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

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We report recent findings in the field of high-pressure mineral physics with important 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 – and (Mg,Fe)O – magnesiowüstite –, undergo electronic transitions at lower mantle pressures, in which iron is transforms from the high-spin state to the low-spin state. The transformations should profoundly alter the thermochemical state of Earth's lower mantle. Minerals bearing high-spin iron 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 thus become transparent in the near-infrared and their radiative conductivity (and therefore total thermal conductivity) increases. Other issues at stake are that of iron partitioning between mineral phases in the bottom third lower mantle. The two 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, since 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 implications of these transitions on the dynamics of the lower mantle will be discussed.