HYDRATED MINERALS ON EUROPA'S SURFACE. T. B. McCord[1], G. B. Hansen[2], J-Ph. Combe[1], P. Hayne[1,3] [1]The Bear Fight Center, P.O. Box 667, Winthrop WA 98862 (mccordtb@bearfightcenter.com), [2]Univ. of Wash. WA, [3]UCLA Los Angeles CA.

Introduction: We have reanalyzed some of the Near Infrared Mapping Spectrometer (NIMS) data from the Galileo mission that were recently reprocessed to improve their calibration and remove radiation spikes and other imperfections [1]. Here we report on some results for two image cubes for the Galilean satellite Europa. We concentrate on the water spectral features in the 07-3-µm spectral region [2]. The NIMS Europa image cubes used here are a high resolution "postage stamp" spectral image (called e6ensucomp02c) and a low resolution image covering a wide area containing the high resolution image (e6enterinc01a) shown in Figs. 1, 2. The approximate pixel size (really IFOV) is 4.7 and 47 km, respectively, but NIMS over sampled spatially and S/C motion distorted the pixel shape.

Fig 1. The two NIMS data sets analyzed here are shown on a Europa hemisphere base image. The small, high resolution image coverage, including the intersection of two lineaments, is shown nested in the upper center of the much larger but lower resolution image coverage.

The water-related spectral features dominate the NIMS reflectance spectra in the 1-3-µm region. Analyses of these features in hemispheric-resolution telescope observations have suggested water ice/frost of several grain sizes mixed with an unknown dark material [3, 4]. From the NIMS measurements, McCord et al., [5, 6] reported highly distorted water absorptions similar to water of hydration features that are preferentially found in disrupted regions (lineaments and chaos) on Europa and they suggested the responsible material was a mixture of heavily hydrated salt minerals such as $MgSO_4$ and Na_2SO_4, perhaps from the ocean below the surface. Carlson [7] suggested hydrated sulfuric acid (H_2SO_4) as a potential single-material explanation for the spectral features and suggested an irradiation process that might convert sulfur implanted from Io in ice on Europa's surface. McCord et al. [8] then suggested that irradiation on the surface would disrupt some Na_2SO_4 (but not $MgSO_4$) [9] and that ubiquitous H^+ in the surface from ice irradiation would substitute for the lost Na^+ and produce H_2SO_4. They suggested that the NIMS spectrum was best duplicated by a mixture of Mg^{++}, Na^+ and H^+ sulfates that are heavily hydrated, supported by Orlando et al. [10], who derived a specific mixture of these components from laboratory studies.

Hydrate Spectrum: We first tried to derive the most pure (endmenber) spectrum for the hydrated material by averaging pixels in the center of the lineaments in the high-resolution data set, shown in Fig. 2. The hydrate spectrum in Fig. 3 shows the hydration features more clearly than earlier versions but no fine structure is evident, as might be expected for weakly hydrated but not heavily hydrated salt minerals [11]. There is a weak 1.344-µm feature in the hydrate spectrum that is missing in the ice spectrum. This feature is similar to one present in some hydrated salt spectra [12] but not in the published sulfuric acid spectra [13], perhaps providing further evidence for salt minerals.

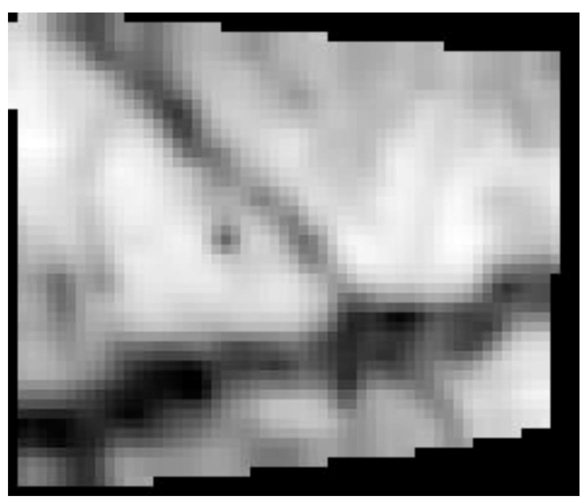

Fig 2. The 0.75-µm image from the e6ensucomp02c (high resolution) NIMS cube that was used in this analysis. Note the two, crossing lineaments and the dark circular feature left of center and just below the upward slanting lineament. The location of Europa of this image is shown in Fig. 1.

Location of Hydrated material: We also mapped the shape of the water of hydration absorption within the lineaments in the high resolution image cube. Fig. 4 shows that the shape is most hydrate-like near the center of the lineament. We show only one case and one absorption here but we attempted this for three locations and two bands with the same results.

