IMPACT CRATERS IN ARABIA TERRA, MARS. N. G. Barlow[1] and J. M. Dohm[2], [1]Dept. of Physics and Astronomy, Northern Arizona Univ., Flagstaff, AZ 86011-6010 Nadine.Barlow@nau.edu, [2]Dept. of Hydrology and Water Resources, Univ. Arizona, Tucson, AZ 85721 jmd@hwr.arizona.edu.

Introduction: A number of geomorphic, structural, elemental, geophysical, geologic, thermal inertia, and albedo characteristics indicate that Arabia Terra is a unique region within the Martian highlands. Impact craters within Arabia also display a number of unusual characteristics. Our analysis unfolds a possible ancient 3000-km-diameter impact basin in this region [1] which has served as a repository for volatile-rich materials over much of Martian history.

Crater Morphology: A global analysis using Viking and MGS MOC data revealed that the northern portion of Arabia displays an enhanced concentration of multiple layer ejecta (MLE) morphology craters [2]. We have recently begun a renewed examination of impact craters in Arabia which includes use of THEMIS VIS and IR imagery in addition to Viking and MOC. THEMIS data are revealing impact crater features in a level of detail not previously seen. The resolutions and image quality are improved over the Viking data and the larger regional extent allows us to obtain a more complete view of the craters than is possible using MOC.

The number of craters displaying a layered ejecta morphology (single layer (SLE), double layer (DLE) or multiple layer (MLE) [3]) is increasing due to the THEMIS analysis. Some craters which were classified with SLE morphology based on Viking analysis are shown to actually be MLE craters in THEMIS data. In addition, many craters which were not classified with an ejecta morphology or whose ejecta morphology was ambiguous in Viking imagery are able to be classified using THEMIS analysis. Ejecta morphologies of approximately 25% of the craters examined to date have had been revised based on THEMIS analysis.

With these ejecta morphology revisions, we find that the concentrations of layered ejecta morphologies, particularly SLE and MLE, are higher than previously reported for Arabia. SLE craters are generally believed to form by impact into ice [4, 5, 6, 7] while the MLE morphology has been proposed to result either from excavation into liquid reservoirs [6] or by interaction of a volatile-rich ejecta curtain with the martian atmosphere [7]. The regional concentrations of MLE morphology craters, their association with other purported indicators of a volatile-rich substrate, and their correlation with the high-water abundance equatorial regions in GRS/NS data provide strong support that subsurface volatiles are involved in their formation and that conditions are different in these regions than where SLE craters dominate.

THEMIS night IR imagery provides information about the thermal properties of the region. Very fresh craters display night-IR-bright ejecta blankets due to the concentration of dust-free surfaces and rocks in the ejecta deposit. Analysis of THEMIS night images shows that SLE and MLE craters display a range of preservation, indicating that the conditions under which these features form have been present for long time periods. Thus, if the MLE morphology results from excavation into liquid reservoirs, the range of MLE crater preservation suggests that this liquid reservoir has been long-lived in this region. Analysis of other crater characteristics used to indicate preservation [8] support this conclusion.

Central Pits: THEMIS imagery also reveals high concentrations of central pits within craters in Arabia, particularly along the rim region of the proposed impact basin. These pit structures occur on the floors and atop central peaks ("summit pits") of the craters, with floor pits being slightly favored over summit pits. Central pits have been proposed as additional indicators of subsurface volatiles, created by degassing of target material during crater formation [6, 9]. *Barlow and Bradley* [6] reported that central pits are distributed preferentially along the rim and the possible outer rings of large impact basins. They suggested that fracturing of target material during basin formation could concentrate volatiles in these locations.

Many of the central pits are found in MLE craters (Figure 1), suggesting that the conditions which favor formation of the MLE morphology may also contribute to central pit formation. Pits are seen in both relatively fresh craters (those with identifiable ejecta blankets) and more degraded craters, indicating that the volatiles responsible for their formation have existed in this region for a substantial period of time. This is consistent with our conclusion above based on the preservation state of layered ejecta morphologies and extends the time period of an active subsurface volatile reservoir beyond that recorded by the ejecta craters.

Discussion: Crater morphologic and central pit data suggest that Arabia hosts a subsurface volatile-rich reservoir of ice and possibly liquid water. The crater data are just one indicator of the uniqueness of Arabia Terra. The combined stratigraphic, topographic, structural, crater, geomorphic, geophysical, elemental, and thermophysical signatures suggest that

Arabia is unusual compared to other highlands regions [1]. GRS neutron spectrometer data reveal Arabia to be one of the most H_2O-rich areas in the equatorial region of Mars [10, 11]. The correlation of this region with crater indicators of subsurface volatiles suggest that volatiles exist over a range of depths in this region, from less than a meter (GRS/NS analysis) to over 2 km depth (based on crater depth-diameter analysis). The existence of ejecta and central pit features over a range of crater preservation ages indicates that this volatile reservoir has existed for a substantial amount of Martian history, perhaps extending back into the Noachian based on the ages of ejecta craters [12].

