# MAPPING OF THE ICY SATURNIAN SATELLITES

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**Commission IV, WG IV/7**

**KEY WORDS:** Cassini, Icy satellites, planetary mapping

**ABSTRACT:**

The Cassini spacecraft was launched in October 1997 from Cape Canaveral, Florida and arrived seven years later at Saturn. The Saturnian system contains 56 satellites, from km-sized bodies to Titan, which has a diameter of 5150 km. This paper deals with the mapping of the so-called medium-sized icy satellites Mimas, Enceladus, Tethys, Dione, Rhea, Iapetus, and Phoebe. Imaging of the medium-sized icy satellites by the Cassini cameras started with Phoebe in 2004 and will continue until the end of the Cassini mission in 2008. We derived global mosaics of the icy satellites, the starting point for any satellite are the Voyager mosaics [Roatsch et al., 2004] in which areas can be replaced gradually by higher-resolution Cassini images as data become available. The global mosaics are usually produced using images of a similar resolution. However, some areas of the satellites are imaged at very high resolution. We describe the data processing and present the first Cassini map, a map of Phoebe.
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## 1. INTRODUCTION

The stated objective of the Cassini Imaging Science Subsystem (ISS) is to obtain global coverage for all medium-sized icy satellites with a resolution better than 1 km/pixel and high-resolution images [Porco et al., 2004]. This goal is being achieved with image sequences obtained during close flybys supplemented by images from greater distances to complete the coverage. Close flybys of all medium sized satellites except Mimas are planned during the nominal mission of the Cassini spacecraft until summer 2008 (http://saturn.jpl.nasa.gov). The first flybys during the mission were those of Phoebe in June 2004 and Iapetus in December 2004 followed by three flybys of Enceladus in February, March, and July 2005 (see Table I) [Porco et al., 2005, 2006].

| Satellite | Flyby Date | Flyby Altitude [km] |
|---|---|---|
| Phoebe | 2004 JUN 11 | 2070 |
| Iapetus | 2004 DEC 31 | 123,400 |
| Enceladus | 2005 FEB 17 | 1260 |
| Enceladus | 2005 MAR 09 | 500 |
| Enceladus | 2005 JUL 14 | 170 |
| Mimas | 2005 AUG 02 | 61150 |
| Tethys | 2005 SEP 24 | 1500 |
| Hyperion | 2005 SEP 26 | 500 |
| Dione | 2005 OCT 11 | 500 |
| Rhea | 2005 NOV 26 | 500 |

Table I: Cassini satellite flybys in 2004/2005

The ISS consists of two framing cameras. The narrow angle camera is a reflecting telescope with a focal length of 2000 mm and a field of view of 0.35 degrees. The wide angle camera is a refractor with a focal length of 200 mm and a field of view of 3.5 degrees. Each camera is outfitted with a large number of spectral filters which, taken together, span the electromagnetic spectrum from 0.2 to 1.1 micrometers. At the heart of each camera is a charged coupled device (CCD) detector consisting of a 1024 square array of pixels, each 12 microns on a side. The data system allows many options for data collection, including choices for on-chip summing and data compression.
Details of the image processing will be described in chapter 2, high resolution Cassini maps will be shown in chapter 3, followed by image maps in chapter 4.

## 2. DATA PROCESSING

Though the Cassini-ISS camera takes images using many different filters [Porco et al., 2004], we used only images taken with the filters CL1, CL2 or GRN, as these images show similar contrast. The Cassini ISS images are distributed inside the imaging team in VICAR (Video Image Communication and Retrieval) format. The first processing step is the radiometric calibration using the ISS calibration program CISSCAL [Porco et al., 2004].. For the Cassini mission, spacecraft position and camera pointing data are available in the form of SPICE kernels [http://naif.jpl.nasa.gov]. While the orbit information is sufficiently accurate to be used directly for mapping purposes, the pointing information must be corrected using limb fits [Roatsch et al., 2006]. High-resolution images that do not contain the limb were registered to limb images to improve the pointing data. For the Cassini maps, newly derived tri-axial ellipsoid models [Thomas, 2006] were used to calculate the surface intersection points. The coordinate system adopted by the Cassini mission for satellite mapping is the IAU "planetographic" system, consisting of planetographic latitude and positive west longitude, but because a spherical reference surface is used for map projections of the satellites, planetographic and planetocentric latitudes are numerically equal. A photometric correction using the Henyey-Greenstein function [Hapke, 1993] was applied to the image data before mosaicking with function parameters adopted from Verbiscer and Veverka [1989, 1992, 1994] and Simonelli et al. [1999] DGlobal digital maps are prepared in simple cylindrical projection, a special case of equirectangular projection. The mapping cylinder is tangent to the equator of the sphere, the longitude range is 0° to 360° W and latitude range –90° to 90° [Kirk, et al., 1998]. The prime meridian is in the center of the map.

