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High-resolution Dione atlas derived from Cassini-ISS images

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Abstract

The Cassini imaging science subsystem (ISS) acquired 449 high-resolution images (<800 m/pixel) during one close flyby of Dione in 2005 and three non-targeted flybys in 2004, 2006, and 2007. We combined these images with lower-resolution Cassini images and one other taken by Voyager cameras to produce a high-resolution semi-controlled mosaic of Dione. This global mosaic is the baseline for a high-resolution Dione atlas that consists of 15 tiles mapped at a scale of 1:1,000,000. The nomenclature used in this atlas was proposed by the Cassini imaging team and was approved by the International Astronomical Union (IAU). The whole atlas is available to the public through the Imaging Team's website [http://ciclops.org/maps].

Keywords: Cassini; Icy satellites; Planetary mapping; Saturnian system

1. Introduction

The Cassini spacecraft started its tour through the Saturnian system in July 2004. The imaging science subsystem (ISS) 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. Dione, the fourth innermost of the medium-sized satellites, was imaged by the Cassini spacecraft during four flybys (Table 1). The images taken during these flybys together with lower-resolution frames allowed us to create a global mosaic of Dione with a spatial resolution of about 150 m/pixel. Unfortunately, the Cassini-ISS has not yet imaged the northern high-latitude regions (>79°) 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 of 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 our high-resolution atlas, which consists of 15 maps of the different regions of Dione. Two 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 Enceladus mosaic (Roatsch et al., 2008). At the time of this writing, a total of 2337 images of Dione 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 mosaic, we selected only those images taken with the filters CL1, CL2 or GRN, as these images show comparable albedo contrasts among

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different Dione terrains. 81 Cassini NAC images and one Voyager image were used to produce a 64 pixel/deg global mosaic. Figs. 1a–c show the location of the individual Cassini images. The resolution of the selected Cassini images varies between 0.16 and 1.72 km/pixel (Table 2). The resolution of the Voyager image C4399616 is 6 km/pixel.

The medium-sized Saturnian satellites are best described by tri-axial ellipsoids as derived from ISS images by Thomas et al. (2007). The latest radii for Dione are 563.8, 561.0, and 560.3 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 a mean radius 562.53 km. 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 (Roatsch et al., 2006). It was not possible to improve the attitude data using a least-squares adjustment as it was possible for the Enceladus mosaic (Roatsch et al., 2008) due to insufficient stereo data of Dione.

Table 1
Cassini Dione flybys from 2004 till 2007

Flyby date	Flyby distance (km)
15 December 2004	72,067
11 October 2005	498
21 November 2006	74,997
30 September 2007	43,431

2.2. Coordinate system

The coordinate system adopted by the Cassini mission for satellite mapping is the International Astronomical Union (IAU) "planetographic" system, consisting of planetographic latitude and positive West longitude. The ephemeris position of the prime meridian as defined by Davies and Katayama (1983) and adopted by the IAU cartography working group as standard (Seidelmann et al., 2007) is defined at 63° East of crater Palinurus. Our Dione mosaic that was calculated using the limb-fitted attitude data has a slight offset (0.6°) to this definition. Therefore we decided to shift the whole mosaic by 0.6° to the west to be consistent with the IAU longitude definition.

