CRATER-DENSITIES AND CRATER-AGES OF DIFFERENT TERRAIN TYPES ON GANYMEDE. Scott L. Murchie and James W. Head, Dept. of Geological Sciences, Brown University, Providence, RI 02912; Jeffrey B. Plescia, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001.

Introduction. Voyager images of Ganymede reveal two basic surface material units, older, heavily cratered dark material and stratigraphically younger, less cratered light materials that dissects the dark material into large polygons [1,2]. The general nature of the crater populations on these materials has been documented [3-5], and crater-ages of many areas have been calculated [6,7] on the basis of a model history of the flux of heliocentric impactors [8]. Large areas of dark material were found to have model ages of 3.8-4.0 Gyr, and younger light materials to have local crater-ages ranging from 3 to 3.8 Gyr [7].

These two material units have been subdivided into several terrain types on the basis of pervasive surface morphology. Large dark polygons have been recognized to possess both a dark furrowed unit cut by parallel troughs, and a dark, smooth, possibly resurfaced unit [9,10]. Some small dark polygons and restricted areas of light material, both cut by orthogonal sets of linear troughs, have been identified as a distinct terrain type called "reticulate terrain" [2,7,9,11,12,13]. Light material is typically pervasively cut by linear grooves, forming "grooved terrain," and on the basis of the presence and spatial pattern of grooves has been divided into four terrain types in addition to reticulate terrain [12,13]: (a) smooth terrain; (b) "groove lanes," elongate linear bands of grooves; (c) "grooved polygons," polygonal domains of parallel grooves; and (d) "complex grooved terrain," possessing complexly crosscutting groove sets. Observed complex grooved terrain is largely confined to the area of 0-40°S, 100-140°W. Smooth terrain, groove lanes, and grooved polygons together comprise nearly all observed light terrain [12]. Stratigraphic relations indicate that both reticulate terrain and complex grooved terrain are relatively older than other types of light and grooved terrain [11,13]; that smooth terrain has a variable age relative to groove lanes and grooved polygons [12,13]; and that groove lanes commonlyy have younger surfaces than do grooved polygons [13]. Crater-densities have been measured on a number of areas of smooth terrain across the satellite, and reveal that it is on average younger than light material possessing grooves [4]. However, crater-densities have been measured separately for some terrain types only in restricted locations [9,10,13], and have not been measured on all terrain types.

In this study we have measured crater-densities and calculated crater-ages of separate occurrences of dark furrowed terrain, dark smooth terrain, reticulate terrain, and complex grooved terrain, and a sample of groove lanes and grooved polygons having stratigraphic relations indicative of a variety of relative ages. We use these measurements and calculations to characterize the global stratigraphy of Ganymede's terrain types through the early stages of light material emplacement, and to assess various hypotheses of the origins of these terrain types. Cumulative densities of $\geq$10-km diameter craters and calculated crater-ages are given in Figure 1.

Reticulate terrain and complex grooved terrain. The two major observed occurrences of reticulate terrain, at the southern edge of Galileo Regio [9,12] and at the southern margin of Marius Regio [7,12], both have model ages of 3.8 Gyr. This crater-age is at least as old as that of all light materials measured by us or by Shoemaker et al. [7], and is only slightly younger than the age of the youngest observed dark furrowed and dark smooth terrains (in western and southern Galileo Regio respectively). The greater crater-age of reticulate than light terrain is consistent with its greater relative age inferred on the basis of stratigraphic relations [11,13].

Complex grooved terrain has a slightly younger model age, 3.7-3.8 Gyr, but is still older than most or all other light terrains. Only south polar light terrain [7] has a comparably high crater-density, but many of its craters appear embayed by the light material and are crosscut by grooves, suggesting the craters' inheritance from an older surface.

Dark furrowed and dark smooth terrains. Areas of dark furrowed and dark smooth terrain have crater-ages ranging from 3.8 to 4.1 Gyr. Crater-ages are generally greater in the trailing than leading hemisphere, as has previously been recognized [3,5,6]. However, there is *not* a smooth increase in crater-age from the apex to antapex of orbital motion, as has been suggested and interpreted to indicate control of solidification of the lithosphere by ancient impacts [6]. For example, southern Galileo Regio and eastern Marius Regio are at similar distances from the apex, but their crater-ages differ by 10^8 yrs; northwestern and southeastern Nicholson Regio are also at similar distances from the apex, and their crater-ages differ by 1-2 x 10^8 yrs.

Furrows occur in the anti-Jovian hemisphere on surfaces ranging in crater-age from 3.8 to 4.0 Gyr, and in the sub-Jovian hemisphere on surfaces ranging from 3.9 to 4.1 Gyr in age. In only one restricted location (part of southeastern Marius Regio) does a large number of the furrows crosscut preexisting craters. These results indicate that furrow formation occurred over 2-3 x 10^8 yrs on fresh, relatively crater-free dark materials, and that itwas not entirely the result of one or two hypothesized cataclysmic impacts [2,6,7,14,15].