## 3. MOSAICS

### 3.1 High-resolution mosaic of Dione

About two hours before the closest approach of Dione on October, 11th in 2005 the Cassini narrow angle camera started to collect 25 images to get global high-resolution coverage of this satellite. Fig. 1 shows the mosaic which was calculated from these images. The nomenclature which was defined from the Voyager images was applied. We are working on name proposals for features which became visible in these new Cassini images and which have to be proposed to the International Astronomical Union (IAU).

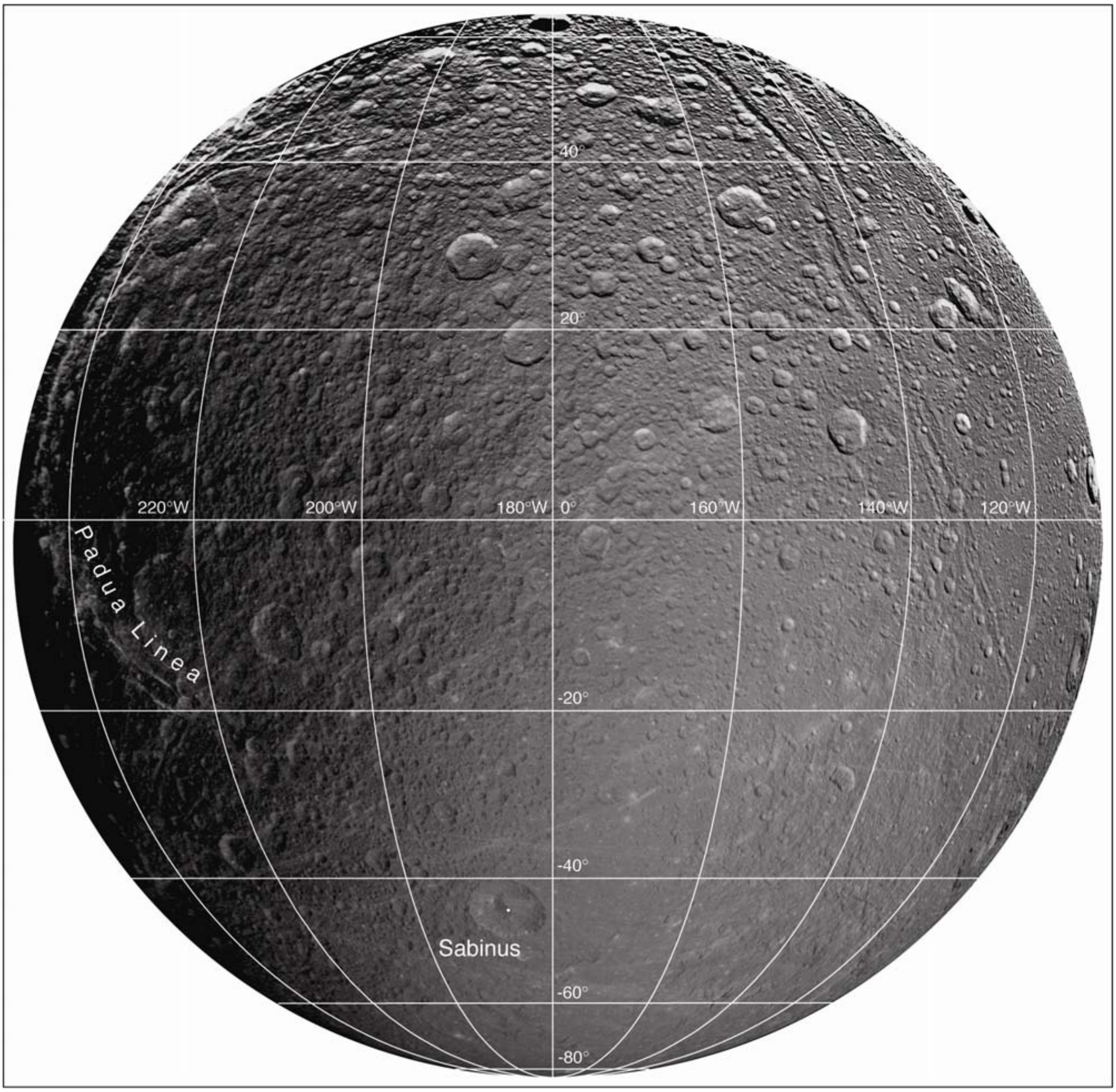


Fig. 1: High resolution-mosaic of Dione (Orthographic projection, map scale of the digital data set is approx. 65 pixel/ degree or 150 m/pixel)

