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Powering hydrothermal activity on Enceladus

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A series of evidence gathered by the Cassini spacecraft indicates that the intense activity at the South Pole of Saturn's moon Enceladus is related to a subsurface salty water reservoir associated with seafloor hydrothermal activity (Hsu et al. 2015, Waite et al. 2017). The observation of an elevated libration implies that this reservoir is global with a thin ice shell (20-25 km in average (Thomas et al. 2016) and < 5 km in the South Polar Terrain, SPT (Cadek et al. 2016)). Such a structure requires 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 and simulate heat transport by water flow for core porosities consistent with Cassini gravity data (Iess et al. 2014). We demonstrate that, for effective viscosity and permeability values typical of water-saturated terrestrial rock analogues, more than 20 GW can be generated in the core, which can maintain a global liquid ocean and power hydrothermal activity at the seafloor. By performing 3D simulations of water flow in a tidally-heated porous rock matrix, we show that heat is extracted from the core in the form of focused outflows of hot water (> 90 °C) mostly in the polar regions, explaining strongly localized ice shell thinning. Owing to strong dissipation in Saturn (Lainey et al. 2017), we show that circulation of hot waters in the core may last at least 20-25 million years and that 10 to 100% of the oceanic volume may be processed in the core at temperature higher than 90°C on this timescale. Whether this has been sufficient for the emergence of life can be explored by future spacecraft missions (Mitri et al., this meeting; Lunine et al. 2017).