A RECENT, EQUATORIAL, PERIGLACIAL ENVIRONMENT ON MARS. M.R. Balme[1], J.B. Murray[1], C. Gallagher[2], J-P. Muller[3], J-R. Kim[3], [1]Dept. of Earth Sciences, The Open University, Milton Keynes, MK7 6AA, UK, m.r.balme@open.ac.uk. [2]University College Dublin School of Geography, Planning and Environmental Policy, University College Dublin, Belfield, Dublin 4, Ireland. [3]Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey, RH6 5NT. UK.

Introduction: During the Viking era, Mars' recent climatic history was held to be cold and dry with little evidence for long-lived liquid water near the surface; signs of a past wetter, warmer climate were confined to ancient Noachian or Hesperian-aged terrains. However, data from recent Mars missions have revealed contemporary near-surface water-ice to be abundant at high latitudes [*1, 2*], and a population of mid-latitude fluvial-like gullies [*3*] that appear to have formed by transient melting of ice or snow [*4*]. Thus today's view of Mars' recent surface evolution is one of global permafrost conditions [*5*], with the latitudinal distribution of near-surface ice depending on changing climatic conditions; the timescales of which are governed by obliquity cycles with periods of tens to hundreds of thousands of years [*6*].

However, in recent geomorphological studies of the equatorial *Elysium Planitia* region using very high resolution images (HiRISE; 25cm/pixel) we have identified landforms that almost certainly formed by the action of repeated thaw of ice-rich ground. These observations appear to be at odds with the equilibrium, obliquity-cycle based model of near-surface ice distribution on Mars

Study area: The Elysium Planitia region of Mars is geologically young (late Amazonian; < 100-200 Ma [*7*]) and hosts a variety of landforms that are morphologically similar to those of periglacial and permafrost environments on Earth [*8-11*]. The region was exposed to massive flooding from deep underground sources during the late Amazonian, as demonstrated by the distinctive fluvial morphologies seen in the outflow channel *Athabasca Vallis* [*12, 13*]. These floods would have provided both the source of ice and particulate material required for a periglacial or permafrost landscape and there was probably a long-lived, but slowly freezing, lake or sea in the downstream Elysium basin [*14, 15*]. However, the provenance of the materials and landforms of this region is disputed: many still regard the Athabasca Vallis and Elysium basin as being flood lava provinces, with effusive volcanic materials reoccupying earlier flood landscapes [*16-20*].

Results: We present context mapping results of this area and show HiRISE images of periglacial landforms in the region that include sorted stone circles, pingos within thermokarst-like basins, retrogressive thaw slumps and sinuous channels incised into polygonal ground (examples of which are shown in fig. 1). The assemblage of landforms is typical of degrading frozen ground in which secondary modification of ice-rich sediments has occurred, but is difficult to explain in terms of a primary, volcanic landscape. Moreover, these landforms point to a recent periglacial (i.e. ground containing ice with annual temperatures that cycle above the melting point), rather than permafrost (i.e. ground ice in which temperatures are always below the melting point) environment.

Discussion: The landforms seen in this region probably took several 100s of freeze/thaw cycles to form and occur in very late Amazonian [*12*] flood deposits. This indicates that this locality was warmer than current climate models predict (see [*21*] for discussion) for at least 100s of martian years in the geologically recent past. If Mars' climate was warmer, this suggests in turn that the atmosphere may also have been denser. One model to explain this might be a minor version of a MEGAOUTFLO event [*22, 23*], in which rare, transient excursions in the martian climate occur. This proposed climate excursion might also explain the formation of the aforementioned fluvial-like gullies: perhaps the gullies formed in this warmer, denser atmosphere when ice or snow could melt rather than sublime as it would do in today's thin atmosphere?

The Elysium/Athabasca periglacial landscape provides a "fingerprint" of a recent warmer climate, but it could be asked why similar landforms are not seen in other equatorial regions of Mars. We suggest that the answer is that only here did recent fluvial flooding provide the extensive ice-rich sediment deposits necessary to record this climate excursion. Thus in other low latitude regions, where the long-term effects of insolation and the thin atmosphere had removed near-surface ice, the climate excursion would not have significantly modified the surface.

Finally we suggest that the presence of retrogressively eroding polygonised surfaces demonstrate that the polygonal pattered grounds seen near the head of the Athabasca Vallis are ground-ice, rather than volcanic in origin. If the polygonally patterned ground is not volcanic, it brings into question a volcanic interpretation for other landforms in the region.

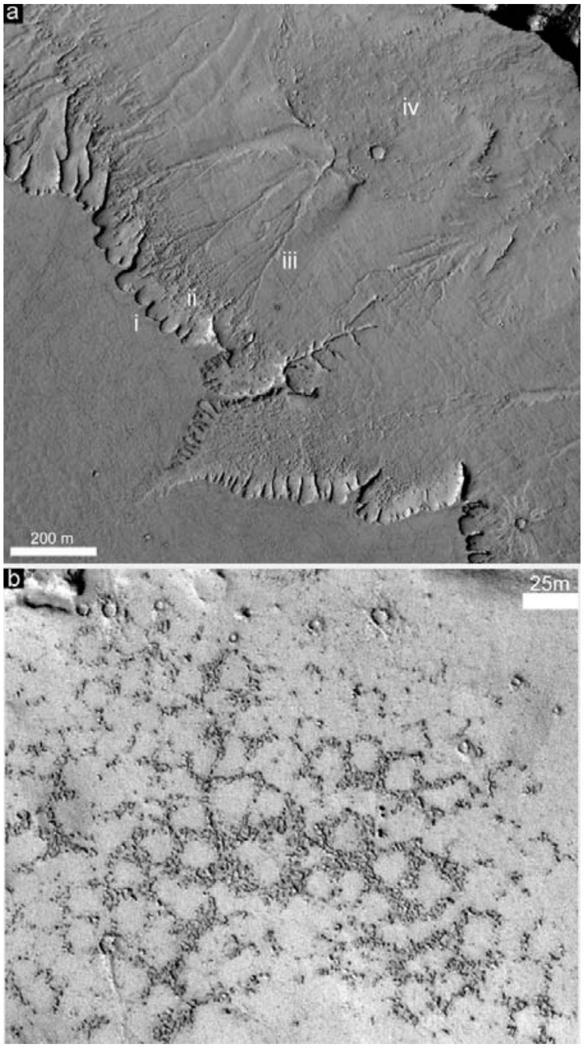

Fig.1. Examples of periglacial landforms found in the Elysium Planitia/Athabasca Vallis region. a) Polygonised surfaces near the head of Athabasca Vallis. This image shows a retrogressive thaw erosion sequence consisting of i) cuspate, multi order niches and embayments with headscarps cut into a polygonised surface, ii) rubbly debris at the base of the scarp, iii) tributary channel networks, iv) possible debris fan. This sequence is typical of degradation of permafrost by thermoabrasion or thermoerosion and requires periglacial conditions. Part of HiRISE image PSP_009280_1905b) Sorted stone circles on the banks of Lethe Vallis – an erosional channel that connects two basins in the Elysium Planitia region. These landforms are indicative of freeze/thaw action. [8] Part of HiRISE image PSP_004072_1845

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