Thermal profile in Enceladus' interior and its compatibility with hydrothermal circulation

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Introduction: The recently discovered molecular hydrogen in the plume emitted from the south pole of Jupiter's moon Enceladus confirmed a high probability that hydrothermal venting exists in its sub seafloor under its ice-covered liquid ocean [1]. This finding, together with the discovery of Enceladus' salty, liquid ocean, as well as its rocky, silicate-rich core, mark the resemblance of the submarine environment in Enceladus and Earth. The rich biological species observed on earth, which derive energy exclusively from hydrothermal venting indicate that similar mechanism on Enceladus could potential support life as well. On Earth, the thermo-gradient resulting from mantle convection and plate tectonics contributes to hydrothermal convections in the porous seafloor, which lead to temperature-dependent chemical reactions needed for supporting life. However, as Enceladus is heated by tidal dissipation in its ice shell and water-saturated rocky interior, the thermal profile in its porous seafloor is likely to be fundamentally different than that on Earth. This difference in heating mechanism and temperature profile, in addition to the lack of apparent geological features such as Mid-Ocean-Ridges, makes it difficult for us to probe if and where hydrothermal venting may exist in Enceladus' sea floor.

Here, we examine the thermal profiles in the rocky interior of Enceladus resulting from tidal heating models, and propose to establish a framework by which this thermal profile is coupled to the thermal convection of sea water driven by the interior thermal gradient, the transport of chemical species relevant to hydrothermal venting in the pore fluids, and use the framework to probe if certain geochemical reactions may happen, as well as their possible locations. By doing so, we can take the first step to interrogate whether, and to what extent, the tidal heating mechanism is capable to sustain a life-supporting, hydrothermal circulation.

References:

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