

## HIGH RESOLUTION ENCELADUS ATLAS DERIVED FROM CASSINI-ISS IMAGES

Th. Roatsch<sup>1</sup>, M. Wählisch<sup>1</sup>, B. Giese<sup>1</sup>, A. Hoffmeister<sup>1</sup>, A. Kuhn<sup>1</sup>, F. Scholten<sup>1</sup>, K.- D. Matz<sup>1</sup>, G. Neukum<sup>2</sup>, P. Helfenstein<sup>3</sup>, and C. Porco<sup>4</sup>, <sup>1</sup>Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany; <sup>2</sup>Remote Sensing of the Earth and Planets, Freie Universität Berlin, Germany; <sup>3</sup>Department of Astronomy, Cornell University, Ithaca, NY, <sup>4</sup>CICLOPS/Space Science Institute, Boulder, CO. ([Thomas.Roatsch@dlr.de](mailto:Thomas.Roatsch@dlr.de))

**Introduction:** The Cassini spacecraft began its tour through the Saturnian system in July 2004. The Imaging Science Subsystem onboard the orbiter consists of a high-resolution Narrow Angle Camera (NAC) with a focal length of 2000 mm and a Wide Angle Camera (WAC) with a focal length of 200 mm [1]. One of the main objectives of the Cassini mission is to investigate the icy Saturnian satellites. Enceladus, the second innermost of the medium sized satellites, was imaged by the Cassini spacecraft during three close flybys [2]. The images taken during these flybys together with lower resolution frames allowed us to create a global mosaic of Enceladus with a spatial- resolution of about 110 m/pixel. Unfortunately, the Cassini ISS has not yet imaged the northern high latitude regions ( $> 67^\circ$ ) because they are shrouded in seasonal darkness and will not be illuminated by the Sun until later in the decade when the Cassini extended mission begins. Fortunately, the Voyager camera was able to take images from these regions during its flyby in the early 1980's. We thus used Voyager images to fill the North Polar gaps in the global mosaic.

**Image Processing:** The image data returned from the spacecraft are distributed to the Cassini imaging team in VICAR format [<http://www-mipl.jpl.nasa.gov/external/vicar.html>]. The first step of the image processing is the radiometric calibration of the images using the ISS Team's CISSCAL computer program [1]. Next, the specific subset of images that is used to construct the global mosaic is selected. At the time of this writing, a total of 2353 images of Enceladus are available. This total data set contains images obtained through different ISS color filters and at spatial resolutions ranging from 3 m/pixel up to 14 km/pixel. For our mosaic, we selected only those images taken with the filters CL1, CL2 or GRN, as these images show comparable albedo contrasts among different Enceladus terrains. 50 Cassini NAC images, one Cassini WAC image, and four Voyager images were used to produce a 40 pixel/deg global mosaic. The resolution of the selected Cassini images varies between 0.064 and 8.8 km/pixel. The resolutions of the Voyager images C4398347, C4400044, C4400412, C4400432 are 8.8, 1.85, 1.0 and 1.0 km/pixel, respectively. The next step of the processing chain is to map-project the images to the proper scale and map format – a process that requires detailed information about the global shape of Enceladus. The inner Saturnian satellites are best

described by tri-axial ellipsoids as derived from ISS images [3]. The latest radii for Enceladus are 256.6, 251.4, and 248.3 km. However, to facilitate comparison and interpretation of the maps, ellipsoids were used only for the calculation of the ray intersection points, while the map projection itself was done onto a sphere with the mean radius of 252.1 km [3]. The Cassini orbit and attitude data used for the calculation of the surface intersection points are provided as SPICE kernels [<http://naif.jpl.nasa.gov>] and were improved using a limb-fitting technique [4]. We chose an equidistant map projection. The coordinate system adopted by the Cassini mission for satellite mapping is the IAU "planetographic" system, consisting of planetographic latitude and positive West longitude. The Hapke photometric model [5] was applied to adjust the brightness of each map pixel so that it represents the reflectance that would be observed by nadir- looking at 30-deg phase angle. Imaging data viewed at incidence and emission angles greater than 80-deg were omitted from the map. After photometric correction, mosaicking was the final step of the image processing [4].

