Post-Spinel Transition in Mg_2SiO_4 determined by high P-T in situ X-ray diffractometry

Katsura et al.

2003

Main Points

- Reinvestigated transition of Spinel to Pv + Pc
- Phase boundary 22 GPa from 1550-2200 K
- 1-1.5 GPa lower than 660
- Clapeyron slope -2 to -0.4 MPa/K
- Ineffective barrier to mantle convection

660 km discontinuity

- $(Mg,Fe)_2SiO_4$ -----⏩

  $(Mg,Fe)SiO_3 + (Mg,Fe)O$
- Well studied: but specifically Ito and Takahashi (1989) quench study
- 23 GPa at 1900 K
- Perfect for 660
- Steep Clapeyron Slop3 -3 MPa/K

Irifune et al.

- Same slope: -3 MPa/K
- Problem for 660
- Disallows post-spinel
- May mean a change in bulk mantle chemistry

DAC work

- e.g. Shim et al.
- Generally consistent with the 660

How is this paper different?

- In situ X-ray diffraction of materials using the same Kawai type setup as Irifune et al.
- If the results match the 2 GPa discrepency the post-spinel may not be relevant to the 660
- Or the multi-anvil press has associated errors

Comparison with Previous works

- Katsura: Phase boundary 22 GPa from 1550-2200 K
- Irifune: 22 GPa, 1500-1700 K,

  but lower P at higher T
- Possible problems with heating and T measurement
- Relied on peak instensity

Vs. Chudinovskikh and Boehler

- Post spinel at 23 GPa at 1800-2400 K
- Laser heating
- Analyzed quench samples
- Some disagreement on boundaries regarding spinel

vs. Shim et al.

- Laser heated DAC
- 23-25 GPa boundary
- Some disagreement on certain points eg. --Periclase disappearance at 22.3 GPa, 1942K

  -Spinel formation at 22.7 GPa, 1756 K

2 GPa wide coexistence of Sp,Pc,Pv

vs. Ito and Takahashi

- 1-2 GPa higher (23-24 GPa)
- -3 MPa/K
- Katsura et al. observe slow spinel dissociation
- This could account for the large Clapeyron slope

X-ray diffraction in the MAP

- Without going into details . . .
- Thermocouple issues
- Gold pressure standard issues

Geophysical Implications

- Absolute pressure for determining deep Earth structure not advisable from this experiment
- What is important is the small Clapeyron slope

20 km depressions of the 660

- Found in arc regions
- 0.86 GPa from PREM
- 400 K lower than the surrounding mantle based on the -2 MPa/K slope of this study
- Water may be the source of this behavior.

660 as a barrier?

- -2 to -3 MPa/K Clapeyron slope for this to occur
- Based on their results, the slope is not steep enough (-2 MPa/K is the limit)
- Some slabs penetrate, some do not
- Clapeyron slope may be close to a critical value for causing slabs to stagnate