Water Indicators in Sirenum Terra and around the Argyre Impact Basin, Mars. J. G. Stern[1], H. V. Frey[2], [1]Montgomery Blair HS, 51 University Blvd E, Silver Spring, MD 20901; jostern@mbhs.edu, [2]NASA's GSFC, Geodynamics Branch, Code 921, Greenbelt, MD 20771; Herbert.V.Frey@nasa.gov.

Introduction: This study examines the relationships between three temporally distinct indicators of water on Mars: ancient craters with fluidized ejecta [1], relatively more recent gullies inside those craters [2], and current abundance of near surface hydrogen around those craters [3]. We find an association between gully occurence and large-scale geologic features; analysis indicates unique depth/diameter ratios for gullied craters in Sirenum Terra. Numerical comparisons of fluidized and non-fluidized, gullied and non-gullied craters suggest that the Argyre region could have had a near-surface water table that receded before recent times, while Sirenum Terra may have had an ancient water table that persists to this day.

Methods:

1. *Finding Craters and their Gullies.* The regions around Sirenum Terra (150° – 195° W, 25° – 60° S) (Figure 1) and Argyre basin (15° – 60° W, 25° – 60° S) (Figure 2) were systematically surveyed for all craters 3 km or larger in diameter. These craters were imaged by the Narrow Angle Mars Observer Camera (MOC-NA) aboard the Mars Global Surveyor (MGS) satellite, by the Viking orbiter camera, or by the Thermal Emission Imaging System Visible Camera (THEMIS-VIS) aboard the Mars Odyssey satellite. After a crater was verified to have photographic coverage, it was surveyed for gullies.

2. *Crater Diameter, Depth, and Ejecta.* The craters were then located in Mars Orbiter Laser Altimetry (MOLA) data, using the visualization software Gridview. MOLA data were used to find each crater's coordinates (°N, °W), diameter (km), and depth (km).

3. *Near-Surface Hydrogen.* To find the hydrogen abundance around a crater, the epithermal neutron flux data from the Neutron Spectrometer (NS) aboard the Odyssey satellite were accessed with Gridview. The coordinates of each crater were found in the epithermal data, and the crater's flux value (number of neutrons/second) was recorded.

4. *Compilation of Data.* All numerical and descriptive data were tabulated. Using these observations of ejecta morphology and slope features, each crater was categorized as either gullied or non-gullied, and fluidized, possibly-fluidized, or non-fluidized.

The criterion for a crater to be "gullied" is observation of at least two of the three components of a gully (alcove, channel, and apron [2]).

For a crater to be "fluidized," it must have a distinct edge to continuous ejecta, with the approximate extent of continuous ejecta at least three-fourths of the crater diameter. At least one-third of the blanket edge must be sinuous, or at least one-third of the edge must have a ridge.

For a crater to be "possibly-fluidized," it must have an edge that is hardly visible in MOLA data but partially visible in the context image. The ejecta extent is

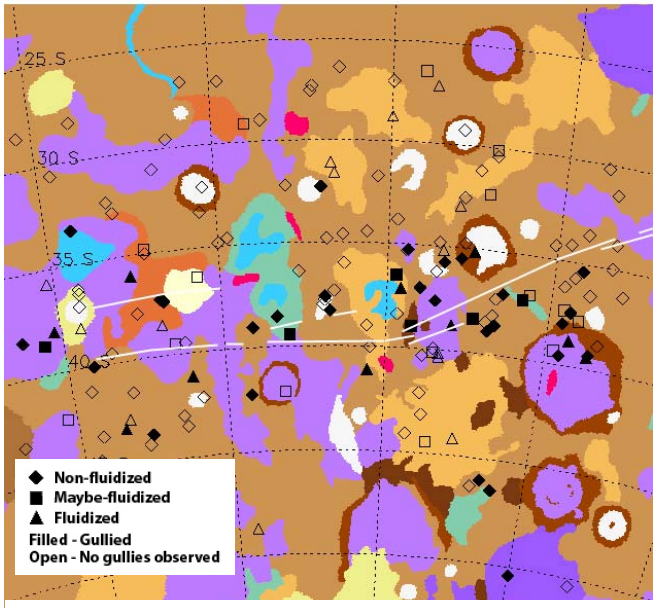

Figure 1: Distribution of surveyed craters superimposed on a geologic map [4] of the Sirenum region. Sirenum Fossae are superimposed with white lines.

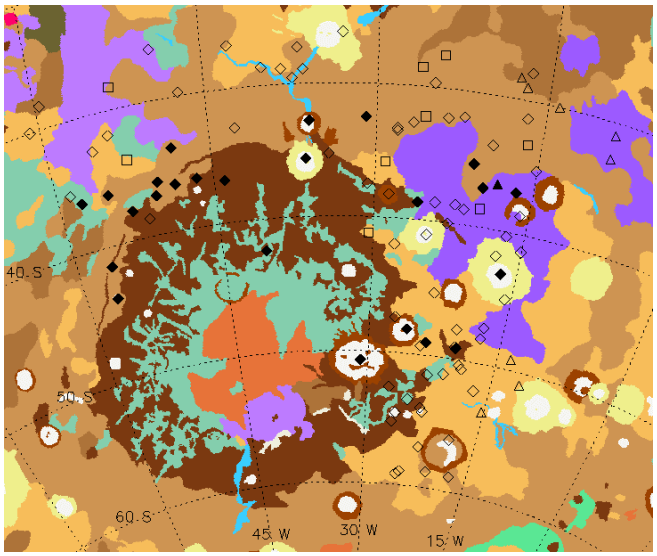

Figure 2: Distribution of surveyed craters around the Argyre basin.

