GEOLOGIC EVIDENCE FOR THE LONG-TERM POTENTIAL OF ENCELADUS'S SUBSURFACE LIQUID LAYER. D. A Patthoff[1], R. T. Pappalardo[1], E. S. Martin[2], T. R. Watters[2], H. T. Chilton[1,3], P. T. Thomas[4], P. Schenk[5], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA (Patthoff@jpl.nasa.gov), [2]Center for Earth and Planetary Studies, National Air & Space Museum, Smithsonian Institution, Washington, DC, [3]Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, [4]Center for Radiophysics and Space Research, Cornell University, Ithaca, NY, [5]Lunar & Planetary Institute, Houston, TX.

Introduction: Time, along with the proper chemistry and enough energy, are all likely to be necessary for life to develop. Jets of water erupting from Enceladus's south polar terrain (SPT) [1,2] have provided evidence that the interior contains organics [3]. Salts found within the plume suggest the jets are likely sourced from a body of liquid water [3]. However, the extent of the hypothesized ocean is uncertain with estimates ranging from a global ocean [4] to a localized sea [5]. Measurements from the Cassini spacecraft have shown the energy produced within Enceladus is much higher than expected [2,6], as generated from the tidal forces induced by Enceladus's elliptical orbit around Saturn [2].

The persistence of Enceladus's subsurface liquid layer is unknown. One hypothesis suggests the moon experiences episodic overturn on a ~1 Gyr year time scale [7]. The periodicity of activity could be induced by a change in the orbital eccentricity where a larger eccentricity results in greater tidal heating, a thinner ice shell, and a larger body of subsurface water [2]. A thin ice shell (<40 km) would induce greater tidal stresses [8] which can create more pronounced tectonic structures on the surface. Here we focus on the long-term geologic history of Enceladus as preserved in its ridges, troughs, and fractures visible on the surface to demonstrate its long-term potential for subsurface liquid water and habitability.

Geologic Structures: Enceladus's oldest structures are observed in the cratered Saturnian and anti-Saturnian hemispheres (1-4 Gyr) [9]. The region contains small ridges 10s m high and 1-15 km long (Fig. 1). The dearth of craters on the SPT, leading and trailing hemisphere terrains (LHT and THT) suggest the features observed in these regions are recent phenomena [9]. However, each of these three terrains contains distinctly unique ridges. The THT contains two main sets: a smaller set of ridges (~50 m high), and the larger dorsa (~50 km long, ~800 m high) (Fig 2A). Two different ridge types dominate the LHT: a smaller set (1-20 km long, 10s m high), and a larger but less numerous set (15-35 km long, >600 m high) (Fig. 2B). The SPT also shows two ridge types, a smaller scale (~50 m amplitude) ropey terrain ridge set (similar to the smaller scale ridges of the THT), and the larger tiger stripes (~130 km long, <200 m high) (Fig. 3).

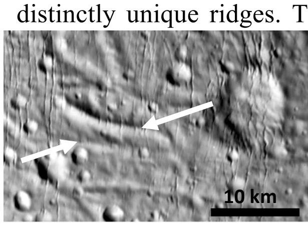

Fig 1. Ancient ridges. White arrows point to two ridges located in the trailing hemisphere cratered terrain. Image N1489050409.

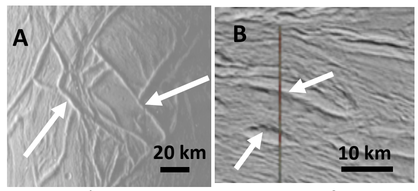

Fig 2. A) Saturn shine image of dorsa. Image N1675146616. B) Leading hemisphere ridge terrain. Vertical line shows the location of a limb profile. Image N160436392. White arrows show locations of ridges and dorsa. Both images in cylindrical projection.

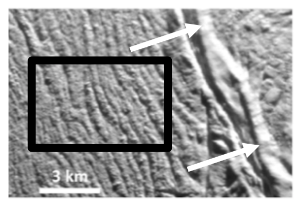

Fig 3. Ropey terrain and tiger stripes. Black box shows the location of some of the ropey terrain ridge-troughs. White arrows mark the location of a portion of the tiger stripe Damascus. Image is a south polar projection of a portion of image N1604167575.

Discussion: We suggest the ridges observed in the Saturnian and anti-Saturnian hemispheres preserve an ancient period of deformation when Enceladus's ice shell was thin enough for tidal stresses to deform the surface. That was followed by later stage of activity in the LHT, THT, and SPT. Differences in the thickness of the ice shell can help explain why the SPT (thick ocean; thin ice shell) is currently active but the regions further north (thin ocean; thicker ice shell) are not. We suggest the ice shell is currently thickening from north to south. This causes the tidal stresses to reduce in magnitude [8,10] limiting the possible tectonic deformation and activity. If the ocean were to survive between the time of the ancient terrains and today, it would point to a long history (>1 Gyr) of subsurface liquid water on Enceladus.

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