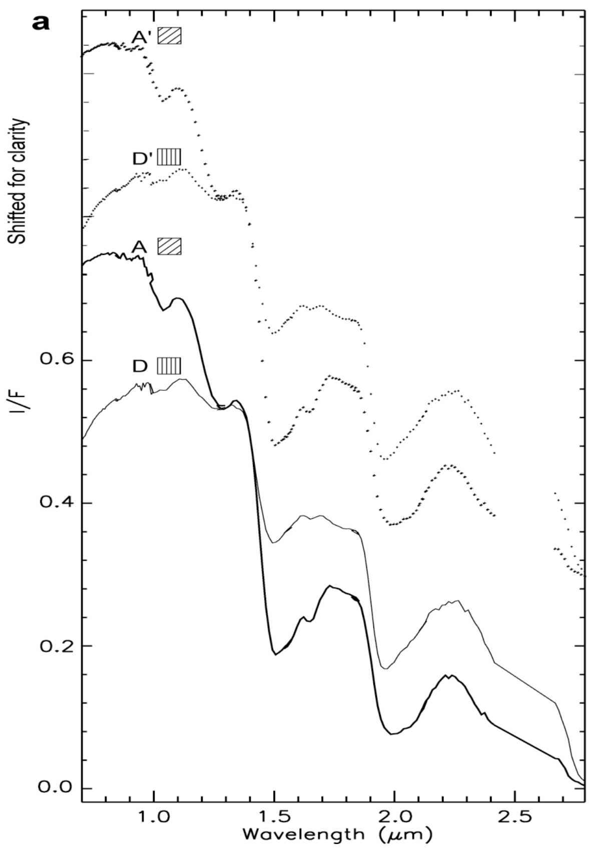

Fig 3. Shown are the endmember spectra for hydrated material and water ice derived from the high resolution NIMS data set treated here. Upper point spectra have points at the NIMS spectral channels and the lower spectra have lines connecting the upper points. A = water ice, D = hydrate material.

We also modeled both images using a spectral mixing analysis (SMA) approach [13] and found that the low resolution image could be modeled using only the two endmember spectra and their mixtures from Fig. 3, while the high resolution image required use of three additional endmember spectra. Two of these are consistent with water-frost of different grain sizes. The other endmember is found only at the dark circular spot at the left of center in Fig. 2, just below the upward-sloping lineament. This suggests different composition at this spot, which might be interpreted as a dome or pit associated with upwelling material such as from thermal convection.

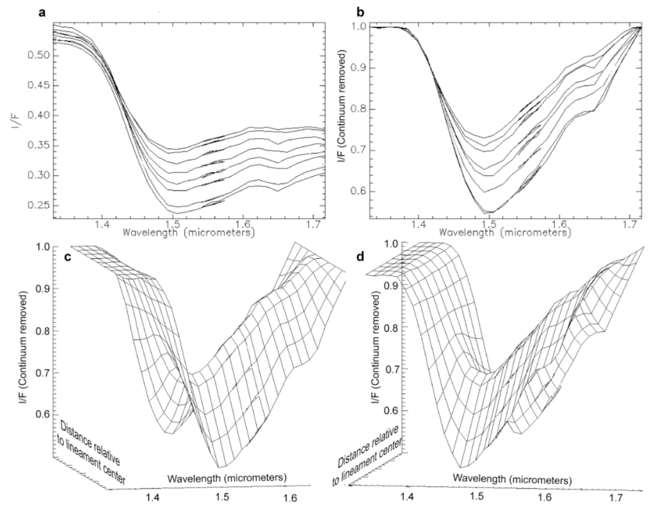

Fig 4. The change in shape of the 1.5-μm water band from ice-like to hydrate-like across the wider lineament for one transect at the lower left of Fig. 2. The spectrum in the 1.5-μm water band spectral region are shown in panel a from the reprocessed cube and in panel b with the "continuum" removed by simply fitting a straight line across the spectral region in an attempt to isolate the band shape from the overall slope of the broader spectral region. In panel c and d are three-dimensional topographic plots shown at two perspectives to illustrate the change in the 1.5-μm water band shape across the lineament. The topo plot axes are: x-wavelength, y-distance across the lineament, and z-I/F (reflectance) at each wavelength and location across the lineament. This plot attempts to illustrate the degree to which the water band has hydrate-like characteristics with location across the lineament.

References: References: [1] Hansen and McCord (2008) *GRL* 109. [2] T. B. McCord et al.(2009) *Icarus* submitted. [3] T. B. McCord (2000) *EOS* 81, 209. [4] W. M. Calvin et al. (1995) *JGR*. 100, 19,041. [5] T. B. McCord (1998) *Science* 280, 1242. [6] T. B. McCord et al., (1999) *JGR* 104, 11827. [7] R. W. Carlson et al. (1999) *Science* 286, 5437. [8] T. B. McCord et al., (2002), *JGR* 107. [9] McCord et al. (2001) *JGR* 106, 3311. [10] T. M Orlando, et al. (2005), Icarus 177, 528. [11] McCord et al., et al. (2002) *Icarus* 189, 409; [12] Dalton (2003) *Astrobio* 34, 771. [13] McCord et al., (2008) *Icarus* 194, 212. Combe et al., (2008) Pl. & Sp. Sci. 56, 951.