Crater Type	Craters in Argyre (less H) (108)	Craters in Sirenum (more H) (159)
Fluidized	**11 (10%)**	**27 (17%)**
• *With Gullies*	*1 (9%)*	*10 (37%)*
• Without Gullies	10 (91%)	17 (63%)
Possibly-Fluidized	**9 (8%)**	**21 (13%)**
• *With Gullies*	*0 (0%)*	*6 (29%)*
• Without Gullies	9 (100%)	15 (71%)
Non-Fluidized	**88 (81%)**	**111 (70%)**
• *With Gullies*	*24 (27%)*	*28 (25%)*
• Without Gullies	64 (73%)	83 (75%)

Table 1: Numbers of craters by gully presence, with respect to geographic area.

abnormal, and the ejecta blanket has an abrupt drop-off but is not sinuous.

Results: Gullied craters found in Sirenum Terra are strongly concentraded between 35° S and 40° S (Figure 1). Craters that have both gullies *and* fluidized ejecta also seem to concentrate between 35° S and 40° S, clustering near the Sirenum Fossae. In the Argyre region (Figure 2), clusters of gullied craters are seen immediately northwest, north, and east near the basin rim; an additional cluster resides slightly farther north-east. In addition to this apparent preference for Argyre's rim, gullied craters are found in highest concentration between 35° S and 40° S, similar to Sirenum's latitude concentration.

Table 1 shows both a fluidized crater and a gully dependence based on the region. Sirenum Terra, which has a higher present-day near-surface hydrogen abundance than Argyre, is observed to have a higher percentage of fluidized craters and possibly-fluidized craters than the Argyre region. Sirenum also has a substantially higher percentage of gullied fluidized and possibly-fluidized craters than Argyre. Both regions, however, have similar gullying fractions for their non-fluidized craters (27% and 25%), consistent with an overall gullying frequency of about 26%. Compared with the non-fluidized craters in each area, the fluidized craters in Sirenum have a higher percentage of gullies, and the fluidized craters in Argyre have a much lower percentage of gullies.

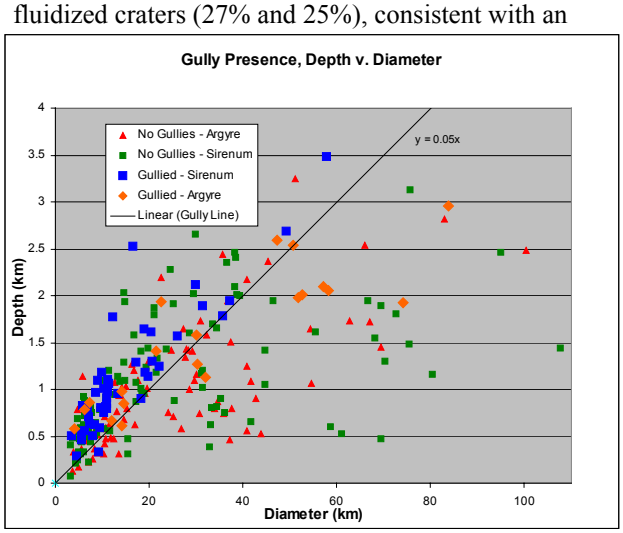

Figure 3: Diameter versus depth broken up by gully presence and region.

Figure 3 shows that almost every single gullied crater measured in Sirenum has a depth/diameter ratio greater than or equal to 0.05. This finding is quite distinct from the broader range of depth/diameter ratios for gullied craters in Argyre and non-gullied craters in both Sirenum and Argyre.

Discussion: Gullied craters in Sirenum Terra and around the Argyre impact basin have a strong latitudinal dependence and perhaps structural associations. Gullied craters tend to be observed near the Sirenum Fossae and along the circumference of the Argyre impact basin. It is possible that these large-scale geologic features have influenced the formations of the gullies present in each region.

A relatively large gully occurrence-rate in Sirenum fluidized craters, coupled with abundant near-surface hydrogen in that region, suggests that a relatively extensive water table may have persisted from when the craters were excavated through gully formation to this day. Alternatively, near-surface water tables in Sirenum could have grown and receded repeatedly between crater formation, gully formation, and the present day.

The unusual depth/diameter ratio for the gullied craters in Sirenum is unexpected and intriguing. It may indicate unique target materials [5]. Unique target properties may be consistent with the idea of a pervasive water table at the time of crater formation, which, by the earlier argument, may have persisted until the present.

References: [1] Carr, M. H., et al. (1977). *J. Geophys. Res.,* 82, 4055-4065. [2] Malin, M. C. & Edgett, K. S. (2000). *Science*, 288, 2330-2335. [3] Boynton, W. V., et al. (2002). *Science*, 297, 81-85. [4] Scott, D. H., et al. (1986). U.S. Geological Survey, Map I-1802-A. [5] Garvin, J.B., et al. (2003). 6th International Conference on Mars, Abstract #3277.