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Effect of Compositional Variation on the Post-Perovskite Transition in the Lowermost Mantle

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Recent studies have shown that thermal effect alone cannot explain important seismic observations of the lowermost mantle and that compositional variation should be considered (Su and Dziewonski 1997; van der Hilst et al., 1999). The discovery of the post-perovskite transition in the deep mantle (Murakami et al., 2004; Oganov and Ono, 2004; Shim et al., 2004) has provided new opportunities to understand complex seismic structures in the lowermost mantle. However, effects of the compositional variation on the depth and seismic detectability of the post-perovskite transition have not been well characterized. We have measured compositional effects on the depth and the thickness (width of two phase region) of the post-perovskite transition up to 170 GPa and 3500 K by combining in-situ X-ray diffraction with the laser heated diamond anvil cell. Different compositional systems we have been investigating include: MgSiO3-FeSiO3, Mg2SiO4-Fe2SiO4, MgSiO3-Fe2O3, MgSiO3-Fe2O3-Al2O3, pyrolite, and basalt. For an accurate and internally consistent data set, our measurements were made using insulating argon medium, longer duration heating at higher temperatures than previous studies, reversal measurements, and the same pressure scale. The depth and the thickness of the post-perovskite transition is strongly dependent on iron and aluminum. Both ferrous and ferric iron result in a shallower post-perovskite transition, with ferrous iron increasing the thickness and ferric iron having no effect. Aluminum pushes the boundary deeper and increases the thinckness over which the transition occurs. Ferropericlase decreases the thickness of the post-perovskite transition and increases the depth of the transition through iron partitioning. Our data suggest that the post-perovskite transition should not occur at mantle pressures and the thickness would be too large for the seismic detection in regions with pyrolitic compositions, which is confirmed by our recent measurements directly on a pyrolitic composition. However, our data indicates that the post-perovskite transition in regions with low aluminum content and elevated Mg/Si ratio, such as harzburgite, may be sharp enough for seismic detection.

Keywords: post-perovskite transition, core-mantle boundary, boundary thickness, transition depth, compositional effects