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Surface Composition of Europa's Icy Bright Plains and Dark Linea: Leading side versus trailing side comparisons

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Abstract

We compare linear mixture modeling solutions yielding surface composition and water ice grain size information for three widely-spaced locations on Europa. Low-noise Galileo Near-Infrared Mapping Spectrometer (NIMS) observations are employed for this analysis. Model solutions indicate that the surface compositions for locations on the orbital leading hemisphere are dominated by fine-grained water ice. Ice abundance ranges from 65%-82% with grain sizes ranging from ~50-µm to ~75-µm. These locations exhibit extremely low abundances of hydrated sulfuric acid and minor amounts of hydrated salts. A location on the orbital trailing side is characterized by a high abundance (>40%) of hydrated sulfuric acid, with lesser amounts of hydrated salts. Large-grained (100-µm to ~250-µm) water ice is present in this trailing hemisphere location. Higher abundances of hydrated salts and distinctive water ice grain size distributions are seen in association with dark materials in all three locations. Our results help distinguish between exogenic and endogenic influences on Europa's present-day surface composition.

1. Introduction

Europa's enigmatic surface holds clues to the past history and likely composition of its subsurface ocean. The potential habitability of Europa's subsurface ocean is an important question which at present can only be addressed through the analysis of remote sensing data. We address this using the linear mixture modeling algorithms of Dalton [1], which employ cryogenic reference spectra of candidate materials including hydrated salts, hydrated sulfuric acid, and water ice of varying grain sizes. A strong spatial gradient of Europa's hydrated sulfuric acid abundance was shown by Shirley et al. [2], with abundance increasing in the direction of the orbital trailing side apex.

2. "Long Spectrometer" Mode NIMS observations of Europa

The NIMS instrument included a scanning mirror that could be stepped through 20 positions to build up a 20-pixel-wide swath across target surfaces. In the typical mode of operation, the scanning mirror's swath was oriented perpendicular to the ground track determined by spacecraft motion, along with the spacecraft scan platform target motion compensation. NIMS also possessed a mode of operation in which the scanning mirror could be turned off. Long spectrometer (LS) mode thus allowed 20 redundant spectral measurements to be obtained for each spatial pixel targeted. The resulting recorded observations take the form of a narrow strip extending along the ground track specified for the observation. An example is shown in Fig.1. The NIMS LS mode trades spatial coverage for a 20-fold redundancy of spectral information. As in laboratory investigations, the availability of multiple spectral scans permits a reduction in noise levels through co-adding of spectra.

3. Spectra

Figure 2 displays representative spectra for dark linea materials from the Galileo NIMS observations 14ENSUCOMP03, 15ENSUCOMP01, and 17ENSUCOMP02. A striking difference in the depth and shape of the principle water ice absorption features at 1.5-µm and 2.0-µm is evident here for the

spectra representing the leading (E15, E17) and trailing (E14) sides. This difference is attributed to the higher abundance of hydrated materials (both hydrated salts and hydrated sulfuric acid) on the trailing side.

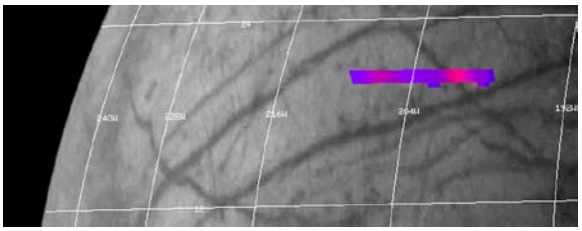

Figure 1: Context image for the NIMS long spectrometer mode observation 14ENSUCOMP03.

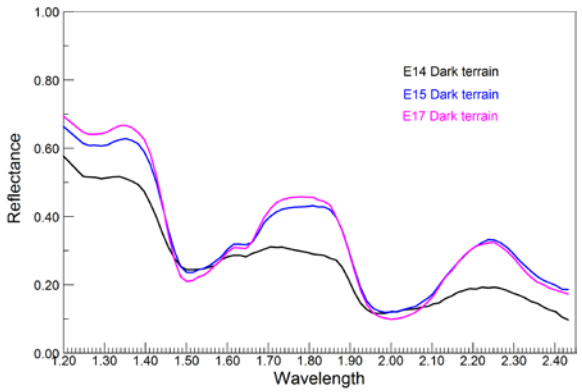

Figure 2: Sample spectra for dark linea materials from three locations on Europa.

4. Results

Detailed results of our linear mixture model runs will be presented elsewhere (Dalton et. al, in preparation). Here we summarize the principle preliminary findings. **E15**: The composition of bright plains materials at this equatorial location on the orbital leading side (7º N, 114º W) is dominated by fine-grained water ice (abundance >80%). This location exhibits a low abundance of hydrated salts and only trace amounts of hydrated sulfuric acid. **E14** (Fig. 1): A northern hemisphere location on the orbital trailing side exhibits strikingly different surface composition and surface properties for the same type of terrain. The modeled abundance of hydrated sulfuric acid exceeds 40% at this site; large-grained water ice (~250 µm diameter) dominates the ice grain size distribution. **E17**: Our third site is at high southern latitudes on the orbital leading side (63º S, 120º W). Solutions for this location exhibit high abundances of water ice (>67%) and no detectable sulfuric acid hydrate. Water ice grain sizes for this location are intermediate between those of the other locations, at 75-100 µm.

6. Summary and Conclusions

The water ice grain sizes for these three observations show a clear progression from largest in the west (14ENSUCOMP03) to smallest in the east (15ENSUCOMP01). This gradient correlates with the intensity of magnetospheric bombardment of Europa's surface as a function of location, which reaches a maximum near the orbital trailing side apex. The results are consistent with those of prior studies which have suggested that sputtering and annealing of water ice may lead to larger grain sizes in locations subjected to greater radiation levels. Our results are also reasonably consistent with prior estimates of water ice grain sizes on Europa.

Non-ice materials in dark linea and adjacent areas: Our investigation found a high abundance (>40%) of hydrated sulfuric acid at the trailing side location, which is consistent with the sulfur cycle model of Carlson et al. [3]. Only relatively minor amounts of hydrated salts (mirabilite, hexahydrite, and bloedite) were detected at the locations analyzed.

Acknowledgements

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References

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