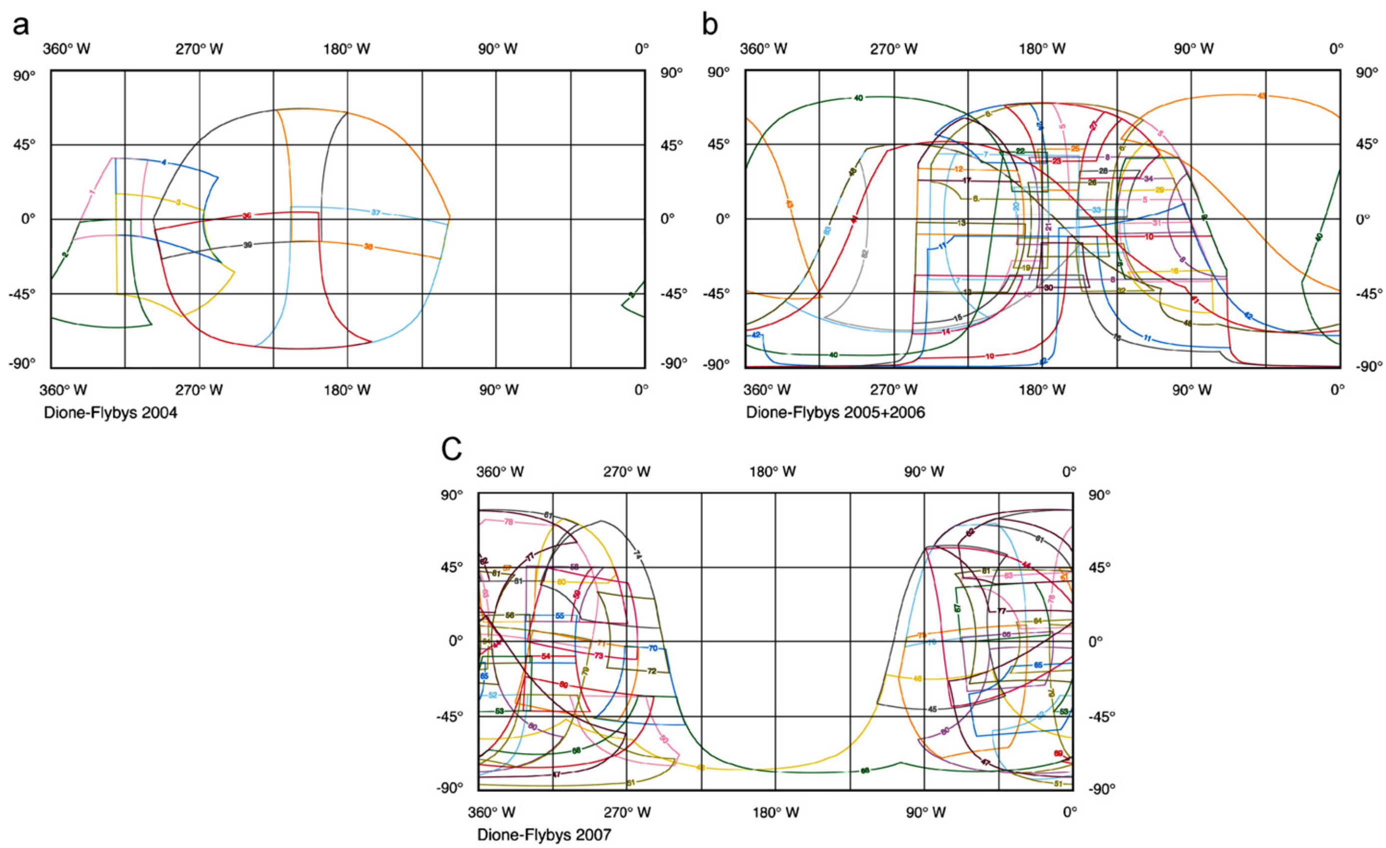

Fig. 1. (a) Global mosaic showing the location of the Cassini-ISS images taken in 2004 (see Table 2). Mosaic is in simple cylindrical projection with latitude = 0°, longitude = 180°W in the center. (b) Global mosaic showing the location of the Cassini-ISS images taken in 2005 and 2006 (see Table 2). Mosaic is in simple cylindrical projection with latitude = 0°, longitude = 180°W in the center. (c) Global mosaic showing the location of the Cassini-ISS images taken in 2007 (see Table 2). Mosaic is in simple cylindrical projection with latitude = 0°, longitude = 180°W in the center.

