THE SEARCH FOR SUBSURFACE ICE CAPS ON MERCURY; Ruth A. Allen, Dept. of Geol. Dickinson College, Carlisle, PA 17013; Nadine G. Barlow, Dept. of Physics, Univ. of Central Florida, Orlando, FL 23816; Faith Vilas, NASA Johnson Space Center/SN3, Houston, TX 77058

Recent ground-based radar observations of Mercury have detected strong, highly depolarized echoes from the north and south polar regions which have been interpreted as possible polar ice deposits [1]. These radar echoes have been correlated with a number of impact craters. Theoretical studies indicate that such surface ice can be stable within permanently shadowed areas, such as the floors of high latitude impact craters. One proposed hypothesis suggests that stable subsurface ice caps exist at the poles of Mercury, and that several of the impact events that created the high latitude craters exposed this subsurface ice [2]. Thus, our study focused on the possibility of ice caps extending below the mercurian surface, down to some unknown latitude in the polar regions. We used the experiences from Mars [3-4], where the depth/diameter ratio (d/D) is smaller for ice rich areas, to investigate whether a comparable latitudinal change in d/D is detectable on Mercury. We found no significant latitudinal differences within the two polar regions of our study or between the north polar and equatorial quadrangles, but craters in the south polar region tend to have slightly lower d/D than those in the north polar region.

Introduction. Polar ice deposits are known to exist on both Earth and Mars and are suspected in permanently shadowed craters in the polar regions of the Moon [5]. In particular, Mars displays some interesting effects on the morphologies of impact craters where surface and subsurface ice are present, including a decrease in depth-diameter ratio and the softening with time of sharp features such as crater rims. This terrain-softening results from the lower strength of materials containing ice versus dry materials [6]. On Mars, impact craters at high latitudes (generally poleward of ±40 latitude) show a significant decrease in d/D compared to craters at equatorial latitudes where ice/water is expected to constitute a lower percentage of the substrate. Unlike Mars, Mercury shows no evidence of channels or lobate ejecta blankets which are suspected signatures of H_20 beneath the surface. However, no quantitative study of possible changes in crater (d/D) with latitude, which could reveal the effects of terrain softening, has been undertaken for Mercury. We thus initiated a study to test this hypothesis and determine if the cratering record on Mercury revealed any indications of subsurface polar ice deposits.

Methods. Three regions were chosen for our study, one at each pole and one at the equator. The areas display similarities in terrain and photo resolution. We utilized Mariner 10 FDS pictures of the Bach (H15), Borealis (H1), and Tolstoj (H8) quadrangles. In all, 220 fresh impact craters ranging in diameter from 0.7 to 32.0 kilometers were identified. Shadow length and crater diameter were obtained by digitization and depth was then derived using shadow length and approximate sun angles. Due to low sun angles at the uppermost latitudes, our analysis was restricted to craters with sun angles between 55° and 89°. This limitation allowed us to accurately measure those craters in latitudes equatorward of ±85°. Our study included three of the permanently shadowed craters suggested to contain ice [1], though most of these exist beyond the ±85° latitude or in unphotographed areas of the mercurian surface. The d/D was calculated for all individual craters, which were then mapped on a shaded relief map and categorized into simple (D<10 km) and complex (D>10 km) craters. We related the resulting ratios to the change in latitude and also looked for differences within the quadrangles. We repeated the procedure with a "control" equatorial region, Kuiper (H6). Craters within Bach, Borealis, and Tolstoj had similar lighting while those in the Kuiper quadrangle averaged lower sun angles. All errors were calculated and the results were analyzed and graphed using a linear regression model.

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Results. From our research, we find no statistical differences in d/D within Bach (south Pole) or Borealis (north Pole) quadrangles, nor between Borealis and the equatorial regions, indicating that no substantial ice cap exists in the north polar subsurface region. We do detect a slight hemispheric difference in d/D of simple craters in the Borealis and Bach quadrangles, with craters in the southern hemisphere tending to have lower d/D (approx. 0.05 ±0.04) compared to craters in the northern hemisphere (d/D approx. 0.10 ±0.04). The three craters that show radar echoes suggesting ice on Mercury also show no significant variation in d/D. Based on these results, we do not see evidence of subsurface polar ice caps on Mercury. Other explanations of the radar echoes, such as the collection of cometary ice within only the permanently shadowed craters at high latitudes [7] or the existence of other substances like elemental sulfur [8], are still possibilities.

Additional Work. Currently we are working on an additional test for our results. Latitudinal variations in crater d/D ratios were documented on Mars, based on Viking orbital imagery. We are currently attempting to document this variation in two selected areas of Mars, one equatorial region and one at the south pole, using Mariner 9 photographs. If successful, this test will give us confidence that similar variations, if they exist, can be identified on Mercury at comparable Mariner 10 resolution.

References. [1] Harmon, J. K. et al. (1994) *Nature*, 369, 213-215. [2] Salvail, J. R. and Fanale, F. P. (1994) *Icarus* 111, 441-455. [3] Carr, M. H. et al. (1977) *JGR*, 82, 4055-4065. [4] Barlow, N. G. and Bradley, T. L. (1990) *Icarus*, 87, 156-179. [5] Nozette, S. et al. (1994) *Science*, 266, 1835-1839. [6] Squyres, S. W. et al. (1992) In *Mars*, Univ. AZ. Press, 523-554. [7] Rawlins, K. et al (1995) *B-AAS*, 27, 1117-1118. [8] Sprague, A. L. et al. (1995) *B-AAS*, 27, 1116.

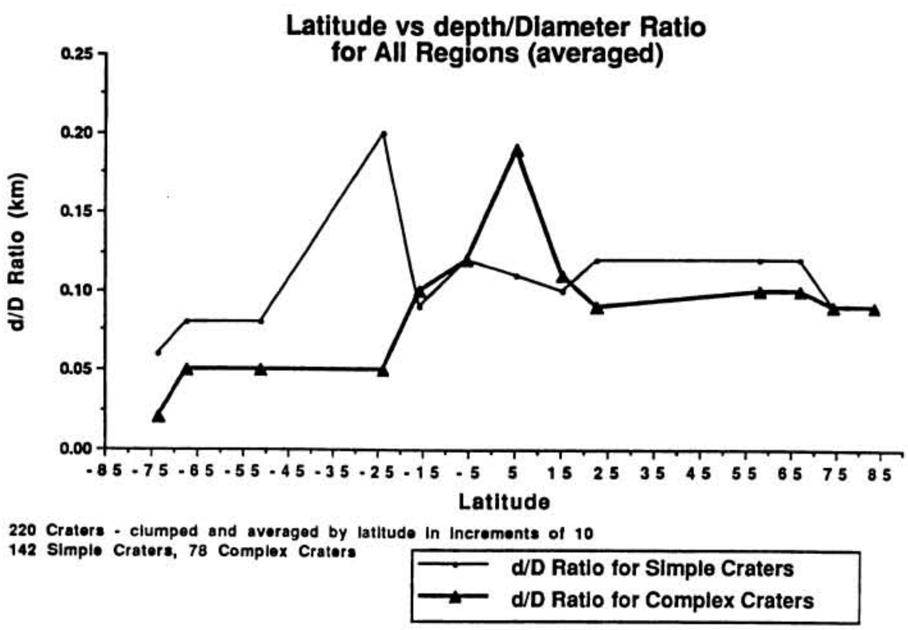

Figure 1 Latitude versus d/D ratio for simple and complex craters