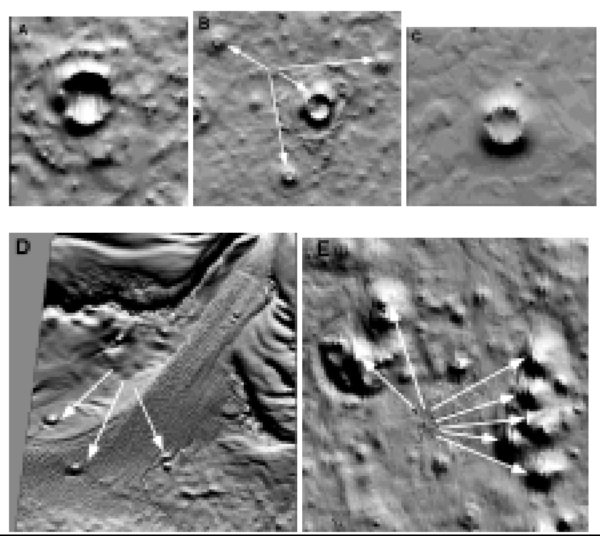
Martian North Polar Impacts and Volcanoes: Feature Discrimination and Comparisons to Global Trends. S. E. H. Sakimoto[1] and S. L. Weren[2,1], [1] GEST at the Geodynamics Branch, Code 921, NASA Goddard Space Flight Center, Greenbelt, MD 20771, sakimoto@geodynamics.gsfc.nasa.gov, [2]Geoscience Department, Franklin and Marshall College, P.O. Box 3003, Lancaster PA, 17604, serena.weren@fandm.edu.

Introduction: The recent Mars Global Surveyor and Mars Odyssey Missions have greatly improved our available data for the north polar region of Mars. Pre-MGS and MO studies proposed possible volcanic features [e.g., 1, 2] , and have revealed numerous volcanoes and impact craters in a range of weathering states that were poorly visible or not visible in prior data sets. This new data has helped in the reassessment of the polar deposits [e.g. 3, 4, 5] From images or shaded Mars Orbiter Laser Altimeter (MOLA) topography grids alone, it has proved to be difficult to differentiate cratered cones of probable volcanic origins from impact craters that appear to have been filled. It is important that the distinction is made if possible, as the relative ages of the polar deposits hinge on small numbers of craters, and the local volcanic regime originally only proposed small numbers of volcanoes. Therefore, we have expanded prior work on detailed topographic parameter measurements and modeling for the polar volcanic landforms [e.g. 6-10] and mapped and measured all of the probable volcanic and impact features for the north polar region as well as other midlatitude fields, and suggest that 1) The polar volcanic edifices are significantly different topographically from midlatitude edifices, and have steeper slopes and larger craters as a group, 2) the impact craters are actually distinct from the volcanoes in terms of the feature volume that is cavity compared to feature volume that is positive relief, and that 3) there are actually several distinct types of volcanic edifices present, and that 4) these types tend to be spatially grouped by edifice. This is a contrast to many of the other small volcanic fields around Mars, where small edifices tend to be mixed types within a field.

Approach: For topographic measurements, we use the released MOLA profiles to grid 30 degree regions at 128 pixels per degree longitude and 256 pixels per degree latitude (approximately 460 m/pixel by 230 m/pixel) using G. Neumann's crossover correction approach to gridding [11] and the publicly available GRIDVIEW software [12]. We measure parameters such as those in [13-14] and [6] for impact craters and volcanoes, respectively. For craters, this includes crater width, depth, rim height, ejecta thickness, rampart height, cavity volume, ejecta volume, etc… For volcanoes, this includes height, diameter, mean flank slope, max flank slope, crater depth, diameter, and volume, edifice volume, area, basal elevation, and locations. The volcano modeling includes the hydrostatic head models used in [7,8]. Examples of some of the features measured are shown in Figure 1 and include impact craters with a relatively fresh cavity, impact craters with filled cavities, cratered cones, steep near-polar cratered cones, and a field of steep cratered cones. The features in this region are compared to those in Tempe Mareotis, Syria, Tharsis, Elysium, the South Polar region, and others.

Figure 1. High resolution MOLA topography shown as shaded relief for A) a fairly fresh polar impact crater, B) a group of partially filled polar impact craters, a C) large cratered cone, D) a group of several near polar cap cratered cones, and E) A field of steeper cratered cones.

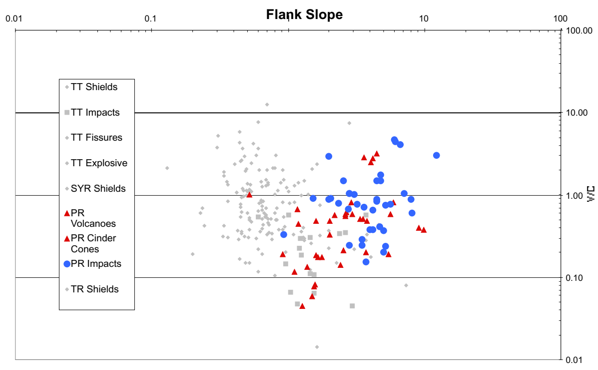


Results:

Polar and Mid-latitude differences. The higher resolution measurements support earlier conclusions that the polar volcanoes are systematically different than the midlatitude volcanoes in flank slope, crater sizes, and other parameters, and that their flank slopes as a group continue the global trend of increasing average flank slope with increasing latitude [e.g. 7, 8].