Table 2
Cassini images used for the mosaic

Image number	Image name	Resolution (km/pixel)	Center latitude (deg)	Center longitude (West/deg)
1	N1481766854	0.433	14.3	32.3
2	N1481766978	0.434	−30.8	23.6
3	N1481767088	0.433	−11.6	63.3
4	N1481767211	0.432	12.3	63.0
5	N1507733604	0.694	N/A	N/A
6	N1507733748	0.687	56.2	168.5
7	N1507733914	0.676	0.2	163.9
8	N1507734092	0.665	−0.3	212.6
9	N1507734234	0.660	0.3	282.8
10	N1507734386	0.650	−50.9	252.1
11	N1507734588	0.638	−49.5	165.5
12	N1507739313	0.368	9.1	143.2
13	N1507739473	0.359	−22.2	140.7
14	N1507739633	0.349	N/A	N/A
15	N1507739776	0.343	−60.3	175.9
16	N1507740062	0.325	N/A	N/A
17	N1507739154	0.376	N/A	N/A
18	N1507743058	0.160	−35.2	168.8
19	N1507742919	0.167	−20.8	173.6
20	N1507742601	0.185	9.1	173.6
21	N1507742761	0.176	−6.5	174.1
22	N1507742440	0.194	27.4	171.4
23	N1507740839	0.283	56.6	195.3
24	N1507740982	0.276	54.5	151.4
25	N1507742295	0.202	28.6	190.5
26	N1507738278	0.425	−0.7	195.1
27	N1507741140	0.267	41.4	225.7
28	N1507741300	0.257	14.2	215.5
29	N1507740542	0.298	N/A	N/A
30	N1507741809	0.229	−27.4	191.4
31	N1507740222	0.318	−19.3	256.8
32	N1507741620	0.239	−28.7	215.9
33	N1507741460	0.248	−7.5	213.8
34	N1507740382	0.309	7.5	248.4
36	N1481738546	0.925	N/A	N/A
37	N1481738450	0.928	N/A	N/A
38	N1481738371	0.932	31.2	210.7
39	N1481738274	0.934	32.7	101.3
40	N1532405126	1.568	4.4	52.5
41	N1501604957	1.723	−43.4	119.3
42	N1514126616	0.901	−45.1	259.5
43	N1540775893	5.620	N/A	N/A
44	N1556123705	0.737	15.2	322.2
45	N1556123415	0.730	−1.3	269.2
46	N1556123129	0.724	−61.9	264.2
47	N1556123988	0.744	−38.5	358.5
48	N1496883311	1.268	−32.5	105.1
50	N1569826692	0.272	−53.2	92.6
51	N1569826794	0.272	−52.2	43.3
52	N1569826902	0.274	−52.6	0.8
53	N1569827019	0.274	−24.2	15.6
54	N1569827127	0.275	−24.0	43.3
55	N1569827462	0.279	1.6	42.3
56	N1569827571	0.280	1.7	15.9
57	N1569827692	0.282	27.4	16.6
58	N1569827799	0.283	27.7	45.0
59	N1569827906	0.286	26.7	80.5
60	N1569828025	0.288	56.7	68.2
61	N1569828131	0.289	57.6	17.0
62	N1569828238	0.292	56.0	312.6
63	N1569828360	0.292	24.1	345.5
64	N1569828482	0.294	−2.0	348.4
65	N1569828604	0.297	−31.1	339.5

Table 2 (*continued*)

Image number	Image name	Resolution (km/pixel)	Center latitude (deg)	Center longitude (West/deg)
66	N1569828720	0.299	−11.0	321.6
67	N1569828843	0.301	17.5	316.5
68	N1569814652	0.419	−60.7	124.9
69	N1569814805	0.416	−52.1	43.9
70	N1569814968	0.410	−26.1	111.4
71	N1569815121	0.407	−21.3	66.1
72	N1569815285	0.402	2.5	104.2
73	N1569815436	0.399	13.4	69.3
74	N1569815593	0.395	34.7	85.9
75	N1569836937	0.530	−21.2	296.4
76	N1569837046	0.534	30.1	291.1
77	N1569837162	0.538	49.7	338.7
78	N1569837277	0.542	31.1	23.1
79	N1569837386	0.546	−21.6	18.5
80	N1569837501	0.551	−37.4	337.9
81	N1569839110	0.610	9.7	333.6
82	N1496883920	1.255	N/A	N/A
83	N1496883812	1.258	N/A	N/A

Resolution, center latitude and center longitude were calculated using reconstructed SPICE kernels.

