Evidence for a Ubiquitous Seismic Discontinuity at the Base of the Mantle

Sidorin, Gurnis, & Helmberger

Science, 1999

Discontinuity @ CMB

- Sharp 2-3% velocity discontinuity ~250 km above the CMB
- Scd phase between S and ScS (core reflection) in the 65 – 83° distance range
- Variation in relative timing and amplitude
  - Intermittent

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Lowermost 240 km of Mantle

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Add a layer anomaly to match PREM to Tomography

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2 Layers = 1 Discontinuity

- What is the depth of this discontinuity?
- How do we use the shear wave anomaly to make inferences about the depth of the discontinuity?

What if the Discontinuity is a Phase Transition

- “Dynamic and seismic models suggest a phase change is more likely than thermal gradients or chemical heterogeneity”

Calculate Synthetic Seismograms

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Statistical Analysis of Phase Boundary Parameter Space Using Synthetic Seismograms

$$\left\langle \delta T_{Scd-S} \right\rangle \quad \left[\frac{1}{N} \sum_{1}^{N} (Tsynth - Tdata)^2 \right]^{\frac{1}{2}}$$

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Preferred Model

- γ_{ph} = 6 MPa/K
- h_{ph} = 200 km

Least Squares fit to the predicted travel time curve

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Compare the fitted curves to observed travel times

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Preferred Model

- γph = 6 MPa/K
- hph = 200 km

γ_{ph} = 0 MPa/K

h_{ph} = 250 km

γ_{ph} = -4 MPa/K

h_{ph} = 275 km

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Preferred Model

- γph = 6 MPa/K
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Southern Caribbean: 2.75% velocity jump @ 250 km above CMB
Northern Caribbean: 2.45% velocity jump @ 290 km above CMB

Depth Dependent Discontinuity

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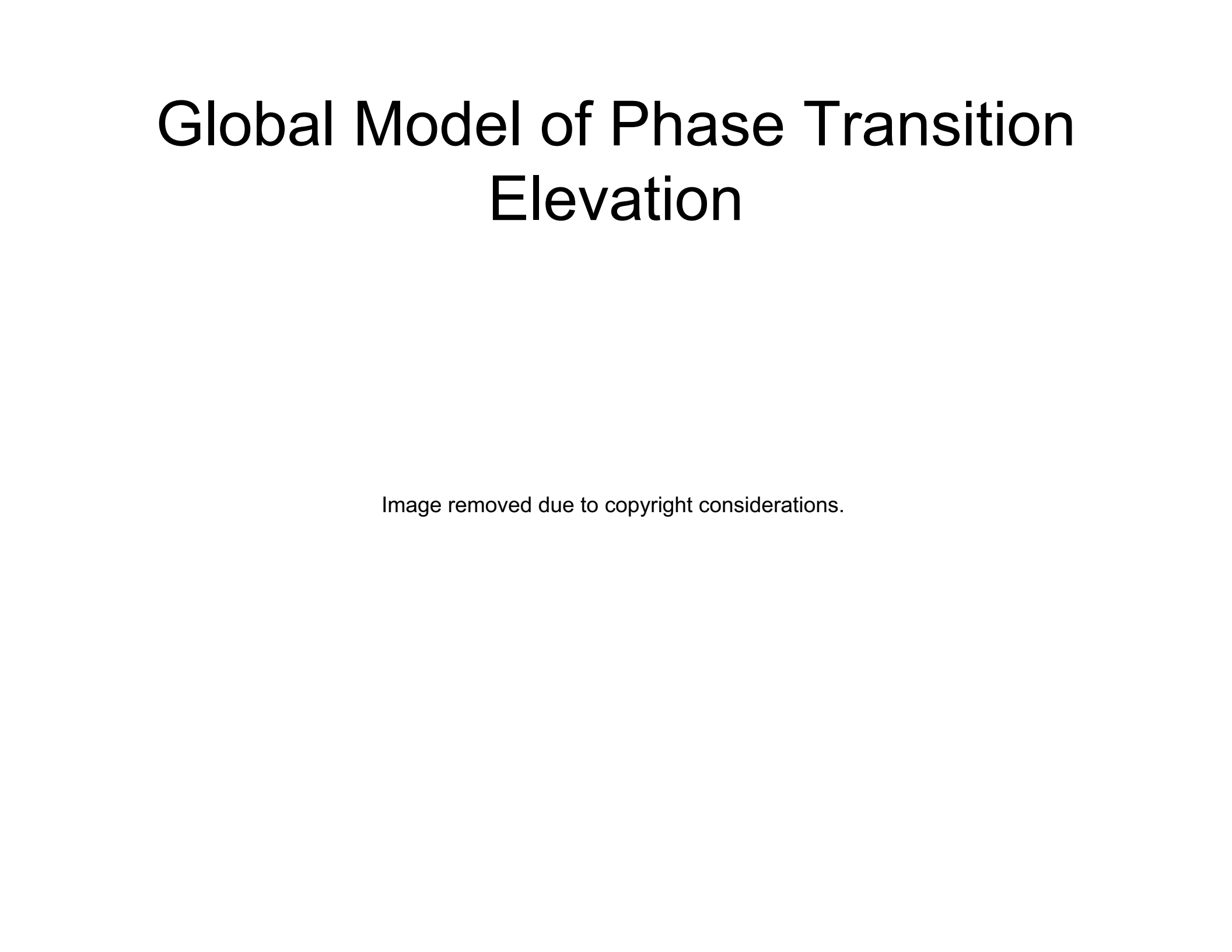
Global Model of Phase Transition Elevation



Inverse Problem

- If local structure can modulate the strength of triplication (assuming ubiquity).
- Is it possible to predict the observed geographic pattern using the structure inferred by tomographic inversions?
- Central Pacific = Weak triplication
- Caribbean = Stong triplication

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Predicted
Stength of triplication

Conclusions

- “The agreement of these trends with observations indicate that the D” discontinuity may a ubiquitous feature with the strength of the resulting seismic triplication modulated by larger scale structure”

- “The discontinuity must be correlated with large scale structures such that it’s elevated in fast regions (*hot*) and depressed in slow regions (*cold*) – implying a positive clapeyron slope.”

These guys look pretty smart now!

- “No relevant phase transition has yet been observed in the major elements of the lower mantle”

Ab-initio calculations for Post Perovskite

- 9.56-9.85 MPa/K (Oganov and Ono 2004)
- 7.5±0.3 MPa/K (Tsuchiya et al., 2004)