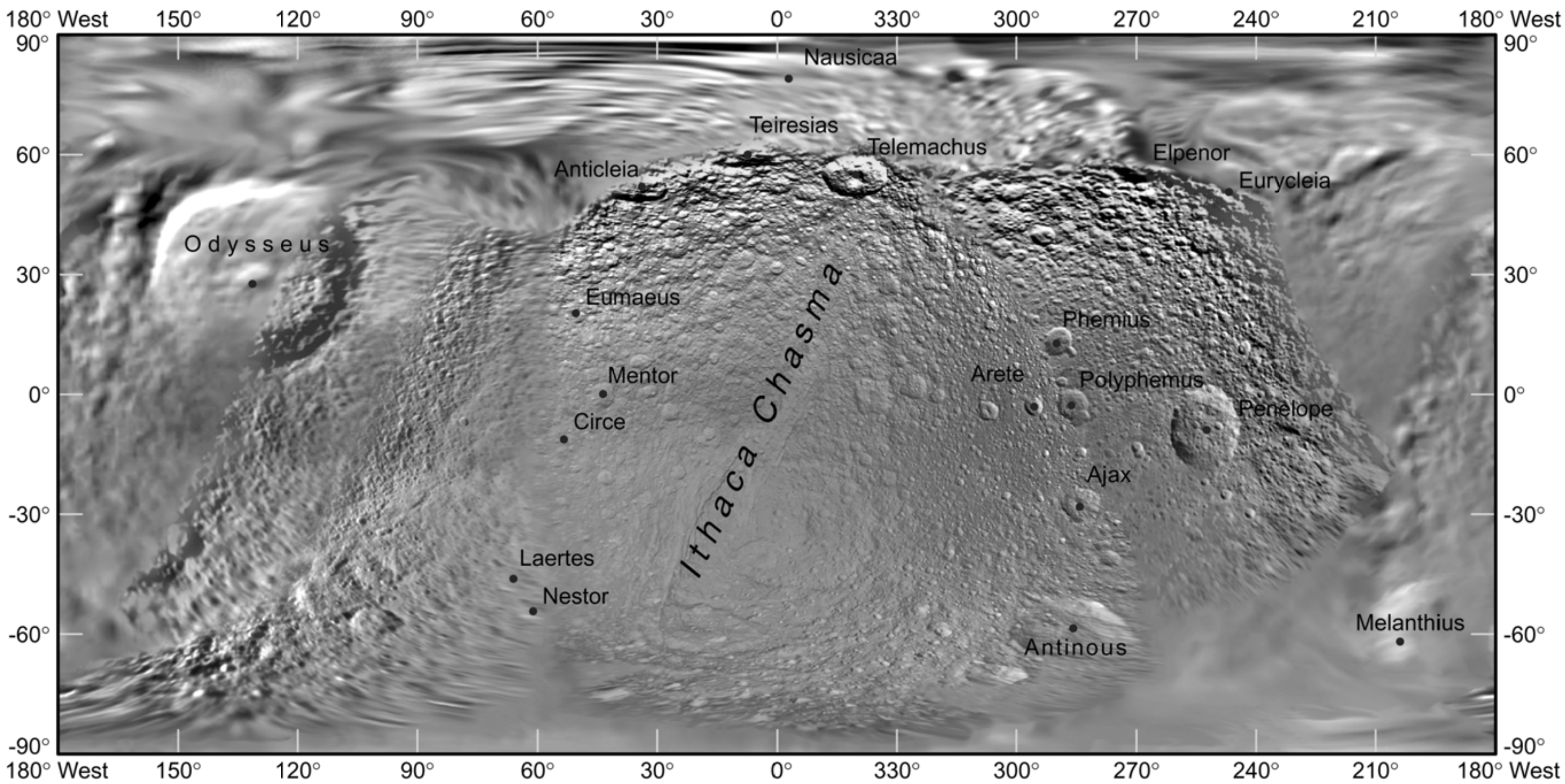


Fig. 2: Global Mosaic of Tethys calculated from Voyager and Casini images (Equidistant projection, map scale of the digital data set is 32 pixel/degree or 292 m/pixel)

### 3.2 Basemap of Tethys

Imaging of the medium-sized icy satellites is an ongoing process and will continue until the end of the Cassini mission, making it possible to improve the image mosaics during the tour. The starting points of global mosaics for any satellite are the Voyager mosaics [Roatsch et al., 2004] in which areas can be replaced gradually by higher-resolution Cassini images as data become available. At some point in time new mosaics can be generated on the basis of Cassini image data, where Voyager data fill the gaps between the Cassini images. One representative example is the global Tethys mosaic, where the resolution of the Voyager mosaic (1800 m/pixel) could be improved to a 292 m/pixel mosaic (see Figure 2). We used the cartographic software tool PIMap of the Technical University Berlin [Gehrke et al., 2006] to add the grid and nomenclature on top of the mosaic.

