

The Transition zone An Introduction

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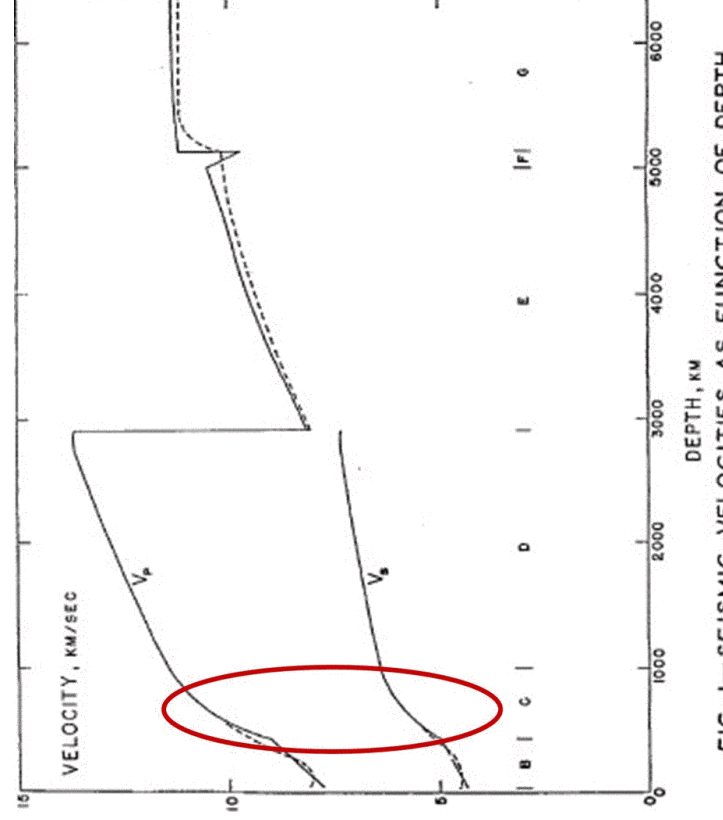
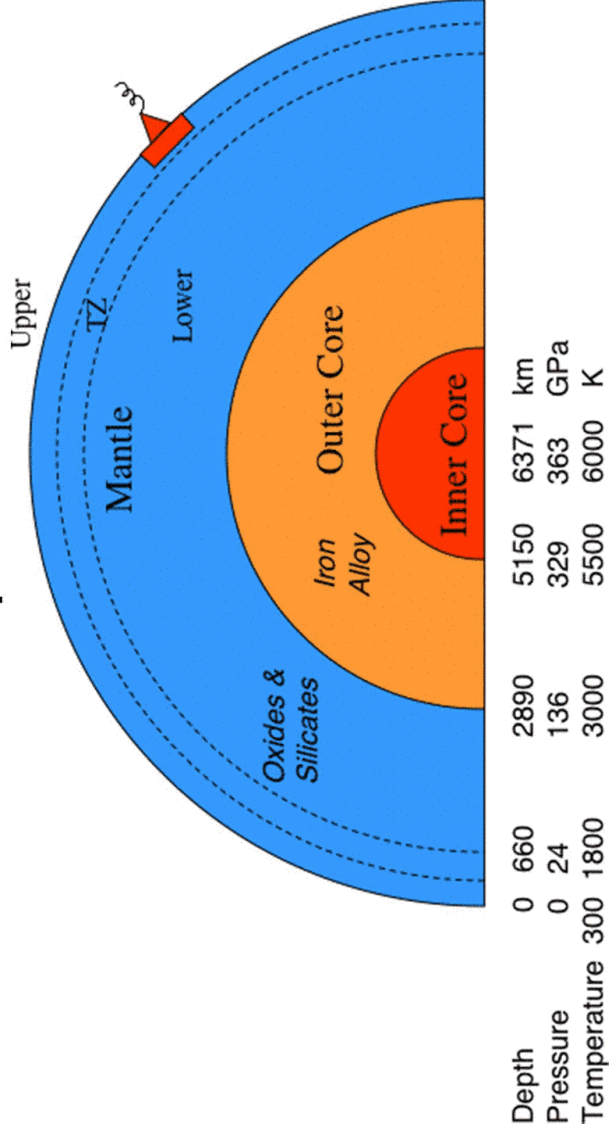


