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A Numerical Model for the Differentiation of Enceladus

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The past close encounters of the CASSINI spacecraft in the Saturnian system have provided unprecedented insight into the geodynamics of small and mid-sized icy satellites. The newly determined average density and equilibrium shape of the most enigmatic satellite Enceladus implies that its interior is composed of ice and rock at nearly equal shares and at least partially differentiated. Characteristic features at the surface of Enceladus further suggest that this satellite has been geologically active during the recent past. Gaseous plumes of water vapor and nitrogen as recently observed by the Cassini spacecraft indicate that Enceladus is still active even at the present time. In the present study, we consider a plausible range of interior structure models that satisfy Enceladus' average density to investigate under which conditions early and/or late differentiation could have run to completion. Our 2D-finite-element numerical model describes viscous Stokes flow and simulates the sinking of numerous rock particles through viscous water ice. The model aims at determining the timescales at which the internal differentiation of small and mid-sized icy bodies would proceed. Depending on rheology or particle size we found a wide range of possible differentiation times for Enceladus. Corresponding to recent convection models, which may explain the heat source for the plume activity, or tidal dissipation models, we can constrain our model variety.