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The Role of H_2O and CO_2 on Mineral Stability and Melting in Eclogite-Enriched Mantle Experiments

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Metasomatism at the lithosphere–asthenosphere boundary results from interactions between lithospheric rocks and asthenosphere-derived fluids or melts. This study investigates the effects of minor H_2O and CO_2 on mineral reactions and melt generation under pressure–temperature conditions representative of this interface. Experiments simulate a metasomatized continental lithosphere in contact with an eclogite-enriched asthenosphere, spanning ~75 km to ~300 km depth.

Starting materials were arranged in layered experiments to replicate a metasomatized lithosphere and an eclogite-enriched asthenosphere. The resulting mineral assemblages comprised olivine, orthopyroxene, clinopyroxene, garnet, amphibole, phlogopite, and magnesite. Under 2.5 and 4.5GPa, reaction textures indicate alkali mobility and CO_2 release, with orthopyroxene and amphibole forming at lithospheric interfaces at moderate temperatures (900-1100 °C), while higher temperatures (≥ 1200°C) promote olivine–clinopyroxene intergrowths. Melts evolve from basanites at low degrees of melting to trachy-andesites and andesites at higher temperatures. At 10 GPa, CO_2 retention increases and H_2O release is enhanced, stabilizing orthopyroxene, garnet, and magnesite, whereas clinopyroxene decreases and amphibole destabilizes. Melts under these conditions range from carbonatitic (1200-1450 °C) to carbonated-silicate at 1500 °C.

These results provide insights into volatile storage and release in the mantle and their potential signature at the surface, highlighting the interactions between mantle heterogeneities, eclogitic components, and asthenospheric fluxes, and suggesting how such enriched environments may control the retention or release of volatiles in thermal anomalies, particularly those leading to large-volume basaltic magmatism.