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Compositional variation versus partial melting: What is the cause of low velocity and high conductivity?

Shun-ichiro Karato
Yale University, Geology and Geophysics, New Haven, CT, United States (shun-ichiro.karato@yale.edu)

The causes for low velocity, high conductivity regions of Earth (asthenosphere in the upper mantle, some regions of the D" layer at the bottom of the mantle) are controversial. I will discuss two possible causes: anomalies in chemical composition and presence of liquids (e.g., partial melt). Based on the thermodynamics and the physics of melt generation and migration, I will discuss the difficulties of partial melt model to explain geophysical anomalies. A brief review will be presented about the hydrogen-based model for geophysical anomalies including a new theory on the relationship between isotope diffusion and conductivity, and the role of grain-boundary sliding to affect seismic wave velocities. I conclude that the variation in hydrogen content is the most plausible explanation for the anomalies in the upper mantle and the transition zone. However, hydrogen model unlikely explains the observed very large velocity reduction in the ultra-low velocity regions in the D" layer. Fe-enrichment is a possible cause for low velocity and high conductivity. However, difficulties with this model are (i) the core is under-saturated with oxygen and hence the mantle next to the core must be depleted with FeO, and (ii) previously proposed mechanisms of Fe penetration are inefficient. A new finding in my lab shows that FeO-depletion at the bottom of the mantle likely promotes the penetration of molten iron leading to the low velocity and high conductivity.