A PRELIMINARY RELATIONSHIP BETWEEN THE DEPTH OF MARTIAN GULLIES AND THE ABUNDANCE OF HYDROGEN ON NEAR-SURFACE MARS

E. L. Frey[1], S. E. H. Sakimoto[2], H. V. Frey[3], [1] South River High School, Edgewater, MD 21037, erin@kasei.gsfc.nasa.gov, [2]GEST at the Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771, sakimoto@core2.gsfc.nasa.gov, [3]Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771, Herbert.V.Frey@nasa.gov,.

Recent compelling evidence has been presented to suggest the presence of near-surface water or water ice on Mars. The Mars Orbiter Camera (MOC) has photographed relatively young fluvial features in the form of gullies [1] which have been attributed to groundwater seepage. The Gamma Ray Spectrometer (GRS) from the Mars Odyssey spacecraft has detected large amounts of hydrogen in the Martian soil, inferred to come from water or water ice within the upper meter of the surface [2]. We explore the model of groundwater seepage as the mechanism of gully formation [1] as opposed to other mechanisms [3, 4]. We investigate the abundance of hydrogen to the depth at which gully-like features form. We see a positive correlation, which implies the presence of a groundwater system for Mars.

Methods and Observations: We correlate the presence of gully like features found in high-resolution MOC images to the abundance of hydrogen on the surface of Mars, as described by Frey et al [5] and below. We use an interactive IDL computer program GRIDVIEW to plot the GRS map of hydrogen [2] with a map showing the locations of previously discovered gullies from *Malin and Edgett* [1]. Using this correlated map, we then choose four gullied areas of differing hydrogen abundance, from hydrogen rich to hydrogen poor. These areas include the polar pits (-70°, 358° W), Newton crater (-40°, 158° W), a crater in Noachis Terra (-47°, 355° W) and Hale crater (-35°, 37° W) from hydrogen rich to hydrogen poor, in that order [see Figure 3]. In each of these four areas, we search MOC images for occurrences of gullies. For our purposes, gullies must coincide along track with the MOLA profile in order to be measured for depth below the surrounding surface. After registering the profile to the image, we determine at what elevation the gullies begin.

We measured the depth of the gullies from the rim of the crater or pit, from the local peak present and from the surrounding surface. For this study, we focused on the depth of gullies below the surrounding surface. In the polar pits, the depths at which gullies emanate ranges from 15 to 55 meters below the surrounding surface. In Newton crater, depths range from 35 to 60 meters. The range of gully depths in Noachis Terra covers 45 to 870 meters below the surrounding surface, and in Hale crater, 250 to 2225 meters.

After searching each area for gullies and measuring their depths, we normalized each gully measurement with the maximum depth of the feature below the surrounding surface, so that we could systematically compare one area to another. We find that gullies in hydrogen rich areas begin relatively closer to the surface, while gullies in hydrogen poor areas begin further below the surface. Also, in dryer areas, the overall range of depths at which gullies form is significantly larger. Figure 1 shows the average depth of all gullies in an area (when normalized by feature depth) appears to be linearly related to the present day abundance of hydrogen.

Implications and Future Work:. The strong linear correlation between gully depth and current hydrogen abundance suggests that the young age of the gullies may be correct. Their presence indicates the presence of a potential groundwater reservoir, also sensed to some extent in the GRS results [2]. This preliminary work also implies that the entire water table in the polar pits and Newton crater is closer to the surface than the water table in Noachis Terra and Hale crater.

Malin and Edgett (2000) have suggested that the gullies form due to the presence of an impermeable layer overlying the gullies. Our data finds weaknesses in this method of gully formation. The use of an impermeable layer model is consistent with the data in Hale crater and Noachis Terra, as the impermeable layer could both form the gullies and prevent water or ice from diffusing to the surface, causing GRS to detect little hydrogen in these areas. The Mars Odyssey Thermal Emission Imaging System (THEMIS) also provides evidence for a likely impermeable layer for the gullies of Noachis Terra. Figure 2 shows a layer above the gullies has a higher thermal inertia than the surrounding surfaces, which could be an impermeable rock or ice layer necessary for gully formation. However, it is highly unlikely that an impermeable layer could account for the gullies in the polar pits and Newton crater, where hydrogen is abundant. The impermeable layer would prevent any diffusion of hydrogen to the surface, and therefore the surface of the planet should be observed to be desiccated in these areas if groundwater depth drives hydrogen abundance. We see abundant hydrogen in these areas, however, and it is unlikely that the source of the hydrogen is different than the source of water that created the gullies, as the gullies appear so close to the surface. Other mechanisms for gully formation should be considered, and further measurements are needed to verify the existence of this preliminary relationship.

References: [1] Malin, M.C. and K.S. Edgett. Science 288, 2330-2335, 2000. [2] Boynton, W.V. et al. Science 297, 81-85, 2002. [3] Stewart, S.T. and F. Nimmo. JGR 107, 5069, 2002. [4] Christensen, P.R. Nature 422, 45-48, 2003. [5] Frey et al. Submitted to Science Talent Search, Science Services, Inc.

