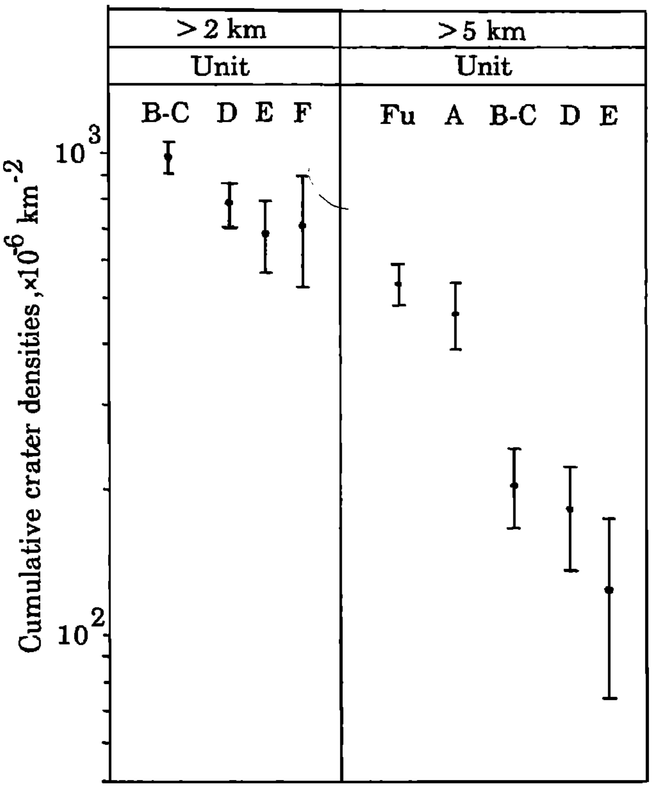

Fig. 11. Cumulative densities of >2-km and >5-km-diameter craters on mapped relative age units in central Uruk Sulcus.

to have occurred is global expansion. *McKinnon* [1982], *Golombek* [1982], and *Zuber and Parmentier* [1984] used thermal modeling of the satellite and estimates of total extension of the lithosphere to place a lower bound of <0.1% and a possible upper bound of about 1% on the increase of the satellite's radius subsequent to furrow formation. If the class of groove sets that we term "groove lanes" are rifts, as is suggested by their resemblance in plan to continental rifts, then global expansion during grooved terrain formation could have driven rifting by passive lithospheric extension. Alternatively, groove lanes could have formed by active rifting in response to mantle convection. The morphology and development of active and passive rifts may be distinctive. Because passive extension of the lithosphere is implied by global expansion, groove lane morphology and development characteristic of passive rifts would be evidence of global expansion during grooved terrain formation. The presence of features diagnostic of active rifts would not disprove global expansion, but would suggest the importance of mantle convection.

There are four independent morphologic properties that suggest a passive rift origin of groove lanes; that is, they are consistent with the hypothesis that Ganymede underwent global expansion during grooved terrain formation. The first three properties were discussed by *Sengor and Burke* [1978] and *Baker and Morgan* [1981], and are commonly but not always uniquely attributed to passive rifts on earth. First, the formation of groove lanes commonly was initiated by the reactivation of relict zones of weakness, namely furrows and probably relict tidal despinning fractures. Second, the sequence of events during the development of a groove lane (Figure 6), (1) formation of an initial trough, (2) minor resurfacing, and (3) pervasive groove formation and resurfacing, is similar to the sequence predicted for the development of a passive rift by both *Sengor and Burke* [1978] and *Golombek et al.* [1983]. There is no evidence for resurfacing without antecedent groove or trough formation, as may be expected in the case of active rifting.

The third line of evidence for a passive rifting origin of groove lanes is that regional and global stresses appear to have had a major influence on the orientations of groove lanes. *Murchie and Head* [1986*a*,*b*] have proposed that two global processes created stresses affecting groove lane development. These two processes are (1) shear offset of large areas of dark furrowed terrain and (2) global reorientation, which would have occurred during the earliest and latest stages of grooved terrain emplacement respectively. Global reorientation would have been caused by perturbation of the global moment of inertia by the formation of the basin Gilgamesh at 62°S,123°W. The calculated amount of reorientation, about 15°-20°, is consistent with several independent lines of geologic evidence detailed in the latter reference. Young throughgoing groove lanes, having densities of superposed craters indistinguishable from that of Gilgamesh, are perpendicular to the trajectories of least compressive stress predicted to have been caused by reorientation. This observation was interpreted to indicate that stresses due to reorientation added to existing stresses responsible for groove lane formation and created a preferred orientation of young groove lanes. The second source of regional stress, shear offset of large blocks of dark terrain [*Murchie and Head*, 1986*a*], is indicated by offsets of the poles of concentricity of arcuate furrows, of dark terrain troughs, and of the most ancient groove sets. Groove lanes in wide areas adjacent to the shear zones have orientations perpendicular to the predicted least compressive stress associated with the shear. This may be a direct effect of shear-related stresses on groove lane formation, or may be the result of the shear-related stresses selectively weakening preexisting zones of weakness perpendicular to the least compressive stress, which later acted as sites of groove lane formation.

The fourth line of evidence for passive rifting is the consistency of observed morphology of narrow groove lanes with that predicted for passive rifts in a lithospheric stretching (viscous) model. *Squyres* [1982] noted that at low strain rates a viscous model may be appropriate for modeling lithospheric deformation on Ganymede. We calculated the maximum plausible local

TABLE 1. Cumulative Crater Densities in Uruk Sulcus, x 10^{-6} km^{-2}

Unit	Area, km²	>2 km	>5 km	>10 km	>20 km
Furrowed	193,072	–	539 ± 53	238 ± 35	41 ± 15
A	111,689	–	458 ± 64	233 ± 46	47 ± 20
B-C	151,149	992 ± 81	205 ± 37	98 ± 25	37 ± 15
D	87,821	797 ± 95	190 ± 46	98 ± 33	47 ± 23
E	48,435	681 ± 119	123 ± 40	75 ± 40	38 ± 27
F	20,750	723 ± 187	271 ± 112	133 ± 80	–