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Could a layer of liquid silicate be present at Mars' core-mantle boundary?

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Recent results of the InSight mission to Mars lead to the suggestion of a molten silicate layer atop the core-mantle boundary (CMB) [1,2]. This result came from the detection of a P wave diffracted along CMB and S-wave reflection from atop the molten silicate layer. Geophysical modeling of this layer suggested that it must be denser than the overlying mantle but less dense than the core, and have a viscosity similar to that of the overlying solid mantle. However, studies of silicate liquid viscosities at the appropriate pressure range for this layer (17–21 GPa), yielded values <1 Pa s [e.g., 3], over 20 orders of magnitude smaller than suggested by the above geophysical models. Additionally, temperatures across the layer must be >2,500 K to be completely molten, and temperature profiles are nearly isothermal [e.g., 4]. We tested this liquid layer hypothesis including thermal, viscous, and compositional constraints, and calculated possible crystallization times.

We constructed a set of models that use silicate liquid equations of state (EoS), 1D heat flow calculations, and convective scaling analysis to determine the properties of a possible liquid layer. A variety of liquid compositions were tested, including bulk silicate compositions [e.g., 5] and mineral endmembers [e.g., 6]. Densities and P-wave velocities were calculated over a range of pressure-temperatures. Crystallization times were calculated over a range of temperatures and viscosities, using the output compositional parameters from the EoS calculations, e.g., density.

Based on the EoS calculations, the layer must be enriched in iron by 25–55 mol.%, which we added as a liquid fayalite component. Using the appropriate compositions and liquid viscosities, crystallization timescales fall between 2–3 Myr. In aggregate, these results indicate that this putative seismically inferred molten silicate layer would have to be formed geologically recently. Viable formation mechanisms have yet to be found.

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