**ANALYSIS AND POSSIBLE FORMATION MECHANISMS OF NOACHIS TERRA CRATER VALLEYS.**

S. W. Hobbs[1], S. J. Conway[2] and M. R. Balme[2], [1]School of Physical, Environmental and Mathematical Sciences, University of New South Wales, Australian Defence Force Academy, Northcott Drive, Canberra, Australian Capital Territory 2600, Australia. (swhobbs2000@hotmail.com) [2]Department of Physical Sciences, The Open University, Milton Keynes, MK7 6AA, UK

**Introduction:** The discovery of valley networks on Mars provided compelling evidence for extensive erosion by flowing water on the planet [1]. Smaller valleys are also found within the crater walls of the Noachis Terra highlands, and show signs of erosion occurring over long periods of time [2]. A variety of mechanisms have been postulated to have formed crater valleys, including groundwater processes [3], precipitation by rain or snow [4, 5] or ice related processes [6]. Here we use a combination of statistical analysis and geomorphic interpretation to investigate valleys residing in four craters within Noachis Terra. We use a combination of CTX images, HRSC and MOLA digital elevation data for our analysis.

**Valley Analysis and Interpretation:** Valleys in our study site possess a variety of morphologies and they fall into two main groups, "fluvial" and "glacial". 45 of our 74 studied valleys have a morphology which is indicative of fluvial processes. The morphology of these valleys does not clearly indicate a single formation mechanism. Most of the fluvial valleys possess amphitheater-shaped heads, suggesting formation by groundwater [7], although many of these were located near the crater rim, making such processes unlikely for all studied valleys. Tributary networks at the head of some of the valleys suggested a distributed source, such as rainfall or snowmelt [2]. Figure 1 shows an example of a "fluvial" type valley, which seems to have formed from a combination of interrelated processes. An upslope series of valleys originates from topographic hollows (black arrows) near the top of the crater wall. On reaching a topographic bench the valleys become indistinct (blue arrows). Then a series of tributary channels and branching valleys appear downslope (green arrows). It is unclear if these valleys formed at the same time, or in separate periods.

We also observed 29 wide valleys whose morphology indicated they were formed by ice-carved processes, such as glacial activity. These valleys are typically U-shaped, wider for their length than valleys interpreted to be fluvial in origin, and are mostly filled with chevron-textured material interpreted to be indicative of once-flowing ice-rich sediment (e.g., [8]). An example of this type of valley is shown in Fig. 2.

Statistical analysis of the valleys revealed that they both increase and decrease in width downstream, and they increase and decrease in gradient downstream.

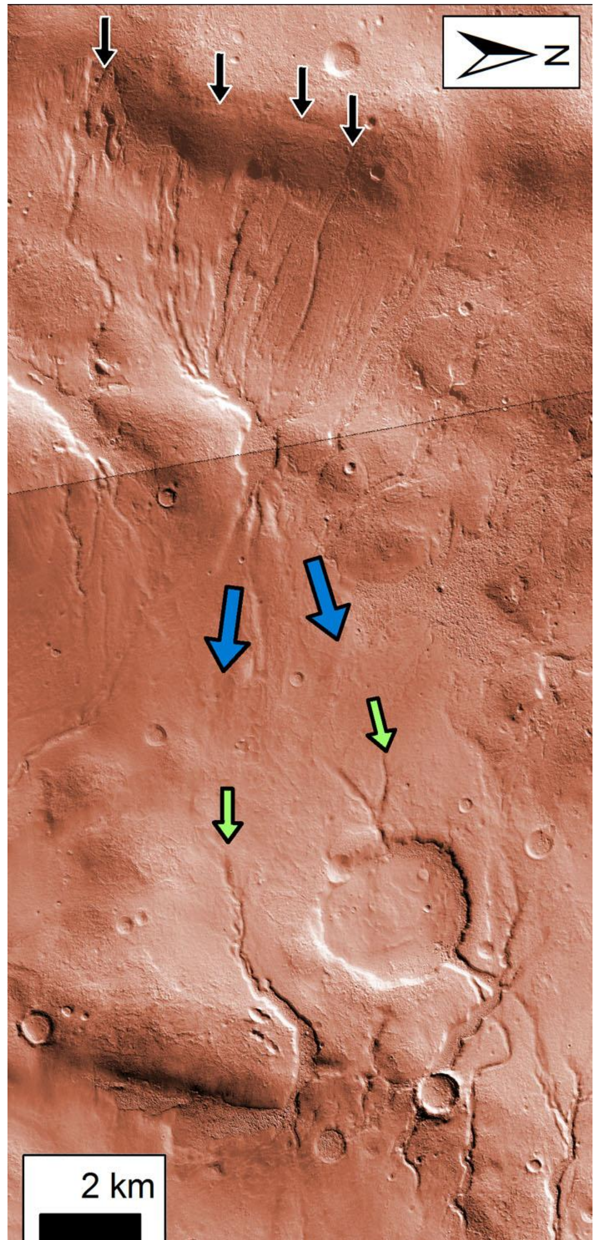


**Figure 1.** Complex "fluvial" valley morphology at the Noachis Terra study site.

This is in contrast to terrestrial valleys that tend to increase in width and decrease in slope downstream [9]. We found that most of our crater valleys in our study area were first order and smaller than previously studied Martian valley networks [10, 11]. The lack of these trends and location of these features on highslope crater walls suggests our valleys are immature and have not evolved a more structured fluvial morphology. Such evolution would be hampered by the higher slopes of these systems, which encourage the formation of sub-parallel channels as opposed to branching morphology [12].

