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Stability of magnesite in the presence of hydrous fluids up to 12 GPa: Insights into subduction zone processes and carbon cycling in the Earth's mantle

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Abstract

Understanding the stability of magnesite in the presence of a hydrous fluid in the Earth's upper mantle is crucial for modeling the carbon budget and cycle in the deep Earth.

This study elucidates the behavior of magnesite in the presence of hydrous fluids. We examined the brucite-magnesite [$Mg(OH)_2$-$MgCO_3$] system between 1 and 12 GPa by using synchrotron in situ energy-dispersive X-ray diffraction experiments combined with textural observations from quenched experiments employing the falling sphere method. By subjecting magnesite to varying pressure-temperature conditions with controlled fluid proportion, we determined the stability limits of magnesite in the presence of a fluid and periclase.

The observed liquidus provides insights into the fate of magnesite-bearing rocks in subduction zones. Our findings show that magnesite remains stable under typical subduction zone gradients even when infiltrated by hydrous fluids released from dehydration reactions during subduction. We conclude that magnesite can be subducted down to and beyond sub-arc depths. Consequently, our results have important implications for the carbon budget of the Earth's mantle and its role in regulating atmospheric CO_2 levels over geological timescales.

Keywords: Deep carbon cycle, brucite dehydration, magnesite melting, EDXRD; Physics and Chemistry of Earth's Deep Mantle and Core