## 4. MAPS

### 4.1 Phoebe map

The data set of Phoebe is the only one that is complete, as no more high-resolution images are expected during the mission. A global mosaic and a standard map sheet of Phoebe were produced in a scale of 1:1,000,000 (see Figure 3). We produced the Phoebe mosaic from 41 narrow-angle (NA) images of the Cassini ISS camera. We used the Mercator projection within the latitude range -57° to +57° and the stereographic projections polewards beyond +/-55°, respectively. As proposed by Greeley and Batson [1990] the projections are conformal, the quadrangles overlap, and the scale of the poles was chosen such that the circumference of the stereographic projection at the center of the overlap is identical to the width of the Mercator projection. The nomenclature was proposed by the Cassini imaging team and has yet to be validated by the IAU. The resolution of the mosaics is 0.233 km/pixel, although the highest resolution images have resolutions of 0.07 km/pixel.

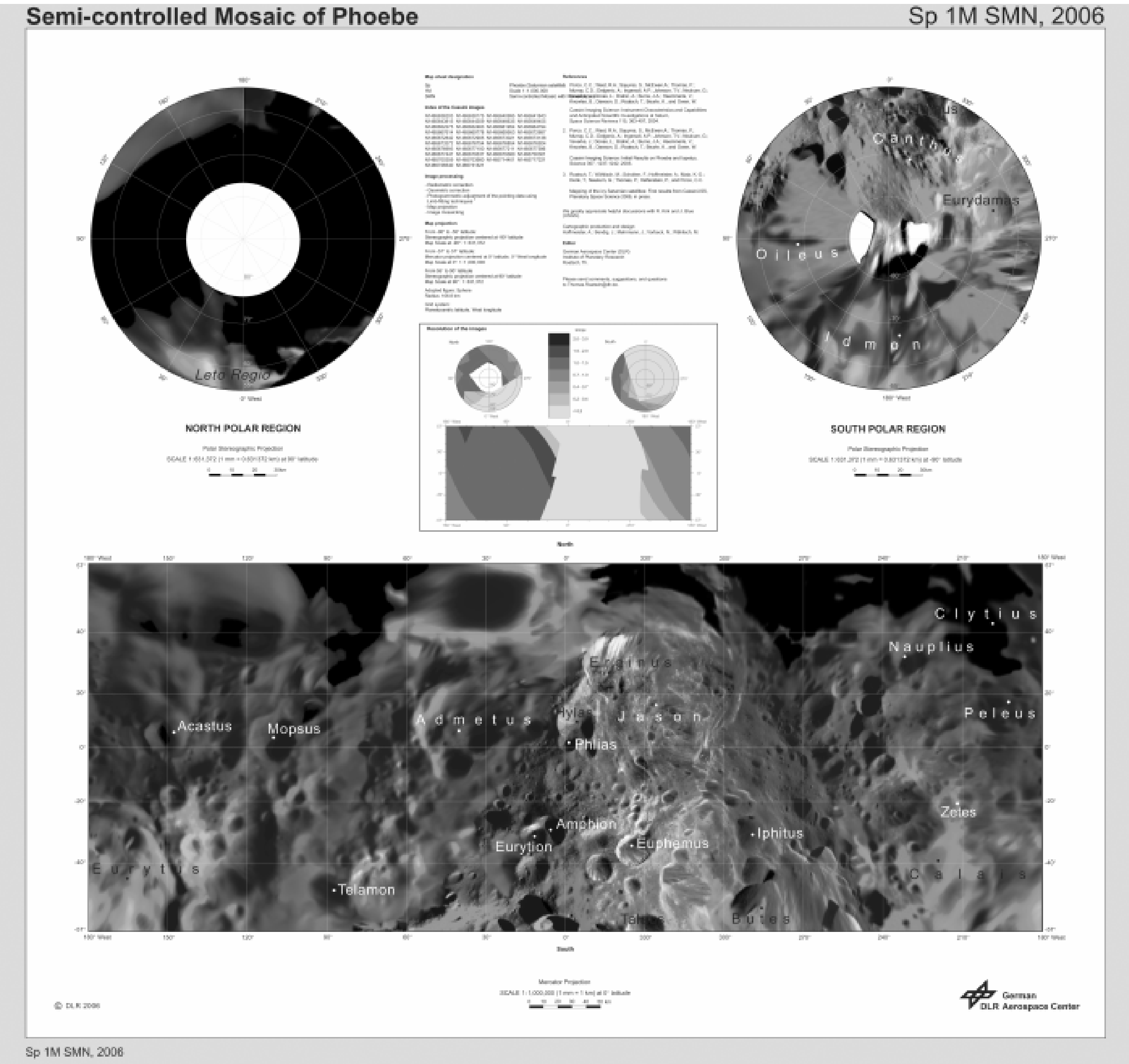


Fig. 3: Phoebe map at 1:1,000,000 scale.

