THE IMPACT CRATERING PROCESS ON TITAN: IMPLICATIONS FOR SURFACE AGE AND EROSION ON TITAN

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Impact cratering is one of the most common geologic processes on planetary surfaces. Studying this process is important because it provides information about the geological history, interior structure, and surface processes of planetary bodies. One planetary body of high interest, because it is much similar to Earth, where we observe and study craters is Titan. Titan is an icy world with a subsurface water ocean and stable liquids (primarily methane) on its surface, and has a thick, nitrogen-rich atmosphere with a few percent methane. This complex climate system results in surface processes like erosion, creates organic compounds, and allows for a methane-based hydrological cycle. We are most interested in studying how erosion affects impact craters. This is also relevant to astrobiology because impacts can produce melt pools of liquid water (on Titan) which can mix with the organics present on the surface to create potentially habitable environments.

First, we perform a comparative study of impact craters on Earth and Titan using synthetic aperture radar (SAR) images to constrain the crater population and in turn, the surface age of Titan. NASA's Cassini mission detected a low number of impact craters on Titan's surface as compared to other icy satellites, likely due to degradation and burial by fluvial erosion and aeolian infilling. This is similar to the reduced number of craters seen on Earth that results from weathering, erosion, and plate tectonics. Given these similarities, Earth serves as an ideal analogue for studying Titan's craters. There are 200 confirmed craters on Earth, of which 67 are buried and therefore unobservable from orbit. This study determines the percentage of the remaining 133 exposed terrestrial craters that can be identified in SAR data, in order to estimate the number of craters that may be obscured on Titan. The results show that of these 133 craters, only ~50% of the terrestrial craters are distinctly visible in radar images. If a similar fraction of craters are obscured on Titan due to similar surface processes on Earth, it suggests that 50% of the craters formed on the current Titan crust are not visible in the Cassini RADAR data set. Thus, the surface age of Titan could be 2x older (~400 Ma – 2 Ga) than currently hypothesized (~200 Ma – 1 Ga).

We therefore wish to investigate the level and style of erosion occurring on Titan. Because the rates of crater degradation and the ages of Titan's craters are unknown, the 'uneroded' morphology of Titan's impact craters is not well understood. Knowing the morphologies of fresh craters will allow us to constrain the amount of erosion that has occurred on Titan. We use the iSALE shock physics code to understand the morphology of fresh craters on Titan. Specifically, we explore the effect of the thermal gradient in the ice crust on crater depths. We consider a range of thermal gradients from 3 - 10 K/km, to represent both a pure water ice case and a surface layer of methane clathrate. The lower thermal conductivity of methane clathrate results in a higher thermal gradient. We find that a higher thermal gradient produces craters that are shallower, and therefore more consistent with the observed crater depths on Titan. We then compare the depths of fresh Titan impact craters inferred from the model outputs to observed crater depths on Titan, to determine the extent of erosion that has occurred since their emplacement. Studying how impact craters evolve over time due to surface processes such as erosion will provide improved insights on Titan and its impact cratering process, and is also important to better understand craters as potential habitable environments.