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The long-term stability of an aqueous ammonium sulfate ocean inside Titan

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The presence of an ocean inside Titan has yet to be confirmed, but is not unexpected. If gravity data do confirm a subsurface ocean, then what might its composition be? A recent model [1] predicts that it will be made of aqueous ammonium sulfate solution (AS), rather than an ammonia-water (AW) mixture [e.g. 2], formed by the leaching of sulfates from a hydrated core during differentiation. The freezing temperature of AS is significantly higher than that of AW, and therefore such an ocean would crystallize quicker upon cooling. The implications of the new internal structure model [1] are significant for surface chemistry and the nature of volcanism on Titan, and so the goal of this paper is to determine under what conditions such an ocean could survive to the present day.

We model the thermal evolution of Titan using a parameterized convection scheme, using the new structural model as the starting reference. In this model, Titan consists initially of a rocky core (˜ 1900 km radius) made of the hydrated mineral antigorite, overlain by an icy mantle (˜ 700 km thick). At the base of the mantle there exists a high pressure ice VI phase (434 km thick), overlain by the AS ocean (153 km thick), and a crust made predominantly of methane clathrate (123 km thick) with small amounts of AS and ice I present. We allow the top and bottom boundaries of the ocean to change according to the rate of crystallization/melting over time. We use detailed material properties derived from experimental data to derive accurate models of each layer.

For a wide range of input parameters and different scaling laws, we find that an ocean made of AS can survive to the present day despite its warmer temperatures, indicating that an AW ocean is not the only possible ocean composition on Titan.

References [1] Fortes et al., 2007. Icarus, 188, 139-153. [2] Tobie et al., 2006. Nature, 440, 61-64.