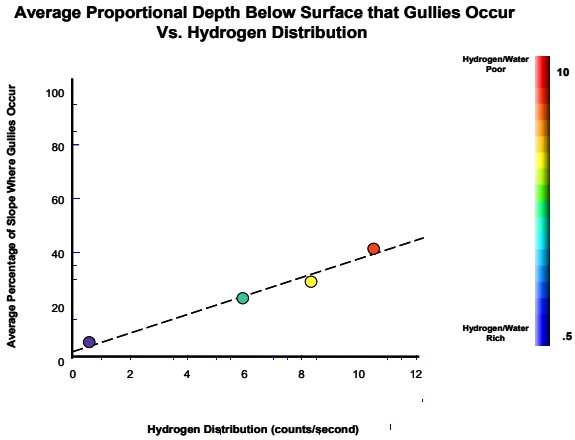

Fig 1. Graph showing the relationship between gully depth and hydrogen abundance as normalized by feature depth. The average depth of gullies in each area is shown by the line. As the areas become progressively dryer, the gullies form further from the surface and the range of depths at which they form becomes greater.

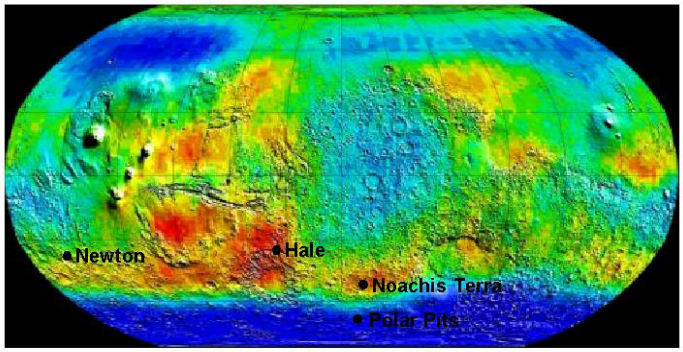

Fig 3. GRS map showing global hydrogen abundance on Mars. Areas that are hydrogen rich appear in blues, while areas that are hydrogen poor are shown in red. The four studied areas are shown on the map.

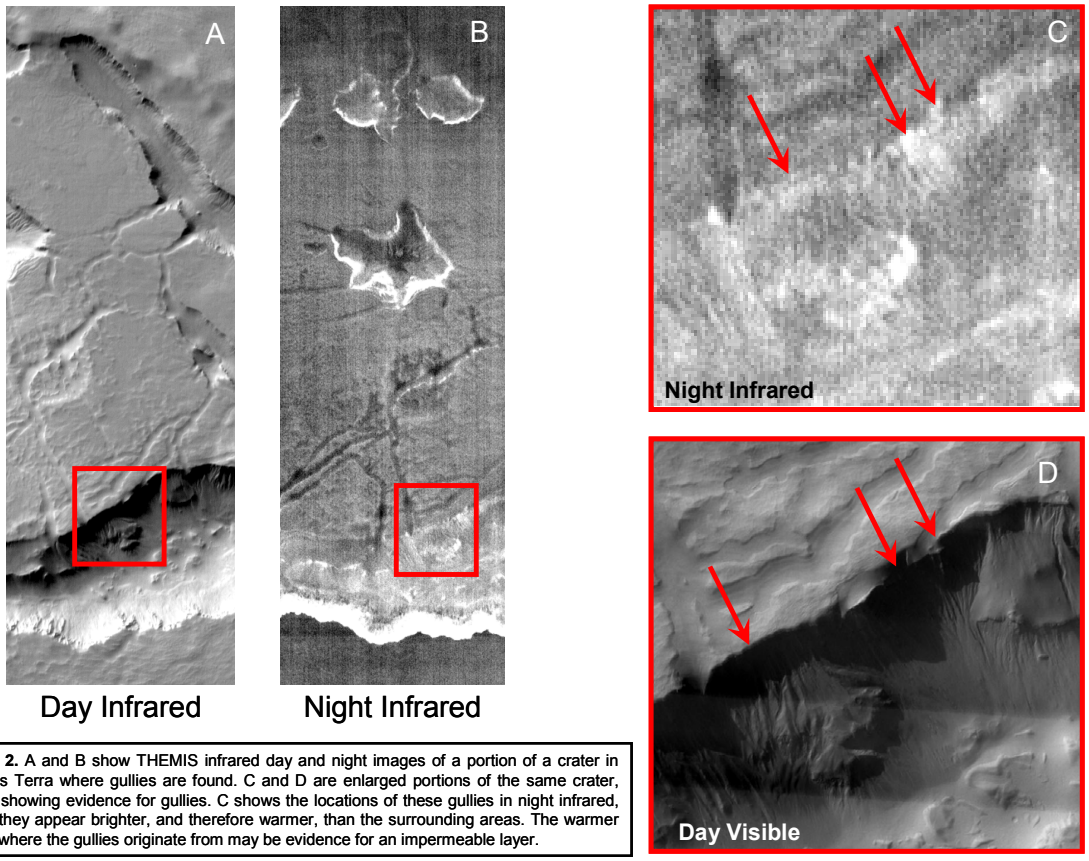

Figure 2. A and B show THEMIS infrared day and night images of a portion of a crater in Noachis Terra where gullies are found. C and D are enlarged portions of the same crater, with D showing evidence for gullies. C shows the locations of these gullies in night infrared, where they appear brighter, and therefore warmer, than the surrounding areas. The warmer bands where the gullies originate from may be evidence for an impermeable layer.