MARTIAN NORTH POLAR CRATER MORPHOLOGY: IMPLICATION FOR AN AQUIFER. A.L. Bacastow[1] and S.E.H. Sakimoto[2], [1]Department of Geology, Washington and Lee University, Lexington, VA 24450, bacastowa@wlu.edu, [2]Department of Civil Engineering and Geosciences, University of Notre Dame, 156 Fitzpatrick Hall, Notre Dame, IN 46556-5637.

Introduction: Recent studies of martian north polar craters have suggested that they have more cavity fill than the global crater population [1, 2, 3]. Fill has been found in craters outside the North polar region, such as Gusev crater, but the fill style is significantly different from their northern cousins [4, 5, 3]. The presence of possible hydraulic pingos, which rely on permafrost as well as a groundwater source [2, 6], implies a possible polar region aquifer. This study examines the properties and distribution of these pingo-like features in an effort to constrain local aquifer depths in the martian north polar region.

Data and Approach: We use high-resolution (256 pixels/degree) gridded topographic data from the Mars Orbiter Laser Altimeter (MOLA) instrument on the Mars Global Surveyor Mission to characterize the topography of 373 polar impact craters and their cavity fill materials. Their locations are shown in Figure 1. The IDL-based *Gridview* program was employed to assist with grid-based measurements [7]. On the basis of initial measurements we classified the polar craters into three groups: pingo-like fill craters, enigmatic fill craters, and typical polar craters. Typical polar craters are the craters that did not fit into the other two categories. Pingo-like fill craters are those craters found to have polar deposits that occupy a large area of the crater floor and have complete or nearly complete topographic moats between the central fill and the cavity wall. Enigmatic fill craters are similar in aerial-view and topographic profile to the pingo-like fill craters, but their deposits are typically smaller and less symmetric. Neither the pingo-like nor the enigmatic fill type is remotely similar in central structure to a typical complex crater central peak. In profile, our two types of polar craters with extensive central cavity fill have massive central deposits that occupy substantially more area than the central peak of a typical polar complex crater; these massive central deposits are also significantly closer to the level of the pre-impact surface than a central peak (see figures 2 and 3).

Results: First, we find that most polar impact craters (those north of 55°N) are drastically different than global trend data for impact craters. Using a depth-diameter assessment of crater shape (figure 4) it is readily apparent that polar craters are substantially less deep than would be predicted by the global data [5]. Although the largest polar craters do seem to approach the global average depth, craters have significantly smaller depths than predicted as diameter decreases. This suggests that while there may be possible target effects, it is also quite likely that there are strong, local modification effects filling the craters.

Within the polar impact craters, we find that pingo-like fill craters and enigmatic fill craters occur only in the very near polar region and in a narrow latitude band (figure 1). Within the region closest to the pole that contains all of the non-typical craters, nearly all of the largest complex craters have pingo-like central features. The moderate-sized complex craters have less pingo-like fill while pingo-like central deposits are not observed at all in the smaller, simple craters. In this population of polar craters, the non-typical central fill is more common at high latitudes, at lower elevations, and in larger craters. Moreover, at lower elevations craters are larger and comparatively deeper below the pre-impact surface. In polar craters, crater cavity volume has a much stronger reliance on crater diameter than crater depth, presumably due to the presence of fill. Lastly, the depth of the non-typical craters increases southward from 0.92 to 1.3 km in the region between 81°N and 71°N.

Conclusions: We confirm that polar impact craters on Mars have substantially different depth-diameter relationships than the global trends [8, 1]. We also have found that as elevation decreases there is an increase in crater depth below the pre-impact surface, crater diameter, and crater cavity volume. When we consider the polar craters with non-typical, or pingo-like central deposits, they differ from the global population even more substantially. Specifically, their fraction of volume fill is significantly higher and they tend to compose a large-diameter, high-latitude segment of the crater population. The lack of similar large central deposits in smaller craters in the same regions supports the hypothesis that the anomalous fill cannot be attributed solely to polar layered deposits. Given the analog with earth pingos, one possible explanation for the existence of these polar craters with extensive fill

is the presence of an aquifer or zone of aquifers that is pierced only by increasingly large caters southward. This model is constrained by the crater depth of the non-typical polar craters that increases linearly with increasing distance from the pole. Their properties may be described by a polar region aquifer or multiple aquifer trend that is approximately a kilometer below the plains and deepens at lower latitudes. In this model, the pingo-like central deposits are only found in craters assumed to have punctured the implied aquifer.