FIG. 1—SEISMIC VELOCITIES AS FUNCTION OF DEPTH

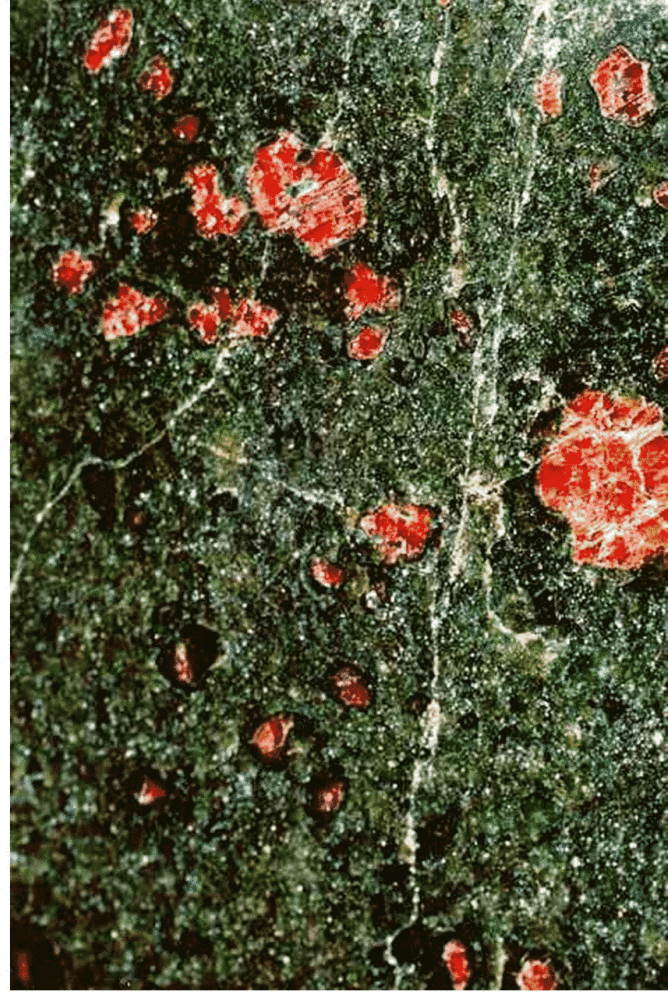
Birch (1952) after Jeffreys, Bullen, Gutenberg

Pressure, Temperature, Composition



Upper Mantle Xenolith, Depth ~ 100 km

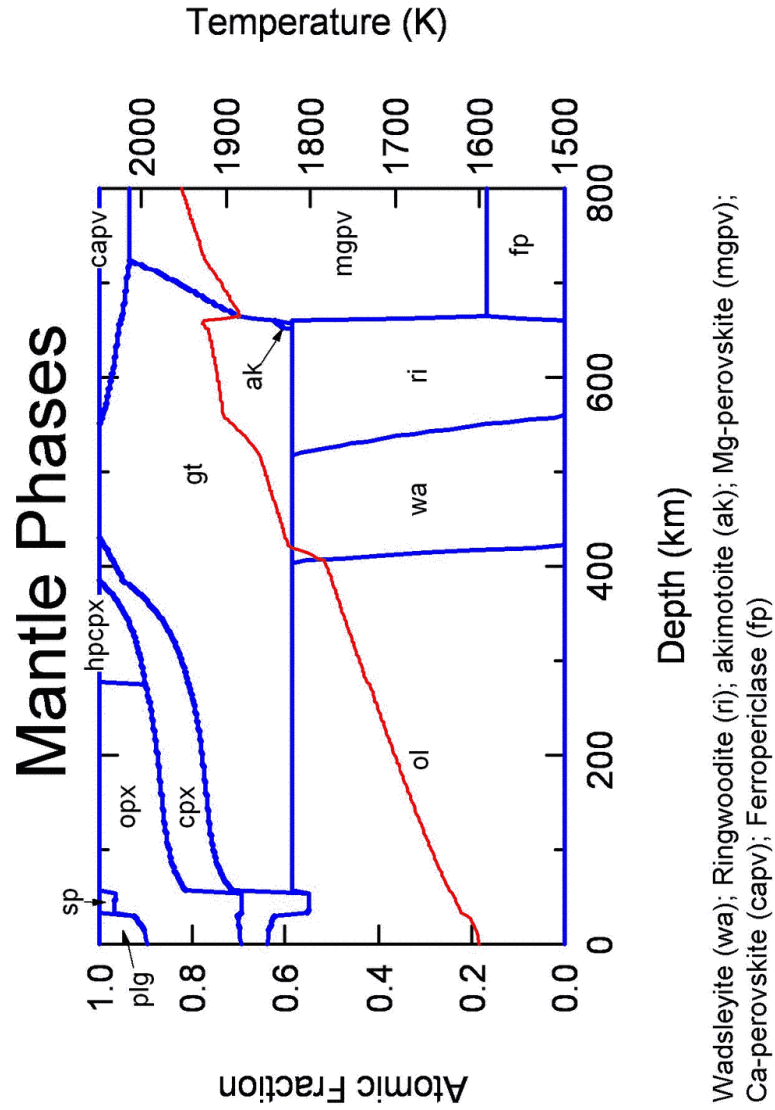
Red=garnet (gt); black=orthopyroxene (opx); green=clinopyroxene (cpx); yellow-green=olivine (ol)

