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Dynamical Influences from the Non-Monotonicity of the Activation Parameters in the Lower Mantle

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The recently discovered iron spin transition in major mantle minerals at high pressures should exert dramatic influences on the transport properties, such as the activation creep parameters in the deep mantle. The high-spin to low–spin transition, which is like a second-order phase transition, changes the electronic environment of the d-orbitals of Fe ++. Following the earlier work of Sammis et al. (1977), one can calculate the changes in the activation enthalpy from an elastic strain energy model, in which the activation parameters are related to the bulk and shear wave velocities. Wentzcovitch et al. (2009) have computed these velocities at high P and T conditions, using the first principles of total energy calculations of the material's elasticity. Due to the strong elastic softening, as a consequence of the spin transition, there is a strong reduction of the activation free energy in the creep law, leading to its non-monotonic behavior occurring in the middle of the mantle. With a parameterized model capturing the basic physics, we have studied the dynamical consequences within the framework of a 2-D convection model. The non-monotonicity in the rheological parameters leads to the formation of a viscosity hill. The results indicate a tendency to superplumes in the lower mantle.