Presenter: Mr DASH, Jitendra Kumar (IIT Kharagpur)

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