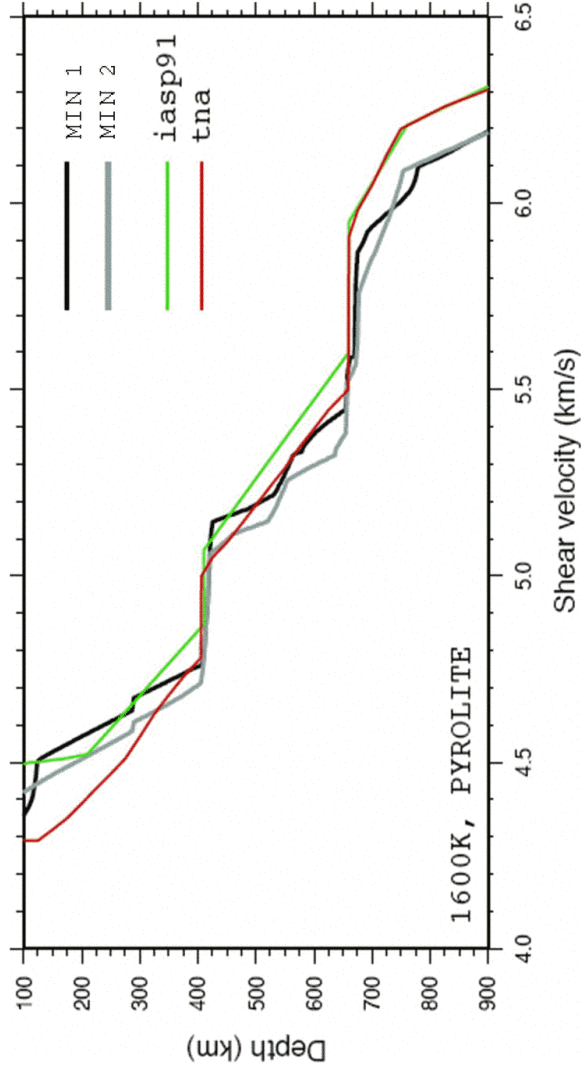


High pressure polymorphs
 Many found in meteorites
 Originally discovered in lab

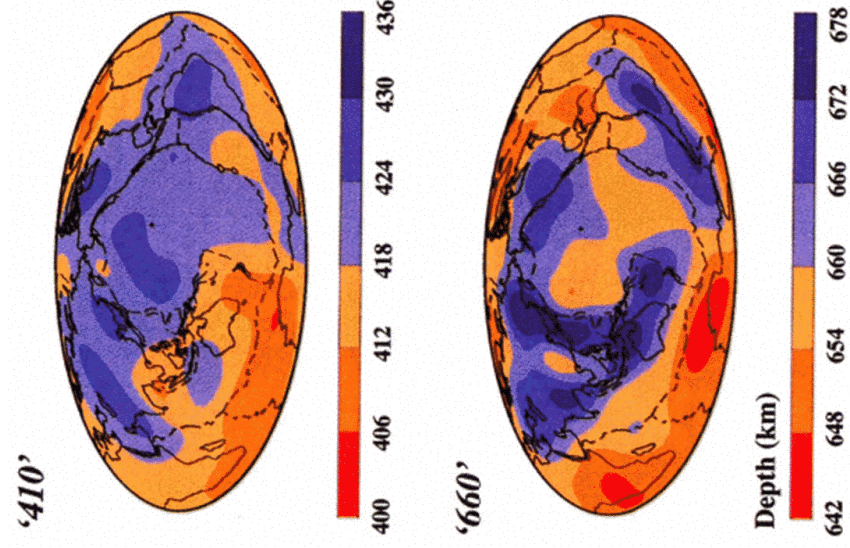


Purple ringwoodite, high pressure polymorph of olivine, in the Tenham chondrite (Spray, 1999)

