DARK HALO CRATERS AND THE THICKNESS OF GROOVED TERRAIN ON GANYMEDE,
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Dark halo craters in grooved terrain on Ganymede represent potential probes of the subsurface geology of Ganymede. Parmentier et al. (1) have suggested that bright grooved terrain may have formed by the flooding of graben within older and darker cratered terrain. If the flooded material is thin enough, craters forming in it may have excavated darker cratered terrain material from below the brighter grooved terrain unit, incorporating the dark material into its ejecta. As the bright ray and rim materials equilibrate with the space environment (approach the albedo of undisturbed grooved terrain), the darker material in the ejecta will remain as a darker albedo ejecta deposit; i.e., dark halo craters. The existence of a transition diameter between craters that do and do not excavate into the buried darker cratered terrain should therefore provide an estimate of the thickness of the flooded material, if this model is valid. We assume that the low albedo is not a photometric effect.

Dark halo craters (DHC) are surrounded by broad, circular, low albedo deposits interpreted here as ejecta (Fig. 1). As such, they are distinct from dark ray craters. Dark ray craters and those with bright deposits were not considered because of the ray deposits. DHCs have been identifiable in most large tracts of grooved terrain, ~55% are concentrated within Uruk Sulcus, the zone of grooved terrain immediately southwest of Galileo Regio. As these are also the most distinct DHCs, this became our study area. This bias toward Uruk Sulcus may be real but is probably due to the lower resolution and contrast inherent in Voyager 1 frames and unfavorable lighting and viewing geometries in other areas. Polar frosts and ray crater deposits may locally mask DHCs. Fig. 2 shows the linear relationship between crater and halo diameter with a slope of ~0.34, consistent with an interpretation as ejecta.

Terrestrial crater studies and experiments (2,3) suggest that the depth of excavation (de) is related to the transient crater diameter (Da) by the following:

\[ \text{de} \propto (0.1 - 0.15)\text{ Dt} \]  

We assume that final observed diameter (Df) is on the order of 1.3 times the transient diameter (4) but we recognize that it is ultimately model dependent. Combining the two equations gives:

\[ \text{de} \propto (0.08 - 0.12)\text{ Df} \]  

The proportionality constant may be as low as 0.06 (3), but this will not substantially alter our result. In our model, the measured diameter of the smallest DHC should yield the maximum depth the buried material can be and still be incorporated into the excavation cavity of the crater. We assume the buried material lies at reasonably constant depth throughout Uruk Sulcus. A frequency diagram (Fig. 3) reveals that, for Uruk Sulcus, the smallest detectable DHC is ~8 km across. The DHCs between 8 and 10 km are clustered together in one area and may mark an area of unusually thin material; thus 12 km is taken as the transition diameter for Uruk Sulcus. Substituting into eq. 2 yields a thickness of 0.96 to 1.44 km for the 12 km craters; 0.64 to 0.96 km for the 8 km craters. As the transition diameters is a maximum (due to limited resolution), the above estimate of grooved terrain thickness is also a maximum. Our results indicate that the resurfacing implied by grooved terrain is thin (on the order of 1 km), and are consistent, at least in part, with models of grooved terrain as graben, as some morphological observations suggest, and that large scale foundering or stoping of Ganymede crust did not occur. These conclusions are of course limited to Uruk Sulcus.
and work is continuing on other areas of grooved terrain.


Fig. 1 Dark halo craters (arrows) in Uruk Sulcus. Scene is approximately 800 km across. Voyager frame number 0470J2-001.

Fig. 2

Fig. 3

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