EVIDENCE FOR IMPACT INTO ICE RICH TERRAIN AND MELTING TO PRODUCE GLACIATION AND VALLEY NETWORKS IN THE AEOLIS/ZEPHYRIA PLANA REGION, MARS.

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Introduction: Just as the environmental histories of Earth and Mars have diverged drastically after the first few hundred million years [1], so, too, would the history of any life on them. While Earth has had liquid water on its surface for billions of years, Mars most likely had long dry and cold environments interspersed with warmer and wetter periods. Throughout the recorded history of Mars, liquid water has distinctly shaped its landscape. Understanding the origin of Martian surface features and their possible relationship to sub-surface geological structures provides important constraints on the paleoclimate of the Red Planet. The volcanic activity peaked around 3.5 Ga ago, but went on until very recently in some areas, especially in Tharsis and Elysium. Over the past ~ 500 Ma until very recently (at least until 4 Ma ago), episodic fluvial/glacial activity occurred regionally or locally, largely confined to a few areas such as Tharsis, Elysium [1]. Pseudocraters are interpreted to be indicators of near-surface volatiles and volcano/ground ice interactions in Elysium Planitia [2]. If Martian rootless cones form in the same manner as terrestrial rootless cones, then equatorial ground ice or ground water in Elysium Planitia must have been present near the surface in geologically recent times [3]. Here, I identify and discuss an assemblage of landforms in Elysium Planitia that is consistent with past and perhaps recent periglacial activity. The Elysium Planitia region of Mars is both geologically young (late Amazonian period; <100 Ma) [4] and hosts a variety of landforms that are morphologically similar to those of glacial environments on Earth. Early studies [5, 6] showed the presence and environments of some younger valley networks on Mars..

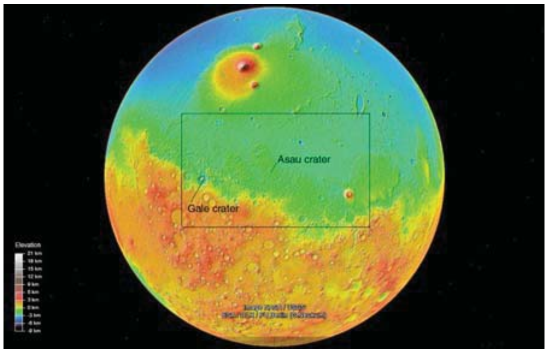

Fig. 1: Mars Orbiter Laser Altimeter (MOLA) map of Mars indicating the position of Asau crater and Gale crater (Mars Science Laboratory landing site).

Paleochannels have been identified, which are interpreted to be the result of melting of ice. A 30 km diameter impact basin (Fig. 3) in the Aeolis/Zephyria Plana region near the dichotomy boundary is characterized by small valley networks (Fig. 4) that are partly located radial to the impact crater ejecta rim. Large glacial deposits, interpreted to be the remains of debris covered glaciers, have been identified in the area surrounding the crater. The spatial association between the crater and the paleochannels suggest that the impact was responsible for their formation. The most outstanding aspect of the area surrounding the crater is the occurrence of valley networks.

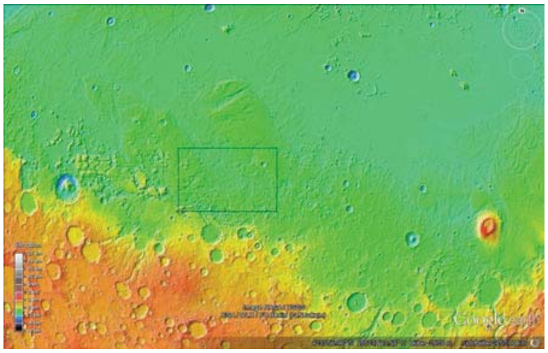

Fig. 2: Context MOLA topographic map of the northern dichotomy boundary in southern Elysium Planitia; the location of the study region, Aeolis/Zephyria Plana region is highlighted by the black box.