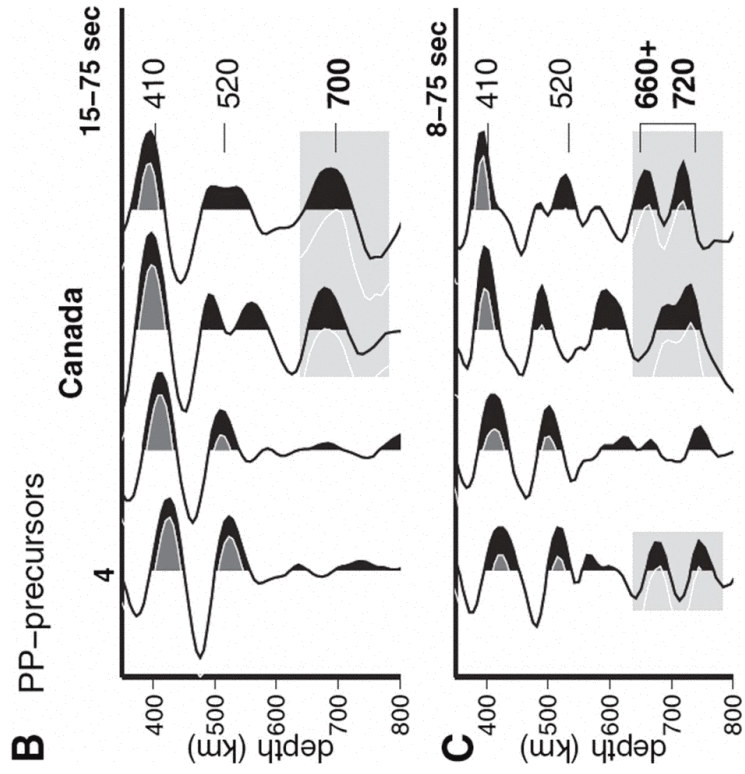




Topography on mantle discontinuities



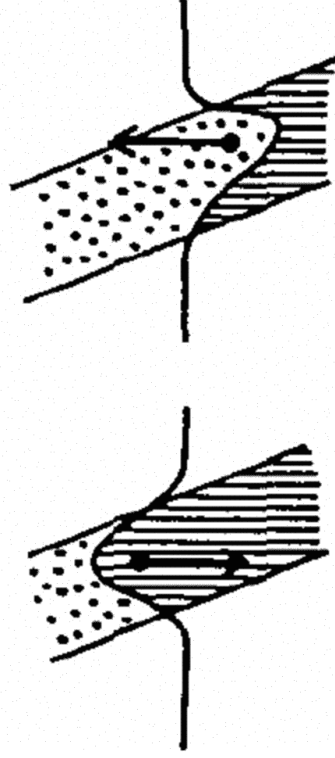
Flanagan and Shearer (1998)



Deuss et al. (2006)

Influence of phase transitions on mantle dynamics

cold slabs



exothermic

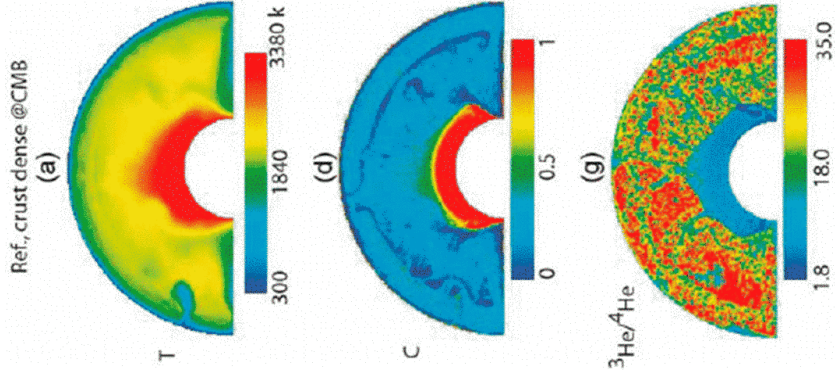
endothermic

light phase

heavy phase

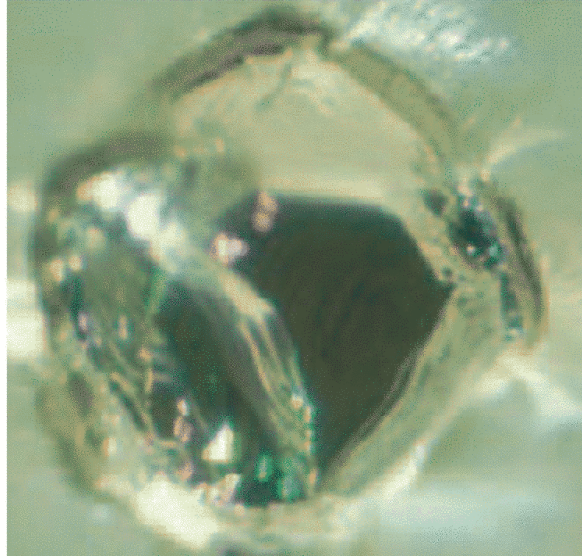
Christensen (1995)

Influence of phase transitions on mantle dynamics and chemistry

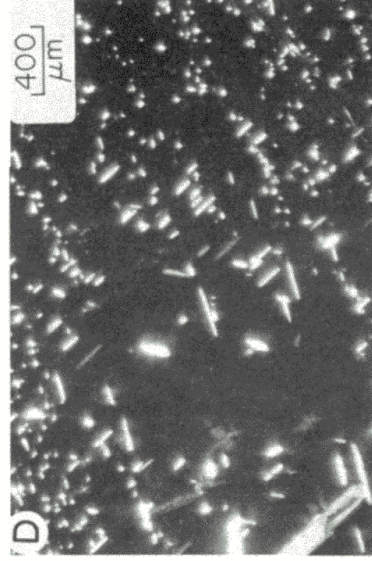


Xie and Tackley (2004)

Samples of the Transition Zone?



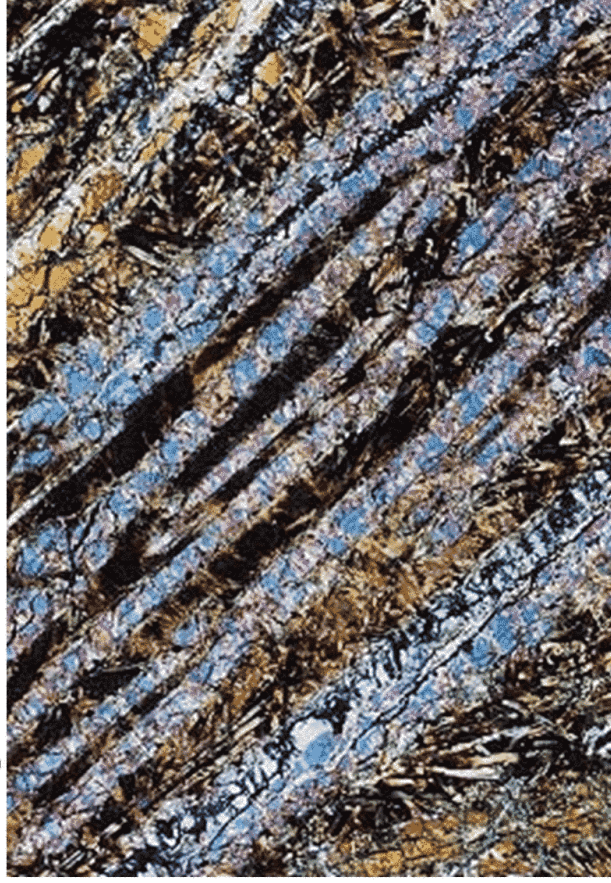
Jeffrey W. Harris (2005)
Ferropericlase inclusion in diamond Sao Luiz alluvial deposit, Brazil



