Post-Spinel Transition in Mg$_2$SiO$_4$
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

- \((\text{Mg,Fe})_2\text{SiO}_4\) ----> 
  \((\text{Mg,Fe})\text{SiO}_3 + (\text{Mg,Fe})\text{O}\)

- Well studied: but specifically Ito and Takahashi (1989) quench study
- 23 GPa at 1900 K
- Perfect for 660
- Steep Clapeyron Slope3 -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 intensity
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