**ASSESSMENT OF POTENTIAL REGIONAL VARIATIONS IN MODIFIED IMPACT CRATER MORPHOLOGY ON MARS.** Robert A. Craddock[1], Lourenço Bandeira[2], and Alan D. Howard[3], [1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560 craddockb@si.edu, [2]Centre for Natural Resources and the Environment, Instituto Superior Técnico. University of Lisbon, Av. Rovisco Pais 1049-001, Lisbon, Portugal, lpcbandeira@ist.utl.pt, [3]Department of Environmental Sciences, PO Box 400123 Clark 205, University of Virginia, Charlottesville, VA 22904, http://erode.evsc.virginia.edu

**Introduction:** Modified impact craters represent some of the very first geologic features observed on Mars by spacecraft data [e.g., *1*], yet we still have a poor understanding of how they were modified, and how these processes may have changed both temporally and spatially. Although arguments that they resulted from the effects of volatile-rich airfall deposits continue to persist [*2*] only erosional processes are capable of explaining the fact that different sized craters are preserved in different stages of modification. Diffusional processes, such as rainsplash or micrometeorite bombardment [*3, 4*], advective processes, such as surface runoff potentially associated with valley network development [*3, 4*], and aggradational processes, such as ejecta from the Hellas impact basin [*5*] have all been proposed. There are also some observations to suggest that the style of crater modification may have changed over time, too [*4*]. With modern spacecraft data it is possible to decipher the types of geologic processes that have occurred while quantifying the amount of modification that has taken place. We have pioneered the models and techniques for doing these types of quantitative analyses [*3, 4, 6*]. To date, however, we have only examined a small number of craters in limited areas. The geologic, climatic and hydrologic history of Mars is recorded in modified crater populations. Here we we present the preliminarly results to systematically extract and decipher that history.

**Approach:** Differences in crater morphology is reflected in the topography, which can be quantified using Mars Orbiter Laser Altimetry (MOLA) data. Although it would seem easier to extract topographic information from the released MOLA gridded products, using these products creates two problems. (1) Gridding averages the shot data within each grid cell and fills empty grid cells, reducing the accuracy. (2) The cross-track spacing between MOLA profiles is ~1 km near the equator, and some gaps are much larger. When such gaps occur near the edges of craters, undersampling makes the gridded maps appear as though the crater was preferentially flattened by erosion, which would cause us to overestimate the amount of erosion that has taken place. As a result, we have developed our own semi-automated techniques to collect and quantify data from individual MOLA tracks for individual fresh and modified impact craters [*6*].

To begin our analysis, we accessed the global Mars crater database compiled by [*7*], which includes a qualitative assessment of the degradation state of individual impact craters ranging from a scale of 1 (“rimless”), 2 (“slightly elevated”), 3 (“some degradation/modification”, and 4 (“sharp”). Although subjective, we generally agreed with the classifications presented by [*7*] and applied it here. To check for differences in crater morphology between regions, we analyzed craters in the Sinus Sabaeus (MC-20, 315°-360° W, 0°-30°S), Iapygia (MC-21, 270°-315°W, 0°-30°S), Mare Tyrrhenum (MC-22, 225°-270°W, 0°-30°S), and Aeolis (MC-23, 180°-225°W, 0°-30°S) quadrangles. To look for potential differences due to latitude, we also analyzed craters in the Eridania (MC-29, 180°-240°W, 30°-65°S) quadrangle. The morphometric parameters presented in Table 1 include average values for the *crater depth*, which is the difference between the lowest elevation in the crater floor compared to the elevation of the surrounding crater exterior, *floor slope*, which is the calculated slope of the crater floor from the base of the wall to the center of the crater, average minimum curavature (*avg min curve*), which is the angle between the crater floor and the crater wall, the average maximum gradient (*avg max grad*), which is the average maximum slope of the crater wall, average maximum curavature (*avg max curv*), which is the angle beween the crater wall and the surrounding exterior, average maximum elevation (*avg max ele*), which is the average maximum elevation of the landscape surrounding the crater out to one crater diameter, and the *rim height*, which is the height of the rim calculated from the average surrounding elevation and the total crater depth.

