

Subsurface Oceans and Deep Interiors of Large Trans-Neptunian Objects

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The detection of Trans-Neptunian objects (TNO's) with a size similar to that of Pluto and Charon has raised the question of the possible internal structures of these class of objects. Estimates of the masses (and hence densities if the radius or shape is determined) of TNOs imply a large fraction of rock (over 60%), similar to the bulk composition of Triton, Pluto and Charon. The volatile component is expected to be mainly water ice including additional minor components of other volatile ices. The high rock-content implies significant heating due to long-lived radiogenic isotopes. Additionally, tidal heating may play an important role in the early evolution of Kuiper-belt binaries. For the largest objects heating may have been sufficient to differentiate the body into a rock core and an ice layer. Depending on the available heat sources and abundances of volatiles, e.g. ammonia, the internal temperatures can exceed the liquidus in the icy mantle. In that case a subsurface ocean would form, which may be maintained even up to present times, depending on the size of the object, its rock content and the abundance of volatiles. Based on an equilibrium condition between heat production and heat loss through the ice layer we calculate models for the largest TNO's and find that liquid layers can exist even if only small amounts of ammonia are available. In that case the oceans are expected to be located between the rock core and about 150 - 200 km of ice. However, depending on the total mass and rock content high-pressure ice phases forming on top of the rock core cannot be ruled out for objects of the size of Pluto, Triton, and Eris. Indirect evidence for liquid layers may be gained from their induced magnetic response to varying external magnetic fields and in case of binaries from the tidal deformation of the outer ice shell, which will be significantly greater even if the ocean is located at a depth of 200 km.