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Surface Geology of Europa: A Window to Subsurface Composition and Habitability

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Observations from the Galileo Near-Infrared Mapping Spectrometer (NIMS) provide a wealth of spectral information on the surface composition of Europa. Recent advances in the analysis of spacecraft observations, combined with newly available reference spectra of expected chemical compounds [Dalton et al., 2005], now permit investigation of composition for individual geologic units. Some of these units appear to represent low-viscosity cryovolcanic flows, presenting substantial evidence for subsurface origin. Subsequent processing by radiolysis and photolysis (chemistry driven by high-energy particle and ultraviolet radiation) has altered the composition of these deposits since their emplacement.

It has been postulated that hydrated sulfate salts from the interior may have been converted to sulfuric acid hydrate by this exogenic processing [Carlson et al., 1999; McCord et al., 2002]. It has also been postulated that much of the observed sulfuric acid hydrate may be derived entirely from water ice and implanted sulfur ions from Jupiter's magnetosphere [Carlson et al., 2005]. Destruction of large molecules by the same radiation [Loeffler et al., 2010] however suggests that there may be an equilibrium between creation and destruction that varies based on sulfur content and radiation flux. Derivation of compositions for multiple exposures of individual surface units reveals a gradient in sulfuric acid abundance that increases from the leading hemisphere to the trailing hemisphere, which receives a higher radiogenic dose.

Certain geologically young cryovolcanic flow surface units exhibit comparatively higher proportions of hydrated salts (with correspondingly lower abundance of sulfuric acid hydrate) than is found for older surface units of the same type, or for surface units of different geologic origin. Taken together these lines of evidence suggest that in at least some of these units, we are observing an intermediate stage of the conversion of endogenically-produced sodium and magnesium sulfate salts into sulfuric acid hydrate by exogenically-driven radiolysis. This is the first step in unraveling the relative influence of exogenic and endogenic processes in determining the composition of Europa's surface deposits.

The apparent presence of large quantities of brine and sulfate salts in certain deposits [Shirley et al., 2010] suggests that these deposits may reflect the composition of subsurface liquid reservoirs that produced these deposits. We will report on variations in composition of various surface units and inferences of interior chemistry based on our spectral analysis. This information will be useful for planning of future missions that will have the capability to further discriminate between these materials and provide additional constraints on habitability of the subsurface.

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