OBSERVATION OF CYCLOIDAL FEATURES ON ENCELADUS.

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Abstract: We observe geologically young cycloidal segments in different places on the surface of Saturn's moon Enceladus. These features likely have formed as tension cracks with their form being controlled by diurnal variation of tides, as suggested for Europa [1]. For this model to work the ice must be weak and, to allow for sufficient tidal amplitude, there must be a fluid layer below the icy surface. Thus, rather than being confined to just southern latitudes [2, 3], our observations hint at the presence of fluid layers in also other areas on Enceladus, potentially at a global sub-suface ocean in recent times.

Introduction: Cycloidal patterns are widely distributed on the surface of Jupiter's moon Europa. They consist of several arcuate segments, each ~ 100 km in length. Diurnal tidal stresses were found to provide a plausible explanation for their formation but require a global ocean to generate substantial tidal stress over a diurnal cycle and, even so, a weak ice shell [1].

Cycloidal segments have also been identified in one place on Saturn's moon Enceladus (Fig. 1). Moreover, it was shown [4] that a formational model based on diurnal variations of tidal stress can explain the observed pattern, which favors this model. Here, we report on new observations of cycloidal segments elsewhere on Enceladus.

Observations: Our observations are compiled into 4 Figures (Figs. 1-4). They show arcuate segments and cuspate features at southern (Fig. 1), northern (Fig. 2), and equatorial (Fig. 3, 4) latitudes. Segment lengths are 25-30 km, and we observe different trends (NE-SW, NNE-SSW, WNW-ESE). Besides Fig. 1, Fig. 2, and Fig. 3 show pronounced examples where the segments have formed in weak ice. The region depicted in Fig. 3 has a smooth appearance likely related to high heat flows in this area which implies a thin lithosphere there. All features shown formed in un- or less cratered terrain and thus are young.

Conclusions: The cycloidal features observed on Enceladus are indicative of a formation by diurnal tidal stresses. This view is also supported by the modelings [4], and is consistent with their formation in weak ice areas where the required stresses for crack initiation and propagation are low (note that tidal stresses are just a few 100 kPa). As a consequence, there must have been a liquid decoupling layer below the surface to allow for sufficient tidal amplitude. Potentially, a global sub-surface ocean existed at the time of formation which would be consistent with the global distribution of the observed features, and which would also allow for non-synchronous rotation as suggested in [4]. However, hints at a sub-surface liquid layer exist only for the SPT yet [2, 3, 5].

After Europa, Enceladus now is the second icy moon exhibiting cycloidal features.

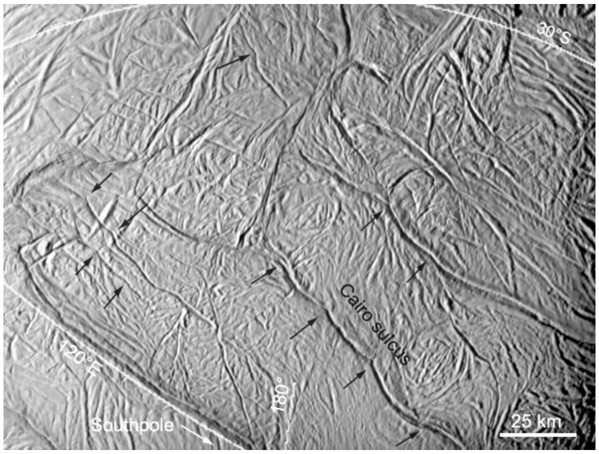

Fig. 1: Cycloidal segments with cuspate features in Enceladus' South Polar Terrains (SPT). The cycloidal trend on Cairo Sulcus was first noted in [4], but there are more candidate features in this area (see arrows).

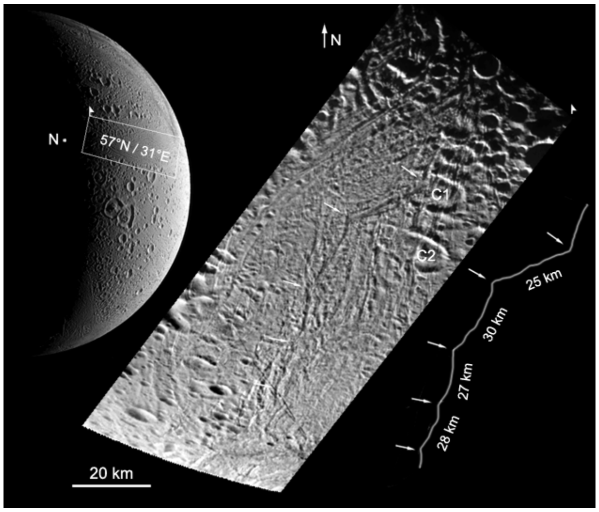

Fig. 2: NE-SW trending arcuate segments and cuspate features (arrows) located at northern latitudes. Note that these segments formed in a weak icy lithosphere which is suggested by two highly-strained craters (c1, c2) in this area.

