Mimas between 0.35-5.1 Microns from Cassini VIMS Observations.

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Introduction: Mimas is the innermost of the five major icy Saturnian satellites. Discovered by William Herschel in 1789 during a Saturn Ring Plane Crossing, the moon is exceedingly difficult to observe due to scatterd light from Saturn (see Figure 1). Similarly, Mimas was the only major Saturnian moon not to have at least one targeted flyby during the entire *Cassini* Mission because of the difficulty of targeting a spacecraft to an object so deep in Saturn's gravitational well and with an orbital period of less than one day (see Table 1).

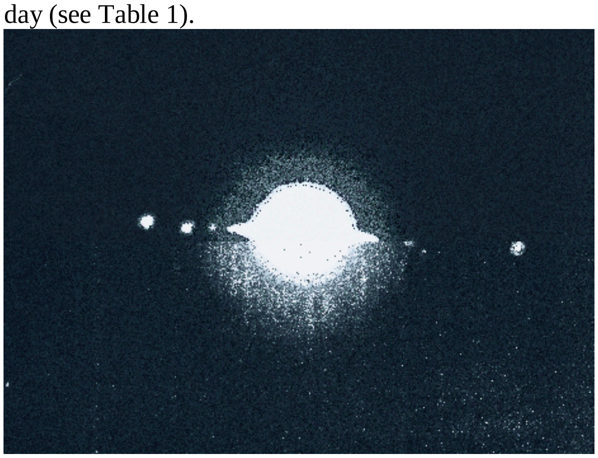

Figure 1. An observation of Saturn shortly after ring plane crossing in 1994 with the COSMIC CCD camera attached to the 200-inch Hale Telescope on Palomar Mountain. Mimas is the faintest satellite directly to the right of the right ansa of Saturn's ring. The main physical properties of Mimas are summarized in Table 1.

Table 1 – Main Properties of Mimas [1], [2],[3]

Size	Density	Albedo	e	Period
415x394 km	1.15	0.96	0.02	0.94 d

During the Cassini extended mission, on February 13, 2010, the spacecraft executed a close nontargeted flyby of Mimas that took it within 9500 km of its surface. The *Cassini* Visual Infrared Mapping Spectrometer (VIMS) obtained measurements between 0.35 and 5.2 μm of the leading hemisphere, particularly around the large crater Hershel at ~10 km resolution. Combined with data from earlier flybys, about 75% of the surface of Mimas has been mapped by *Cassini* VIMS. Figure 2 shows mosaics of Mimas at 1,2,3, and 5 μm.

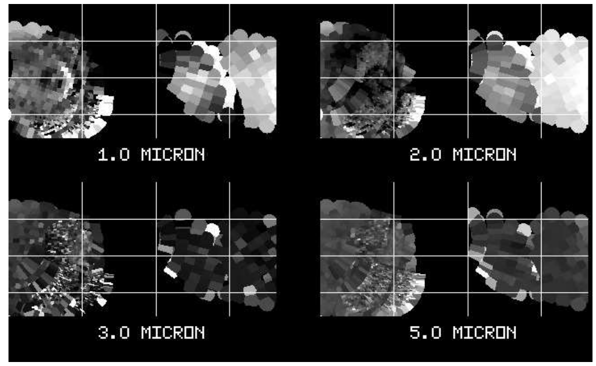

Figure 2. VIMS mosaics of Mimas at 4 wavelengths representing the full range of the infrared channel of the VIMS instrument.

Surface Particle Sizes: Band depths are a sensitive indicator of grain particle size on a planetary surface [4]. Figure 3 shows spectra extracted from various regions of Mimas: leading, trailing, and the large Herschel crater. No components other than water ice, such as carbon dioxide, have been identified. However, there is a dip in the spectrum at 1.8 μm that was originally noted by ground-based observers [5,6] and still has an unknown origin. The spectra exhibit marked changes in the band depths of the water ice absorption bands, especially at 1.5 and 2.0 μm. Models have been fit to these bands to derive average ice grain particle sizes on the surface of Mimas (Table 2). The trailing side has substantially smaller particle sizes. There is also some evidence, based on differences in grain-size measurements from bands at different wavelengths, that particles may be smaller at the very top of the regolith.

