The Potential for Oceans Within Icy Outer Planetary Bodies – A Comparative Study

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ABSTRACT

Several outer planetary moons and related bodies are investigated for their likelihood of containing an aqueous (i.e.; a water-dominated) layer between an assumed rocky core and icy mantle. A steady-state thermal analysis of differentiated bodies is used to estimate temperature profiles in their interiors prior to the formation of such a layer. This analysis assumes radiogenic heating at chondritic rates localized in a rocky core, a two-layer composite sphere, and non-convective heat transfer in the mantle. The largest bodies such as Ganymede, Titan and Callisto, should have substantial subsurface oceans. Intermediate-sized bodies such as Triton, Europa and Pluto, are likely to have aqueous strata, but of a reduced extent. Smaller bodies such as Titania, Rhea, Oberon and Iapetus, may have aqueous core-mantle interfaces, but only if other heat sources such as tidal dissipation or warming from past epochs are important. A Trans-Neptunian Object with radius of 910 km and a density of 1725 kg/m^3 is the smallest that may have an aqueous seam at present day. Bodies having as small a radius as 539 km may have had melted layers in past epochs, or even currently if present day rates of radiogenic heating have been underestimated. If the radiogenic heating rate is closer to that of in-situ lunar samples (i.e.; about twice the chondritic rate), then oceans may be common in the outer Solar System. A descriptive criterion is proposed that describes the likelihood of the existence of an aqueous layer based on a pre-melt temperature calculated at the rock-ice interface. The steady-state two-layer analysis provides a language by which primitive icy bodies can be better understood.