**Results:** In general, there is no obvious difference in morophometric parameters seen in modified impact craters located in different regions. For example, differences in the average maximum curvature has shown to be particularly diagnostic of craters that have been modified exclusively by linear diffusional creep versus craters that have also been modified by extensive surface runoff [*3, 4, 6*]. However, the minimum average value seen in Type 1 craters located in the Mare Tyrrhenum quadrangle is 10.9±6.7 versus a high of 12.2±7.2 for Type 1 craters located in the Iapygia quadrangle. While we cannot rule out the possibility that there are individual crates with unique morphologies that may be the result of differences in local lithol-

| | DEPTH | FLOOR SLOPE | AVG. MIN CURV | AVG MAX GRAD | AVG MAX CURV | AVG MAX ELE | RIM HEIGHT |
|---|---|---|---|---|---|---|---|
| **SINUS SABAEUS** | | | | | | | |
| **AVERAGE TYPE 1** | **424.4688** | **0.0289** | **9.8141** | **0.1267** | **11.8700** | **12.5177** | **77.3779** |
| Standard Deviation Type 1 | 341.4358 | 0.0202 | 5.7502 | 0.0799 | 6.8009 | 7.3091 | 158.5398 |
| **AVERAGE TYPE 2** | **1096.1800** | **0.0545** | **14.6224** | **0.2472** | **17.5646** | **18.5680** | **172.0819** |
| Standard Deviation Type 2 | 506.0065 | 0.0405 | 8.5864 | 0.0776 | 10.2421 | 10.9511 | 257.8756 |
| **AVERAGE TYPE 3** | **1254.0514** | **0.1230** | **7.9689** | **0.3613** | **9.7280** | **9.8548** | **162.9506** |
| Standard Deviation Type 3 | 440.3839 | 0.0366 | 4.8502 | 0.0993 | 5.8358 | 6.2244 | 226.2438 |
| **AVERAGE TYPE 4** | **1158.8566** | **0.1476** | **6.0865** | **0.3698** | **7.5009** | **7.3612** | **147.6143** |
| Standard Deviation Type 4 | 250.5244 | 0.0285 | 1.7479 | 0.1293 | 2.1959 | 2.2127 | 136.7709 |
| | | | | | | | |
| **IAPYGIA** | | | | | | | |
| **AVERAGE TYPE 1** | **492.3537** | **0.0332** | **10.0381** | **0.1505** | **12.1562** | **12.8281** | **90.2259** |
| Standard Deviation Type 1 | 367.4816 | 0.0225 | 6.0200 | 0.0840 | 7.2726 | 7.8167 | 189.5104 |
| **AVERAGE TYPE 2** | **1155.7900** | **0.0630** | **13.2958** | **0.2736** | **16.1134** | **16.9249** | **251.4145** |
| Standard Deviation Type 2 | 538.9480 | 0.0367 | 8.3547 | 0.0844 | 10.0317 | 10.7596 | 310.2110 |
| **AVERAGE TYPE 3** | **1288.0029** | **0.1296** | **7.8410** | **0.3792** | **9.5506** | **9.6973** | **194.3229** |
| Standard Deviation Type 3 | 434.5118 | 0.0392 | 4.5168 | 0.1145 | 5.4267 | 5.8512 | 257.3045 |
| **AVERAGE TYPE 4** | **1298.3502** | **0.1464** | **6.8147** | **0.3610** | **8.3753** | **8.2064** | **188.6785** |
| Standard Deviation Type 4 | 414.7159 | 0.0186 | 1.8818 | 0.1338 | 2.2700 | 2.5137 | 133.5801 |
| | | | | | | | |
| **MARE TYRRHENUM** | | | | | | | |
| **AVERAGE TYPE 1** | **468.1848** | **0.0359** | **9.0601** | **0.1638** | **10.8881** | **11.4297** | **85.6204** |
| Standard Deviation TYPE 1 | 331.3683 | 0.0228 | 5.5876 | 0.0837 | 6.6669 | 7.3749 | 166.2673 |
| **AVERAGE TYPE 2** | **974.7508** | **0.0500** | **13.0491** | **0.2606** | **15.6156** | **16.3349** | **233.1468** |
| Standard Deviation TYPE 2 | 486.2858 | 0.0296 | 8.0941 | 0.0701 | 9.6861 | 10.2303 | 263.6800 |