References:
[1] Sakimoto, S.E.H., (2005), The Role of Volatiles and Atmospheres on Martian Impact Craters, p 3036. [2] Sakimoto, S.E.H., (2005), LPSC XXXVI, no. 2099. [3] Garvin, J.B., et al. (2003), Sixth International Conference, no. 3277. [4] Cabrol, N.A., et al, (1997), LPSC XXVIII, p 193. [5] Garvin, J.B., et. al., (2000), *Icarus* 144, 329-352 . [6] Soare, R.J., et al., (2004), ICARUS p 373-382. [7] Roark, J.H., et al., (2004), LPSC XXXV, no. 1833. [8] Garvin, J.B., et al. (2002), LPSC XXXIII, no. 1255.

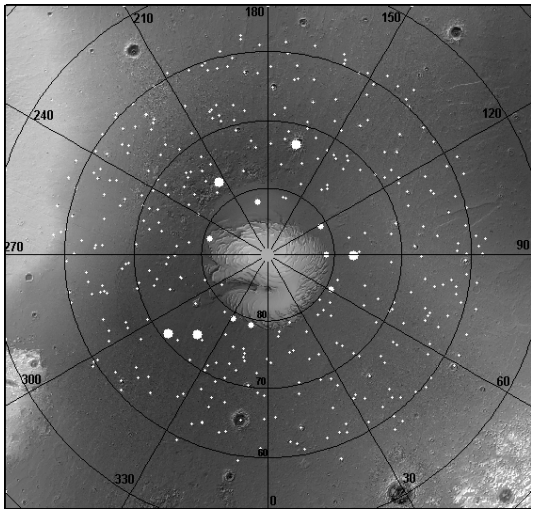

Figure 1. Location map for the 373 craters measured in this study from 55°N to 90°N. The base map is shaded relief MOLA topography (from USGS Planetary GIS Web Server-PIGWAD). The small white points are typical polar craters, the medium white points are "enigmatic fill" craters, and the large white points are "pingo-like" fill craters.

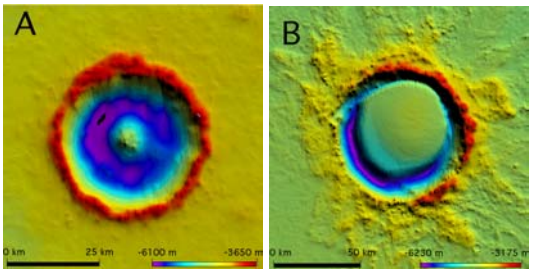

Fig. 2. Examples of gridded and shaded MOLA topography for typical polar and "pingo-like" fill crater. Figure 2A shows a 45 km crater at 63.72N and 11E. Figure 2B shows an 85 km crater at 72.77N and 164.57E. Illumination is from the upper right.

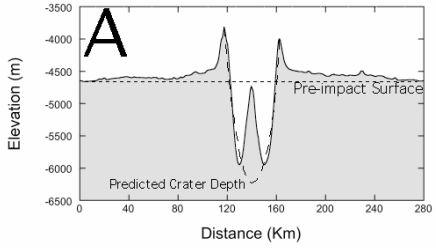

Figure 3A. Typical near-polar crater of 45 km diameter at 63.72N and 11E.

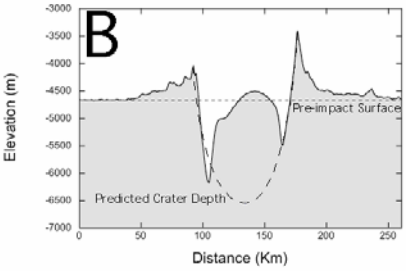

Figure 3B. Typical near-polar crater of 85 km diameter with pingo-like fill at 72.77N and 164.57E.

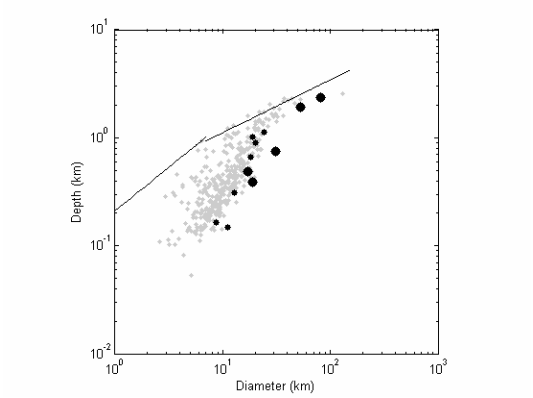

Fig 4. Depth versus Diameter for all 373 craters measured in this study. The small grey points are typical polar region craters, the small black points are "enigmatic fill" craters, and the large black points are "pingo-like fill" craters. The solid lines are the global depth-diameter relationships reported by Garvin et al [5].