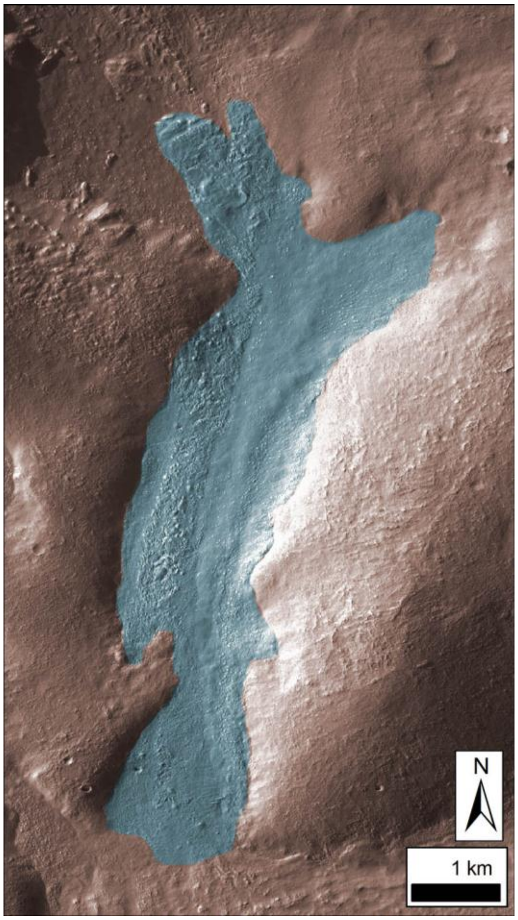


**Figure 2.** Example of carved "glacial" valley within our study site. Material interpreted to be ice-cored is highlighted in blue.

Valley morphology at our study site also revealed a sensitivity to orientation (Fig. 3). We observed that valleys on northern and eastern crater walls are steeper than those on southern and western walls, while valleys on northern (pole facing) and southern (equator facing) walls are wider. Although Hartmann [8] observed a north-south orientation difference in valleys within Greg Crater our study site revealed evidence of past glaciation on both pole facing and equator facing crater walls. This contrasts with the mechanism postulated by other research ([8], [13]). We are currently investigating alternative mechanisms that may have operated on our study site.

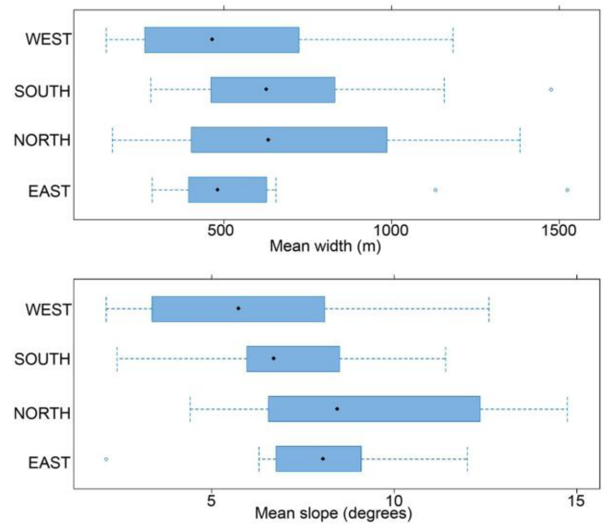


**Figure 3.** Mean valley width and slope dependence on orientation.

**Conclusion**: Our study of Noachis Terra crater valleys revealed a diverse range of morphologies and possible erosive processes. We found that although fluvial erosion appears to have been a major factor operating on our study site, we could not identify a single mechanism that could account for the range of different morphologies that we observed. Differing origins, such as snowmelt or groundwater processes, may have formed valleys at our study site. Additionally our crater valleys have also been modified by varying levels of post-fluvial processes. We also observed strong evidence of valley modification by ice and raise the possibility that some of our studied valleys were modified or even formed by glacial activity.

**References:** [1] Carr M.H. (1996) *Water on Mars*, Oxford. [2] Craddock, R.A. and Howard A.D. (2002) *JGR*, *107*, doi:10.102. [3] Goldspiel J.M. and Squyres S.W. (2000) *Icarus* 48, doi: 10.1006. [4] Ansan V.R. and Mangold N. (2004) *Plan Space Sci.* 54, doi:10.1016. [5] Squyres S.W. and Hasting J.F. (1994) *Science* 265, 744-749. [6] Dickson J.L. et al. (2009) *JGR Lett*, 36:L08201. [7] Hannah J.C. and Phillips R.J. (2005) JGR 110, doi.10.1029. [8] Hartmann W.K. et al. (2014) *Icarus* 228, 96-120. [9] Som S.M. et al. (2009) *JGR* 114, doi:10.1029. [10] Ansan V. and Mangold N. (2013) JGR 118, 1873-1894. [11] Pernido J.C. et al. (2013) *Plan Space Sci* 75, 105-116. [12] Schumm S.A. et al. (1987) *Experimental Fluvial Geomorphology*, Wiley. [13] Conway S.J. and Mangold N. (2013) *Icarus* 225, 413-423.