Haggerty and Sautter (1990)

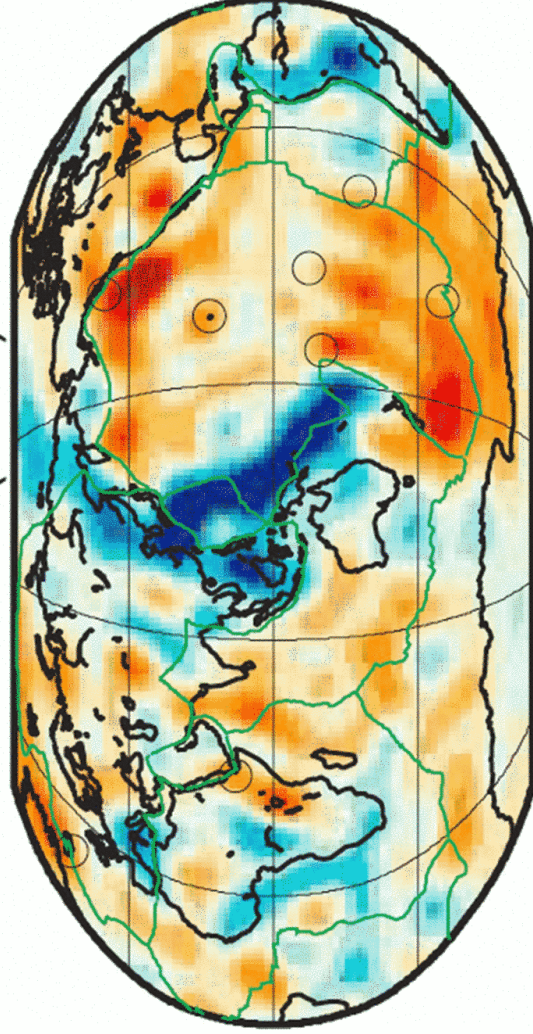
Cpx exsolution lamellae from garnet, Jagersfontein Kimberlite, South Africa

Magma from the Transition Zone?



Spinifex texture, Komatiite, scale ~ 1 cm

575 km (4.0%)

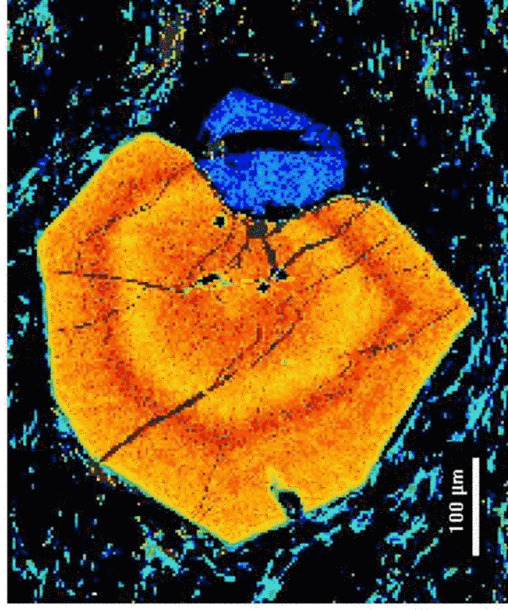


Upper mantle ~ Geology + half-space cooling
Lower mantle ~ Subduction history
Transition zone?

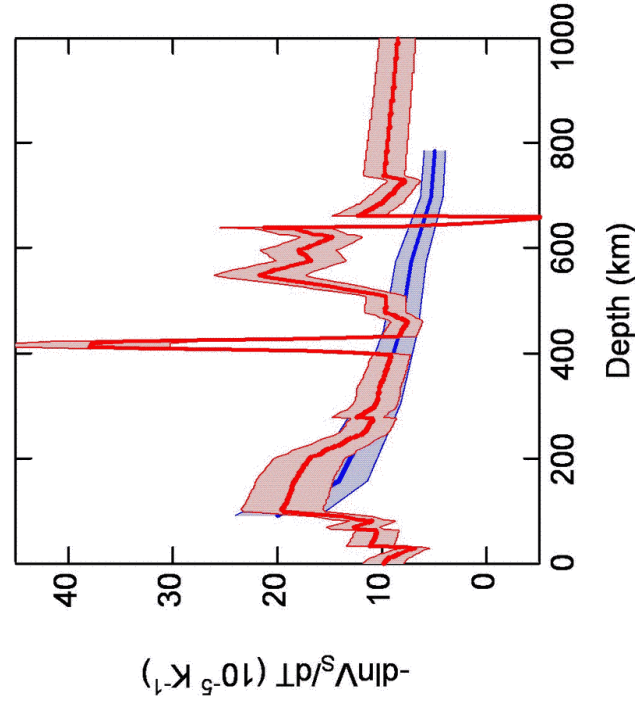
Ritsema et al. (2004)

