

Partial Melting of Hydrous Pyroxenite in the Sub-Arc Mantle

ADITI CHATTERJEE¹, CHUTIAN SHU^{1,2}, SVYATOSLAV
S. SHCHEKA¹, NATHAN R. DACZKO¹ AND STEPHEN F.
FOLEY^{1,3}

¹Macquarie University

²Curtin University

³Australian National University

Subduction zones are among the most tectonically active regions of the Earth's crust, facilitating significant heat and mass transfer that drives geochemical evolution. This process leads to the formation of diverse igneous rocks and ore mineralization. Several critical metals are hosted in the volatile-bearing mantle, which releases them through partial melting and subsequent transfer via the mantle and lower crust before they reach the overlying crust. Understanding the mantle source and reactive flow transfer of melt through the upper mantle and lower crust is therefore essential for deciphering geochemical variations in the Earth's crust.

While mantle-derived magmas are traditionally thought to originate from peridotite, hydrous pyroxenites may also serve as voluminous source rocks contributing to the enrichment of critical metals, especially in subduction zones. Additionally, the formation of common mantle-derived basalts and arc magmatism indicates the presence of mixed source regions, including hydrous pyroxenites. This highlights the need for further investigation into hydrous pyroxenite as a potential source rock.

In this study, we conducted partial melting experiments on a synthetic hydrous pyroxenite composition using a piston-cylinder apparatus under subduction wedge P–T conditions (2.0–2.5 GPa, 1000–1200°C). High-resolution SEM imaging revealed that hydrous minerals, such as phlogopite and amphibole, dominate the sub-solidus assemblage. The solidus temperature was bracketed between 1000°C and 1100°C at 2 GPa, and was below 1000°C at 2.5 GPa. With increasing degree of partial melting, hydrous minerals are gradually consumed, with amphibole melting completely before phlogopite. EPMA analysis of the partial melt showed increasing concentrations of SiO₂ (~39–40%), Al₂O₃ (~10–15%), and K₂O (~1–4.5%) with higher degree of melting. Furthermore, the major element composition of the experimentally derived partial melt aligns with reaction experiments conducted on natural mineral assemblages and hydrous pyroxenite mantle xenoliths.

Future work will focus on examining the interaction between the partial melt defined by these experiments and upper mantle/lower crustal rocks to better understand the geochemical evolution of melts as they migrate toward the upper crust.