RADAR DEPTHS OF LARGE MARTIAN CRATERS, L. E. Roth, C. Elachi, R. S. Saunders, Jet Prop. Lab., Calif. Inst. of Tech., Pasadena, CA 91103, G. Schubert, Dept. of Earth & Space Sci., Univ. of Calif., Los Angeles, CA 90024.

The Goldstone radar system of the Jet Propulsion Laboratory's Deep Space Network probed the surface of Mars at each opposition since 1963[1,2]. This paper presents a new set of depth measurements for 133 martian craters ranging in diameter from 18 to 475 km, based on the 1971 and 1973 Goldstone data[3,4,5]. The depth of a crater is the distance from the rim crest to the lowest point on the crater floor, and the diameter is the maximum crest to crest distance. The data set presented here revises and augments the radar measurements reported previously[6,7] and complements the data obtained through the use of other techniques[6,8,9,10].

In the course of the radar observations, the subradar point (the point on Mars closest to the transmitter on Earth) traces an arc of constant latitude on Mars. The time delay between the transmitted and returned signals represents the altitude of the subradar point. A plot of successive time delays vs. the longitudes of respective subradar points, referred to a reference figure of the planet, constitutes an altitude profile of the martian topography. The time delay measurement errors during the 1971 and 1973 Goldstone Mars experiments were equivalent, on the average, to uncertainties of less than 100 meters[4,5].

During the 1971 experiment, the latitudes of the subradar point varied between -14.3° and -18.6°. During the 1973 experiment, the latitude range was -14.9° to -22.4°. Combined, the 1971 and 1973 scans provide a fairly dense coverage, with many overlaps, of a strip about 8° wide in latitude, around the entire planet. The size of a radar footprint (a cell on the martian surface isolated by the range-doppler gating) was 0.16° in longitude and about 1.30° in latitude, i.e., about 8 km in the E-W direction, and 80 km in the N-S direction[4,5]. Because the rough immediate vicinity of a crater tends to diffuse the transmitted signal more than the relatively smooth crater floor would, it is possible, exercising cautious judgment supported by photography, to place minimum estimates on the depths of craters scanned off-diagonally and of craters with diameters less than 80 km. Diameters were measured on the MC series quadrangle maps of Mars.

The crater depths derived from the Goldstone radar scans fall into two groups, the higher-confidence Group I, and the lower-confidence Group II. The major criterion for including a depth measurement in Group I is its apparent consistency with crater morphology. In particular, the shallow depth readings (300 to 600 m) of a number of fresh or slightly modified craters[11] with diameters greater than about 20 km were placed in Group II. Although this criterion is somewhat subjective, a large number of depth readings in Group I are based on multiple scans at different latitudes and/or multiple returns from a crater floor in a single scan (Fig. 1). 16 of Group I depth readings are based on craters scanned in both the 1971 and 1973 experiments, and for which the depth measurements differed by no more than 500 m. 47 of the Group I depth readings are based on at least two radar returns from a single scan of the crater floor. 25 of the Group I depth readings are based on craters scanned more than once in a single experiment, and

RADAR DEPTHS OF LARGE MARTIAN CRATERS

L. E. Roth

for which the depth measurements differed by no more than 500 m. Since radar gives a minimum depth estimate, we chose the largest of all radar depth measurements to represent the crater depth.

Of the 133 recognized and measured craters, the depths of 88 were classified as belonging to Group I. The remainder formed Group II. Group I contains depths of 13 craters located between 210° and 270°, in an area obscured by dust during the operation of the Mariner 9 UVS[12].

As a first step in the analysis of the radar depth measurements, the data were smoothed using the moving averages method[10]. Fig. 2 shows the moving averages (of the order 9) of the data comprising Group I. Fig. 3 is a similar plot for both groups. The figures also include least-squares logarithmic fits to depth-diameter data for fresh lunar[13], fresh mercurian[14], and martian[9] craters.

