WHAT HAPPENED ON ENCELADUS BETWEEN VOYAGER AND CASSINI? D. A. Patthoff[1], C. B. Phillips[2], M. T. Bland[3], G. V. Hoppa[4] [1]Planetary Science Institute (apatthoff@psi.edu), [2]Jet Propulsion Laboratory, California Institute of Technology, [3]U.S. Geological Survey, Astrogeology Science Center, [4]Raytheon.

Introduction: Saturn's small (diameter ~500 km) icy moon, Enceladus (Fig. 1), is one of the most dynamic bodies in the solar system. Near the satellite's south pole are large fissures which serve as the source for an active plume of water emanating into space [1]. Beyond the south polar region, the geology is much more complex and far younger than is expected for such a small world. Numerous ridges and fractures dominate some terrains while other areas contain extremely relaxed craters (e.g. [2]). Large swaths of terrain contain no craters larger than 1 km diameter (Fig. 1). This suggests that much of Enceladus's surface is extraordinarily geologically young. However, the reason for the young surface remains unknown. Part of the mystery lies in the uncertainty in the rate of geological activity, cratering rates, and orbit-rotational dynamics, namely nonsynchronous rotation (NSR) and true polar wander (TPW).

Missions to Enceladus Separated by Time: Enceladus was first viewed by Voyagers 1 and 2 in 1980 and 1981, respectively. Roughly a quarter century later, Cassini began imaging the icy world at a higher resolution, and with greater coverage, than Voyager. One benefit of this ~25-year gap is that we can take advantage of the long time interval to constrain geological resurfacing rates, cratering rates, and possible rates of motion for the ice shell, either through NSR or TPW.

Voyager 1 obtained images that were at best about 25 km/pixel. Voyager 2 was able to get images at up to 1 km/pixel. Voyager 1 did not provide images of high enough resolution for geological comparisons; however, the full disk images can be used to look for potential brightness changes (See future work section). Voyager 2 was able to image Enceladus's trailing and more northern hemispheres (Fig. 1) at sufficient resolution for geological analysis.

When Cassini arrived to orbit Saturn, the portions of Enceladus that were previously imaged by Voyager were mostly in the dark. However, as the mission continued and the seasons changed, the northern regions came into the light and were reimaged by Cassini. As Cassini continued to orbit Saturn for ~13 years, it was able to image new terrains and reimage many portions of Enceladus viewed by Voyager and Cassini earlier in the mission. Many places were imaged multiple times with years between each image. A large portion of Cassini's imaging campaign focused on the region near the south pole, where the most activity is located. However, all of Enceladus was eventually imaged by Cassini [3]. Our work focuses on comparing images of Enceladus taken by Voyager to those taken by Cassini to look for any changes that took place between the missions, as well as look for any changes that took place during Cassini's 13 years in the Saturn system. See the future work section for details about using the full suite of Cassini data.

Geology of Enceladus: Enceladus's surface can be grouped into four main terrains: south polar terrain (SPT), leading hemisphere terrain (LHT), trailing hemisphere terrain (THT), and the cratered terrain [4]. Each of these preserves a unique history of deformation. The south polar terrain, arguably the most recognizable region, contains the four large linear tectonic features nicknamed "tiger stripes" and is the source location of the erupting plume of water vapor and dust (mostly ice).

The leading and trailing hemispheres both contain numerous ridges. However, the terrains look very different from one another. The LHT is dominated by two differing ridge domains. The northern region consists of a small amplitude ridge-trough terrain that is interspersed with larger ridges (nearly 1 km high and 10s of km long) that have broad rounded crests and are lens-shaped in map view. The other area is south of the equator and consists of smaller amplitude ridges with shorter wavelengths (<5 km). The whole region is bound by a fracture network, which indicates recent northward movement of the entire LHT [5].

Located on the opposite side of the moon, the THT possesses another unique set of features, including a series of large (nearly 1 km high and up to approximately 25 km long), linear ridges termed dorsa (Fig. 1). Among the dorsa are a series of smaller amplitude (10s of m high) linear ridges that make up the striated plains. This region also contains numerous fractures that bisect the dorsa and all other structures; however, there are very few craters suggesting the surface has experienced very recent resurfacing. It is this region that was best imaged by Voyager 2 and is a focus of this abstract.

The final unit, the cratered terrain, lies between the leading and trailing hemispheres and forms a narrow band that stretches from the SPT, up the Saturn-facing hemisphere, over the north pole, and down the anti-Saturn-facing hemisphere. This unit is a bit of a puzzle. It appears to be the oldest terrain, as determined by the relatively large number of craters; however, the region also contains very young fractures that cut through all other structures [6] (Fig. 1) and could be among the youngest features on Enceladus [7]. The amount of deformation observed throughout Enceladus's surface suggest the tiny moon has recently experienced, or possibly still is experiencing, large-scale tectonism.

