Large Impacts on Icy Bodies and Habitability: The Case of Menrva Crater on Titan

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Titan is a unique potentially habitable world: it is, at the same time, an ocean world, an icy world, an organic world, and has a dense atmosphere. Although Titan's low surface temperatures are not conducive to life, the liquid ocean underneath the ice shell is warm enough at ~260K to be potentially suitable for life. Titan´s surface, in turn, is coated by a complex mixture of organic molecules, and has plenty of liquid methane in the form of rivers, lakes and seas. Thus, pre-biotic and biotic life forms may have developed in its water ocean underneath the ice shell, provided pathways connecting surface materials and subsurface water ocean existed. For these pathways to exist, its relatively thick ice shell (between 80 and 100 km thick) would have to be broken or penetrated. Large hypervelocity impacts are among the likely mechanisms capable of inducing the connection between the atmosphere/surface layer and the underground liquid ocean. The effects and consequences of large cosmic impacts on rocky planetary bodies is nowadays reasonably well constrained and understood. The same cannot be said about impacts on icy bodies, of which little is still known. The knowledge is even more limited on planetary bodies with ice shells formed by mixtures of ice and methane clathrates with an underlying liquid ocean, as in the case of Titan. We examine the role of large impacts on Titan in creating such conditions, as hypervelocity collisions of large bodies may have allowed exchange of materials (organic compounds, water, etc.) between the surface, the near subsurface and the ocean, creating niches for the development of primitive lifeforms. To investigate impact-induced potential exchange pathways we modeled the formation of the largest crater on Titan, Menrva, with a diameter of ca. 425 km, using numerical simulations performed in iSALE-2D shock physics code.