Mantle Heterogeneity Composition

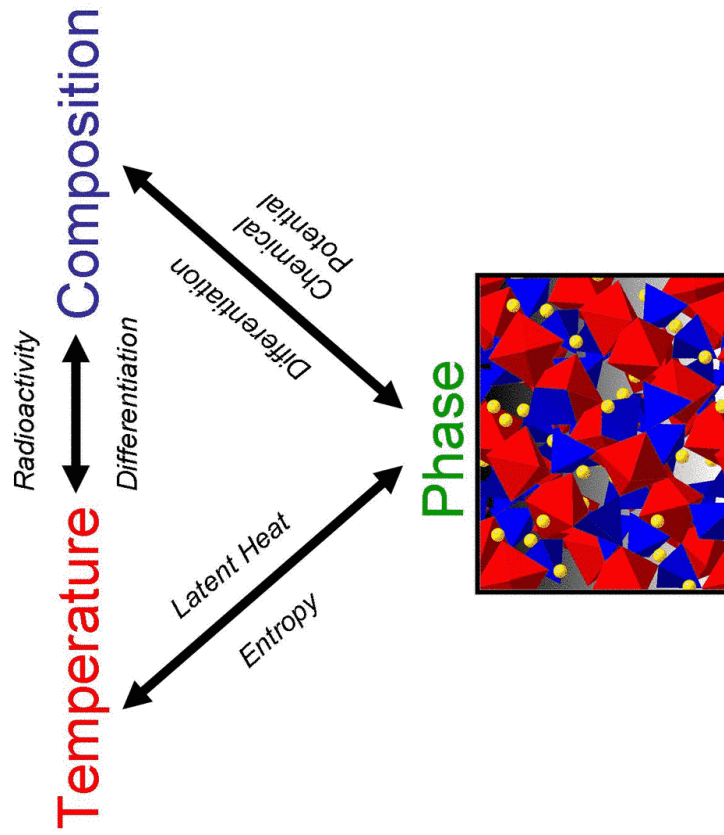
- Physical properties depend on composition
- Phase proportions depend on composition
- Major element heterogeneity is dynamically active



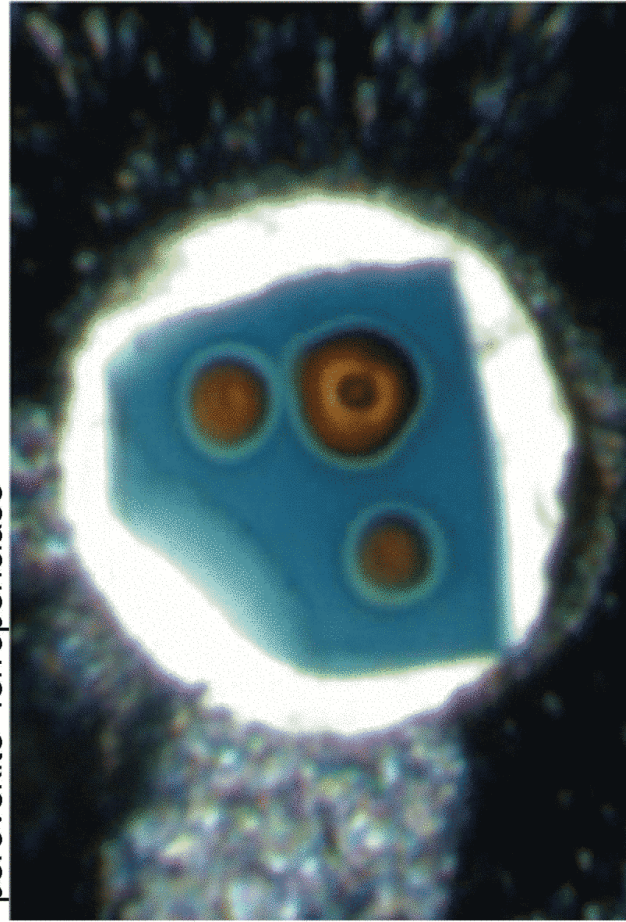
Mantle Heterogeneity Phase



Origin of Lateral Heterogeneity



Blue hydrous ringwoodite viewed in situ through the diamond anvil cell, transformed in laser-heated spots to perovskite+ferropericlavite



