IMPACT CRATER MORPHOLOGY VARIATIONS ON ENCELADUS. V. J. Bray[1], D. E. Smith[2], E. P. Turtle[3], J. E. Perry[2], J. A. Rathbun[4], A. N. Barnash[4], P. Helfenstein[5] and C. C. Porco[6]. [1]Imperial College London, Exhibition Road, London, SW7 2AZ, United Kingdom, [2] Lunar and Planetary Lab., University of Arizona, Tucson, AZ 85721, United States [3]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723- 6099, United States, [4]University of Redlands, [5]Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853-6801, United States, [6] CICLOPS, Space Science Institute 4750 Walnut Street Suite 205, Boulder, CO 80301, United States; veronica.bray@imperial.ac.uk.

Introduction: The varied geological terrains of Saturn's moon Enceladus suggest a complex thermal history and internal structure. The heavily cratered plains of the northern hemisphere are in stark contrast to the younger, tectonically dominated regions to the south. This dichotomy in apparent surface age is attributed in part to intense geological activity now centered at the South Pole [1]. The current South Pole plume activity is hypothesized to be produced as the result of a diapir that has moved relative to the spin axis of Enceladus and possibly its upper crustal layers [2]. The presence of relict south polar terrains acts as evidence for this movement [3]. Further understanding of Enceladus' crustal structure will provide clues to the thermal evolution of the body and perhaps provide evidence for, or against, plume migration.

A powerful tool for investigating the upper crustal structure of remote bodies is the study of impact craters. Craters offer direct probes of a body's subsurface and allow crustal structure to be inferred on the basis of their morphology. We are conducting mapping and measurement of craters on Enceladus, detailing their locations, diameters and morphological characteristics, so that crater morphology variations in the different geological units can be assessed.

Method: The geographic coordinates of ~460 craters were recorded from global mosaics of *Cassini* images. To prevent inaccurate measurements due to distortion at the image edges, each crater diameter was measured from an image that had been reprojected around the crater's approximate central coordinates. These individual images were orthographically projected with a 200 m/pixel resolution, so that trends could be compared equally across areas covered by different resolution images. To reduce errors at this resolution, only craters above 4 km in diameter have been recorded at this stage. The morphological type, relaxation state, local terrain type and extent of fracturing were documented while viewing these images.

We classified most craters as simple, central peak, domed or undetermined. The relaxation state of each crater was recorded simply as 'unrelaxed', 'uncertain/shallowed due to minor relaxation or infill' or 'relaxed', similar to previous work [4]. In collaboration with research into other aspects of the craters [5], the presence of fracturing and the type of crater-fracture interaction were also noted. Crater diameters were measured using a program which fits an average circle about selected points on the crater rim [4]. As a consequence of this method, a small number of severely degraded crater forms with no obvious crater-terrain boundary were omitted from the database.

Results and Discussion: *Morphology and Distribution*: The majority of craters above 15 km in diameter are north of 30° N, as expected with a general progression to younger terrain towards the South Pole. When considering only the older, cratered terrains, the density of craters below 15 km in diameter shows no variation with latitude on the anti-Saturnian hemisphere.

Central peak craters with diameters as small as 2.8

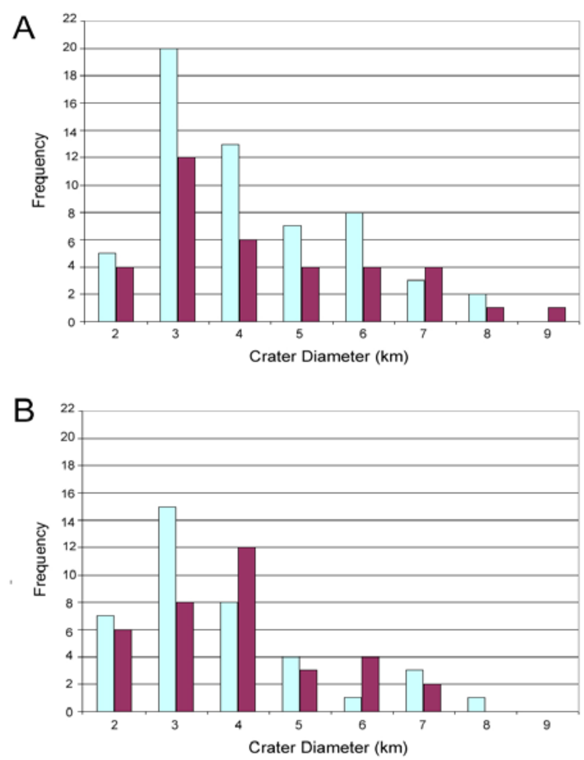

Figure 1: Numbers of simple (light columns) and central peak (dark columns) craters on the northern (A) and southern (B) sections of cratered terrain.

± 0.2 km have been recorded in both southern and northern sections of the cratered terrain. Such craters were noted to be more common at southern latitudes and in the newer, tectonized regions (figure 1). There is a wide range of crater diameters over which central peaks and simple craters both occur (~3 -12 km in the old cratered terrain) making it difficult to define the transition diameter between simple and complex morphologies. Inclusion of craters with smaller diameter in the database will help constrain this value.

