resulted from the selective weakening by transtensional deformation of relict structures that were later reused during grooved terrain formation, or from a continued effect of whatever process drove the shear motions. Important observations consistent with this hypothesis would be identification of regionally dominant groove orientations which are both (1) parallel to relict structures such as arcuate or radial furrows, and (2) at high angles to the inferred least principal stresses related to the shear zones. These observations not only would provide further evidence for large-scale shear motions but would also have major implications for the character of grooved terrain formation.

Bianchi et al. [1986] identified eleven large areas of grooved terrain ("superdomains") having different regionally dominant groove orientations (Figure 17, "A"-"K"). Ten of the 11 superdomains have dominant groove orientations that are parallel to arcuate or radial furrows or parallel to the global grooved terrain "structural fabric." The dominant orientations in nine of these 10 are also at high angles to the least principal stress inferred to have accompanied nearby shear deformation. These observations are consistent with shear motions or the shear's driving mechanism having had a long-term effect on patterns of deformation of Ganymede's lithosphere.

The fundamental structural patterns in each of the superdomains are now briefly described. In four wedge-shaped superdomains adjacent to the proposed shear zones, parallel groove lanes and prominent grooves have orientations that are (1) consistent with reactivated radial furrows and (2) at high angles to the inferred least principal stress. These superdomains are, in Figure 17, "A," grooved terrain within and to the north and west of area 2, proposed earlier to have occupied an older zone of distributed left-lateral shear; "D," southeast of Galileo Regio and north of lineament I (shown in Figure 11); "F" (at 30°-50°S,140°-150°W), southeast of central Marius Regio and adjacent to a proposed right-lateral shear zone; and "K" (at 0°-20°S,300°-320°W), east of Nicholson Regio and adjacent to another proposed right-lateral shear zone.

In the majority of the sub-Jovian hemisphere (superdomains "H," "I," and "J") grooves are parallel to system III arcuate furrows and at high angles to the least principal stress inferred for the left-lateral shear zone. Grooves in superdomains "H" and "I" are also parallel to the global structural fabric. In the anti-Jovian hemisphere in Uruk Sulcus (superdomains "B" and "C"), orthogonal dominant groove orientations are nearly parallel to system I arcuate and radial furrows. Whereas most of the east-southeast oriented grooves are located in elongate groove lanes (Figure 2), the north-northeast oriented grooves are found in "grooved polygons." The groove lanes dominate the structure of Uruk Sulcus and have an orientation consistent with all three factors proposed to have affected groove orientation: the groove lanes are (1) nearly parallel to furrows, (2) parallel to the global structural fabric, and (3) orthogonal to the least principal stress associated with shear. Single, regionally dominant groove orientations also are observed in other superdomains in which the three factors favor a single groove orientation: superdomains "A," "D," "H," and "I" (Figure 17).

Two of the 11 superdomains, "E" and "G" in Figure 17, have regionally dominant groove orientations inconsistent with the least principal stress inferred to have accompanied nearby shear deformation. However, the groove orientation in superdomain "E" is approximately parallel to the global "structural fabric."

Character of Distributed Shear Deformation

Several locations have been identified where there is evidence for distributed deformation related to shear (e.g., Figures 2, 8, 12, and 19). In some cases, such as formation of reticulate terrain and the possible en echelon fractures in Figure 19, the deformation may have resulted directly from shear. In the case of regionally dominant groove orientations, extensional grooves may have occupied zones of weakness that were preweakened by transtensional deformation. What is notable about this possible distributed deformation is the relative abundance of evidence for pervasive deformation or transtension and the relative lack of evidence for transpression. The locations shown in Figures 12 and 19 are the only ones where possible transpressional features were clearly recognized.

Three possible explanations for the relative lack of evidence for transpression may be advanced. First, unfractured ice fails at lower stresses by tension fracturing than by shear failure (e.g., normal faulting, thrust faulting) [*Gold*, 1977]. If strain was accommodated by widespread tension fracturing (or pervasive deformation of reticulate terrain), then stress may seldom have accumulated to a sufficient magnitude for thrust faulting to occur. Second, shear offsets may have occurred during a period of global expansion, which is expected to have generated very large tensional stresses [*Zuber and Parmentier*, 1984*b*]. Global expansion may have inhibited shear-related compressional deformation, provided that fault zones were curvilinear, possessed major bends that are right-echelon if the fault zone were left-lateral, or possessed left-echelon bends if the fault zone were right-lateral. All of the proposed shear zones may be described by one of these geometries.

The third possible explanation is that transpressional deformation did occur, but that its manifestations are difficult to recognize. *Parmentier et al.* [1982] and *McKinnon and Parmentier* [1986] noted that there might be little morphological distinction between bands of troughs ("groove lanes") and bands of ridges or folds. Transpressional features therefore might exist without being easily recognized, except possibly under the most favorable illumination conditions. Particular attention is now called to the northwest oriented, offset feature at the arrows in Figure 19, which is illuminated at a low sun angle. Individual structures within this band are best described as pairs of ridges which surround intervening troughs; low, northwest oriented features to the west have a similar morphology but grade to single ridges. Arguments could be made that the structures within the offset band are either raised-rimmed grooves or folds with extensional features on their crests. If the latter is true and if the band is a train of folds, then its orientation is consistent with the following regional deformational history derived independently from the other observed structures: a northeast oriented greatest principal stress and northwest oriented least principal stress led to northwest oriented transpressional features, northeast oriented transtensional features, and east-west left-lateral shear faulting. If this scenario is correct then, by extrapolation, grooved terrain in general may have had a more complicated deformational history than has generally been recognized.

Relationship of Shear Zones to the Lithospheric "Structural Fabric"

Three of the four shear zones proposed in this study, those occurring along lineaments IIa, III, and IIIa, are parallel to the global grooved terrain "structural fabric" whose orientation is approximated by a global system of small circles centered on a pole of about 70°-75°N,95°-110°W (fine dashed lines, Figure 17). This observation is further evidence that the "structural fabric," whatever its origin, was long-lasting and was reactivated during the formation of tectonic features younger than the furrows.