Impact Crater or Volcano?? While the cratered cones of presumed volcanic origin [e.g. 2, 6] have craters perched above the surrounding plains, local impact –craters with readily apparent ejects ramparts also have craters perched above the surrounding plains, and for those craters with minimal eject ramparts, the volcano/crater distinction is not always obvious in images or topographic grids. Additionally, the volume/diameter versus flank slope that helps differentiate between volcano types sometimes yields overlapping impact and crater field plots (see Fig. 2).

Figure 2. This plot shows feature volume/diameter versus average flank slope in log-log axes for Tempe small volcanic features (in gray for comparison), polar small volcanic features (red triangles), and polar impact craters (blue circles).



However, the readily identifiable impact craters with remnant ejecta blankets and topographically visible ramparts have a larger fraction of the landform occupied by the crater cavity than the features mapped as probable volcanoes do. We use this observation as the basis of plotting newly identified probable volcanoes and possible volcanoes with the impact craters in Figure 3, as crater cavity volume/edifice volume versus crater diameter. This plot tends to show fairly distinct impact and volcanism fields may hat help separate enigmatic features by most likely origins.

Volcanic Types and Origins. With the higher resolution topographic data, the prior suggestion of several different volcanic types within the polar volcanic landforms [e.g. 8, 10, 15] appears much more robust. The large cratered cones identified by several authors as probable volcanics are distinct from the steeper (< 7 degrees flank slope) cratered cones found closer to the polar cap, and these are also distinct from the cluster of steep cratered cones found directly between the polar cap and Alba Patera. The latter features overlap significantly, range in sizes, and are quite numerous within a defined region, while the near polar steeper cones tend to be more isolated, or are found in small groupings.

Conclusions: 1) Polar and mid-latitude volcanoes are fundamentally different in topography, thus and presumably eruption style, 2) Careful parameter measurements appear to assist in differentiating between impact and volcanic features, and there are several probable volcanic edifice types present in the north polar region, with the implication that eruption styles by sub-region tend to be distinct.

References: [1]Tanaka, K. L. and Scott, D. H. (1987) USGS Map I-1802-C. , [2] Hodges, C. A. and Moore, H. J. (1994) USGS Prof. Pap. 1534. [3] Tanaka et al., JGR-Planets, *108* (E4), GDS 24-1, CiteID 8043, DOI 10.1029/2002JE001908, 2003. [4] K.L. Tanaka, and E.J. Kolb, Regional Geologic History of the Polar Regions of Mars, *International Conference on Mars Polar Science and Exploration,*, p 168-169, 2000.[5] Plaut, J. J. et al. (1988) Icarus 73, 357-377. [6] Garvin J.B. et al., (2000), *Icarus*, 145*,* 648-652. [7] Sakimoto S.E.H. et al., (2002) *LPSC XXXIII*, Abstr.#1717. [8] Sakimoto S.E.H. et al., (2001) *LPSC XXXII,* Abstr.#1808. [9] Wong, M.P. et al., (2001) *LPSC XXXII,* Abstr.#1563. [10] Weren, S.L. and S. E. H. Sakimoto, Abstract #66446, submitted to GSA Fall meeting, 2003. [11] Neumann, G.A., et al., JGR, *106* (E10), p. 23573-23768, 2001. [12] Roark, J., et al., *LPSC XXI, Houston, TX*, *CDROM*, Abstract # 2026, 2000. 13] Garvin, J.B., et al., *LPSC XXI, Houston, TX*, *CDROM*, Abstract # 1619, 2000. [14] Garvin, J.B., et al., *Icarus*, *144* (April), 329-352, 2000. [15] Sakimoto, S.E.H., et al., *LPSC XXI, Houston, TX*, *CDROM*, Abstract #1971, 2000.

Acknowledgements: This research was supported in part by funding from the Mars Data Analysis Program and the MOLA Scence Team. Essential software support from J. Roark, helpful discussions and support from J. Garvin, and supplemental funds for S. Weren from H. Frey and Franklin and Marshall College are gratefully acknowledged. We thank E. King and J. Chadwick for assisting with collection of high-resolution mid-latitude volcanism data.

Figure 3. This plot shows crater cavity volume/edifice volume versus diameter for polar features. Polar impact craters (filled blue circles), large cratered cones previously mapped as volcanoes (large open red triangles), small cratered cones that are probable volcanis features (large filled red triangles) andsome enigmatic features that appear to be possibly volcanic (small filled red triangles) so far tend to be fairly distinct groupings. We are in the process of adding more complete data.