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A recent, equatorial, periglacial environment on Mars

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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. Recent missions have revealed contemporary near-surface water-ice to be abundant at high latitudes, and a population of mid-latitude fluvial-like gullies that appear to have formed by transient melting of ice or snow. Thus today's view of Mars' recent surface evolution is one of global permafrost existing within a framework of climate change, the timescales of which are governed by obliquity cycles with periods of tens to hundreds of thousands of years.

However, in recent mapping work of the equatorial Elysium Planitia region using the latest very high resolution images of Mars (HiRISE; 25cm/pixel) we have found evidence for longer-lived, geologically recent liquid water at the martian surface. This suggests that there was a recent period when the climate was warmer than current obliquity cycle-based models predict. The Elysium Planitia region of Mars is both geologically young (late Amazonian period; <100 Ma) and hosts a variety of landforms that are morphologically similar to those of periglacial and permafrost environments on Earth.

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. 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. However, the provenance of the materials and landforms of this region is disputed: many authors still regard the Athabasca Vallis and Elysium basin as being flood lava provinces, with effusive volcanic materials reoccupying earlier flood landscapes (a classic problem of convergent morphology).

We present context mapping results of this area and show HiRISE images of periglacial landforms in the region that include sorted stone circles, pingoes and retrogressive scarp erosion. These point to a recent periglacial (i.e. ground ice with temperatures that cycle above the melting point), rather than permafrost (i.e. ground ice in which temperatures are always below the melting point) environment, and thus a recent period in which Mars' climate was warmer (and thus the atmosphere was likely to have been denser) than current models suggest. Interestingly, this proposed warm period might also explain the formation of the aforementioned fluvial-like gullies: perhaps the gullies formed in this warmer, denser atmosphere when ice or snow would melt rather than sublimate, in contrast to the behaviour of ice under today's thin atmosphere? Furthermore, the morphology of the degradational landforms demonstrate that the polygonal patterned grounds seen near the head of the Athabasca Vallis are ground-ice, rather than volcanic, in origin, bringing into doubt the hypothesis that the wider Elysium/Amazonis deposits are flood lavas.

The source of the water and ice that was once present here was likely to have been a sub-surface aquifer. Models suggest that liquid water could persist beneath the cryosphere for geologically long time periods. Thus the debris that comprises these deposits represents an exciting target for astrobiological studies and, if engineering constraints can be met, the Elysium/Athabasca region could be considered a prime target for the ExoMars lander.