Relaxed or infilled craters are seen over much of the investigated area, amounting for nearly 40% of the craters in the database. The small number of craters on the ridged terrain of Diyar Planitia (~0° N, 240° W) and other young areas are not yet relaxed. There are two regions with predominantly relaxed or infilled craters: The cratered terrain on the north western edge of Diyar Planitia and that around 50° S, 180° W; both are close to areas of noticeable tectonic activity.

Interaction with Fractures: We identified 60 examples of fractures influenced by the presence of craters. These craters are distributed randomly relative to craters that do not affect fractures, and are of a range of diameters with no obvious mode. Craters of similar diameter that are intersected by the same fracture do not necessarily interact the same way and it has been noted in the course of this work that the relaxation state of the crater may be a factor in this matter; perhaps indicating that only craters of a suitable depth, relative to the fracture depth, will deflect the fracture path. Examples of fractures at all scales are observed to be influenced by the presence of a crater; however, not all fracture sets local to any given crater are affected. If this phenomenon were due simply to the relative depths of a crater and a fracture that crosses it, then some relationship between fracture and crater size might be apparent. Such a relationship has not been seen during this work as fractures of all scales show interaction with a range of crater sizes. This shows the relationship to be more complex and other alternatives, such as the evolution of crustal stresses associated with the craters, are still to be investigated.

Terrain Type: Cratered terrain starts to appear more subdued, possibly blanketed, south of 30° N. This effect becomes more pronounced south of 20° S, suggesting that the acting process is latitude dependent. One possible explanation is that particles from the South Polar plumes are covering the surface, filling the craters, and making them appear more subdued at southern latitudes. The change in appearance of the cratered terrain with latitude could also be explained by the thermal activity at the South Pole. A warm diapir concentrated at the South Pole will produce increased temperatures over a wide area, leading to increased relaxation and driving higher levels of tectonic activity at southern latitudes.

Acknowledments: Our thanks to the Cassini Project and to Dr. J. V. Morgan of Imperial College London for funding this work.

References: [1] Porco, C. C. et al. (2006), *Science* 10, Vol. 311. no. 5766, 1393–1401. [2] Nimmo, F. and R.T. Pappalardo (2006),Nature 441 614-616. [3] Helfenstein et al., In Prep. [4] Smith, D. et al. (2006), DPS meeting 38, Abstract #24.07. [5] Barnash, A. et al. (2006), DPS 38, Abstract #24.06. [6] Melosh, H. J. (1989), Impact Cratering: a Geological Process, Oxford Univ. Press.

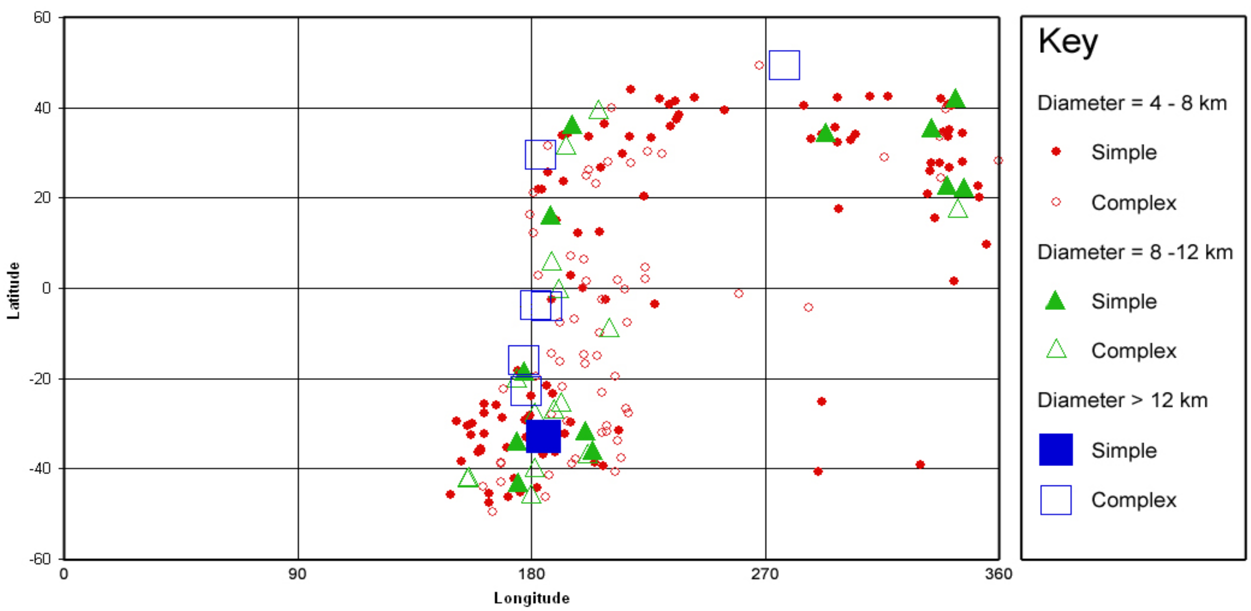

Figure 2: Location of studied craters. Craters are marked to represent their diameter and morphological type as either 'simple' or central peak ('complex'). This plot does not include larger craters with domed morphology or information on relaxation or fracture interaction. 0° to ~140° W is currently imaged at low resolution (~1 km/pixel) and was not included in the survey.