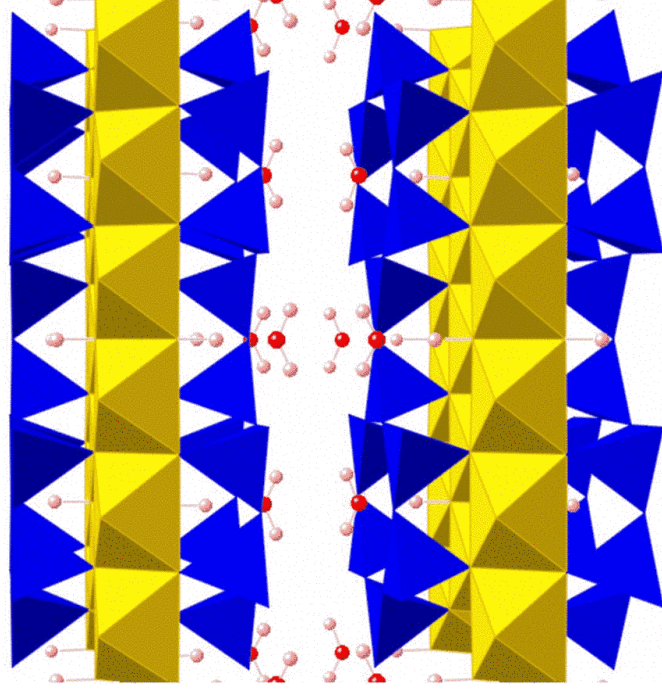
Jacobsen and Lin (2005)

In search of the terrestrial hydrosphere



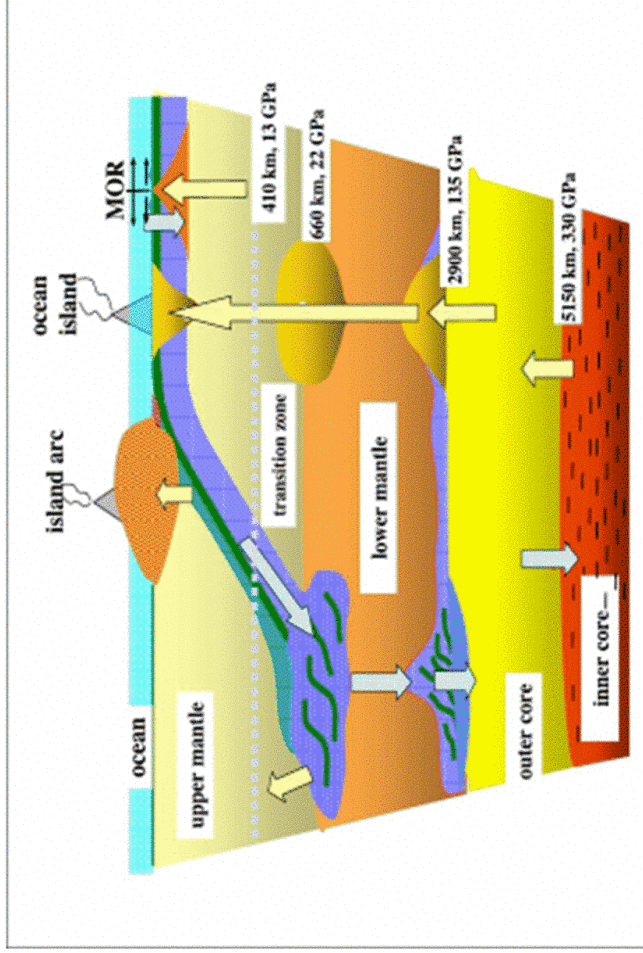
- How is water distributed?
 - Surface, crust, mantle, core
 - What is the solubility of water in mantle and core?
 - Can we detect water at depth?
 - Physics of the hydrogen bond at high pressure?
- Has the distribution changed with time?
 - Is the mantle (de)hydrating?
 - How is “freeboard” related to oceanic mass?
 - How does (de)hydration influence mantle dynamics?
- Where did the hydrosphere come from?
- What does the existence of a hydrosphere tell us about Earth’s origin?

Hydrous Phases, e.g. 10 Å phase Nominally anhydrous phases, e.g. ringwoodite



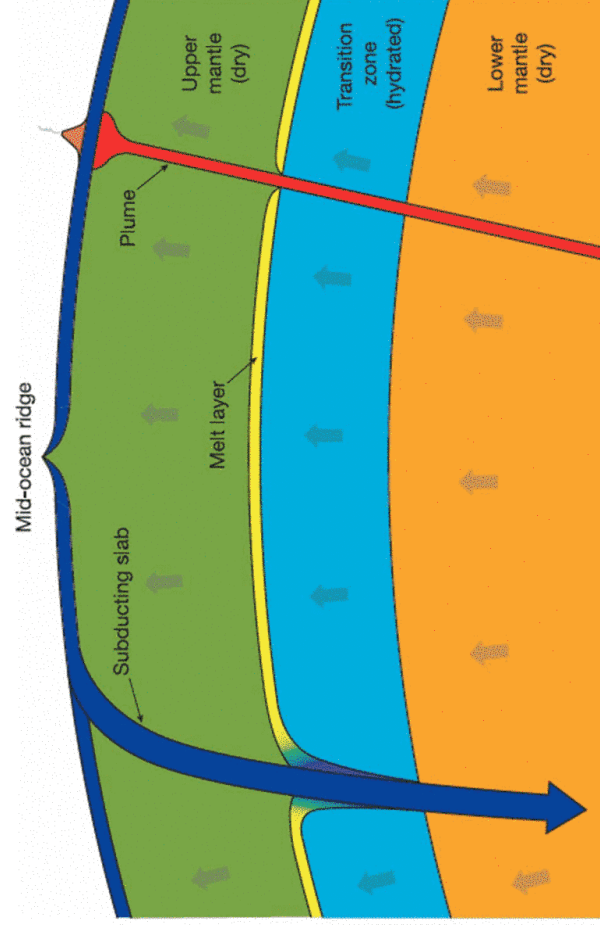
The 10 Å phase
Fumagalli et al. (2000)

