GEOLOGY OF LARGE IMPACT BASINS ON GANYMEDE AND CALLISTO;

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Impact craters on the icy Galilean satellites are characterized by an astonishing variety of unique morphologies, which are clearly related to impact in ice. New stereo images of Ganymede and Callisto have recently been constructed that considerably improve geologic mapping and interpretation. Recent studies of craters on Ganymede have suggested that internal structure or composition may be important in controlling crater morphology. Basin scale structures should probe these satellites to significant depths. In light of these recent advances, as well as the approaching Galileo tour, we have completed the first systematic geologic study of large impact structures on these bodies since 1982 [1].

PALIMPSESTS

Palimpsests are circular high-albedo, very low relief structures [e.g., 1, 2], found exclusively on older dark terrain. Diameters range from 90 to 380 km. The largest, Memphis Facula (R~175 km) has a distinct, 100 m high, topographic edge with a locally lobate planform (Fig. 1). This edge is interpreted as a 'flow front' based on relationships with preexisting terrain. A second similar topographic step occurs interior to this margin and separates regions of different brightness. A complex sequence of bright flows is suggested. Otherwise, very little relief is visible in palimpsests in stereo, and no mappable ejecta or secondary deposits have been identified. Circularity and the presence of concentric scarps are the only indication of impact origin. Only a few palimpsests are visible on Callisto, despite the greater age of that surface.

PENEPALIMPSESTS

Similar to palimpsests, these structures have greater topographic relief and are surrounded by obvious secondary craters and ejecta. They are also seen on all terrain types and postdate bright terrain formation. They appear to be absent on Callisto except for three poorly observed candidates [3]. Prominent concentric ridges surround a central smooth area, although it is difficult to identify which ridge is the rim. If anything, these structures are slightly elevated above the surrounding plains. The inner limit of the secondary fields roughly coincides with the outer margin of the bright hummocky deposit, indicating that the high-albedo deposit is analogous to the continuous ejecta deposit. From the observed ejecta scaling law for Ganymede [4] we can then estimate the original rim diameter for many penepalimpsests.

BASINS: *Gilgamesh*

Outward from the center, Gilgamesh (Fig. 2) can be divided into several units: a smooth central depression (which may be partially volcanic in origin [5]), a 200 km wide zone of quasi-concentric discontinuous ridges, an outer somewhat continuous scarp (R~290 km), a hummocky continuous ejecta blanket (R~520 km), and a zone of secondary craters and chains. The dimensions of the ejecta blanket [4] confirm that the outer scarp at R~290 km is probably the crater 'rim', and is the equivalent to the Cordillera in the Orientale Basin. One distal graben-like ring at R~275 km, resembles Valhalla type rings. The complete absence of secondaries to the west indicates this was a very low angle impact.

BASINS: *Valhalla*

Valhalla is the largest impact structure on the icy satellites and consists of three mappable zones: a central bright deposit, a 600 km wide inner zone of v-shaped ridges, and an extensive outer zone of grabens and scarps that extends to 2000 km from the center. The central bright deposit (mistakenly referred to as a palimpsest), has lobate to digitate margins, and appears to lie over and partially bury ridges, some of which are seen as dark material within the deposit [3]. A number of hills are seen in the central area in stereo.

The ridge and graben zones are geologically complex. Obscuration of impact craters puts the nominal crater rim of Valhalla somewhere inside the inner ridge zone (and continued stereo mapping may lead to a formal diameter estimate). Extrusive deposits are seen at the bases of some outer scarps and in the centers of many graben as well, consistent with ring tectonic theory [6].

LARGE IMPACTS ON GANYMEDE AND CALLISTO

Interpretation of the cratering record is complicated by 3 factors: the low resolution and variable lighting conditions inherent in Voyager images, and the apparent variation of crater morphology with time on Ganymede and Callisto as the lithosphere cooled. Lighting conditions are important because of the inherent low relief of all craters on Ganymede [7]. Punt Facula, for example, was viewed under very high sun conditions, but when inspected is seen to be an ordinary central pit crater very similar to Osiris.

Penepalimpsests, although they are younger than smooth terrain, tend to have more superposed craters than most large craters. Penepalimpsests for which we have diameter estimates tend to be similar in size to regular central pit craters such as Osiris and Melkart. The degraded rim topography clearly indicates a much weaker lithosphere. The significance of palimpsests is more difficult to determine until higher resolution images are obtained (which is true of all cratering on the icy satellites).

Among recent proposals to explain palimpsests and central pits craters are that anomalous bright material exposed in these features is relatively 'clean' ice mobilized from depth [e.g., 2, 8]. The impact structures described may represent a continuum in time and size, which indirectly record the state of the lithosphere of these bodies, and the mobility of this layer. In this work, we explore these issues and attempt to construct a unified cratering theory for the icy satellites that can be tested during the upcoming Galileo orbital tour.

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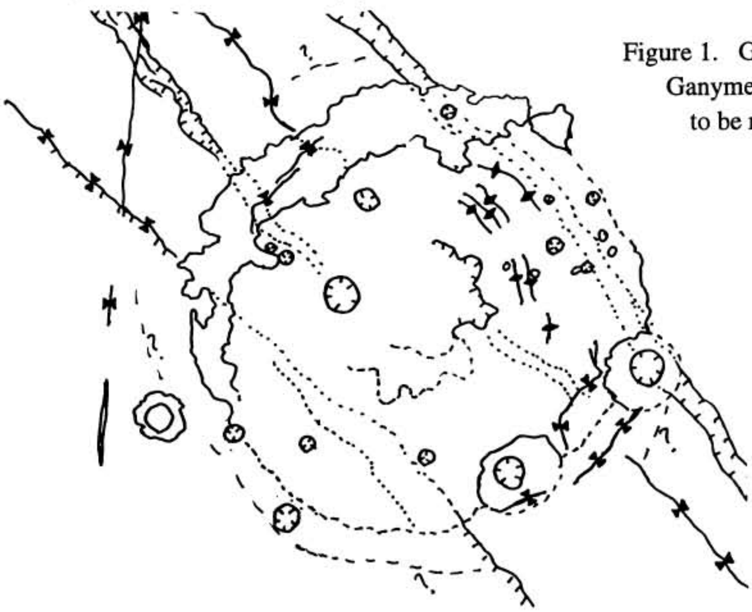

Figure 1. Geologic map of Memphis Facula (D~350 km), Ganymede. The outer portions of this structure appear to be relatively thin deposits that blanket preexisting terrain and structures [2, 9].

Figure 2. Geologic map of Gilgamesh, Ganymede. The radius of the continuous ejecta deposit (outer solid line) is ~520 km.