GANYMEDE AND CALLISTO: IMPACT CRATER EJECTA TYPES;

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Ejecta types on Ganymede and Callisto have been identified from Voyager 1 and 2 images. Image resolutions used in this study range from ~0.6 to ~3 km/pxl for Ganymede, and from ~1 to ~4 km/pxl for Callisto, which allowed us to survey almost all of the mappable surface of the two satellites.

Seven ejecta classes have been identified on Voyager images of Ganymede on the basis of albedo pattern and type of terminus. Type G1 is pedestal ejecta, as described by Horner and Greeley (1). The distinctive characteristic of this ejecta class is the sharp, convex terminus. The albedo of the ejecta appears to be slightly higher than the surrounding terrain, yet underlying topography can be discerned. At terrain boundaries, the ejecta is sometimes truncated, with a diffuse deposit appearing beyond the boundary at about the same distance as an extrapolated pedestal ejecta boundary (2). Type G2 ejecta has a uniformly high albedo, with a sharp outer albedo boundary. Type G3 has a moderate to high, mottled albedo and a gradational terminus. Type G4 is similar to type G3, except that it is an outer ejecta unit. Inner ejecta classes are predominately from types G1 and G2. Type G5 ejecta is identified only by changes in surface texture circumferential to the crater and a gradational terminus. Type G6 is similar to G5 except for a sharp ejecta boundary. Type G7 represents low albedo ejecta discussed previously by Schenk and McKinnon (3). Type G8 represents ejecta on the grooved terrain with diffuse termini and albedos which are just slightly higher than the surrounding terrain.

The effects of different terrains on ejecta characteristics were investigated for the most populated ejecta types - G1, G2, G3, and G4. Using power law regression calculations to the equation (ejecta diameter) = 10^a x (crater diameter)^b, it was observed that neither of the coefficients changed significantly for any ejecta type between the grooved and dark terrains. Thus ejecta extent is apparently unaffected by terrain units. There is some relationship of ejecta type to terrain unit: type G3 is observed more often on the cratered terrain, and pedestal ejecta (G1) is more prevalent within the grooved terrain. However, contrary to a previous study (5) craters with pedestal ejecta are present in significant numbers in the cratered terrain, representing ~15% of all craters with measurable ejecta within that unit.

On the basis of the power law regression calculations, crater ejecta on Ganymede can be divided into two classes; ejecta types with $a>0.4$, and those with $a<0.4$. Ejecta types with $a<0.4$ - types G1, G2, and G6 - are tightly clustered along the best fit curve to the data. Ejecta diameters for classes with $a>0.4$ - types G3, G4, G7, G8, and G9 - show more variation with respect to crater diameter, although power law fits are also valid for these data. Ejecta type G5 fits neither catagory. Because of its appearance and as it is observed predominately near the terminator, this class may represent G3 ejecta which is sufficiently eroded be observable only near the terminator. Slopes for these classes are all within ±0.05 of the value $b=1.01$ derived for post-Orientale lunar craters (6).

Differences in ejecta appearance as a function of sun angle may also explain why relatively few pedestal craters are seen on the cratered terrain. For both the grooved and cratered terrains, there is a reciprocal shift in the percent occurrence of ejecta types G1 and G2 with sun angle. For sun angles of 70°-90° (near the terminator) on the grooved terrain, ~50% of all ejecta types are G1, and ~10% are type G2, whereas for sun angles of 30°-50°, only ~10% are type G1 and ~30% are type G2. On the cratered terrain, for sun angles of 70°-90°, 25% of all ejecta types are G1 and ~10% are type G2, whereas for sun angles of 30°-50°, ~10% are type G1 and ~35% are type G2. As it was shown above that ejecta types

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G1 and G2 have similar morphometries, it seems plausible that at high sun angles, pedestal crater ejecta appears as a uniformly bright annulus with a sharp albedo edge. If ejecta type G2 is included as possible pedestal craters, the average percentage of pedestal ejecta to other ejecta types on the cratered terrain increases to ~33%.

Two major ejecta types have been identified on Callisto: both have counterparts on Ganymede. Type C1 has a uniformly high albedo and a sharp terminus. On Ganymede, this ejecta type (G2) may represent pedestal crater ejecta seen at moderate to high sun angles, but no pedestal craters have yet been positively identified on Callisto. Type C2 is has a gradational terminus and a moderate albedo: it is similar to ganymedean ejecta type G3. As on Ganymede, Type C2 ejecta is more extensive than Type C1 ejecta, although the differences are not as great. The calculated values of coefficients a and b are different for the callistoan ejecta types compared to those on Ganymede. However, as plots of the best statistical fits to these data are similar to those of the two major ejecta groups on Ganymede, the coefficient values may be partly the result of the small number of craters with measurable ejecta identified thus far on Callisto. No craters with dark rays or ejecta similar to those on Ganymede have been observed on Callisto; however, the low surface albedo would render them almost unidentifiable.

The similarity in ejecta types on Ganymede and Callisto may indicate similarities in the near-surface environment of the two satellites, with different ejecta types representing several possible conditions for the impact environment. Although the hypothesis that pedestal formation requires target viscosities lower than the cratered terrain (5) is intriguing, the identification of ejecta types G1 (1) and G2 on the cratered terrain of Ganymede, as well as the discovery of an ejecta type on Callisto (C1) similar to type G2 on Ganymede, indicate that this hypothesis is untenable. The diffuse bright ejecta may indicate transport ballistically and/or by vapor expansion (7). Morphological studies indicate that pedestal crater ejecta, and by extension, ejecta with a high albedo and sharp terminus, may be a more dense, ground-hugging mixture of vapor, ice and silicate fragments (1,2). However, whether these conditions result from different projectile characteristics or target properties, such as layering (8), is still undetermined.

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