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Investigation of the martensitic-like transformation from Mg_2GeO_4 olivine to its spinel structure polymorph

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Abstract

A coherent mechanism for the transformation of olivine to its spinel structure polymorph has been investigated in Mg_2GeO_4 olivine at conditions ranging from 6 GPa to 18 GPa at 300 to 1250 °C using a multi-anvil apparatus. This transformation mechanism, which produces plates of spinel lying parallel to the (100) planes in olivine, becomes increasingly important above 10 GPa at temperatures between 300 and 400 °C. The primary effect of temperature above 400 °C is to increase the length of the lamellae. The primary effect of pressure is to increase the number of lamellae that have nucleated. The distribution of transformation is very inhomogeneous. Lamellae first appear in patches associated with grain edges and corners. As the degree of transformation increases, patches become more extensive and more heavily populated until the majority, if not all grains, contain large numbers of lamellae that span large portions of their host grains. The mechanism that produces the lamellae requires three factors, high pressure overstep of the equilibrium boundary, some level of differential stress (either microscopic or macroscopic), and high enough temperature to facilitate rearrangement of the cations. It is most consistent with a martensitic-like transformation mechanism. The results of this study suggest that olivine may exhibit similar behavior in cold, rapidly subducting lithospheric slabs. If conditions are too cold for olivine to transform by reconstructive nucleation and growth, it could instead progressively transform by the martensitic-like mechanism as conditions deviate further and further from the equilibrium phase boundary.