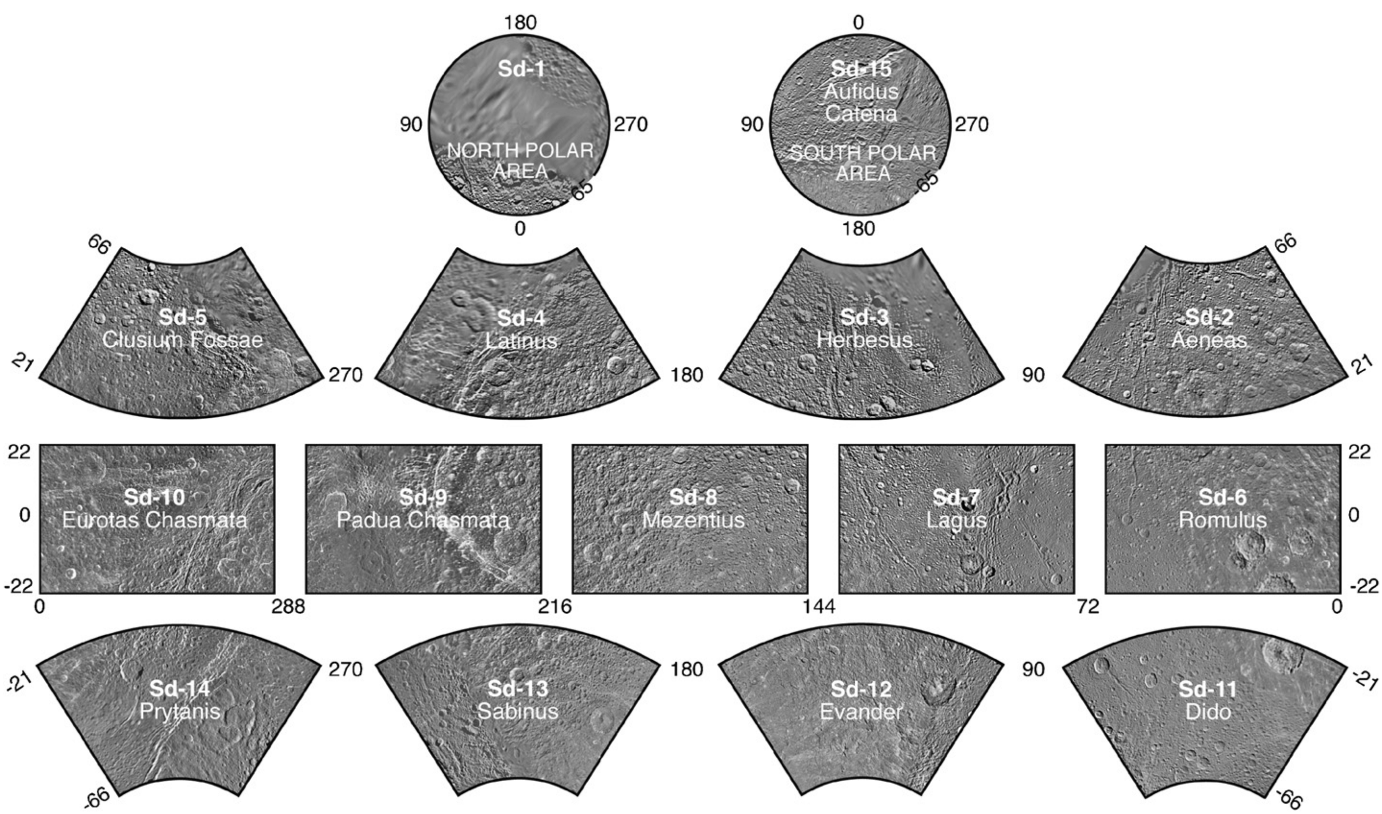

Fig. 2. Quadrangle scheme filled with the 15 Dione tiles.

3. Dione map tiles

The Dione atlas was produced in a scale of 1:1,000,000 and consists of 15 tiles that conform to the quadrangle scheme proposed by Greeley and Batson (1990), Kirk et al. (1998), and Kirk (2002, 2003) for large satellites (Fig. 2). The same scheme was also used for the Enceladus atlas (Roatsch et al., 2008). A map scale of 1:1,000,000 guarantees a mapping at the highest available Cassini resolution and results in an acceptable printing scale for the

