crater densities to a standard distance from the apex (90°), assuming some value of δ.

Several investigations have addressed the relative roles of heliocentric and planetocentric impactors in the cratering of Ganymede, generally by determining whether different classes of crater materials do or do not have an apex-antapex density gradient. In general, large (≥30-km) craters in both light and dark terrains possess apex-antapex density gradients [*Passey and Shoemaker*, 1982; *Croft and Duxbury*, 1988], and bright young crater deposits are also more abundant in the leading hemisphere [*Murchie et al.*, 1989*a,b*]. Smaller (10-20 km) craters in light and dark terrains do not possess an unambiguous density gradient, and at least in light terrain they exhibit substantial lateral density variation [*Passey and Shoemaker*, 1982; *Shoemaker et al.*, 1982; *Croft and Duxbury*, 1988]. Croft and Duxbury interpreted these data to indicate two bombardments of Ganymede, an older one by small planetocentric impactors and a younger one by larger heliocentric impactors. *Murchie et al.* [1989*a,b*] interpreted these trends as the result of ancient shallow, laterally nonsynchronous resurfacing of craters formed mostly by heliocentric impactors. Resurfacing would have preferentially buried smaller old craters and obscured their apex-antapex density gradient; larger old craters with greater rim heights would have been less degraded by this resurfacing, so that their density gradient would have been less obscured. There is substantial evidence for laterally nonsynchronous resurfacing in both dark and light terrains, including embayment of large craters by dark and light deposits, regionally depleted densities of smaller craters, and complex stratigraphic relations of dark and light materials with tectonic features [*Woronow et al.*, 1982; *Casacchia and Strom*, 1984; *Croft and Strom*, 1985; *Croft and Goudreau*, 1987; *Murchie et al.*, 1989*b*; *Croft et al.*, 1990].

Using the presence or absence of an apex-antapex density gradient for some class of craters as evidence for or against heliocentric bombardment implicitly assumes a laterally uniform surface age, and the evidence for laterally nonsynchronous resurfacing makes this extremely unlikely. *Murchie et al.* [1989*a,b*] performed two tests for heliocentric or planetocentric bombardment which do not assume a laterally uniform surface age. First, they examined the variation with distance from the apex in the shapes of crater size-frequency distributions that are interpreted to be production functions. Mixing of heliocentric and planetocentric impactor populations having different size-frequency distributions [*Croft and Duxbury*, 1988] would result in an apex-antapex trend in the shapes of crater production functions. No such trend is observed, suggesting that dark terrain was cratered predominantly by a single impactor population. Second, as a test for the heliocentric or planetocentric character of this population, they compared stratigraphic relations of different dark material deposits with the deposits' normalized and measured crater densities. The normalized densities were found to be more consistent with stratigraphically determined relative ages, consistent with a heliocentric population.

In summary, these tests, in conjunction with previously published results, suggest that dark terrain was cratered predominantly by a single heliocentric impactor population. This cratering flux could have produced the observed spatial distributions of different classes of craters, through modification of surfaces in production by ancient shallow, laterally nonsynchronous resurfacing. For these reasons, we determined relative crater ages of widely separated dark terrain surfaces by assuming heliocentric impactor bombardment with an intermediate δ of 15, and by calculating normalized densities on this basis (Table 2 and Figure 5). Assumption of a slightly inaccurate δ would affect relative crater ages primarily in areas close to the trailing edge, that is, area 1 ("Eastern Barnard Regio"). The normalized density of this area is therefore excluded from the following analyses.

If the same heliocentric population bombarded dark terrain on Ganymede and Callisto as bombarded cratered inner solar system surfaces, then absolute ages of terrestrial and lunar cratered surfaces could be used to calibrate the cratering record in the Jupiter region. *Woronow et al.* [1982], *Chapman and McKinnon* [1986], and *Strom* [1987] compared crater size-frequency distributions in dark terrain on Ganymede and Callisto to those of cratered inner solar system surfaces such as the lunar highlands and maria. They found different size-frequency distributions in the inner and outer solar system, even after taking into account probable differences in crater-forming processes on rocky and icy bodies. These researchers interpreted their results to indicate that heavily cratered surfaces in the inner solar system were bombarded by a population of impactors distinct from that which bombarded dark terrain on Ganymede and Callisto.

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TABLE 2. Descriptions and Normalized Crater Densities of Counted Areas

ID[a]	Counting Area, km^2	Description	Latitude, Longitude	Angular Distance From Apex, deg.	Normalized Density, x 10^{-6} km^{-2} ≥10 km	≥20 km
1	167,485	"Eastern Barnard"	22°N,316°W	131	596±90	108±39
2	669,138	SE Nicholson	20°S,335°W	114	420±32	96±15
3	125,614	Barnard	5°N,350°W	100	244±47	67±25
4	322,038	NW Nicholson	15°S,355°W	95	216±28	52±13
5	356,873	NW Marius	16°N,195°W	105	342±35	97±19
6	561,827	east-central Marius	5°S,175°W	85	299±22	52±9
7	145,011	SW-central Marius	5°S,200°W	105	234±46	55±22
8	255,780	eastern Marius	15°S,155°W	65	252±27	47±12
9	431,773	western Galileo	35°N,155°W	62	173±17	46±8
10	430,578	southern Galileo	10°N,140°W	51	150±14	47±8

[a] See Figure 3 for location.