Where's the water?



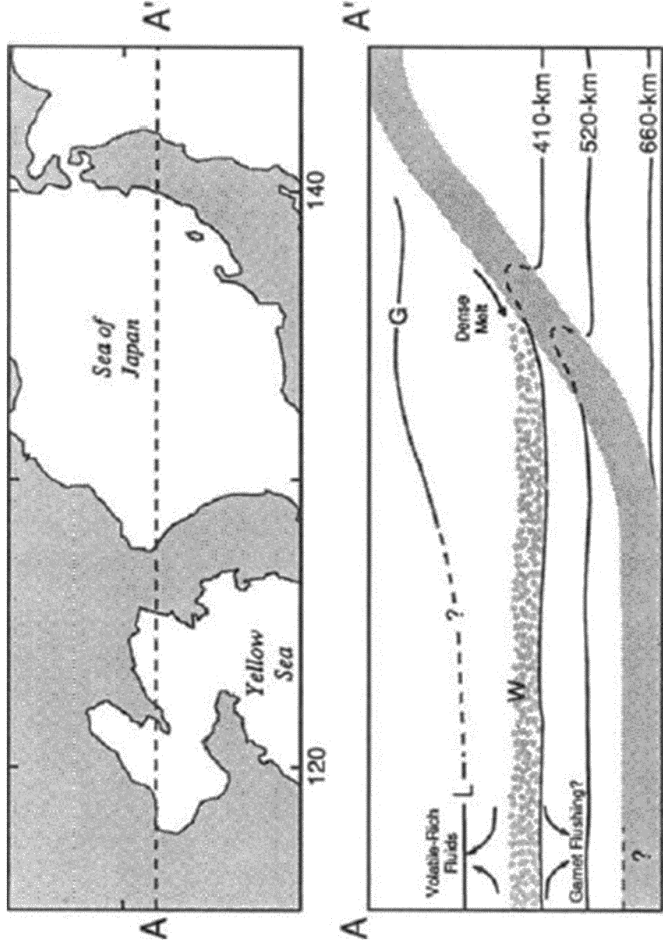
Ohtani (2005)

Transition zone water filter...



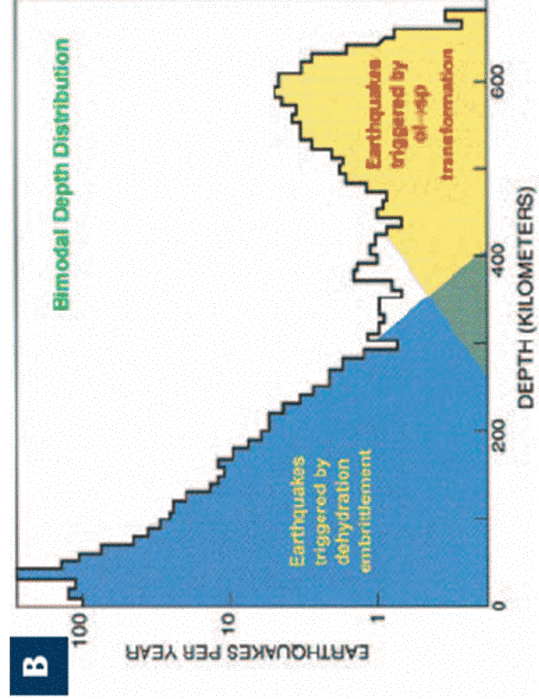
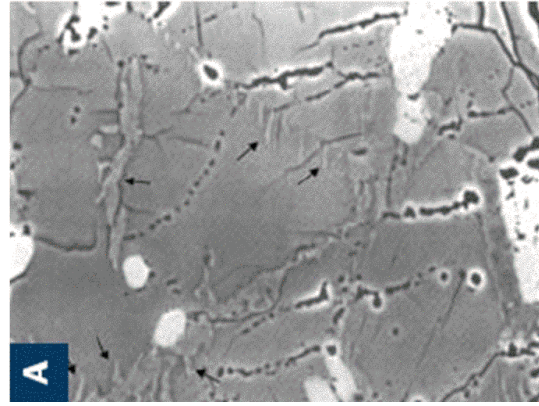
Bercovici and Karato (2003)

Melt atop the 410?



Revenaugh and Sipkin (1994)

Deep Earthquakes?



Green, Jung (2005)