The uniqueness of Arabia has led *Dohm et al.* [1] to propose the existence of an ancient buried basin, possibly of impact origin, approximately 3000 km in diameter and centered near 15°N 33°E. This basin, forming in the early Noachian, would serve as a collection zone for volatiles throughout Martian history, producing a long-lived aquifer in this region. Central pit craters are concentrated along the proposed rim of this basin, consistent with earlier reports of central pit craters preferentially occurring along basin rims/outer rings [6]. MLE and SLE craters are found throughout the proposed basin interior and along its rim, consistent with the proposed aquifer location. If the MLE morphology results from excavation into liquid water reservoirs, the basin has contained (and perhaps continues to contain) liquid at some depth. The proximity of Hesperian-aged volcanics at Syrtis Major and Lunae Planum could provide a possible heat source for maintaining a liquid water aquifer in this region over a long period of time.

Crater statistical data can be used to determine if any variation in age exists across the basin. We have selected representative areas constituting the northern rim, center, and southern rim of the proposed basin and conducted crater size-frequency distribution analyses on each region. The results (Figure 2) indicate an ancient (Noachian) age for the region, but no statistically significant difference in age is observed between the north rim and center of the basin. The south rim is slightly younger, resulting from ejecta deposits of the younger Hellas impact basin to the southeast. These results can neither confirm nor deny the existence of the proposed impact basin since erosion and deposition likely have altered the original crater record of this ancient feature.

References: [1] Dohm J. M. et al. (2004) this volume. [2] Barlow N. G. and Perez C. B. (2003) *JGR, 108*, 10.1029/2002JE002036. [3] Barlow et al. (2000) *JGR, 105*, 26733-26738. [4] Mouginis-Mark P. (1979) *JGR, 84*, 8011-8022. [5] Costard F. M. (1989) *Earth Moon Planets, 45*, 265-290. [6] Barlow N. G. and Bradley T. L. (1990) *Icarus, 87*, 156-179. [7] Stewart S. T. et al. (2004) submitted to *Nature*. [8] Barlow N. G. (2004) submitted to *GRL*. [9] Wood et al. (1978) *PLPSC 9th*, 3691-3709. [10] Feldman W. C. et al. (2002) *Science, 297*, 75-78. [11] Boynton W. V. et al. (2002) *Science, 297*, 81-85. [12] Barlow N. G. (1990) *JGR, 95*, 14191-14201.

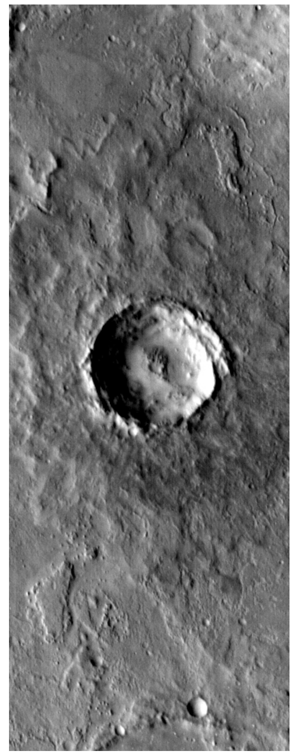

Figure 1: MLE morphology crater with central pit located along the northwestern rim of the proposed Arabia basin. Both the multiple-layer ejecta structure and the central pit are proposed indicators of subsurface volatiles. Crater is 16 km in diameter and located at 15.09°N 348.64°E. (THEMIS image I02035009)

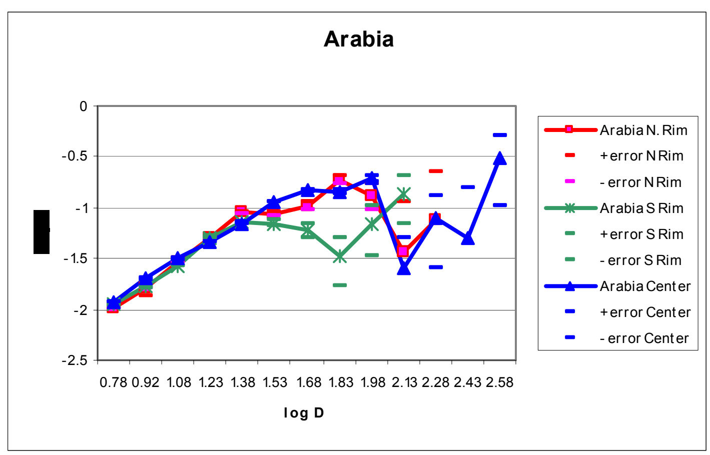

Figure 2: Crater size-frequency distribution curves for craters ≥5-km-diameter for the northern rim, center, and southern rim of the proposed Arabia basin.