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The effects of thermodynamics on the composition and structure of planetary mantles

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The thermal, geochemical, and dynamical evolution of planetary mantles is intimately linked to the planet's composition and structure. Planetary mantles are multi mineralic and likely multi compositional. For any give composition, the changes in pressure and temperature in the interior lead to new stable phase assemblages and physical properties. In other words, the mineralogy of an upwelling is not simply the reverse of a downwelling. Both convective flow and seismic structure are affected by these changes in phase assemblage and consequent changes in static (and transport) thermodynamic properties. A simple example is the potential role of phase transitions in layering and delayering the mantle, which can exert a controlling influence on the planet's thermal and geochemical history. In this talk I will briefly present the basis upon which the thermodynamic code HeFESTo (Stixrude and Lithgow-Bertelloni, 2005b; 2011, 2022, 2024) was built and review some key past and new results. These include the properties of a mantle that is a mechanical mixture of pyroxenite and basalt, rather than an equilibrium assemblage, seismic structure, and predictions for the effects of phase transitions on thermal evolution. I will also show predictions for relevant physical properties and phase assemblages for other planetary bodies (Mars, Moon, and Venus). I will highlight the effects of our latest updates, which include iron disproportionation and spin transition, on physical properties and mantle dynamics.