Radiolytic Influence on the Surface Composition of the Galilean Satellites

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The Galiliean satellites are bombarded by energetic particles that profoundly affect the surface composition. Reactive sulfur is implanted from the Iogenic plasma, and new chemical species are produced by radiolysis. Characteristic times for radiolytic destruction are very short compared to geological time scales, and the depth of direct radiolytic influence is ~ 1 mm, comparable to the depth of the optically observed layer. We summarize the compositional measurements by Galileo's Near Infrared Mapping Spectrometer (NIMS) and others, and discuss the influence of radiolysis on the surface composition.

Radiolysis and implantation strongly affects Europa's surface. The lifetimes for destruction and production range from a few years to about 3,000 years for the most radiation resistant materials (e. g., sulfates). The radiolytic products hydrogen peroxide and molecular oxygen are present, as well a hydrated material that exhibits a strong trailing side enhancement. We identified the latter as hydrated sulfuric acid and proposed that it is part of Europa's radiolytic sulfur cycle, wherein elemental sulfur, sulfur dioxide, hydrogen sulfide, and sulfuric acid are in dynamic equilibrium between continuous production and destruction. A dark material is spatially associated with hydrated sulfuric acid suggested to be radiolytically produced sulfur allotropes. Ion implantation can provide the observed amount of total sulfur in about 30,000 years, suggesting that burial by impact gardening may be occurring. The variegated surface coloring may be due to diapiric heating of the surface, which sublimates water and preferentially concentrates sulfurous material. Endogenic sources of sulfurous material may also contribute to the surficial sulfur compounds.

Io is resurfaced by volcanic effluents (sulfur and sulfur dioxide) at a rate comparable to radiolysis rates, so the major species detected is SO_2. However, a material that absorbs in the 1 to 1.5 μm region is present and concentrated in the dark polar regions. We suggest that this material is short-chained sulfur allotropes or sulfanes, produced in the radiolysis of SO_2.

Ganymede contains O_2 in its surface and atmosphere, likely produced from the radiolysis of H_2O. Both Ganymede and Callisto show surficial CO_2, and a corresponding CO_2 atmosphere has been found on Callisto. The trailing side enhancement of surficial CO_2 on Callisto suggests that charged particle impact generates CO_2 or modifies its retention in the surface.