AMMONIA HYDRATE ON TETHYS' TRAILING HEMISPHERE. A. J. Verbiscer[1], D. E. Peterson[1], M. F. Skrutskie[1], M. Cushing[2], P. Helfenstein[3], M. J. Nelson[1], J.D. Smith[2], J. C. Wilson[1], [1]University of Virginia (P.O. Box 400325 Charlottesville VA 22904-4325 verbiscer@virginia.edu), [2]Steward Observatory (University of Arizona, Tucson AZ 87512), Cornell University (Ithaca NY 14853).

Introduction: The detection of ammonia hydrate on the surface of any body in the Solar System is of particular interest because its presence enables geologic activity. The melting temperature of ammonia hydrate at 1 bar is ~194 K [1], considerably lower than that of pure water ice. On a saturnian satellite, photolysis would deplete a 10-µm layer of ammonia-rich ice in only 100 years [2], and sputtering would deplete the uppermost surface layer of any ammonia molecules on time scales of less than 10^6 years. [3]. Therefore, the presence of ammonia hydrate on the surface of an icy satellite implies recent emplacement, possibly by cryovolcanic activity. Such activity has been invoked to explain the presence of ammonia hydrate on Pluto's satellite Charon [4-6].

In an effort to search for any non-water ice components such as ammonia hydrate, we obtained near-infrared spectra 0.8 – 2.5 µm of Tethys' trailing hemisphere (latitude -26° S, longitude 250° W) with the CorMASS spectrograph [7] on the 1.8 m Vatican Advanced Technology Telescope (VATT) at the Mt. Graham International Observatory. The spectral resolution ($R = \lambda/\Delta\lambda$) of these CorMASS data (R ~ 300) is comparable to but nevertheless higher than that of Cassini's Visual and Infrared Mapping Spectrometer (VIMS) (R = 225). Previous analyses of high resolution (R ~ 800) near-infrared spectra of Tethys' trailing hemisphere [8-9] did not report the detection of any non-water ice components.

Our spectrum of Tethys' trailing hemisphere (black line in Fig. 1) is dominated by the absorption bands of water ice at 1.04, 1.25, 1.52, 2.02 µm. A narrow water ice band at 1.65 µm and a weaker one at 1.31 µm are strongly temperature dependent, increasing in depth with decreasing temperature [10]. A weak band at 2.21 µm matches that of ammonia hydrate (1% $NH_3 \cdot H_2O$) (Fig. 3). The spectrum is normalized to the albedo of Tethys' trailing hemisphere at 0.9 µm [11].

Spectral Modeling: We model the spectrum of Tethys using a Hapke [12] spectrophotometric mixture model in the same manner in which spectra of Enceladus obtained with the same telescope and instrument were analyzed [13]. We find that spectral models (red line in Fig. 1) which include as much as 80% by weight of ammonia hydrate (1% $NH_3 \cdot H_2O$) intimately mixed with water ice at 60 K covering 30% of the illuminated surface area fit the observed spectrum.

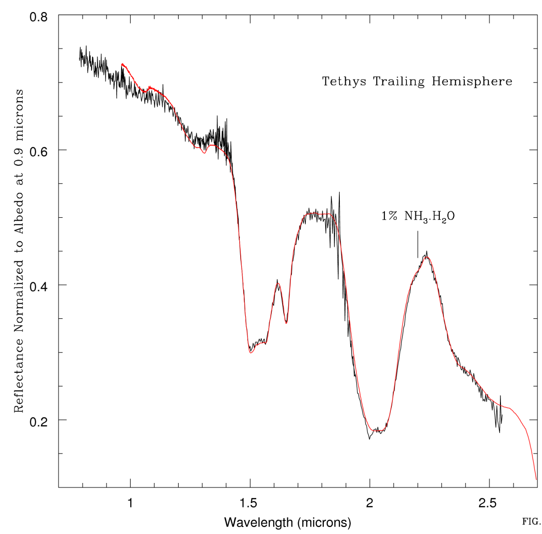


FIG. 1

Comparison with Enceladus: We compare this spectrum with that of the trailing hemisphere of Enceladus [13] in Fig. 2. Enceladus has a pronounced blue spectral slope, particularly in the region 0.8 – 1.3 µm, relative to Tethys. The relatively weaker water ice absorption bands in Tethys' spectrum indicate that, in general, particles on its trailing hemisphere are smaller than those on Enceladus. Close examination of the water ice band at 1.52 µm reveals that its arcuate shape is also more pronounced on Enceladus. The difference in the relative shapes of this band suggest that Tethys either has more amorphous water ice on its surface and/or there is ammonia hydrate present. In addition, the shape of the peak at 1.7 µm in Tethys' spectrum is consistent with amorphous water ice and/or ammonia hydrate. The absorption at 2.21 µm, however, cannot be due to amorphous water ice and indicates the presence of ammonia hydrate on Tethys.

Future work: Optical constants for all hydration states of ammonia at temperatures between 50 – 100 K are not currently available. New laboratory measurements would significantly enhance our ability to model the near-infrared spectra of all icy bodies in the Solar System on which ammonia hydrate has been found.

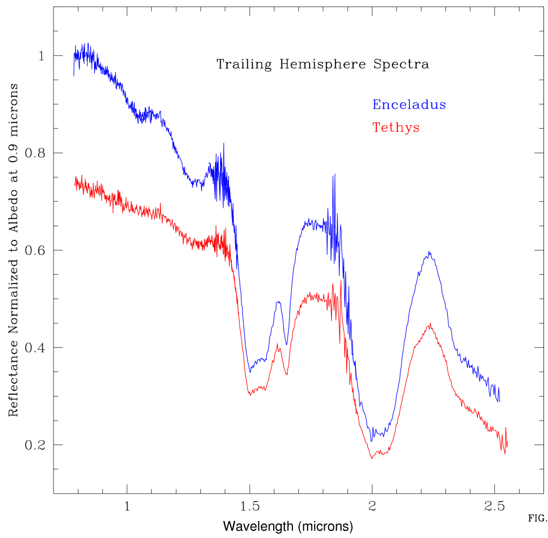
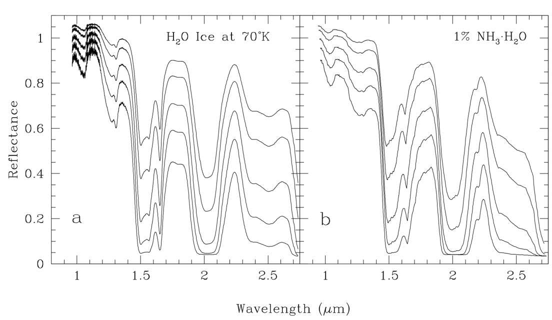


FIG. 2

Figure 3 (below) [13] illustrates model spectra of (a) pure water ice at 70 K and (b) 1% ammonia hydrate at 77 K calculated using optical constants derived from laboratory spectra [14, 15]. Grain sizes from top to bottom are 50, 100, 250, 500, and 1000 µm. All bands strengthen with increasing particle size until they reach saturation. Spectral slopes increase with particle size as does the width of the 2 µm band. Correspondingly, the peaks centered at 1.8 and 2.25 µm narrow with increasing particle size.



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