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FROM THE ICY SATELLITES TO SMALL MOONS AND RINGS: SPECTRAL INDICATORS BY CASSINI-VIMS UNVEIL COMPOSITIONAL TRENDS IN THE SATURNIAN SYSTEM

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ABSTRACT: Despite water ice being the most abundant species on Saturn satellites' surfaces and ring particles, remarkable spectral differences in the 0.35-5.0 μm range are observed among these objects. Here we report about the results of a comprehensive analysis of more than 3000 disk-integrated observations of regular satellites and small moons acquired by VIMS aboard Cassini mission between 2004 and 2016. These observations, taken from very different illumination and viewing geometries, allow us to classify satellites' and rings' compositions by means of spectral indicators, *e.g.* 350-550 nm - 550-950 nm spectral slopes and water ice band parameters [1, 2, 3]. Spectral classification is further supported by indirect retrieval of temperature by means of the 3.6 μm I/F peak wavelength [4,5]. The comparison with syntethic spectra modeled by means of Hapke's theory point to different compositional classes where water ice, amorphous carbon, tholins and CO_2 ice in different quantities and mixing modalities are the principal endmembers [3, 6]. When compared to satellites, rings appear much more red at visible wavelengths and show more intense 1.5-2.0 μm band depths [7]. Our analysis shows that spectral classes are detected among the principal satellites with Enceladus and Tethys the ones with stronger water ice band depths and more neutral spectral slopes while Rhea evidences less intense band depths and more red visible spectra. Even more intense reddening in the 0.55-0.95 μm range is observed on Iapetus leading hemisphere [8] and on Hyperion [9]. With an intermediate reddening, the minor moons seems to be the spectral link between the principal satellites and main rings [10]: Prometheus and Pandora appear similar to Cassini Division ring particles. Epimetheus shows more intense water ice bands than Janus. Epimetheus' visible colors are similar to water ice rich moons while Janus is more similar to C ring particles. Finally, Dione and Tethys lagrangian satellites show a very flat reflectance in the visible, making them remarkably different with respect to the other small moons. Moreover, we have observed that the two Tethys' lagrangian moons appear spectrally different, with Calypso characterized by more intense water ice bands than Telesto. Conversely, at visible wavelengths Polydeuces, Telesto and Methone are in absolute the more blue objects in the Saturn's system. The red slopes measured in the visible range on disk-integrated spectral data, showing varying degrees on all of the satellites, could be caused more by exogenic processes than by geologic and endogenic events which are operating on more localized scales. The principal exogenic processes active in the Saturn's system [11] which alter the satellites and rings surfaces are the E ring particles bombardment, the interaction with corotating plasma and energetic particles, the bombardment of exogenic dark material [12] and the water ice photolysis. A discussion about the correlations between these processes and the observed spectral classes is given. With the approaching of the Cassini "Gran Finale" orbits, VIMS will unveil with unprecedented spatial resolution the spectral properties of many small moons and rings. These data will be extremely valuable to improve our classification of the Saturn's satellites and rings.

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