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High-resolution Atlases of Mimas, Tethys, and Iapetus derived from Cassini-ISS images

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ABSTRACT

The Cassini Imaging Science Subsystem (ISS) acquired 282, 258, and 513 high-resolution images (<800 m/pixel) of Mimas, Tethys, and Iapetus, respectively, during two close flyby of Tethys and Iapetus and eight non-targeted flybys between 2004 and 2007. We combined these images with lower-resolution Cassini images and others taken by Voyager cameras to produce high-resolution semi-controlled mosaics of Mimas, Tethys, and Iapetus. These global mosaics are the baseline for high-resolution Mimas and Iapetus maps and a Tethys atlas. The nomenclature used in these maps was proposed by the Cassini imaging team and was approved by the International Astronomical Union (IAU). The two maps and the atlas are available to the public through the Imaging Team's website [http://ciclops.org/maps] and the Planetary Data System [http://pds.jpl.nasa.gov].

1. Introduction

The Cassini spacecraft started 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 (Porco et al., 2004). One of the main objectives of the Cassini mission is to investigate the icy Saturnian satellites. Mimas, Tethys, and Iapetus were imaged by the Cassini spacecraft during ten flybys, two targeted to Tethys and Iapetus, and eight non-targeted flybys at a distance of 18,000 km and higher (Table 1). The images taken during these flybys allowed us to create global mosaics of Mimas, Tethys, and Iapetus with a spatial resolution of about 430, 290, and 800 m/pixel, respectively. Unfortunately, the Cassini ISS has not yet imaged the northern high latitude regions ($>79^{\circ}$) because they are shrouded in seasonal darkness and will not be illuminated by the Sun until later in the decade during the Cassini Extended mission. Fortunately, the Voyager camera was able to take images from these regions during its flyby in the early 1980s. We thus used Voyager images to fill the North Polar gaps in the global mosaic.

Details of the image processing will be described in Section 2. Section 3 summarizes the high-level cartographic work that produced the high-resolution maps and the atlas. Three examples of these maps are shown. A brief overview of future work is given in Section 4.

2. Data processing

2.1. Image processing

The image processing chain is the same as it was used for the generation of the high-resolution Dione mosaic (Roatsch et al., 2008b). At the time of this writing, a total of 2434, 2131, and 3896 images of Mimas, Tethys, and Iapetus are available. This total data set contains images obtained through a variety of different ISS color filters and at spatial resolutions ranging from 15 m/pixel up to 160 km/pixel. For our mosaics, we selected only those images taken with the filters CL1, CL2 or GRN, as these images show comparable albedo contrasts among different terrains. Figs. 1–3 show the location of the individual Cassini images. The resolution of the selected Cassini images is given in Tables 2–4.

The Cassini orbit and attitude data used for the calculation of the surface intersection points are provided as SPICE kernels [http://naïf.jpl.nasa.gov] and were improved using a limb-fitting technique (Roatsch et al., 2006). It was not possible to improve the attitude data using a least-squares adjustment as it was possible

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for the Enceladus mosaic (Roatsch et al., 2008a) due to insufficient stereo data.

As the medium-sized Saturnian satellites are best described by tri-axial ellipsoids as derived from ISS images by Thomas et al. (2007), ellipsoids were used for the calculation of the ray intersection points during the map projection process. However, to facilitate comparison and interpretation of the maps, the projection itself was done onto a sphere with a mean radius. The radii used for the calculation of the mosaics are summarized in Table 5.

2.2. Coordinate system

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 ephemeris position of the prime meridians as defined by Davies and Katayama (1983a, b, 1984) and adopted by the IAU cartography working group as standard (Seidelmann et al., 2007) is defined by a crater Palomides, Arete, and Almeric, for Mimas, Tethys, and Iapetus, respectively. Our mosaics which were calculated using the limb-fitted attitude data has a slight offset to this definition. Therefore we decided to shift the whole mosaics to be consistent with the IAU longitude definition (Table 6). This may lead to an update of a rotational parameter, the so called W_0, which is used for the calculation of the prime meridian location (Seidelmann et al., 2007).

3. Cartographic maps

Three different quadrangle schemes were used for the generation of the maps and the atlas (Figs. 4, 6 and 8):

- A synoptic map for making planet-wide maps on a single sheet was used for Mimas. The same format has already been used for the Phoebe map (Roatsch et al., 2006).
- A quadrangle scheme with 15 tiles for Mercury-sized bodies and high-resolution imaging was used for Tethys. The same schema has already been used for Enceladus (Roatsch et al., 2008a) and Dione (Roatsch et al., 2008b).

