such inheritance of preexisting albedo contrasts in areas resurfaced by light terrain, and suggested as a mechanism the flotation of porous regoliths of varying albedo on fluid resurfacing material.

Interpreted geologic history. Sometime before 3.8-4.0 Ga, a giant impact in southeastern Marius Regio created abundant ring fractures and fewer radial fractures extending more than 3500 km from the central palimpsest. This impact punctuated or preceded a prolonged period of global dark material resurfacing and extensional tectonism. The impact-generated fractures were entirely buried by resurfacing materials, but they served as loci for extensional deformation, generally preserving the fractures' configurations. Where this structural pattern was aligned with that of the older system III fractures, the older system exerted considerable influence on the trend of tectonic features. Additionally, arcuate furrow-defined, ringlike blocks failed in tension, forming the short subradial furrows of southern Galileo Regio and eastern Marius Regio. Volcanic resurfacing continued for the longest time in eastern Marius Regio and southern Galileo Regio, resulting in partial to complete burial of the system I furrows there.

System II

Description. System II (Figure 17) contains troughs commonly 500-2000 km in length, which are arranged radially to a point near 25°S,122°W (in a reference frame with younger shear offsets removed and Marius Regio held fixed). The distance from the center of radial symmetry to the most distant furrows is at least 5000 km, 60% of the distance to the antipode. A few orthogonal troughs having orientations nearly identical to those of system I furrows crosscut or splay off two of the longest system II radial furrows; these may have reactivated older system I or system III structures. System II furrows may extend to the western part of the sub-Jovian hemisphere (Figure 10), but there they would have the same orientation as do system III arcuate furrows. Poor resolution in Voyager 1 images of that area preclude recognition of crosscutting relations of the two furrow systems. The crater age of system II is bracketed at a normalized ≥10-km crater density of about 160 x 10^{-6} km^{-2} on the basis of calculated crater ages of dark terrain units and reticulate terrain [Table 2 and *Murchie et al.*, 1989*b*], the crosscutting of all dark terrain units by system II furrows, and the disruption of the furrows by reticulate terrain.

The center of system II coincides with a large area characterized by a concentration of smooth dark volcanic materials and intense fracturing. A small circle 3000-3500 km in radius and centered on the center of the system would circumscribe the majority of smooth to hummocky deposits which bury system I furrows (Figure 16). Also, 30- to 100-km-long system I subradial furrows (interpreted to have formed by fracturing of arcuate furrow-defined rings) are concentrated in the parts of Galileo Regio and Marius Regio which are less than 2500-3000 km from the center of system II. *Croft and Goudreau* [1987] also noted this regional concentration of endogenic geologic activity.

The primary recognized occurrence of an unusual type of light grooved terrain, "complex grooved terrain" [*Murchie et al.*, 1986, 1989*b*], straddles the center of system II (Figure 16). This type of terrain contains complexly crosscutting and intertwined grooves and a mantle of light material that mostly obscure underlying topography. (The other grooved terrain surface that we would classify as this terrain type occurs in the south polar region, unit "tb" of *DeHon et al.* [1989].) Both measured and normalized ≥10-km crater densities of complex grooved terrain (Tables 1 and 2 and Figure 5) place it as the oldest observed type of light terrain on the satellite, with the possible exception of some south polar light grooved terrain [*Shoemaker et al.*, 1982; *Murchie et al.*, 1989*b*]. Therefore the oldest or nearly oldest large occurrence of light terrain is in the same area where dark terrain underwent some of its most intense fracturing and latest resurfacing.

Comparison to models. The only model which predicts the enormous extent of radial furrows in system II is fracturing of a circular, isostatic uplift (model 3). The concentration of dark smooth materials and the oldest light materials around the center of system II are evidence for a persistent, very large scale mantle thermal anomaly. Development of such a region of warmer mantle in a cooler interior could have caused isostatic uplift, and is consistent with two independent observations. First, the lack of recognized distal compressional features in system II is consistent with the uplift having occurred in an environment of global tensional stress, which is predicted to have accompanied internal warming [Zuber and Parmentier, 1984*b*]. Second, the concentration of short system I subradial furrows around the center of system II is consistent with concentration of global tensional stress by lithospheric thinning over the thermal anomaly.

Interpreted geologic history. Some of the youngest dark terrain surfacing and most intense dark terrain fracturing occurred around the future center of system II, interpreted to be the location of a large-scale mantle thermal anomaly. As dark material emplacement tapered off at or before 3.8-4.0 Ga, system II furrows formed by fracturing of a circular, isostatic uplift over the anomaly. Subsequently, early stages of grooved terrain formation included the development of reticulate terrain with little resurfacing [*Murchie et al.*, 1989*b*]. Light terrain emplacement then began, at least regionally at the site of the major thermal anomaly.

DISCUSSION

This analysis of the geology of dark terrain, previous analyses of dark terrain geology by *Casacchia and Strom* [1984], *Croft and Strom* [1985], *Croft and Goudreau* [1987], and *Croft et al.* [1990], and the analyses of cratering of dark terrain by *Woronow et al.* [1982] and *Murchie et al.* [1989*b*] lead to three fundamental inferences about the early geologic evolution of Ganymede: (1) dark materials consist of accumulated volcanic deposits; (2) a population of older craters, such as that observed on Callisto, was removed by burial by these deposits; and (3) most furrows formed by prolonged, endogenic, global extension that reactivated impact-generated zones of weakness. These results have important implications for the evolution of Ganymede's lithosphere, the satellite's internal thermal state, and the origin of the Ganymede-Callisto "dichotomy," which are briefly explored below.

Dark Terrain Evolution on Ganymede and Callisto

One of the primary geologic questions about the Galilean satellites is why the surface of Callisto consists entirely of dark terrain and lacks the light material and grooved terrain covering half of Ganymede's surface, despite the similarity of