Mars: From Core to Mantle

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Constraining the thermal history of Mars, in how heat is transferred between the core and mantle, is key to understanding the formation and evolution of Mars. In particular, using the observed potential dynamo shutoff early in Mars' history (a constraint on core heat flow) and continued volcanism based on the relatively young ages of lava flows, such as those on Olympus Mons (temperature state of the mantle), we can place constraints on the temperature state of the planet throughout its history. To this end, we used what is known about the geochemistry of Mars' core and mantle to inform inputs and outputs of our 1D coupled thermal mantle-core model.

We tested three starting scenarios for Mars that set the initial temperature and density profile for the planet to be used in the 1D parameterized, coupled core-mantle convection model. These were constructed with a fixed composition for the mantle of Mars and a variable S content in the core. We used the bulk silicate composition proposed by Dreibus and Wanke as the majority of experimental work was conducted with this composition allowing us to check the mineralogy calculated with a thermodynamic model, and determine a solidus and liquidus to determine the fraction of melting throughout the model evolution. The starting conditions were 1. a global magma ocean that cooled from the base upward, i.e., a homogenous mantle, 2. a 'hot' start that also assumes a global magma ocean but with an overturning dense garnet layer that settles at the core-mantle boundary during crystallization, and 3. a 'cold' start that considers a shallow magma ocean that allows for an unmelted basal mélange layer assumed to be composed of ringwoodite, majorite, and Fe±S metal, possibly due to incomplete core formation.

Initial model results suggest that the 'hot' start scenario would not allow for any core dynamo in Mars history, while the 'cold' start allows for a core dynamo that shut off early, and a mantle hot enough to have continued melting through the present day.