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Radar Altimetry of Mercury: A Preliminary Analysis

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Measurements of Mercurian topography based on Arecibo radar observations are presented. The data, which were obtained from 1978 to 1984, cover much of the equatorial zone of Mercury between 12°N and 5°S latitude. Over thirty continuous altitude profiles were obtained, each spanning from 20 to 90 degrees of longitude at a resolution of 0.15° (longitude) by 2.5° (latitude). Radar depths for large craters support previous indications from imagery that Mercurian craters are shallower than lunar craters of the same size. One very large (800 km) impact basin shows some distinct topographic structure, although its relative shallowness suggests postimpact modification by isostatic relaxation or volcanic filling. The plains of Tir Planitia appear topographically smooth to the radar. These plains extend well into the hemisphere not imaged by Mariner 10, possibly forming part of a large annulus of smooth plains around Caloris Basin. The circum-Caloris smooth plains are strongly down-bowed, indicating subsidence under a load. This and other similarities to lunar maria suggest a volcanic origin for these plains. Additional areas of topographically smooth terrain have been found in both the imaged and unimaged hemispheres. Several ridges, scarps, and fault zones have been identified in the altimetry. Three mapped arcuate scarps show heights of about 700 m and cross-sectional widths of about 70 km. One of these features is clearly a ridge, while the other two scarps have a more ridge-like appearance than is suggested by images. One large-scale topographic drop of 3 km correlates well with a mapped system of faults and intracrater scarps. The equatorial zone of Mercury shows 7 km of maximum relief, although the typical elevation difference between highlands and lowlands is closer to 3 km. Three major highland areas are found, the largest two of which are roughly antipodal and aligned within about 10° of the "hot poles" of Mercury. The unimaged hemisphere, possessing both large craters and topographically smooth areas, does not appear to be markedly different in its topography from the imaged hemisphere. No evidence has been found for another Caloris-type impact structure in the unimaged hemisphere.

1. INTRODUCTION

A program of 2380 MHz radar observations of Mercury has been conducted at Arecibo Observatory since 1978. These observations have yielded an extensive set of altitude measurements over the equatorial zone of the planet. In this paper we present the altimetry results and discuss some of the possible implications for Mercurian geology.

The earliest information on Mercurian topography was provided by radar-ranging observations [*Smith et al.*, 1970; *Ingalls and Rainville*, 1972]. These measurements showed that the range of altitudes on Mercury was somewhat less than had been measured for the equatorial zones of Venus and Mars. The most detailed of the Mercury radar measurements, and the last to be published, were by *Zohar and Goldstein* [1974]. Their data showed "hills and valleys" with 1–2 km relief and provided the first evidence of craters.

With the Mariner 10 spacecraft encounters of 1974–1975 came the first detailed look at the surface of Mercury. The Mariner 10 photographic images, which covered 45% of the planet at 0.1–4 km resolution, revealed a heavily cratered, lunar-like surface [*Murray et al.*, 1974; *Trask and Guest*, 1975]. The images suggested tectonics dominated by compressive forces as manifested in the unique Mercurian scarp system. While these results were consistent with the relatively subdued topography measured by earth-based radar, Mariner 10 carried no altimeter and quantitative altimetry was limited to shadow measurements of high-relief features such as craters and scarps [*Gault et al.*, 1975; *Strom et al.*, 1975] and a few photoclinometry results [e.g., *Hapke et al.*, 1975]. In addition, many of the Mariner 10 images were obtained at unfavorable illumination angles and one entire hemisphere (the dark side at the times of encounter) was not imaged at all.

It was clear, then, that useful earth-based radar work on Mercury remained to be done and a regular program of radar-ranging observations of the planet was undertaken at Arecibo. In the following section we present a brief discussion of the observations and the data reduction to altitude profiles. This discussion is followed by a display of the altitude profiles in a form which is intended to be convenient for the reader wishing to make comparisons with the U.S. Geological Survey shaded-relief and geologic maps and the Mariner 10 images. In the latter half of the paper we point out some of the more interesting features of the Arecibo altimetry, and discuss them in the context of the geological interpretations which have accumulated in the decade since the Mariner 10 encounters.

2. DATA ACQUISITION AND REDUCTION

Observations and Planet Coverage

The observations were made with the 2380 MHz (12.6 cm wavelength) radar on the 305-m-diameter telescope at the Arecibo Observatory in Puerto Rico. The specifications of the

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