The following observations can be made:

(I) The martian craters are systematically shallower than fresh lunar and mercurian craters, in agreement with previous investigations.

(II) The smoothed plot of Group I craters (Fig.2) shows only a weak dependence of depth on diameter, in contrast to the conclusion reached from the analysis of the Mariner 9 UVS data[9]. The smoothed Mariner 4 photoclinometric data set[10] also shows little dependence of depth on diameter for large craters.

(III) The averaged depths of the largest Group I craters are essentially independent of diameter and may even show a decrease with increasing diameter (Fig. 2). This latter dependence may be real since the depths of the largest basins were determined with the highest accuracy.

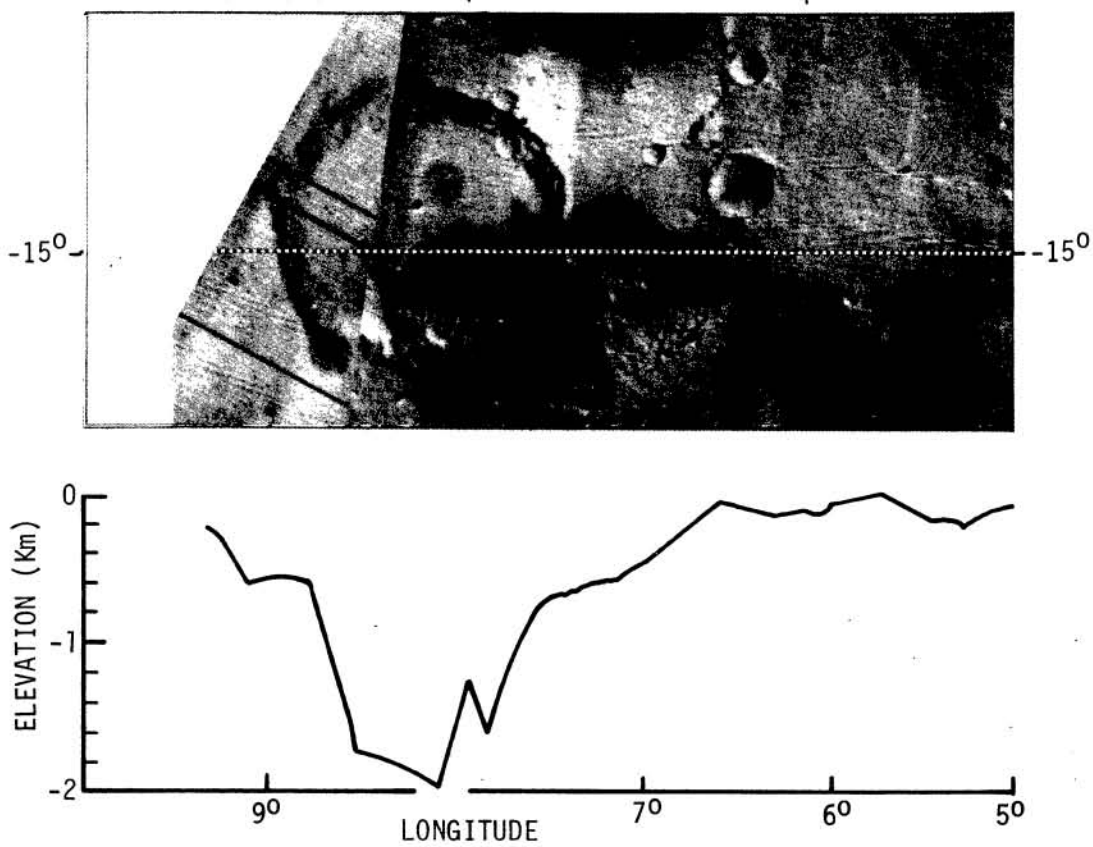
(IV) In connection with (II), we believe that the slope of the least-squares line presented by Cintala et al.[9] is too steep; the slope of their line even exceeds that of the least-squares fit for fresh lunar craters[13]. We find that inclusion of the lower-confidence Group II data steepens the depth-diameter relation (Fig. 3).

