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Habitability potential of icy moons: a comparative study

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Looking for habitable conditions in the outer solar system focuses in our search on the natural satellites rather than the planets themselves. Indeed, the habitable zone as traditionally defined may be larger than originally conceived. The strong gravitational pull caused by the giant planets may produce enough energy to sufficiently heat the interiors of orbiting icy moons. The outer solar system satellites then provide a conceptual basis within which new theories for understanding habitability can be constructed. Measurements from the ground but also by the Voyager, Galileo and the Cassini spacecrafts revealed the potential of these satellites in this context, and our understanding of habitability in the solar system and beyond can be greatly enhanced by investigating several of these bodies together [1]. Their environments seem to satisfy many of the "classical" criteria for habitability (liquid water, energy sources to sustain metabolism and chemical compounds that can be used as nutrients over a period of time long enough to allow the development of life). Indeed, several of the moons show promising conditions for habitability and the development and/or maintenance of life. Europa and Ganymede may be hiding, under their icy crust, putative undersurface liquid water oceans which, in the case of Europa [2], may be in direct contact with a silicate mantle floor and kept warm by tidally generated heat [3]. Titan and Enceladus, Saturn's satellites, were found by the Cassini-Huygens mission to possess active organic chemistries with seasonal variations, unique geological features and possibly internal liquid water oceans. Titan's rigid crust and the probable existence of a subsurface ocean create an analogy with terrestrial-type plate tectonics, at least surficial [4], while Enceladus' plumes find an analogue in geysers. As revealed by Cassini the liquid hydrocarbon lakes [5] distributed mainly at polar latitudes on Titan are ideal isolated environments to look for biomarkers. Currently, for Titan and Enceladus, some geophysical models try to explain the possible existence of an oceanic layer that decouples the mantle from the icy crust. If the silicate mantles of Europa and Ganymede and the liquid sources of Titan and Enceladus are geologically active as on Earth, giving rise to the equivalent of hydrothermal systems, the simultaneous presence of water, geodynamic interactions, chemical energy sources and a diversity of key chemical elements may fulfill the basic conditions for habitability. In the solar system's neighborhood, such potential habitats can only be investigated with appropriate designed space missions, like JUICE-Laplace (JUpiter ICy moon Explorer) for Ganymede and Europa [6]. JUICE is an ESA mission to Jupiter and its icy moons, recently selected to launch in 2022.

References:

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