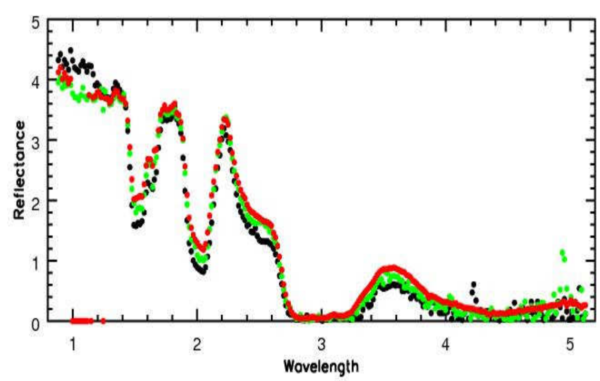

Figure 3. Spectra from the leading (green), trailing (red) and Herschel (black) regions of Mimas.

Table 2 – Ice Grain Particle Sizes

Location	Leading	Trailing	Herschel
Particle size (μm)	10-50	20-80	50-100

Figure 4 shows a band-depth and thus ice grain particle size map for Mimas, which again illustrates that the leading side (left) has substantially larger grain sizes.

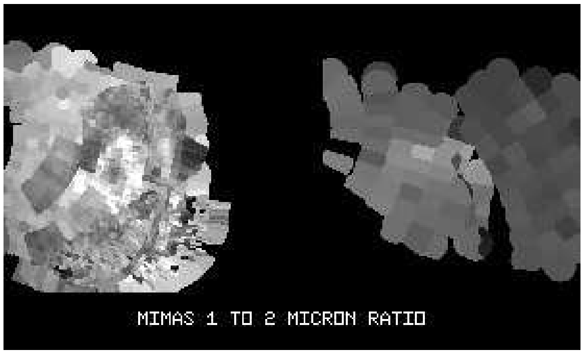

Figure 4. A ratio of the 1 to 2 μm VIMS mosaics, corresponding to the continuum and water ice absorption band, respectively. The leading hemisphere is on the left. The brighter regions have larger grain sizes.

The solar phase curve: The solar phase curve provides knowledge of the surface physical properties, including roughness, particle size, and compaction state. Throughout the nominal and extended missions, data have been gathered between solar phase angles of 0º and 152º. This data is sufficient to show some differences between leading and trailing hemispheres, especially in the water ice bands. There is not enough data to separately model the leading and trailing hemispheres for differences in particle sizes, macroscopic roughness and compaction states. During the *Cassini* Solstice Mission (CSM), data will be gathered at additional solar phase angles, particularly at opposition, where the measurements are sensitive to the compaction state of the optically active portion of the regolith.

The plausible scenario: Models of the E-ring [7] suggest that the E-ring coats the leading side of satellites exterior to Enceladus, and the trailing side of satellites interior to Enceladus. It appears this is exactly what is happening, as the leading sides of Tethys, Dione, and Rhea are brighter than the trailing sides due to deposit of E-ring particles, but the trailing side of Mimas is brighter [8]. Because the *in situ* Cassini experiments tended to show that smaller particles (on the order of a micon) comprise the plume and E-ring of Enceladus, some type of annealing process that caused the particles to be fused together must take place on the surface of Mimas.

During the non-targeted flyby of Mimas on February 13, 2010, the Composite Infrared Mapping Spectrometer (CIRS) detected a thermal anomaly of 15K on the trailing side of Mimas; this anomaly was attributed to differences in the thermal inertia rather than to geophysical activity [9]. The thermal intertia of the trailing side of Mimas (the "hot" side) was thus more in line with that of the other inner medium-sized icy Saturnian satellites. There is a color anomaly on the leading side of Mimas that seems to match the CIRS anomaly; this pattern has been attributed to the bombardment of the surface of the satellite by high energy electrons in Saturn's magnetosphere [10]. Another phenomenon that needs revisiting and that may have an effect on the thermal properties of icy satellites is the solid state thermal greenhouse effect [11].

Future work: With the discovery of a thermal anomaly on Mimas, the *Cassini* project has put new focus on observing it during the CSM. Although the project will end in 2017 still without a targeted flyby of Mimas, several "*Voyager* class" flybys occurring at closest approaches less than 200,000 km will occur. In addition, four opportunitities to observe Mimas at small solar phase angles (<1º) at various subspacecraft longitudes are in the 7-year CSM plan. Finally, the Satellites Orbiter Science Team (SOST), which leads the *Cassini* planning effort for the satellites (except Titan), has initiated a plume search campaign during the CSM, with focus on observations at large solar phase angles (~150º and higher). The purpose of this compaign is to detect any forward scattered radiation from a plume on Mimas, especially at 2 μm where the plume of Enceladus is most prominent,

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