scarps, ridges and moderate-sized craters, to the 1000–2000 km scales of large impact basins and major upland regions. When used in tandem with Mariner 10–derived images and maps, radar altimetry has allowed us to better constrain and more closely examine previous interpretations of the geology of the planet.

Crater depth measurements appear to confirm earlier findings from shadow measurements [*Gault et al.*, 1975; *Malin and Dzurisin*, 1977], although the slightly shallower radar depths warrant further study. Both radar and shadow measurements suggest that Mercurian craters are shallower, on the average, than lunar craters. Only one large (800 km) basin has been found to show a radar altimetric signature, the overall shallowness of which suggests significant modification by isostatic relaxation or volcanic filling.

Altimetry over the southern environs of Caloris Basin indicates that the circum-Caloris smooth plains extend well into the unimaged hemisphere. Both imaged and unimaged sections of these plains are strongly down-bowed, suggesting that there has been subsidence under the load of the smooth plains fill. This and other similarities to lunar maria offer evidence, albeit circumstantial, in favor of a volcanic origin for the smooth plains around Caloris. Although the Arecibo data are consistent with the hypothesis that there is an irregular annulus of smooth plains surrounding Caloris Basin, new photographic images of the region to the west of the Mariner 10 terminator will be required to establish this definitively.

Some of the most important results of this study bear upon the tectonic evolution of Mercury. We have obtained altimetric profiles across three features mapped as arcuate scarps. One of these features appears to be a ridge rather than a scarp while the other two features, though showing some cross-sectional asymmetry consistent with thrust-faulting, have profiles which are more ridge-like than is suggested by images. These results should be factored into models that account for such structures as compressional tectonic features. Altimetry has allowed us to document the existence of at least one large fault zone associated with 3 km of relief. This fault zone also appears to be intimately connected with one of the two broad topographic bulges in the equatorial zone of Mercury. These bulges rise roughly 3 km above the mean equatorial radius and are aligned along an axis within about 10° of the so-called "hot poles" of Mercury. These bulges present an interesting alternative to the hypothesis that the smooth plains in or around Caloris control the dynamical figure of Mercury. The question of whether their origin is due to tidal stresses or to some endogenic process is crucial to understanding the tectonic history of the planet.

Radar observations of the equatorial zone of the unimaged hemisphere reveal uplands and lowlands, a number of large craters, and some topographically smooth areas. The topography of this hemisphere shows no marked differences with respect to the imaged hemisphere and no evidence has been found for the existence of another Caloris-type impact structure.

The discussion we have included in this paper is intended to be descriptive and preliminary. There are several areas which warrant more intensive study. Further geophysical modelling of the Caloris region should include the radar topography as a constraint. It is clear, however, that a reasonably complete understanding of this complex and interesting region of Mercury will require an orbiting spacecraft with altimetric, gravimetric, and imaging capabilities. The Arecibo altimetry has provided some new information on the topography of ridges, scarps and faults; more detailed interpretation of these findings is in order. Finally, we note that the possibilities for study of the topography of Mercury with earth-based radar have not been exhausted, and continued observations should be made of the unimaged hemisphere and of areas in the imaged hemisphere deemed interesting on the basis of existing data.

APPENDIX: THE MERCURIAN COORDINATE GRID

Since the spatial resolution of the Arecibo radar altimetry is comparable with uncertainties or inconsistencies in the cartographic grid systems, an assessment of the grid systems is in order.

Longitude Coordinate

The USGS shaded-relief map of the H-6 quadrangle adopts the longitude reference used in the Mariner 10 cartography [*Davies and Batson*, 1975], in which the 20° longitude meridian is defined as passing through the small reference crater Hun Kal. *Davies and Batson* [1975] state that the IAU 0° longitude meridian (defined by referencing to the subsolar meridian on January 1, 1950) is at 359.5° ± 0.5° on the Mariner 10 grid. Comparisons of Arecibo altimetry features with the USGS H-6 quadrangle showed the Arecibo longitudes to be systematically larger by approximately 0.4°. This difference implies that the 0° longitude reference used in the Arecibo altimetry reduction programs is at approximately 359.6°W in the Mariner 10 (Hun Kal) system, which is consistent with the *Davies and Batson* [1975] estimate of the position of the IAU meridian. Comparisons of Arecibo longitudes with longitudes tabulated in the *Astronomical Almanac* [*U.S. Naval Observatory*, 1984], which uses the 1979 IAU system, shows precise agreement to within 0.01°.

A position check of the longitudes of altimetry features with their locations on the USGS H-7 and H-8 shaded-relief maps showed no systematic discrepancies such as that found in comparisons with the USGS H-6 map. This contrast implies that there is an inherent misregistration of the USGS H-7 and H-8 maps relative to H-6. A check of the common boundary of the H-6 and H-7 relief maps does, in fact, show such a mismatch. These findings were confirmed by spot checks between the USGS relief maps and the Mercury Control Net [*Davies and Katayama*, 1976]. This check showed precise agreement between USGS and Control Net longitudes for the H-6 quadrangle, but that the USGS longitudes were approximately 0.5° larger than Control Net longitudes for the H-7 and H-8 quadrangles.

Since the USGS shaded-relief maps provide the best means of interpreting the radar altimetry, it was decided to adjust the Arecibo profiles to conform to the USGS longitudes. Accordingly, the Arecibo profiles on the H-6 quadrangle (Figure 2*a*) were shifted east by 0.4°, whereas no shift was made to profiles on the other quandrangles.

Latitude Coordinate

Both the Arecibo and USGS coordinate systems follow the IAU convention placing the Mercurian spin axis normal to the orbital plane. The best estimate of the pole position from Mariner 10 data is offset by 2° from the IAU pole, with an error oval encompassing the IAU pole [*Klaasen*, 1976]. Invoking some dynamical studies by *Peale* [1969], Klaasen concluded that the spin axis was most likely aligned within approximately 1° of the orbit normal. This, then, admits the possibility of errors in subradar latitude of the order of a degree.