**Least-squares adjustment of attitude data:** A 3D control network was set up to correct errors in the nominal camera pointing data, by least-squares adjustment techniques [6]. The image coordinates of 88 control points collected in 11 NAC images were applied as observational data in the adjustment, and the ground coordinates of the control points and the camera pointing angles were treated as unknowns. The spacecraft orbit was fixed during the calculations. As a result, we obtained improved camera pointing angles and a 3D control net with average  $1\sigma$  errors of 736 m, 335 m, 608 m for the x, y, z coordinates, respectively. The resulting altitude data were used to compute a fully controlled basemap. Unfortunately, owing to a lack of stereo data and control points, the basemap is limited in coverage [7]. Nevertheless, the high-resolution mosaic described above was registered to this controlled basemap.

**Enceladus map tiles:** The Enceladus atlas was produced in a scale of 1: 500,000 and consists of 15 map sheets that conform to the quadrangle scheme proposed by Greeley and Batson [8] (Fig. 1). A map scale of 1: 500,000 guarantees a mapping at the highest available Cassini resolution and results in an acceptable printing scale for the hardcopy map of 4.5 pixel/mm. The individual tiles were extracted from the global mosaic and reprojected [7]. The south

polar map is shown in Fig. 2 as an example. The entire Enceladus atlas consisting of 15 map tiles will be made available to the public through the Imaging Team's website [http://ciclops.org/maps].

