

BAND POSITION VARIATIONS IN REFLECTANCE SPECTRA OF THE JOVIAN SATELLITE GANYMEDE. K. Stephan¹, R. Jaumann¹, C. A. Hibbitts² and G. B. Hansen², ¹German Aerospace Center (DLR), Rutherfordstr. 2, 12489 Berlin, Germany, ²Planetary Science Institute, Northwestern Division, Washington, USA.

Introduction: The strong fundamental O-H stretching vibration near 3 μm active in water-ice as well as in hydrated and hydroxylated materials [1] was identified in the reflectance spectra of the icy Galilean satellites. Being largely independent of photometry and also grain size variations, the state of the wavelength position of the 3- μm band provides unequivocal relative abundance information of water-ice and non-ice components. The influence of additional surface components other than water ice shifts the wavelength position of maximum absorbance [1,2]. We performed detailed analyses of the 3- μm band to study the spatial distribution of band position variations with respect to compositional changes and grain size variations across the surface of Ganymede.

Data processing: The analysis was conducted on reflectance spectra acquired by the Near Infrared Mapping Spectrometer (NIMS).

First of all the available spectra were fitted to a meaningful mathematical function. A principle component analysis was applied to eliminate undesired noise from the spectral data before fitting. Piecewise polynomials, such as cubic splines were found to provide the best fit of the data. The first derivative of the absorbance as a function of wavelength were calculated from the fitted 3- μm absorption spectrum which can assume both positive and negative values. The wavelength position of the zero value of the absorbance defines the specific band position of the 3- μm band.

Results: The spatial distribution of band position variations could well be correlated with terrain types and surface features on Ganymede by combining spectral information with albedo and morphological information based on Voyager and Galileo Solid State Imaging (SSI) data. Generally, band positions shift to longer wavelengths when moving from bright to dark material [1] as seen in the visible spectral range based on imaging data.

Ganymede's polar caps exhibit band positions between 2.832 and 2.845 μm which are positions at the shortest wavelength measured in this study. Similar values occur in the vicinity of large bright impact craters with extensive ejecta rays on the leading side, like Osiris (-39°lat, 161°lon) and Ptah (-66°lat, 118°lon). Both polar caps and the brightest impact craters are assumed to exhibit almost pure water ice [3]. Large bright ray craters on Ganymede's trailing side show band positions at distinctly longer wavelengths (2.861-

2.869 μm) which indicate small compositional differences, especially a lower amount of water ice. Impact structures of relatively small and intermediate size, including bright craters with both bright and dark ejecta rays are visible across all terrains. They exhibit a relatively high variability of band positions. Values occur between 2.832 to 2.906 μm , which indicate also a high variability in mixing ratio of water ice and non-ice material. Often the band position seems to be related to the band position of the specific surrounding terrain and could be the result of limited spatial resolution of the spectral data than of actual composition. However, some impact craters were found within Uruk Sulcus (0-10°lat, 160-170°lon), which exhibit values distinctly different from the surrounding terrain and more similar to large bright craters on the leading side and the polar caps. These are supposed to exhibit a comparable abundance of water ice. Band positions at the longest wavelengths measured for bright craters were determined only in the case of impact crater which are characterized by dark ejecta, like Antum (5°lat, 219°lon), and are strongly related to the non-ice material which is concentrated in the dark ejecta of these craters. The analyses of the relative bright grooved terrain which include mainly sulci, for example Uruk and Nippur Sulcus, render band positions between 2.885 and 2.904 μm . The measured band positions of areas of the heavily cratered, less icy dark terrain show a broad range of values, which include values similar to the grooved terrain, but also band positions at distinctly longer wavelengths (2.9 μm) for the central parts of Galileo Regio. The high variability of band positions is consistent with a heterogeneous visible albedo as seen in SSI imaging data [4]. Both the grooved and the dark terrain show no evidence of hemispherical differences. Band positions at the longest wavelengths (2.901 – 2.925 μm) discussed here could be obtained for the dark ejecta rays of some impact craters (Antum and Mir) and two dark spots observed within Uruk Sulcus. The dark rayed impact crater Kittu (0.5°lat, 334.5°lon) exhibits band positions at slightly shorter wavelengths (2.89 – 2.90 μm).

Conclusions: 1. Shifts of wavelength positions of the 3- μm occur in direction to longer wavelengths as water becomes bound in hydrated minerals [2]. Similar band positions indicates similar composition, which becomes apparent in the case of polar caps and the large bright rayed impact craters on Ganymede's leading side, which exhibit almost pure water-ice.

2. Areas on Ganymede which represent mixtures of varying amounts of water-ice and non-ice material(s) also show broader ranges of band positions. Overlapping values for grooved and dark terrain indicate a smoother transition of compositional changes between these two terrain types with some areas of nearly similar composition.

In summary analyses of band position variations at 3 μm provide the possibility to study relative compositional changes without the influence of viewing geometry and scattering effects and offer the opportunity for the direct comparison of regions observed under different observing conditions. Furthermore, derivative spectroscopy provides an accurate technique to analyse the absorption bands of reflectance spectra. The derived spectra were found to be extremely sensitive to any changes in the gradient of the absorption spectra and are well suited to the analysis of superimposed absorption bands as in the case of the 3- μm band. Further analyses will be focused upon the isolation of the absorption band within this spectral region

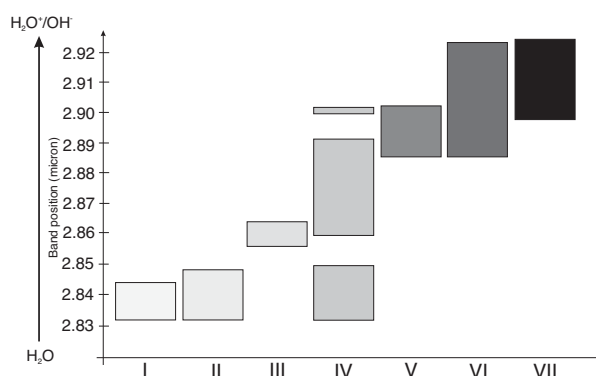


Figure 1: Overview of the measured ranges of wavelength position of the 3- μm band with respect to different terrain types and surface features like impact craters (I – Polar caps; II – large bright impact craters on the leading hemisphere; III – large bright impact craters on the trailing hemisphere; IV – impact craters of intermediate size; V – grooved terrain (sulci); VI – dark heavily cratered terrain; VII – dark ejecta of impact craters and dark spots. Shifts of wavelength positions of the 3- μm occur in the direction to longer wavelengths as water becomes bound in hydrated materials.

References: [1] McCord T. B. et al. (1998) *JGR*, 103, 8603–8626. [2] McCord T. B. et al. (2001) *Science*, 292, 1523-1525. [3] Stephan K. (2002) *LPS XXXIV*, Abstract #1687. [4] Hibbitts C. A. (2003) *JGR*, 108, 5036–5057.