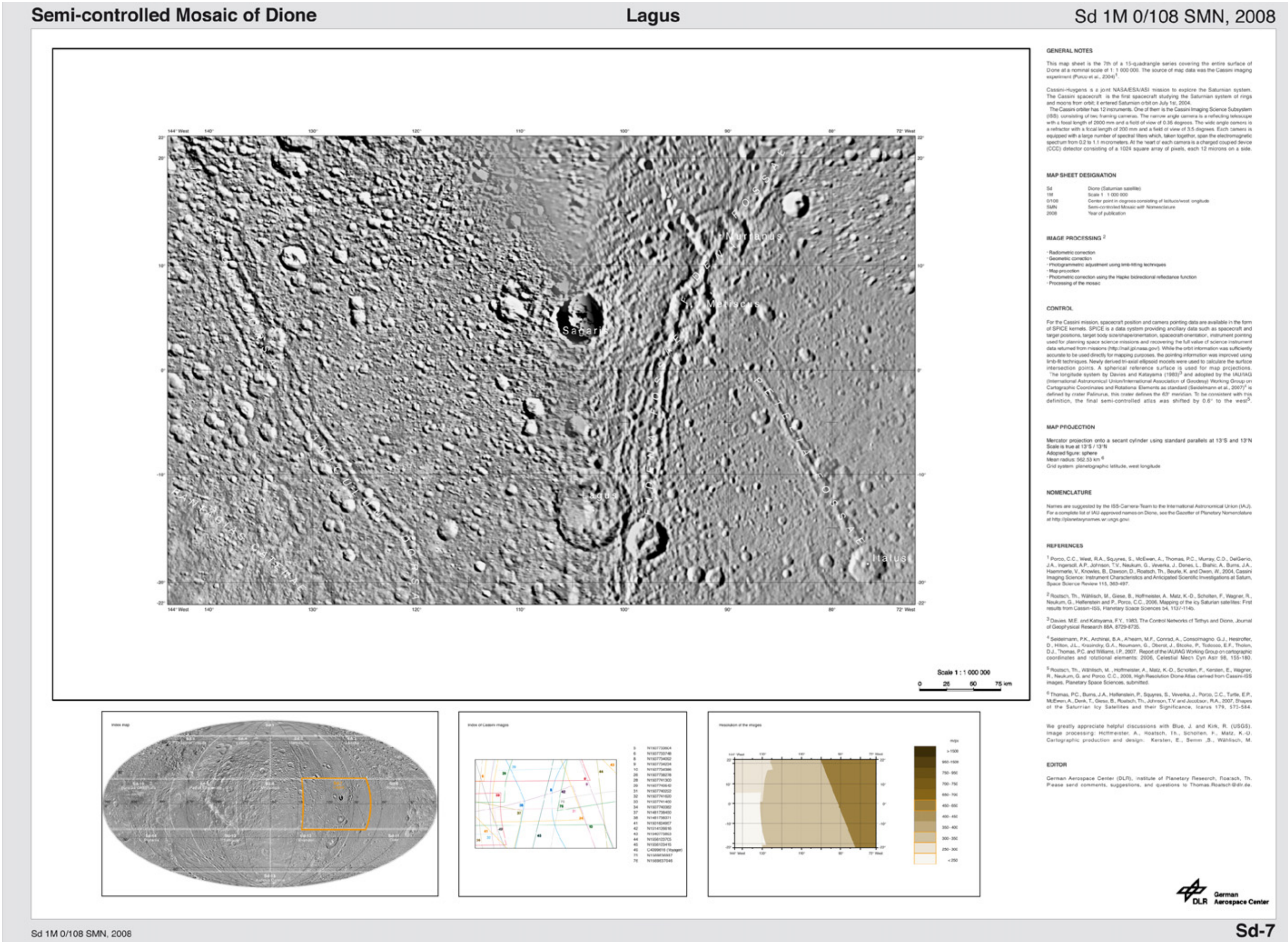

Fig. 3. Dione map sheet 07: Lagus.

hardcopy map of 6.5 pixel/mm. The individual tiles were extracted from the global mosaic and reprojected. The equatorial part of the map (-22° to 22° latitude) is in Mercator projection, the regions between the equator and the poles (-66° to -21° and 21°–66° latitude) are projected in Lambert conic, and the poles (-65° to -90° and 65°–90° latitude) are projected in stereographic projection. See Roatsch et al. (2008) for details of the projections. Using this quadrangle scheme in the 1:1,000,000 scale for Dione, we get the printed maps in the same user-friendly size of 1200-mm width by 870-mm height. We also added resolution maps and index maps for every individual tile, showing the image resolution, the image numbers and the location of the images for every map, respectively. Two map examples in different projections are shown in the Figs. 3 and 4.

The Cassini imaging team proposed 45 names for geological features, in addition to the 31 features already named by the Voyager team that are used in the maps. By international agreement, the features must be named after people or locations in the "The Aeneid of Virgil" (Mandelbaum, 1972). The locations and dimensions of all previously known features were measured again on the basis of the Cassini data and were corrected when necessary. Table 3 shows a comparison of the locations measured on the basis of the Voyager data and the Cassini data for four craters. The nomenclature proposed by the Cassini-ISS team was approved by the IAU [http://planetarynames.wr.usgs.gov/].

The entire Dione atlas consisting of 15 map tiles will be made available to the public through the Imaging Team's website [http://ciclops.org/maps]. The map tiles will also be archived as standard products in the Planetary Data System (PDS) [http://pds.jpl.nasa.gov/].

4. Future work

The Cassini spacecraft will continue its imaging campaign through the Saturnian system. The next close flyby of Dione is scheduled for April 2010 (altitude about 500 km). The upcoming flyby will help to replace the low-resolution parts of this atlas with higher resolution image data.

