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Models of a partially hydrated Titan interior with clathrate crust

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We present an updated model of the interior evolution of Titan over time, assuming the silicate core was hydrated early in Titan's history and is dehydrating over time. The original model presented in Castillo-Rogez and Lunine (2010) was motivated by a Cassini-derived moment of inertia (Iess et al., 2010) for Titan too large to be accommodated by classical fully differentiated models in which an anhydrous silicate core was overlain by a water ice (with possible perched ocean) mantle. Our model consisted of a silicate core still in the process of dehydrating today, a situation made possible by the leaching of radiogenic potassium from the silicates into the liquid water ocean. The crust of Titan was assumed to be pure water ice I. The model was consistent with the moment of inertia of Titan, but neglected the presence of large amounts of methane in the upper crust invoked to explain methane's persistence at present and through geologic time (Tobie et al. 2006). We have updated our model with such a feature. We have also improved our modeling with a better physical model for the dehydration of antigorite and other hydrated minerals. In particular our modeling now simulates heat advection resulting from water circulation (e.g., Seipold and Schilling 2003), rather than the purely conductive heat transfer regime assumed in the first version of our model.

The modeling proceeds as in Castillo-Rogez and Lunine (2010), with the thermal conductivity of the methane clathrate crust rather than that of ice I. The former is several times lower than that of the latter, and the two have rather different temperature dependences (English and Tse, 2009). The crust turns out to have essentially no bearing on the temperature of the silicate core and hence the timing of dehydration, but it profoundly affects the thickness of the high-pressure ice layer beneath the ocean. Indeed, with the insulating methane clathrate crust, there must be a liquid water ocean beneath the methane clathrate crust and in contact with the silicates beneath for most of Titan's history. Although a high-pressure ice layer is likely in place today, it is thin enough that plumes of hot water from the dehydrating core probably breach the high pressure ice layer maintaining contact between the ocean and the silicate core.

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