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Powering prolonged hydrothermal activity inside Enceladus

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Abstract

A series of evidence gathered by the Cassini spacecraft indicates that Saturn's moon Enceladus is even more active than anticipated:
1) the observation of an elevated libration implies the existence of a global subsurface salty reservoir with a thin ice shell (20-25 km in average [1] and < 5 km in the South Polar Terrain, SPT [2, 3, 4]),
2) the intense jets at the South Pole seem associated to ongoing seafloor hydrothermal activity [5, 6].

Both observations require a huge heat power and a mechanism to focus the release of heat in the SPT, unexplained by previous models. Here we investigate heat generation by tidal friction in the porous core for core porosities consistent with Cassini gravity data [7]: tidal power potentially generates more than 20 GW thus explaining the existence of a global ocean.

We also model water transport in the tidally-heated permeable core in 3D geometry; simulated water circulation exhibits hot narrow upwellings with temperatures exceeding 90^{o}C, providing the fundamental mechanism for efficient water-rock-organics interactions. This results in the formation of powerful (1-5 GW) hotspots at the seafloor, explaining heat release in narrow regions, especially at the South Pole and thus, the uneven shell structure [2]. This also favors the transport of hydrothermal products from the core to the plume sources, consistent with the production of silica nano-particles [5] and the level of hydrogen estimated in Enceladus' plumes [6].

We predict that such activities can be sustained for tens of millions to billions of years.

References

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