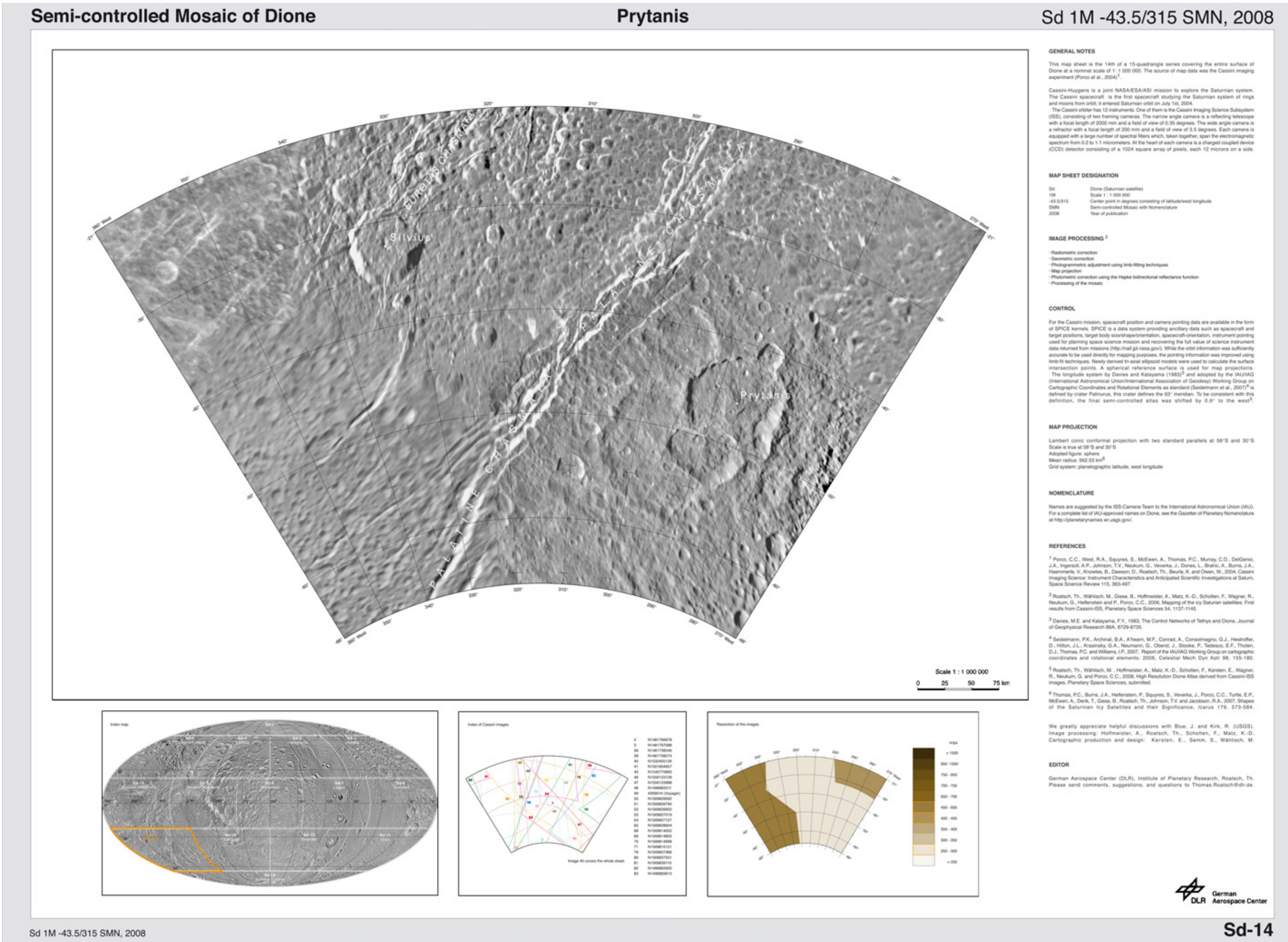

Fig. 4. Dione map sheet 14: Prytanis.

Table 3
Comparison of Voyager and Cassini crater location

Crater name	Voyager		Cassini	
	Latitude (deg)	Longitude (West) (deg)	Latitude (deg)	Longitude (West) (deg)
Antenor	−6.5	10.4	−6.8	11.6
Caieta	−23.3	80.5	−24.6	79.9
Catillus	−1.6	273.0	−2.0	275.2
Sabinus	−47	175.6	−43.5	187.0

The northern part of Dione will be illuminated during the extended mission providing an opportunity to obtain high-resolution Cassini coverage of high northern latitudes.

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