### 4.2 Planned Enceladus map sheets

We will not obtain new high-resolution Enceladus images until 2008. Therefore standard map sheets will be generated for Enceladus soon. The map will be produced in a scale of 1:500,000 consisting of a quadrangle scheme with 15 tiles, as proposed by Greeley and Batson [1990] and Kirk [1997, 2002, 2003] for large satellites (see Figure 4). A map scale of 1:500,000 guarantees a mapping in the highest possible resolution. The equatorial part of the map (-21° to 21° latitude) is in Mercator projection onto a secant cylinder using standard parallels at -13° and 13° latitude. The regions between the equator region and the poles (-66° to -21° and 21° to 66° latitude) are projected in Lambert conic projection with two standard parallels at -30° and -62° (or 30° and 62° respectively). The poles are projected in stereographic projection (-90° to -65° latitude and 65° to 90° latitude).

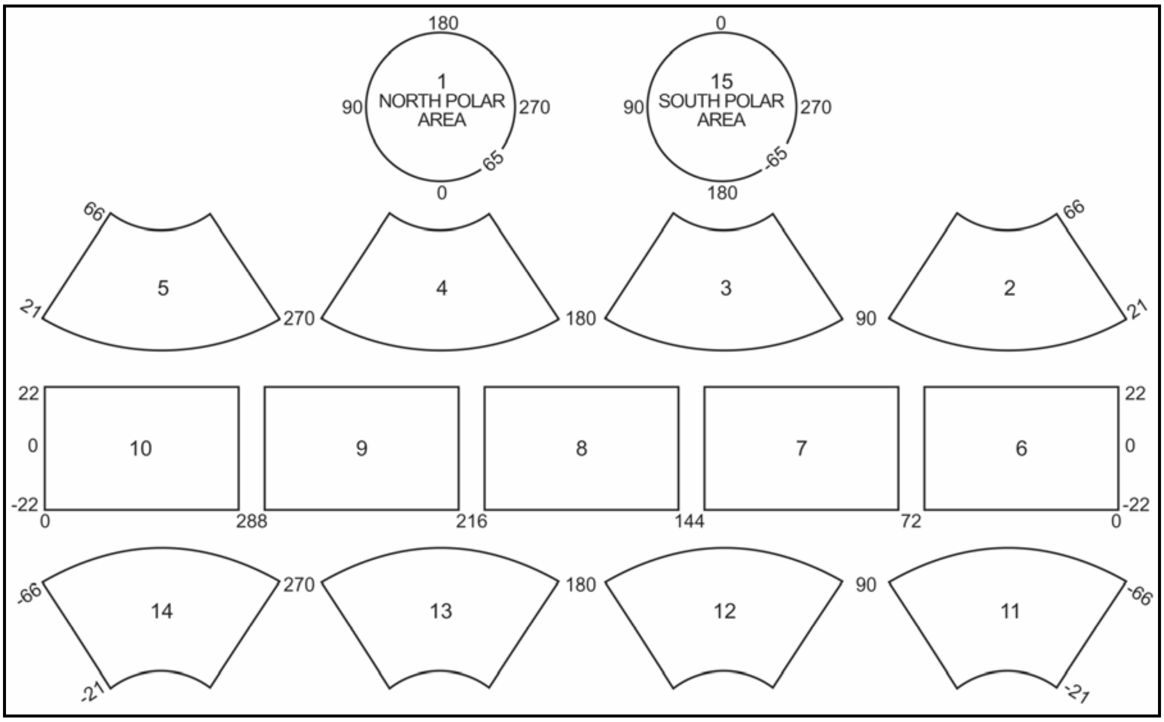


Fig. 4: Quadrangle scheme adopted for regional mapping, beginning with high-resolution maps of Enceladus.

**Acknowledments**

The authors gratefully acknowledge helpful discussions with J. Blue and R. Kirk (USGS) about the cartographic standards to use for the Cassini mapping activities and for reviewing the maps.

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