DISTRIBUTION OF HYDROGEN PEROXIDE, CARBON DIOXIDE, AND SULFURIC ACID IN EUROPA'S ICY CRUST. R. W. Carlson, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109 (rcarlson@lively.jpl.nasa.gov)

Introduction: *Galileo's* Near Infrared Mapping Spectrometer (NIMS) detected hydrogen peroxide [1], carbon dioxide [2, 3] and a hydrated material on Europa's surface, the latter interpreted as hydrated sulfuric acid ($H_2SO_4 \cdot nH_2O$) [4] or hydrated salts [5]. Related compounds are molecular oxygen [6], sulfur dioxide [7], and two chromophores, one that is dark in the ultraviolet (UV) and concentrated on the trailing side, the other brighter in the UV and preferentially distributed in the leading hemisphere [8]. The UV-dark material has been suggested to be sulfur [9].

Hydrogen Peroxide: H_2O_2, a photolytically unstable molecule, is continuously formed on Europa by energetic charged particle bombardment and its presence demonstrates the importance of radiolysis on Europa [1]. H_2O_2 is present in equatorial and mid latitudes on Europa's leading hemisphere. The peroxide and CO_2 distributions are correlated, consistent with experiments showing enhanced H_2O_2 production in the presence of electron scavengers such as CO_2 [10]. The presence of H_2O_2 on the leading side and its non-detection on the trailing hemisphere may be due to the greater abundance of pure ice (i. e., less hydrated material) on the leading side compared to the trailing hemisphere. Hemispherical differences in chemical impurities and the resulting radiation chemistry pathways may also be involved.

Carbon Dioxide: CO_2 is present in the equatorial region of the leading hemisphere but is not apparent on the trailing hemisphere. Band strength maps show a non-uniform distribution that correlates with dark regions on the leading hemisphere that contain the UV-bright material mentioned above. Since meteoritic infall is greatest on this hemisphere, Europa's CO_2 is suggested to be radiolytically produced in dark carbonaceous meteoritic deposits. A tenuous CO_2 atmosphere, similar to Callisto's atmosphere [11], will be produced from molecules diffusing out of the surface. Atmospheric loss rates of CO_2 are consistent with radiolytic production and meteoritic infall.

Sulfuric acid: Europa's hydrated material, assumed to be sulfuric acid hydrate that is continuously produced and destroyed by radiolysis [4,12,13] was mapped using spectral fits and measured optical constants of $H_2SO_4 \cdot 8H_2O$ and H_2O. Radiative transfer calculations for intimate granular mixtures were used to find the fraction of hydrate and the radii of ice and hydrated acid grains (Fig. 1). The distribution exhibits a strong trailing side enhancement with maximum hydrate concentrations of about 80% (by number). The hydrate concentration correlates with ultraviolet-dark material and the SO_2 concentration [14], consistent with the radiolytic sulfur cycle [4, 12]. High-resolution maps show patterns that correlate with geological features. Lineae resolved by NIMS show hydrate concentrations on the flanks, with reduced or null hydrate concentrations in the upwelled lineae material. Sublimation of water during diapiric heating of the surrounding crust can enhance sulfur and sulfuric acid concentrations and produce such correlation. The trailing side enhancement of sulfurous material suggests Iogenic sulfur ion implantation as the source. Over the 10-My age of the surface, more sulfur is deposited than is observed (as sulfate, SO_2, and sulfur) but the concentration is consistent with burial by gardening and asynchronous rotation. Endogenic sources of sulfurous material may also contribute.

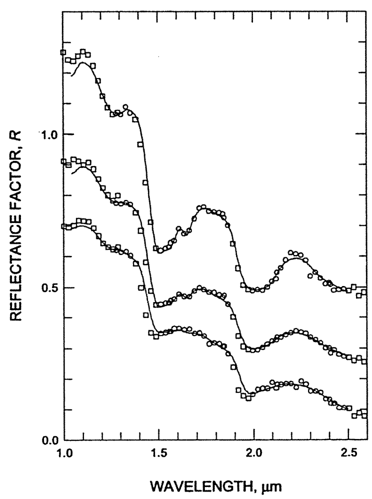

Fig. 1. Example fits to NIMS spectra. The fractional H_2SO_4 hydrate concentrations are: ~ 30% (top), ~ 50% (middle), ~ 80% (bottom).

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THE SURFACE COMPOSITION OF EUROPA: MIXED WATER, HYDRONIUM, AND HYDROGEN PEROXIDE ICE. R. N. Clark, U. S. Geological Survey, Denver, CO (rclark@usgs.gov).

Interpretations of the composition of the surface of Europa have been controversial, with different identifications resulting in correspondingly different implications for the origin and evolution of the satellite. The surface of Europa has an unusual water spectrum that has previously been interpreted as resulting from sulfate and carbonate salt minerals. However, the spectra of such minerals at the temperatures of Europa's surface have features which preclude their presence. This has led some investigators to postulate an unspecified hydrated mineral as the cause, and the term "non-icy" is now generally used to describe the Europa material. Europa's "non-icy" spectrum has also been interpreted as a sulfuric acid hydrate. Sulfuric acid hydrate spectral features are not unique to sulfuric acid, because other acids show similar features. These features are interpreted here as being due to hydronium, H3O, in the ice structure. Thus, Europa's "non-icy" material is interpreted as being due to hydronium. Hydronium ice may be caused by ionization defects in regular ice due to bombardment by magnetospheric particles, implantation of protons in the ice surface, or endogenic processes indicating an acidic ocean, or all three. Hydrogen peroxide also has been identified on Europa, and hydrogen peroxide-acid mixtures provide close matches to Europa's "non-icy" material. This too may be caused by ionization defects from the particle bombardment, or may indicate an ocean of acid and hydrogen peroxide.

Spectra of Ganymede and Callisto show spectral characteristics of the Europa water-hydronium-peroxide ice, but with less intensity and are consistent with an exogenic modification of the surfaces by particle bombardment, rather than decreasing amounts of salt and oceanic processes as one moves away from Jupiter.

Europa's "non-icy" spectra may be composed of >99% ordinary ice that has been disrupted by the particle bombardment, or an acid-hydrogen peroxide mixture composed of about 2/3 water. Liquid acid-hydrogen peroxide mixtures readily attack organic molecules, metals, and other compounds. If a lander melted this surface during its operations, the liquid could attack lander components and destroy experiments. An ocean composed of an acid-hydrogen peroxide mixture is a hostile environment for life as we currently know it.