Table 1
Cassini flybys at Mimas, Tethys, and Iapetus during the Nominal Mission (2004–2008), in which (t) means targeted flyby and (nt) means non-targeted flyby.

Target	Flyby date	Flyby distance (km)
Iapetus (nt)	31 December 2004	123,402
Tethys (nt)	9 March 2005	82,868
Mimas (nt)	15 April 2005	82,489
Tethys (nt)	2 May 2005	51,858
Mimas (nt)	2 August 2005	61,149
Mimas (nt)	23 September 2005	70,012
Tethys (t)	24 September 2005	1,498
Tethys (nt)	27 June 2007	18,420
Iapetus (t)	10 September 2007	1,645
Mimas (nt)	3 December 2007	84,165

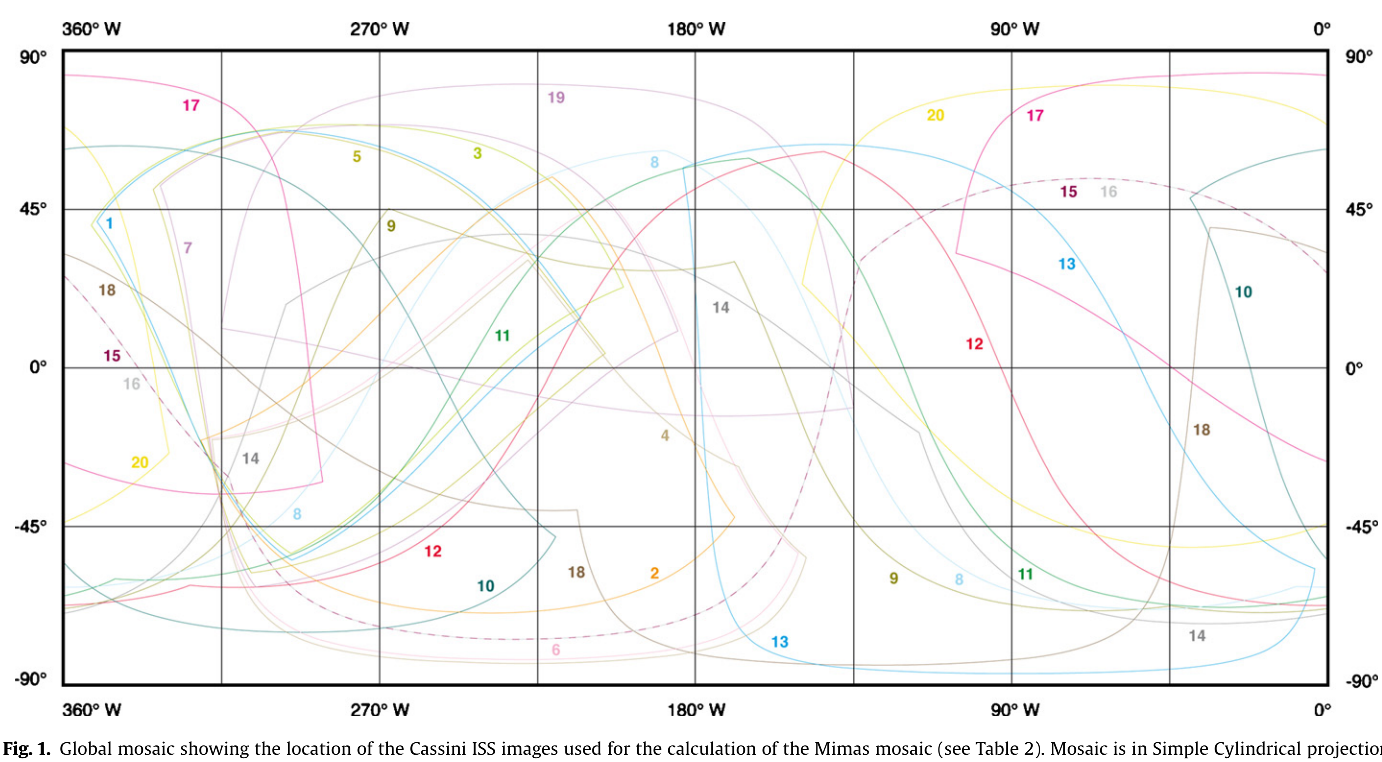

Fig. 1. Global mosaic showing the location of the Cassini ISS images used for the calculation of the Mimas mosaic (see Table 2). Mosaic is in Simple Cylindrical projection with latitude = 0°, longitude = 180°W at the center.