| **AVERAGE TYPE 3** | **1271.9136** | **0.1284** | **8.0359** | **0.3684** | **9.7210** | **9.9282** | **206.9546** |
| Standard Deviation TYPE 3 | 417.2479 | 0.0381 | 4.8633 | 0.1078 | 5.8286 | 6.2376 | 215.7420 |
| **AVERAGE TYPE 4** | **1139.7065** | **0.1372** | **5.9365** | **0.4220** | **7.2678** | **7.3173** | **178.1608** |
| Standard Deviation TYPE 4 | 242.7316 | 0.0264 | 1.2333 | 0.0999 | 1.3824 | 1.5041 | 172.0588 |
| | | | | | | | |
| **AEOLIS** | | | | | | | |
| **AVERAGE TYPE 1** | **474.7582** | **0.0351** | **9.5400** | **0.1642** | **11.5176** | **12.0795** | **102.2380** |
| Standard Deviation TYPE 1 | 327.4705 | 0.0222 | 6.0950 | 0.0829 | 7.3869 | 7.9364 | 193.6262 |
| **AVERAGE TYPE 2** | **919.6988** | **0.0471** | **12.2871** | **0.2645** | **14.7394** | **15.4780** | **235.6668** |
| Standard Deviation TYPE 2 | 451.6106 | 0.0222 | 7.1917 | 0.0747 | 8.6093 | 9.3067 | 279.2618 |
| **AVERAGE TYPE 3** | **1248.5662** | **0.1285** | **7.6517** | **0.3729** | **9.2969** | **9.4273** | **186.9793** |
| Standard Deviation TYPE 3 | 367.2849 | 0.0355 | 3.8268 | 0.0921 | 4.5421 | 4.8703 | 203.0818 |
| **AVERAGE TYPE 4** | **1164.3676** | **0.1162** | **6.6568** | **0.4085** | **7.9936** | **8.1557** | **148.0553** |
| Standard Deviation TYPE 4 | 334.9862 | 0.0190 | 1.9714 | 0.0716 | 2.2346 | 2.5532 | 160.8445 |
| | | | | | | | |
| **ERIDANIA** | | | | | | | |
| **AVERAGE TYPE 1** | **376.1940** | **0.0267** | **9.3535** | **0.1251** | **11.4193** | **12.1320** | **65.6144** |
| Standard Deviation Type 1 | 285.9383 | 0.0180 | 5.4197 | 0.0759 | 6.5178 | 7.0716 | 149.0631 |
| **AVERAGE TYPE 2** | **773.0100** | **0.0460** | **11.0959** | **0.2060** | **13.4550** | **14.4221** | **162.4578** |
| Standard Deviation Type 2 | 431.0075 | 0.0265 | 7.0847 | 0.0657 | 8.4502 | 9.2418 | 233.9325 |
| **AVERAGE TYPE 3** | **1087.6500** | **0.0929** | **8.3945** | **0.3137** | **10.2346** | **10.4420** | **209.5433** |
| Standard Deviation Type 3 | 492.8625 | 0.0346 | 4.6388 | 0.0936 | 5.5062 | 5.8893 | 235.0930 |
| **AVERAGE TYPE 4** | **1440.8470** | **0.1176** | **10.1665** | **0.3645** | **12.6917** | **13.3117** | **135.7143** |
| Standard Deviation Type 4 | 532.0351 | 0.0554 | 7.9019 | 0.0861 | 9.8679 | 10.4795 | 131.3886 |

ogy or perhaps brief climatic epoisodes on Mars, our preliminary results indicate the the general morphology of the modified impact craters remains consistent at different stages of modification, even at higher latitudes. This may reflect the effects of an ancient climate that was global. A global climate may be the result of a primordial atmosphere that was dense enough to prohibit many regional or latitudinal variations in climate that are typical on the Earth. Essentially, modified impact craters may be the result of condensation and collapse of a primordial steam atmosphere and record the period of time before lakes, oceans, and valley network formation occurred. Continued statistical analyses of the morphometric parameters we derived along with a systematic analyses of the other modified impact craters can test this hypothesis.

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