1. Goldstein, R.M., Gillmore, W.F. (1963). Science 141, 1171-1172.
2. Goldstein, R.M., Melbourne, W.G., Morris, G.A., Downs, G.S., O'Handley, D.A. (1970). Radio Sci. 5, 475-478.
3. Downs, G.S., Goldstein, R.M., Green, R.R., Morris, G.A. (1971). Science 174, 1324-1327.
4. Downs, G.S., Goldstein, R.M., Green, R.R., Morris, G.A., Reichley, P.E. (1973). Icarus 18, 8-21.
5. Downs, G.S., Reichley, P.E., Green, R.R. (1975). Icarus 26, 273-312.
6. Malin, M.C., Dzurisin, D.D. (1977). J. Geophys. Res. 82, 376-388.
7. Schubert, G., Lingenfelter, R.E., Terrile, R.J.(1977). Icarus 32, 131-146.
8. Burt, J., Veverka, J., Cook, K. (1976). Icarus 29, 83-90.
9. Cintala, M.J., Head, J.W., Mutch, T.A. (1976). Proc. Lunar Sci. Conf. 7th, 3575-3587.
10. Pike, R.J. (1971). Icarus 15, 384-395.
11. Arvidson, R.E. (1974). Icarus 22, 264-271.
12. Hord, C.W., Simmons, K.E., McLaughlin, L.K. (1974). Icarus 21, 292-302.
13. Pike, R.J. (1974). Geophys. Res. Lett. 1, 291-294.
14. Gault, D.E., Guest, J.E., Murray, J.B., Dzurisin, D., Malin, M.C. (1975). J. Geophys. Res. 80, 2444-2460.

RADAR DEPTHS OF LARGE MARTIAN CRATERS

L.E. Roth

Fig.1 Radar profile of the Crater Beer (-14.8°, 8.1°). The dashed line represents the subradar path.



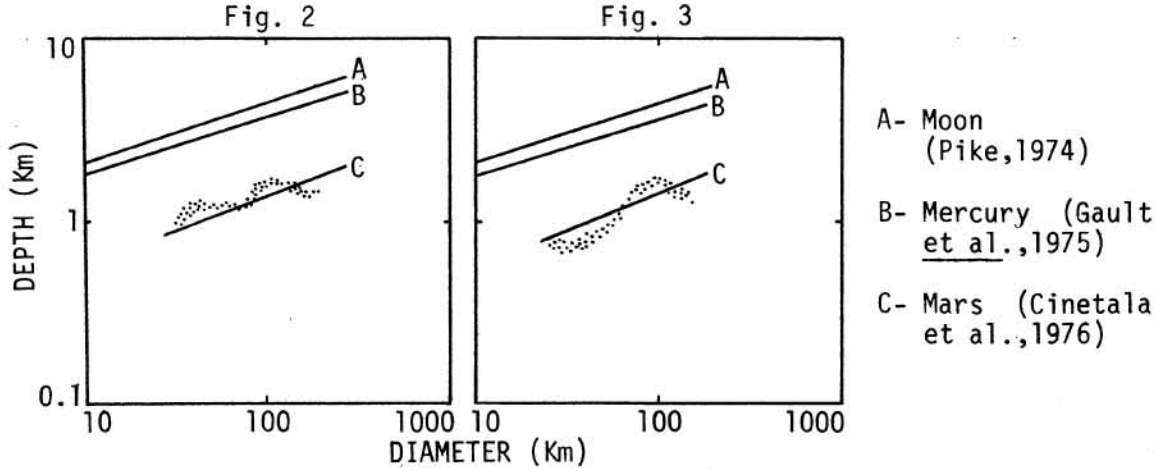


Fig.2 Smoothed depths/diameters plot for Group I craters.
Fig.3 Smoothed depths/diameters plot for Group I and II craters