made here regarding applications of these mechanisms to the origin of the rim plana. First, there is no evidence of an impact basin under SMP [*Schaber*, 1982], and while there is an older basin southeast of Hellas [*Schultz et al.*, 1982], no such basin has been recognized in the region of MP. Second, although SMP is located where the I–NF becomes radial to the Hellas basin (Figure 1), the I–AF system also possesses a Hellas–radial extension that should have been an equally favored site for rim planum formation. No comparable intersecting basin–radial component has been identified for MP. Third, although reorientation can explain the observed rim planum locations, this mechanism assumes that the lithosphere is decoupled from the interior by a low viscosity layer similar to the Earth's and that an impact induced thermal anomaly below this layer can survive for times of the order of 100 m.y.

CONCLUSIONS

The history of tectonic and volcanic activity about the Isidis and Hellas basins shows a common trend in basin evolution. Large canyon forms develop outside the basin scarp near the time of impact; radial troughs form shortly thereafter; and basin tectonic activity ends with the development of graben in the massif rings. While times for initial volcanic activity are poorly constrained, rim planum volcanism terminates after massif ring graben formation. Final volcanism in both basin sequences corresponds to the age of Syrtis Major Planum.

Comparison of first–order stress distribution models for various basin–centered processes with the observed evolution of basin–related tectonic systems suggests that different mechanisms may control different stages of this sequence. Distant canyon formation conceivably could result from the dynamic effects of transient cavity collapse. Alternatively, these canyons could represent structures formed in a thick lithosphere by elastic flexure under basin ejecta or transient loads and widened by early modification processes. The basin radial troughs are consistent with lithospheric flexure during isostatic basin uplift, and the massif ring graben fit traditional models of elastic flexure under central basin fill loads [*Solomon and Head*, 1979, 1980]. The localization of volcanism into rim plana on the basin rims seems inconsistent with all of these mechanisms, and other mechanisms such as "lithospheric reorientation" over an impact–generated thermal anomaly [*Wichman and Schultz*, 1988*a*] or superposition of basin structures on a regional lithospheric weakness may be necessary to explain their origin.

Each of these tectonic processes are associated with a characteristic distance of deformation that appears to diminish over the course of basin modification. Impact deformation and ejecta loading theoretically can extend significantly beyond the basin scarp and radial trough formation should breach the basin scarp. Late stage flexural grabens, however, are limited to an annulus within the massif ring. Since the extent of uplift and/or impact deformation directly depends on basin size, these deformation stresses become insignificant for basins smaller than Isidis and Hellas. Only the largest basins on Mars, therefore, are likely to induce the complex style of tectonic modification found in the cratered uplands surrounding Hellas. Since the earliest stage of this modification appears to be related in part to the transient cavity aspect ratio, modeling of the observed extent of deformation further suggests that aspect ratios for the excavation cavity of the order of 20:1 may be necesary for these impact basins in contrast with the 5:1 value often assumed for smaller craters.

Finally, there is a finite lifetime to basin volcanism of the same order as the lunar maria. The common age of terminal volcanism in both basins thus may indicate a global curtailment of volcanism associated with a global contraction regime similar to that postulated for the end of mare volcanism on the Moon [*Solomon and Head*, 1979]. The style of rim planum volcanism which dominates the observed basin sequences on Mars, however, is distinctly different from the mare volcanism observed on the Moon, and further study of the rim plana is needed to clarify the mechanisms responsible for this difference.

APPENDIX: LINEAR DATING TECHNIQUE

The linear dating technique used for this study is a modification of that developed by *Tanaka* [1982] and uses the sizes of the crater population superposed on a narrow, elongate feature to define an envelope of greater area about the feature to which craters overlapping the feature can be referenced. This increases both the number and size of craters used in the age determination, and thereby improves the reliability and ease of the determinations. In detail, *Tanaka* [1982] derived a relation for the crater number which, for a crater population divided into preassigned size ranges or bins, depends upon the number of craters per bin and various parameters related to the bin crater size distributions. We have modified this relation to use the number and arithmetic mean diameter of all craters larger than a chosen reference diameter and further assumed that the feature has no effective width or area in comparison to the size of the counted craters. Under these assumptions, the equations of *Tanaka* [1982] simplify to the relation

$$\frac{N(>D)}{A} = \frac{n}{L}\left(\bar{D} + \frac{\pi}{4L}\bar{D}^2\right)^{-1} \qquad \text{(A1)}$$

where D is the reference diameter, n is the number of craters larger than D on the dated feature, L is the length of the dated feature, $\bar{D}$ is the arithmetic mean diameter of the count ($>D$), and $N{>}D/A$ is the areal crater age of the feature.

Several considerations are further required for the use of this relation in dating linear tectonic features.