Experimentally determined grain growth kinetics of the spinel structure through the upper mantle to 660 km

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Abstract

The spinel structure is common in the mantle, as aluminous MgAl2O4 stable to depths of 60 km (< 2 GPa) and silicate ringwoodite Mg2SiO4, known to exist from depths of 520 – 660 km. The spinel minerals partake in important dissociation reactions throughout the mantle:
1. CaAl2Si2O8 + 2Mg2SiO4 = MgCaSi2O6 + 2MgSiO3 + MgAl2O4;

the plagioclase to aluminous spinel transition occurs at depths greater than 20 km, (0.8 GPa).

2. MgAl2O4 + 4MgSiO3 + Mg3Al2Si2O4 + Mg2SiO4;

spinel to garnet peridotite at 2 GPa, 60 km onwards.

3a. Mg2SiO4 = MgSiO3 +MgO;

the downwelling reaction of silicate spinel ringwoodite to perovskite plus periclase, and;

3b. (Mg4,Al)(Si4,Al)O15 +MgO = Mg2SiO4 + Mg3Al2Si3O12;

the upwelling reaction for aluminous perovskite plus periclase reacting to ringwoodite plus majorite across the 660 km discontinuity.

To evaluate the importance of these dissociation reactions the diffusion driven kinetics governing them, and the grain growth of their products must be determined. We are measuring these for reactions 2 and 3.
Time series experiments have been run in the multi anvil press at University College London (UCL) at pressures less than 2 GPa for reaction 2 and at 21 and 23 GPa for reactions 3a and 3b. Both the kinetics of the reaction and the kinetics of grain growth of the inter grown reaction products are being determined.

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