IMPACT MELT POOLS AS POTENTIALLY HABITABLE PLACES ON TITAN.

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NASA's Dragonfly mission will explore the region surrounding Selk crater, an 84-km diameter impact structure on Titan [1]. Among the mission's science goals are the search for biologically relevant chemical compounds and potential chemical biosignatures [2]. The impact that formed Selk crater may have produced a melt pool of liquid water that could have mixed with organics present on the surface. For this reason, impact melt pools are an ideal location for Dragonfly's exploration and search for such chemical compounds. However, the formation process of Selk-size craters and their impact melt pools are still poorly constrained. In this work, we perform impact simulations on Titan to study the formation of Selk-size craters and their melt pools.

We use iSALE-2D shock physics code to simulate impacts on Titan [3,4,5]. Since methane interacts with solid water ice and forms methane clathrate on Titan's surface [6], we study a methane clathrate surface layer. Methane clathrate has two important properties that affect crater formation: (1) methane clathrate is ~20 times stronger than water ice [7] and (2) its thermal conductivity is 4 times lower than that of water ice [8]. The difference in strength changes a crater morphology from a pure water ice target. The thermal conductivity affects the temperature profile within the icy target, which affects the target strength and thus crater morphology. To evaluate these effects, we consider 5–15 km thick methane clathrate layers over pure solid water ice using the temperature profiles that include the thermal properties of methane clathrates [9]. We simulate spherical icy impactors 3-4 km in diameter striking Titan's surface at 10.5 km/s. To determine the amount of melt produced in the icy target, we consider the peak pressure of the icy materials.

We find that a 4 km-diameter-impactor striking a 10-km-thick methane-clathrate layer best reproduces a Selk-sized crater [10]. Moreover, we confirm a melt pool of liquid water formed during the Selk formation event, and find a melt volume of 360–400 km^3. Our simulations indicate that the shape of the melt pool is sensitive to the thickness of the methane clathrate layer. Whereas a shallower melt pool is formed in a 5-km-thick methane clathrate surface layer, a torus-like melt pool is produced in the case of a 10 or 15 km thick clathrate layer. These melt pools are a few kilometers in depth, so it could take tens of thousands of years to cool to ambient temperatures. We expect that this duration could be enough time for complex prebiotic chemistry to occur on Titan's surface.

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