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Geology and Stratigraphy of Saturn's moon Tethys

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1. Introduction

Tethys is 1066 km in diameter and one of Saturn's six mid-sized icy satellites, orbiting Saturn between the volcanically active moon Enceladus und Dione. The satellite was imaged for the first time by the cameras aboard Voyager 1 & 2. These images showed two major landforms: (a) the 445-km large impact basin *Odysseus*, and (b) the graben system *Ithaca Chasma* [1][2]. The Cassini spacecraft, in orbit about Saturn since July 1, 2004, has made several close passes at Tethys, providing an almost complete image coverage at 200 – 500 m/pxl resolutions.

2. Procedure

In this work, we present an updated global map of Tethys' geology. We mapped geologic units, based primarily on albedo and morphology, in an ISS basemap put together with images from several orbits [3]. We used a (reduced) resolution of 1 km/pxl for comparison with spectral maps obtained with Cassini VIMS data [4]. Varying viewing geometries between images taken during different orbits are problematic for mapping geologic units in the global mosaic. For an exact location of geologic boundaries, we used the original higher-resolution image data as a reference. In a second step, we performed crater counts in mapped units to confirm stratigraphic relationships, using crater frequencies as a tool for relative age dating. Both geologic mapping and crater counts were carried out with the ArcGIS mapping software.

3. Geologic units and stratigraphy

In this work, Tethys' geologic units were subdivided into three groups: (1) cratered plains with a variety of morphologies, (2) large impact basins, and (3) impact craters.

3.1 Cratered plains units

Hilly, rugged, undulating densely cratered plains (**cpd**) were previously identified in Voyager images [5]. Fine-scale tectonic features such as narrow, linear to slightly arcuate fractures, are abundant in some localities of this unit. A smooth cratered plains unit (**cps**) occurs near the impact basin *Penelope*. This unit was detected in Voyager images [5], but its boundaries can now be located more precisely in ISS data. To the south of impact basin *Odysseus*, the Cassini ISS data revealed a previously unknown hilly cratered plains unit (**cpsc**) which has a lower superimposed crater density than, e.g., units **cpd** or **cps**, locally a sharp linear contact with unit **cpd**, and shows subdued older larger craters suggesting resurfacing. The prominent tectonic graben system of *Ithaca Chasma* was mapped in two facies, fractured cratered plains 1 & 2 (**cpf1** & **cpf2**). Along most of its expanse, tectonic features are well discernable (facies **cpf1**), while in its northern part to the east of crater *Telemachus* they appear subdued (facies **cpf2**). The superimposed crater density is lower than that for densely cratered plains (**cpd**) but is still high, suggesting an old age of the tectonic features (*Fig. 1*).

3.2 Impact basin materials

Tethys shows a comparably large number of impact basins. We refer to impact craters larger than 100 km as basins. We identified and mapped three erosional classes: (1) heavily degraded old basins (unit **bi1**), (2) partly degraded basins (**bi2**), and the large relatively young basin *Odysseus*. The basins of unit **bi1** are more or less basin ruins showing a high superimposed crater frequency like the densely cratered plains (**cpd**) and highly degraded rims. This unit is represented by, e.g., *Dolius* or *Telemus*. Basins of unit **bi2** are better preserved and feature more pristine rims but still have a high superimposed crater frequency. Type locality is *Penelope* which shows an interior ring in stereo data. *Odysseus* represents the youngest basin on Tethys and was subdivided into several units: (a) rim and continuous ejecta (unit **boc**), (b) terrace materials (**bot**), (c) a horse-shoe shaped central peak complex (*Scheria Montes*, unit **bocp**), (d), radial, linear clusters of secondary craters (**bocs**), and smooth deposits (**bos**), possibly representing impact melt. Crater counts in *Odysseus* confirm earlier measurements [6] and infer that the basin appears to be younger than *Ithaca Chasma* (*Figure 1*).

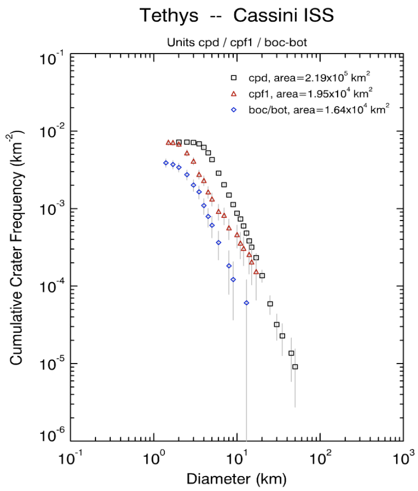

Figure 1: Crater distributions of geologic units on Tethys, showing relative ages. Heavily cratered plains (unit **cpd**, black quadrangles) are oldest, youngest unit shown is the large impact basin *Odysseus* (units **boc/bot**, diamonds, blue; new counts in data from orbit 168). Fractured cratered plains of *Ithaca Chasma* (unit **cpf1**, triangles, red) are older than *Odysseus*.

3.3 Crater materials

Like impact basins, impact craters (< 100 km in diameter) were subdivided into three erosional classes. Oldest unit are heavily degraded craters (unit **c1**), which in many cases represent crater ruins. Partly degraded crater materials (unit **c2**) are the most abundant crater form. Craters of class **c3** are fresh, have sharp crater rims, well-preserved continuous ejecta, and a relatively low superimposed crater density. *Telemachus* (92 km in diameter) is the type example of this class.

4. Summary

The impact basin and crater units represent an age sequence, inferred from their state of degradation. Young fresh craters such as *Telemachus* show strong water ice absorptions compared to other impact features. Other than on the moons Dione or Rhea, however, tectonic features in *Ithaca Chasma* are not characterized by strong water ice absorptions [4]. *Odysseus* has a significantly lower superimposed crater frequency than *Ithaca Chasma*. New crater counts carried out in more recent ISS data (e.g., from Cassini orbit 168) confirmed our earlier results [6] (*Fig. 1*). Our results do not verify that the huge impact that formed *Odysseus* was the source of the stress that created *Ithaca Chasma*, as suggested by [5]. In unit **cpsc**, the older large craters were resurfaced. Since no *Odysseus* secondaries are found superimposed on unit **cpsc**, and because of the remarkable drop in crater frequency along the linear boundary between units **cpd** and **cpsc**, the resurfacing took place after *Odysseus* was formed. The stratigraphic results presented in this work will be further refined by detailed mapping at higher resolution, and crater size-frequency measurements, in comparison with previous work (e.g., [6][7]).

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