Parts of this cratered terrain were also imaged by Voyager 2 and are examined for changes in this work.

Each of the geologic terrains have been examined to characterize the visible geologic features. Some terrains (e.g., the south polar region) have received more attention than other regions (e.g., cratered terrains). However, none of these areas have had a dedicated comparison among images, both Cassini and Voyager, to look for changes in the morphology of the numerous geological structures.

The Changes We Are Looking For: In the preliminary work presented here, we are focusing our efforts on geological changes that occurred between Voyager 2 and Cassini, specifically any new craters, or new fractures or lengthening of existing fractures in the trailing hemisphere and the cratered terrains. As of this writing, no additional craters or fractures have been recognized but the analysis is ongoing. One of the biggest obstacles is the, at-best, 1- km resolution Voyager 2 images. The largest craters we are able to reliably identify are about 4–5 km across. However, following [8], we would only expect an impactor of that size approximately every 1–100 Myr. For the fractures, we have also yet to detect any new or modifications. However, again the image resolutions are quite limiting. It is difficult to determine if a narrow fracture is new or just unresolvable on the older Voyager images.

Future Work: At the time of this writing no definitive geologic changes have been observed between the Voyager and Cassini datasets; however, our next step is to examine the higher resolution Cassini images for any changes. The higher resolution images will allow for smaller features to be identified and thus, finer changes to be detected. We will also search for brightness changes on the surface to constrain any possible plume changes or fallout pattern differences. Lastly, we will examine the locations of features relative to the inertial reference frame to determine if there has been any ice shell movement due to NSR or TPW. Even if no changes or evidence for motion are found, we will still be able to set limits on the rates of geological deformation and rates of motion due to NSR or TPW.

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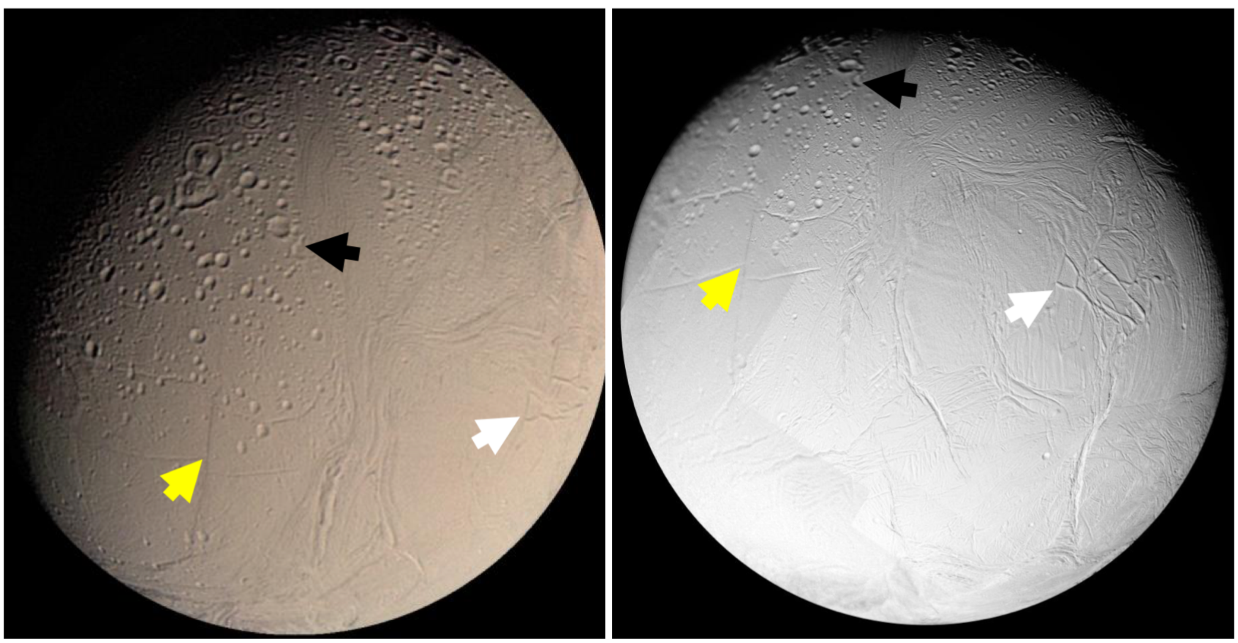

Fig. 1: Voyager 2 disk image (left) and Cassini mosaic of Enceladus (right). These images are of similar viewing geometries of the trailing and anti-Saturnian hemispheres. White arrows point the same dorsa locations, black arrows point to the same sheared crater, and yellow arrows point to the same intersection of fractures. Left image is PIA00347. Right image is PIA08353.