Enhanced Convection and Fast Plumes in the Lower Mantle Induced by the Spin Transition in Ferropericlase

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Using a numerical model we include the intrinsic density change that occurs from high to low-spin ferropericlase around 50 GPa [*Sturhahn et. al., 2005*]. This generates buoyancy similar to a discrete phase change. However, in pressure-temperature space the spin transition occurs over an extended pressure range for warmer material (Figure 1). The temperature broadening effect distributes spin-buoyancy over a large pressure range for warm plumes and a tight pressure range for cold slabs. In the deep mantle, spin-buoyancy works with thermal buoyancy and convection is enhanced for both upwellings and downwellings. In the shallow lower mantle spin-buoyancy mildly hinders convection.

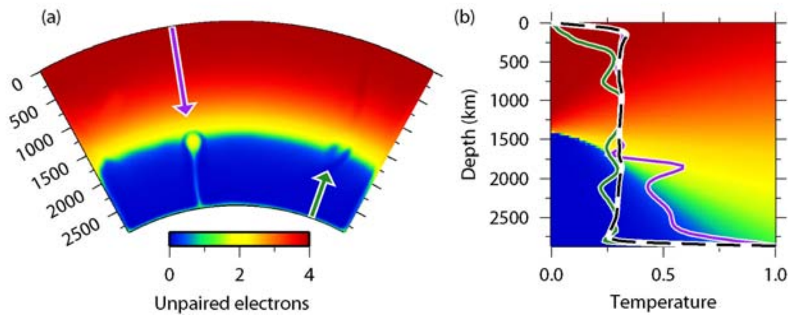

Figure 1. *(a) Spin-state from simulation based on Sturhahn et. al. (2005) spin model. Purple line is warm geotherm, green line is cold. (b) Geotherms with Sturhahn et. al. (2005) spin-state model. Black dashed line is horizontal average.*

Although the additional buoyancy does not fundamentally alter the large-scale dynamics, the Nusselt number increases by 5-10%, and vertical velocities by 20-45% in the lower mantle. Advective heat transport is more effective and temperatures in the core-mantle boundary region are reduced by up to 10%.

The spin transition, in addition to the Pv-pPv phase change, is a destabilizing mechanism that will further work against the stability of lowermost mantle structures. Furthermore, it provides additional buoyancy to small-scale hot plumes, such as those that possibly emanate from the edges of large low velocity structures.

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References

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