

Pargasite stability in the upper mantle at H₂O-undersaturated conditions

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Amphibole is the most commonly occurring hydrous mineral in mantle xenoliths and the majority of upper mantle amphiboles have compositions close to pargasite end member. Previous experimental work has demonstrated that pargasite stability is sensitive to variations in bulk alkali and water content of the starting material. While it has been successfully shown that addition of more alkali leads to stabilization of pargasite to higher P and T, the effect of water on amphibole stability is not so straightforward.

At H₂O-saturated conditions, alkali elements partition strongly into aqueous fluid and become less available for crystallization of amphibole. As a result, amphibole seemingly becomes stable at higher P and T when less H₂O is added to the starting material. This observation led to the hypothesis that pargasite may be a ubiquitous phase in the upper mantle, which is believed to contain only several hundred ppm of H₂O. However, most of the previous studies determined pargasite stability at H₂O-saturated conditions where solid phases coexist with an aqueous fluid during experiments. Since such environments are not representative of the nearly dry upper mantle, the purpose of this study is to investigate pargasite stability at H₂O-undersaturated conditions.

Because of the high specific surface area of powders, adsorption of atmospheric H₂O on fine grained starting materials prevents attaining H₂O-undersaturation by adding small amounts of water to the sample. Instead, H₂O-undersaturated conditions may be precisely controlled by diluting the water in the sample with another component. Under such conditions, solid phases are expected to coexist with a low water activity fluid throughout the experiment. As molecular nitrogen is mostly insoluble in upper mantle minerals, it can be used to adjust the water activity of the fluid to a desired low value.

All experiments were performed in a piston cylinder apparatus. The samples for H₂O-undersaturated experiments were prepared by adding silver azide (AgN₃) and brucite to a synthetic peridotite mixture. In several experiments water was added directly as H₂O_(l). The amount of water was kept constant in all experiments (1 wt. percent) and the molar fraction of water in the N₂-H₂O fluid was adjusted to the desired value by weighing an appropriate amount of AgN₃, which decomposed to metallic silver and molecular nitrogen during heating. In H₂O-saturated experiments, no silver azide was added to the peridotite mixture. Experimental products were analyzed using JEOL JXA-8200 electron microprobe.

Preliminary results show that pargasite is not stable in equilibrium with fluids diluted to $X_{\text{H}_2\text{O}}=0.1$ at pressures above 1 GPa. At H₂O-saturated conditions pargasite stability field can extend to pressures of 4 GPa and above 1100 °C, depending on bulk alkali and water contents. Results from experiments at $X_{\text{H}_2\text{O}}=0.1$ and $X_{\text{H}_2\text{O}}=1$ suggest that pargasite can exist only in regions of the upper mantle which have been affected by high water activity fluids, such as areas in the vicinity of subduction zones. The ambient nominally anhydrous upper mantle, better represented by experiments at H₂O-undersaturated conditions, is not expected to contain pargasite.

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