EUROPA: GEOLOGIC IMPLICATIONS OF SPECTROPHOTOMETRY;

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Detailed photometric measurements are particularly useful for helping to interpret surface features on poorly-imaged planets like Europa because the definition of most surface units is based on color and albedo. Lucchitta and Soderblom (1) used Voyager 2 multispectral images to make a limited number of measurements (3 to 9 per spectrum) of the spectral reflectance of 6 color units on Europa. In this abstract we apply an extensive data set of roughly 500 detailed photometric measurements from Voyager 2 images to the geologic interpretation of 6 mapped geologic units and 3 types of lineations on Europa.

Eight high resolution (~4.5 km/pixel) Voyager images were used to measure camera calibrated I/F in the ultraviolet, violet, blue, and orange filters. Each measurement consists of the average I/F values within a 3x3 pixel box (unless the tectonic lineation was too narrow). Minnaert's photometric function was fitted by a non-linear least squares method to the measurements for each geologic terrain in each filter:

$$I = F\, B_o\, \mu_o^{k}\, \mu^{k-1}$$

where I is the specific intensity, $\pi F$ is the incident solar flux, $\mu_o$ and $\mu$ are the cosines of the incidence and emission angles, k is the limb darkening parameter, and $B_o$ is proportional to the albedo of the surface. For a phase angle of zero degrees and $\mu_o$ and $\mu$ equal to unity, $B_o$ equals the normal reflectance.

The terrain-averaged measurements fall into two distinct groups: dark, red spectra and light, bluer spectra. The former group, which includes the brown spots, wedge-shaped bands and gray bands, show a shallow increase in reflectance from the ultraviolet to the violet, followed by a uniformly steep increase to the orange wavelength. The light group of spectra which consists of data from mottled gray and brown terrains, bright, dark, and fractured plains, and triple bands all show a steeper increase in the ultraviolet to violet with progressively smaller increases from violet to blue and blue to orange (a convex upward curve). This light group has 3 units (mottled brown terrain, fractured plains, and triple bands) that are slightly darker at all wavelengths.

These observations are consistent with the hypothesis (1) that the plains units (lightest) are fractured and the fractures locally infilled with dark material similar to that constituting the brown spots and wedge-shaped bands. This process of disruption results in slightly darker light terrains (e.g. mottled brown terrain and fractured plains). Triple bands appear lighter than brown spots and wedge-shaped bands due to their central bright stripe.

Histograms of the albedo (Minnaert's $B_o$) in the orange and violet filters show the variation in albedo for these geologic units and lineations. The lowest albedo features are the brown spots. The albedo range of the wedge shaped bands extends from a region which overlaps with the brown spots into a

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region which overlaps the generally brighter triple bands. The mottled gray and brown terrains and fractured plains overlap the albedo range of the triple bands. The dark plains and the fractured plains are the darkest of the plains units.

The overlap in the albedos of the brown spots, wedge-shaped bands, and triple bands is consistent with the latter two features being fractures in-filled with dark silicate-rich ice equivalent in albedo to the dark spots. The albedo distribution of the plains and terrains is similarly consistent with progressive darkening by the addition of fractures filled with this lower-albedo material.

Twelve detailed albedo scans were made across wedge-shaped bands and triple bands. All seven scans across the triple bands show the general decrease in albedo associated with the dark flanking stripes; six of these show a distinct increase in albedo at the central pixel that corresponds with the central bright stripe. This increase is almost to the level of the surrounding plains, which implies they are composed of similar materials. The slightly lower albedo recorded by the middle pixel is due probably only to part of the pixel falling on the adjacent dark band. All five scans across the wedge-shaped bands show the expected darkening within them. Two of these profiles also show an increase in albedo at the center of the structure, similiar to that recorded for the triple bands. For approximately half of the triple bands, the orange to violet ratio increases across the dark flanking stripes, then at the central stripe decreases to a value equivalent to that of the surrounding plains material. The other half, however, show only an increase in the ratio within the band. The orange/violet albedo ratio scans across the wedge-shaped bands generally show an increase. In addition, two or three of these show a decrease in the ratio within the center of the structure, similiar to some of the triple bands. These profiles indicate that many wedge -shaped bands may, in fact, be triple bands whose bright central stripes are below the resolution of the Voyager images.

The similarity in albedo scans across wedge-shaped bands and triple bands indicates that both are similiar types of structures, perhaps flooded grabens and flooded grabens with uplifted horsts as suggested by Golombek and Bruckenthal (2). The similarity in albedo between the central bright stripe of the triple bands and the surrounding plains implies that the center of the triple band is structurally dislocated plains material, consistent with them being uplifted horsts (2), or high albedo clean ice, consistent with them being subsequent clean ice extrusions (3).

References:

(1) Lucchitta, B.K., and L.A. Soderblom (1982) in Satellites of Jupiter, D. Morrison, ed., U. Ariz. Press, p. 521-555.

(2) Golombek, M., and Bruckenthal, E. (1983) Lunar Planet Sci. XIV, 251-252.

(3) Finnerty, A.A., G.A. Ransford, D.C. Pieri, and K.D. Collerson (1980) Nature, 289, 24-27