Tectonism and Volcanism in Ganymede's Dark Terrain; S.K. Croft and B.N. Goudreau, Lunar and Planetary laboratory, University of Arizona, Tucson, Arizona 85721

The surface of Ganymede has long been recognized to consist of two basic terrains (1): the heavily cratered dark terrain, and the less cratered light terrain. Tectonics and morphologies on the two terrains are markedly different. Early attention was focused largely on the light terrain, perhaps because of the more spectacular tectonic formations in the light terrain and the larger spread in crater densities in the light terrain compared to the dark terrain suggesting a longer and more interesting period of geologic activity (fluid resurfacing and fracturing). Attention in the dark terrain was centered largely on the enormous arcuate furrow system in Galileo and Marius Regiones, which was suggested to be of impact origin (1,3). More recent studies of the dark terrain (4-7), however, have begun to delineate the great complexity of the dark terrain in both its tectonic and volcanic histories. We report here the recent results of our continued study of Ganymede's dark terrain.

Furrows. We have surveyed the morphology and occurrence of "furrows" (defined here as any elongated depression) globally on Ganymede's dark terrain. We have recognized seven major classes and several subclasses: class 1: Galileo Regio curvilinear furrows; 2: N. Marius Regio curvilinear furrows (classes 1 and 2 were noted by (8)); 3: linear graben-like depressions with no rim structure-type area E. Barnard Regio; 4: groove-like depressions including subclasses a: primary groove-like wholly within dark terrain; b: primary groove-like traversing light-dark borders ("throughgoing" grooves), c: "groove set" type, virtually identical in geometry and spacing to groove sets on light terrain; 5: meandering furrows with rough, irregular rims - type area near 220°W long. and 0° lat. (9); 6: sinuous furrows reminiscent of linear sinuous rills - type area NW of Melkart, and 7: rectilinear furrows that are short and straight - type area reticulate terrain of Galileo Regio bordering Uruk Sulcus. Types 1-3 and 4c tend to occur in sets with characteristic widths and spacing. The other classes tend to occur as isolated examples. New measurements of the spacing in the first three classes of furrows confirm preliminary measurements (5) that spacing between furrows fall near 40-50 km in the three large circular regiones (Galileo, SE Nicholson and S.W. Marius, stipple pattern in figure 1) and near 15-20 km in the "linear" regiones (NE Marius, NW and W Nicholson, and Bernard, vertical line pattern in figure 1) and the smaller "islands" (e.g., SE of Osiris). Regional strikes of furrow sets change discontinuously over short distances in some areas, usually accompanied by a change in morphology, e.g. across Tiamat Sulcus, across Mysia Sulcus, and near Erech Sulcus in eastern Marius Regio (near the postulated center (1,8) of the Galileo-Marius furrow system). Such abrupt changes in strike imply numerous regional stress domains. The multiplicity of "furrow" morphologies implies the existence of several furrow-producing mechanisms.

Crater Densities. The range of crater densities is smaller in the dark than in the light terrain, yet variations of factors of 2 exist in adjoining counting areas ($\approx 10^5$ km^2) in Galileo Regio (see Table 13.1 in ref. 2). Unfortunately, confidence in these variations is low because of the small size of the counting areas which allows for significant variations of a purely statistical nature. Variations in crater density correlated with surface texture were suggested by (7). New crater counts have been done in Galileo and NE Marius Regiones specific to areas that have been mapped as

separate geologic units (4,7). Significant depletions of smaller craters have been found in the dark smooth terrain (see ref. 4) of Galileo Regio bordering Uruk Sulcus between 140° and 150° long. (depletion below ≈ 15 km diameter) and in central NE Marius Regio between Thebes Facula and Erech Sulcus (depletion below ≈ 25 km). The nature of the depletions are similar to those of lunar crater populations on the maria where smaller craters have been eradicated by flooding. The edges of the areas of depleted crater counts are poorly defined and exhibit no recognizable flow fronts. Thus the resurfacing fluid was of low viscosity, probably muddy water. Interestingly, the sinuous furrows occur within the resurfaced area of central NE Marius Regio, suggesting that these unusual features may in fact be volcanic rather than tectonic in origin.

Discussion. The dark terrain on Ganymede thus appear to be a complex of different tectonic regions and volcanic units. While our data do not solve the problem of internal vs. impact origin for the Galileo-Marius furrow system, we note that furrows of orientations discordant with the concentric system occur near the geometric center of the system, and we find no evidence of a central structure reminiscent of Valhalla. Further, class 1 furrow systems in Nicholson Regio strike about 45° away from the strike expected from a global extension of the Galileo-Marius system, suggesting either multiple impacts (not unlikely) or multiple internal stress regimes (also not unlikely). On the other hand, we find the greatest variety of furrow morphologies and unusual geologic structures in the vicinity of the system center, indicating a site of unusual geologic properties perhaps associated with some incredibly modified impact site or unusual heat sources in the deep interior.

References

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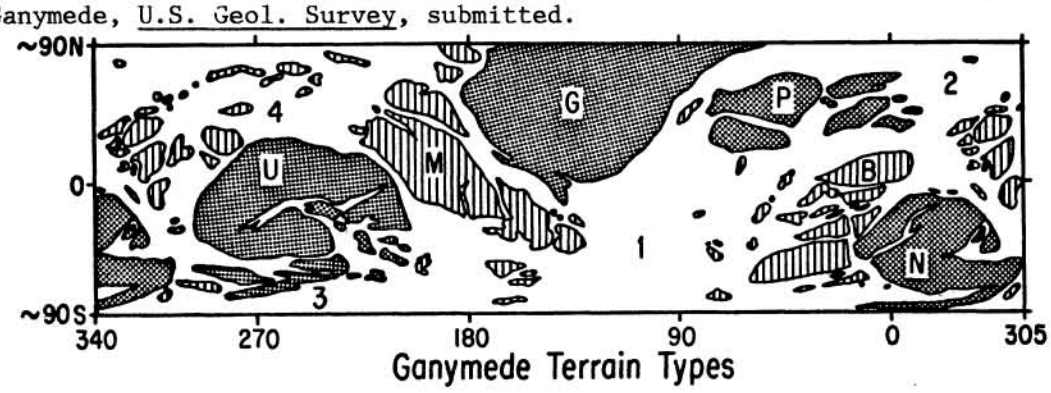

Figure 1. Sketch map of dark terrain on Ganymede. G = Galileo Regio, N = Nicholson R., U = SW Marius R., M = NE Marius R., B = Bernard R., P = Perrine R.. #'s refer to large continuous areas of light terrain.