Ejecta deposit: The release of water is initiated by the melting of ice from the deposition of hot ejecta over its surface. Such a mechanism would generate fluvial features in the absence of a climatic regime favorable for fluvial activity. To the north, there is an apparent radial pattern that forms striations orientated perpendicular to the crater rim. The pitted texture to the southeast of the crater is interpreted to be caused by the action of sublimation and thus suggests that the deposits once contained a significant amount of ice. Many valleys close to the rim of Asau crater originate from plains adjacent to the crater rim crest.

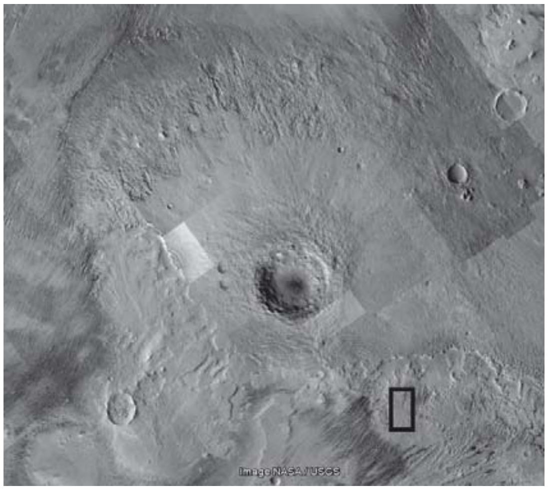

Fig. 3: CTX Image mosaic of an impact crater (Asau crater) in the Aeolis/Zephyria region. Black box marks position of Fig. 4. The map highlights the Asau impact crater in the region near the dichotomy boundary, that is characterized by small valley networks (Fig. 4) that are partly located radial to the crater rim.

Conclusions: I propose that the valley networks originated from the release of water due to the deposition of hot ejecta over ice deposits present in the area during the impact event. Glacial deposits have been identified elsewhere on Mars [7-13]. Water sources originate from the melting of snow/ice deposits and extensive fluvial features in close proximity to the large crater are in a region interpreted to have experienced significant glacial activity. This suggests that Mars has undergone significant glacial periods most likely associated with obliquity variations through large portions of its history. Martian general circulation models indicate that the formation of glaciers could have been initiated during previous climatic regimes associated with the cyclic transition from higher (35 deg) to lower (present) obliquity values [14]. The occurrence of anastomosing drainage patterns and broad, flat valleys in this study region is not consistent with rainfall. Atmospherically derived snow and ice deposits are an alternative source of water, providing that the deposits could be heated sufficiently to generate the meltwater required for erosion. The thermal anomaly associated with the impact event that formed Asau crater would have provided an alternative but substantial energy source, capable of melting surface ice deposits if they had existed on the plateau prior to the impact. This would also explain the close spatial association between the valleys and Asau crater ejecta. The spatial relationship between the valleys and the main crater suggest that they are related, and the hot ejecta deposit associated with the impact provides an explanation for the melting of ice deposits that were present on the plateau at the time of impact.

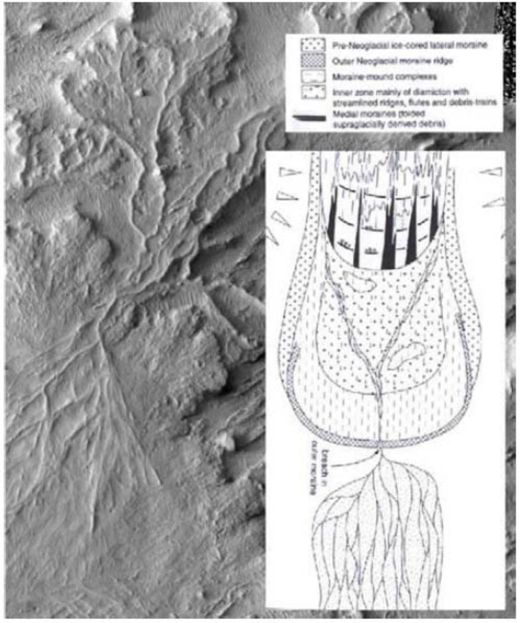

Fig. 4: Themis Image V05875001(left) and terrestrial analog (right, glacier and drainage system, Svalbard, adapted from [15], suggesting the action of glacial meltwater as a water source for fluvial channels.

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