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Dating Titan's surface with impact crater count from the Cassini Radar swaths

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Introduction

The Cassini Radar instrument in SAR (Synthetic Aperture Radar) mode benefits from a good spatial resolution (down to 300m/pixel) and allows an accurate imaging of the surface of Titan. The first Cassini Radar data revealed impact craters at the surface of Titan [1,2]. At the end of the nominal mission, the Radar SAR coverage reaches 33% of the surface. With a third of the satellite covered, it is possible to create a catalogue of impact craters. We have mapped all the potential craters seen on the SAR swaths integrated in a Geographic Information System (GIS) of Titan. Then, we compared the crater size distribution to age models deduced from numerical simulation of Titan impact cratering. Our results allow us to discuss what model is the most relevant for the crater distribution of Titan, and what the estimation of the age of the surface is.

Dataset

The Radar instrument can observe through the thick hazy atmosphere of Titan. We used the Radar data in SAR mode, mainly sensitive to roughness, surface topography and dielectric constant variations of the surface. We retrieved the swaths from Ta to T44 (May 28th 2008) flybys from the PDS (Planetary Data System) website and reprojected the data using the ISIS2 (Integrated Software for Imagers and Spectrometers). The SAR swaths have a spatial resolution from 300m/pixel to 1.5 km/pixel [1].

Mapping craters

The swaths are then gathered in a Geographic Information System (GIS) to allow the mapping. We mapped 129 impact craters. We took into account in our study both confirmed and unconfirmed craters (Fig. 1). The morphology of the largest impact craters has been previously described by several authors [1, 2, 3, 4]. Some of them are fresh craters, some others have very eroded rims, and others are completely covered up by dunes or by a featureless dark unit (with a distinguishable circular form but without real rims). We considered all circular forms (complete and slightly incomplete) that could be identified. We have ruled out circular shapes related to polar lakes. In the polar regions, there are numerous lakes and channels [5] that might have erased the craters. The poles might be the younger regions found on Titan [6]. We observed numerous craters in the dune fields that are entirely or partially filled with dunes material and/or sand sheets at the center. The bright rims seen in younger impacts have been eroded. In few cases, the ejecta can be recognized, appearing bright in the radar data [6].

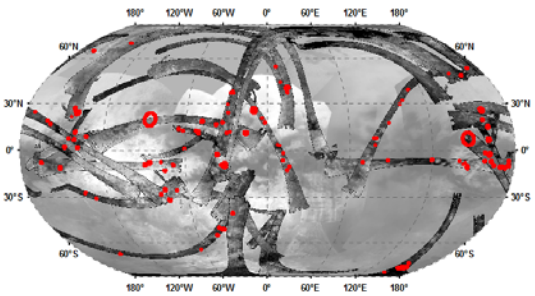

Fig.1: Global distribution map of craters (in red) in Robinson projection centred at 0 longitude. Radar swaths and ISS maps are used as background.

Our dataset of 129 impact craters has a good coherence with others crater count [7] for diameter greater than 30 km. We observed that there is a lack of big impact structures in the crater size distribution (Fig. 2). Indeed, very few craters are well preserved (Sinlap [1, 2, 4, 8], Menvra [1, 2, 8], Ksa [6, 8], and Selk [6]). Numerous craters less than 10 km were found, but we are approaching the limit of spatial resolution of the instrument for this diameter range.

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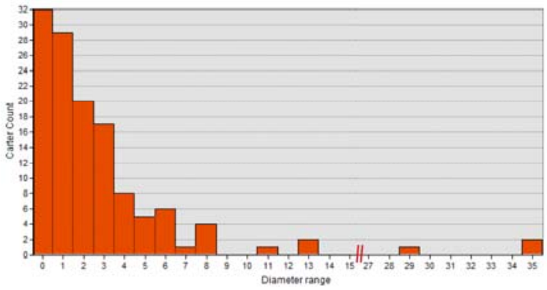

Fig.2: Histogram of the distribution of the diameter of craters (on the x axis, from 0 to 366 km, with each unit corresponding to 10 km range).

Comparison to Titan's impact cratering models

We reported the crater size distribution of the 129 mapped impact craters in Hartmann's incremental diagram [9]. We plotted the 4.5 Gy isochrone issued from calculations of [10] and 1 Gy isochrone from [11] that correspond to two different hypothesis of cometary impactor populations: the case A refers to an impactor population similar to the crater distribution observed on Galilean satellites; the case B matches Triton's crater distribution (see Fig.3).

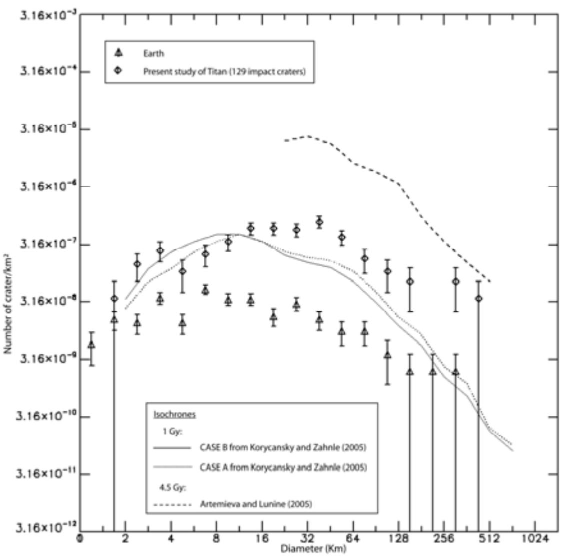

Fig.3: Graphic representing isochrones of 2 models [10, 11] along with Titan's crater density curve (Diams: 129 impacts craters for Titan, triangles: Earth's crater distribution). The error bars are plotted on the assumption of [√(N)/surface] possible variations.

Discussion

The distribution is flat for impacts larger than 128km. That expresses large scale and early resurfaçing processes. Between 32 and 128 km crater diameters, Titan's impact crater distribution curve fits quite well the slope of the isochrones (Fig.3). This part of the curve may express the average age the Titan's surface. Extrapolating the model of [10] under the hypothesis of a decreasing as 1/t of the impact flux, the distribution would fit the 200 My age. On the other hand, the extrapolation of model of [11] using a constant impact flux over the last 3 Gy, would give an age between 2 and 3 Gy. Both models [10, 11] used for the calculation of the isochrones take into account an atmospheric cut off on the crater distribution. [10] assume that the positive slope associated with the atmospheric cut off is about a crater diameter of 30km, whereas [11] estimates it about 10km. The roll over due to atmospheric effects in our data seems to be readily visible near the 30km-crater region of the curve. Our dataset appears to be rather consistent with the model of [10]. However the minimum diameter of crater observed (slightly less than 2 km) can match the model from [11]. Where there is no apparent physical process to account for the roll over, it might be due to a spatial resolution effect (below 10 km) that causes a lack in the crater count. In term of global shape of the crater size distribution, our study highlights that the Titan distribution resembles to Earth's crater distribution as it was previously observed by [7] and [8]. This can be correlated to the intense resurfacing processes that operate on both planetary bodies.

Perspectives

We will attempt to draw the outlines of Titan's geological history by relatively dating the different spectral units seen by the Cassini/VIMS (Visual and Infrared Mapping Spectrometer) which has a near global coverage of the surface.

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