Crater-densities were measured on four major occurrences of dark smooth terrain, in southern Galileo Regio [9], central Marius Regio [10], southwestern Marius Regio, and northwestern Nicholson Regio. Each of these deposits possesses a sinuous or diffuse contact with adjacent dark furrowed terrain (western Galileo Regio, western Marius Regio, or southeastern Nicholson Regio), suggesting superposition of the smooth material. In all four cases, the dark smooth terrain has a younger crater-age than the adjacent furrowed terrain. In addition, as has been previously documented [9,10], the dark smooth deposits are typically depleted in craters $\leq$20 km in diameter compared to the furrowed terrain. These results support the hypothesis that the dark smooth materials were emplaced during periods of thin volcanic resurfacing of an older cratered surface [9,10]. Alternatively, it has been suggested [15] that dark smooth terrains in southern Galileo Regio and central Marius Regio are the ejecta of a giant impact feature. The $\geq 10^8$-yr age difference of the two areas of dark smooth terrain is inconsistent with this hypothesis.

Summary. Crater-densities were measured and crater-ages were calculated for several terrain types of Ganymede, in order to characterize the global stratigraphy of the satellite's older surfaces and to test various hypotheses of the origins of these surfaces. We find that both dark terrain and its furrows formed over 2-3 x 10^8 yrs, from 3.8 to 4.1 Gyr ago. Furrows formed thoughout this period, not solely as the result of one or two cataclysmic events, and were buried in large areas by dark, probably volcanic resurfacing materials. Reticulate terrain was deformed immediately following the end of dark material emplacement, about 3.8 Gyr ago, before significant light materials had been emplaced. Some of the oldest light material, about 3.7 Gyr in age, occurs in a restricted area as a distinct terrain type ("complex grooved terrain"). Following formation of the latter type of surface, the bulk of light and grooved terrain was emplaced as smooth terrain, groove lanes, and grooved polygons.

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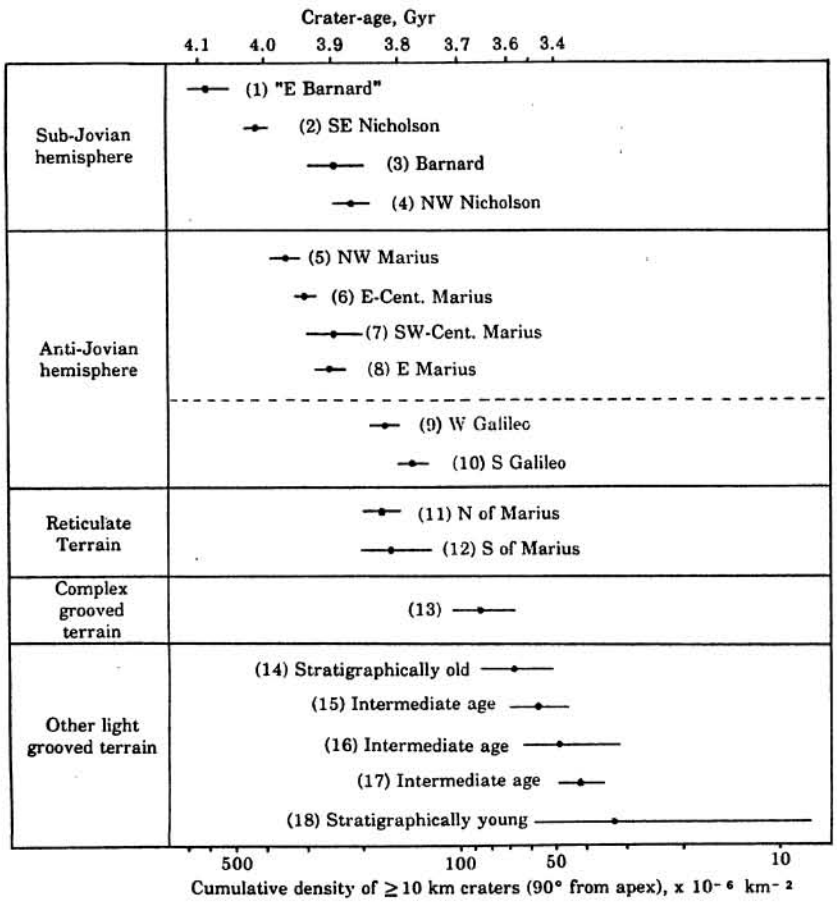

Fig. 1. Crater-densities and crater-ages of the surfaces measured in this study. From top to bottom, the groups of surfaces are: dark terrain in the sub-Jovian hemisphere, dark terrain in the anti-Jovian hemisphere, reticulate terrain, complex grooved terrain, and selected other examples of grooved terrain which have stratigraphic relations suggesting a variety of relative ages. All crater-densities were normalized to 90° from the apex of orbital motion, to remove the effect of the apex-antapex impactor flux gradient that would result from the assumed population of heliocentric impactors.