**References:**

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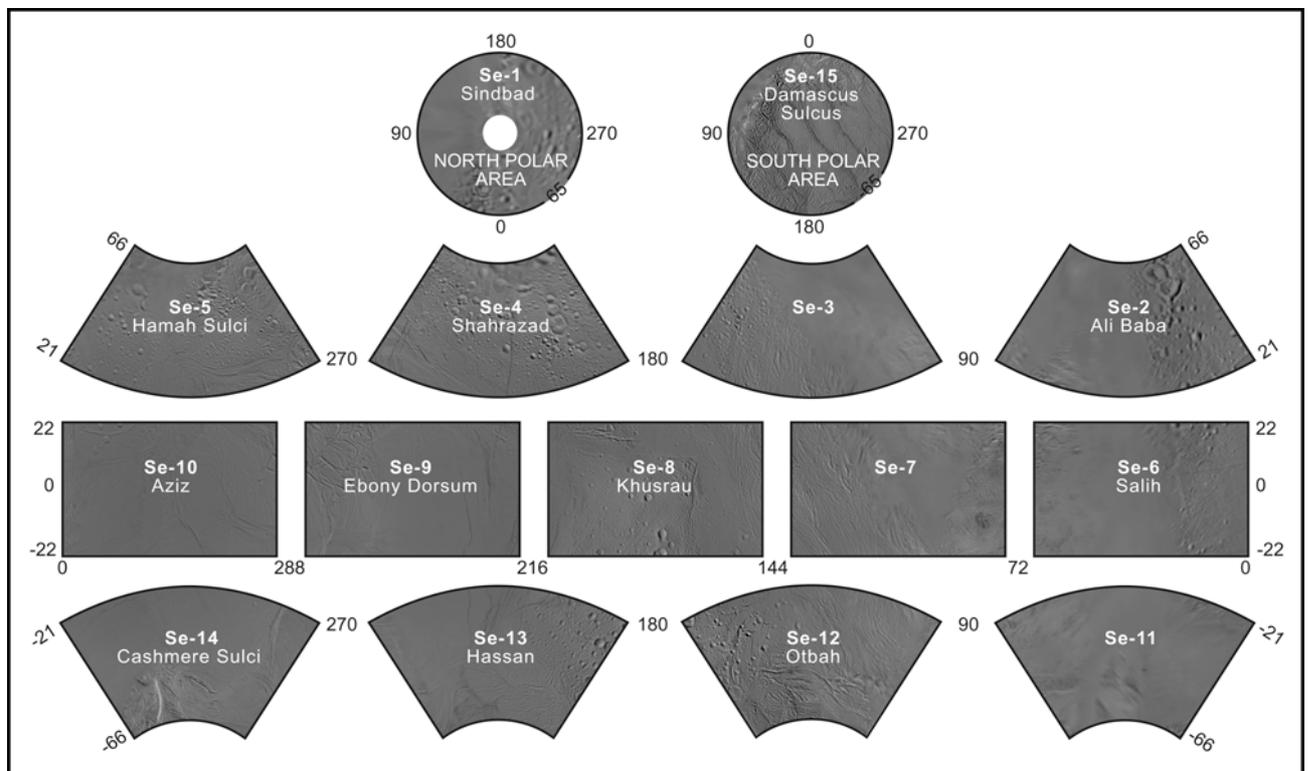
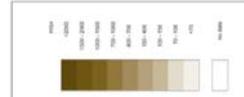
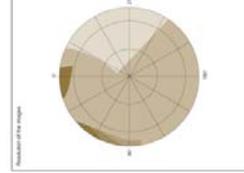
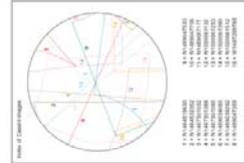
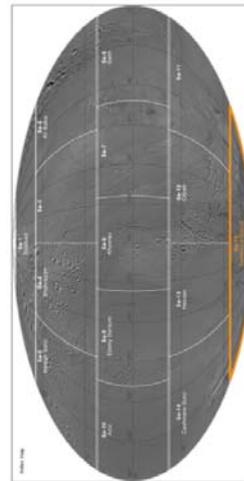
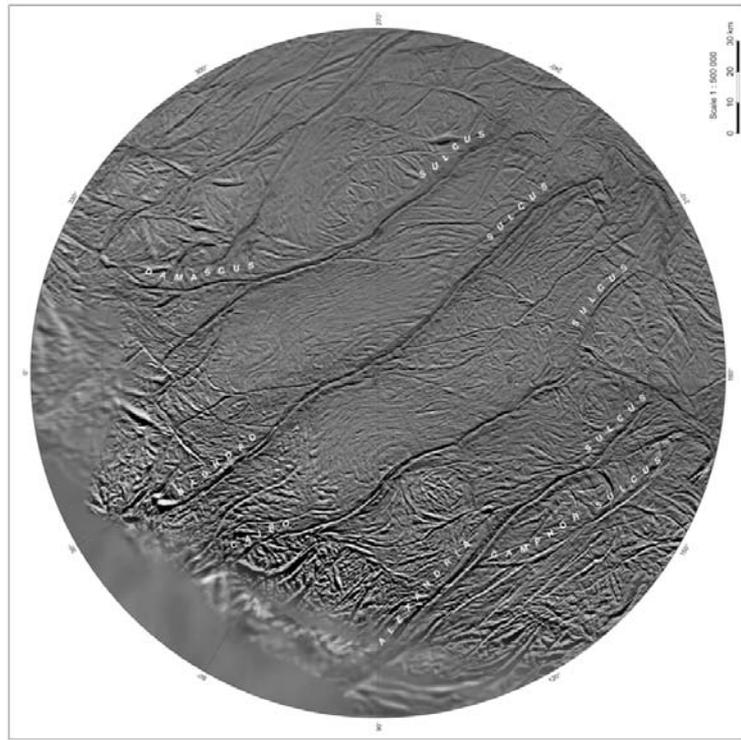


Figure 1: Quadrangle scheme of the Enceladus atlas



GENERAL NOTES

This map is a 1:500,000 scale map of the south pole of Enceladus. The map is based on data from the Cassini spacecraft. The map is a controlled mosaic of the south pole region. The map is a topographic map. The map is a shaded relief map. The map is a circular map. The map is a map of the south pole of Enceladus. The map is a map of the Damascus Sulcus. The map is a map of the south pole of Enceladus. The map is a map of the Damascus Sulcus. The map is a map of the south pole of Enceladus. The map is a map of the Damascus Sulcus.

MAP SHEET DESIGNATION

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IMAGE PROCESSING

Map projection: Mercator  
Map datum: WGS 84  
Map scale: 1:500,000

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MAP PROJECTION

Map projection: Mercator  
Map datum: WGS 84  
Map scale: 1:500,000

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2. ...

EDITOR

Editor: ...