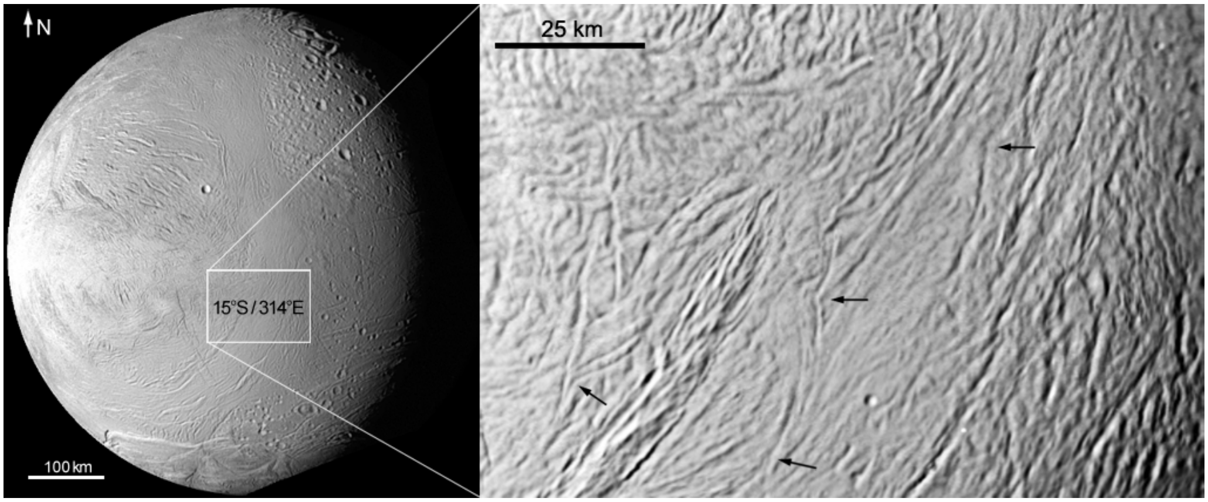

Fig. 3: NNE-SSW trending arcuate segments and cuspate features (arrows) located in resurfaced band-shaped terrain near the equator between the leading- and Saturn facing side of Enceladus.

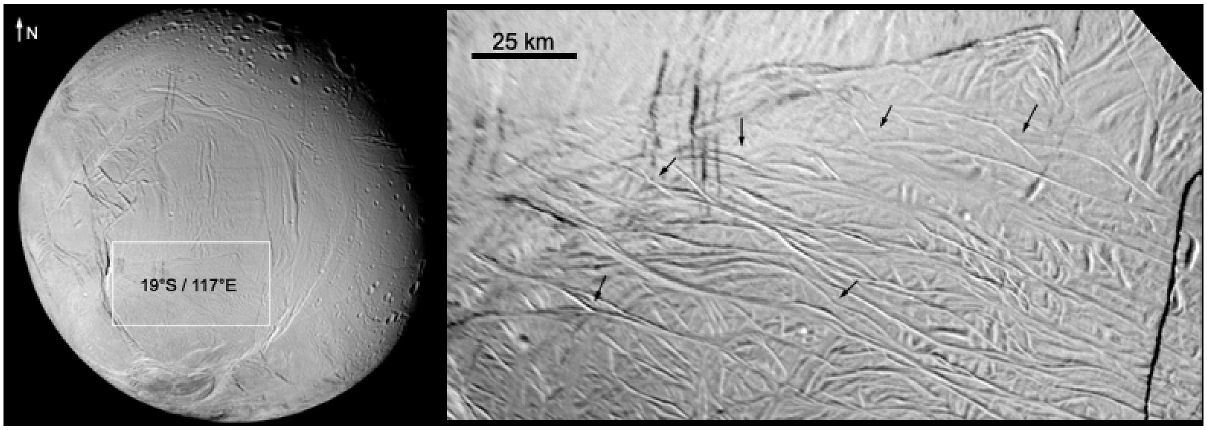

Fig. 4: WNW-ESE trending arcuate segments and cuspate features (arrows) located in resurfaced terrain near the equator at the trailing side of Enceladus.

References:

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