J248-011 **Room: 303** **Time: May 17 17:15-17:45**

On the chemical heterogeneity in the lowermost mantle

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A phase transition from $MgSiO_3$ perovskite to post-perovskite at the vicinity of the core-mantle boundary was discovered in 2004. Rapid developments in experimental and theoretical mineral physics, seismology, and geodynamics have ensued, resulting in significant progress in our understanding of the lowermost mantle. Several long-term enigmas may be reconciled by the properties of this new phase, including the presence of an abrupt seismic velocity increase around 2600-km depth, lowermost mantle seismic anisotropy, and anticorrelation between anomalies in S-wave and bulk-sound velocities. By virtue of its location, it is naturally expected that the lowermost mantle has complex thermal, chemical, and mineralogical structures. Indeed, recently reported S-wave and P-wave structures in the lowermost mantle under the Cocos plate are in principle reconciled with the post-perovskite phase but these observations show much more complex futures (Hutko et al. 2008 Science). Strong chemical heterogeneities are likely to exist in the bottom boundary layer as a result of deep subduction of basaltic crust. The iron-rich proto-crust, anorthosite, and BIF (banded iron formation) may have also subducted into the mantle in the past. They are likely denser than the mantle and possibly have accumulated above the core-mantle boundary. Phase transition in these crustal materials could produce the multiple seismic velocity jumps in the lowermost mantle. Chemical boundary can be also a cause of such velocity discontinuity. The sharpness of the seismic boundary and its lateral extension are the key to distinguishing the chemical boundary from the phase transition boundary. The interpretation of large low shear velocity provinces (LLSVPs) in the lowermost mantle under the Pacific and Africa is an important issue as well. Geodynamical simulations have repeatedly suggested that these LLSVPs represent chemical piles being enrich in former basaltic crust. However, the very recent mineral physics predictions showed the opposite; shear velocity travels faster in basaltic material than in pyrolitic mantle (Xu et al. 2008 EPSL). It is very challenging but is necessary to estimate the absolute seismic velocities of these crustal materials in the deep lower mantle more precisely. The most recent seismic observations and the mineral physics and geodynamical studies of the lowermost mantle will be discussed in the presentation.