Thermochemical State of the Lower Mantle: New Insights from Mineral Physics

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The recent observation of electronic transitions in iron in lower mantle minerals will be presented, along with the implications for Earth's lower mantle. We find that the two main constituents of the lower mantle, namely (Mg,Fe)SiO_3 – magnesium silicate perovskite – [1] and (Mg,Fe)O – magnesiowüstite – [2], undergo electronic transitions at lower mantle pressures (70 GPa for magnesiowüstite, and 120 GPa for perovskite), in which iron transforms from the high-spin state to the low-spin state. The volume of low-spin iron is smaller than that of high spin iron, and such transitions should have a strong influence on the partition coefficient of iron between the two pahses. Moreover, minerals bearing high-spin iron generally have characteristic absorption lines in the near-infrared, hindering radiative conductivity at lower-mantle temperatures. These absorption lines shift in low-spin iron-bearing minerals to the visible range (green to violet), and their intrinsic intensities decrease; the minerals should thus become more transparent in the near-infrared and their radiative conductivity (and therefore total thermal conductivity) should increase, affecting the dynamics of the lowermost mantle. The transition pressures correspond to the bottom third of the lower mantle (70 GPa, 1700 km depth), and to the last 300 km above the core-mantle boundary (120 GPa, 2600 km depth); these regions have very special geophysical signatures, as large-scale chemical heterogeneities have been reported in the bottom third of the lower mantle, and that the bottom 300 km of Earth's mantle is constituted by the D″ layer. Our observations could provide a mineral physics basis for these two regions of Earth's lower mantle. The geochemical and geodynmical implications of these transitions in the lower mantle will be discussed.

References

[1] J. Badro et al. (2003), *Science* **300**, 789.
[2] J. Badro et al. (2004), *Science* **305**, 383.