AN AMAZONIAN GROUNDWATER SPRINGLINE AT PEACE VALLIS FAN, GALE CRATER; IMPLICATIONS FOR A LATE PERIOD OF SURFACE WATER FLOW.

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Introduction: Analysis of Mars orbital and Curiosity rover surface imagery and high-resolution digital elevation models of Gale Crater's Peace Vallis fan (Figure 1) reveals two large drainage features with cross-sectional forms, stepped downslope profiles, erosional scarps and locations analogous to groundwater seepage and springline features found on terrestrial fans [1]. Crater counting statistics indicate that these features have implications for understanding the latest surface conditions that might have been conducive to liquid water flow.

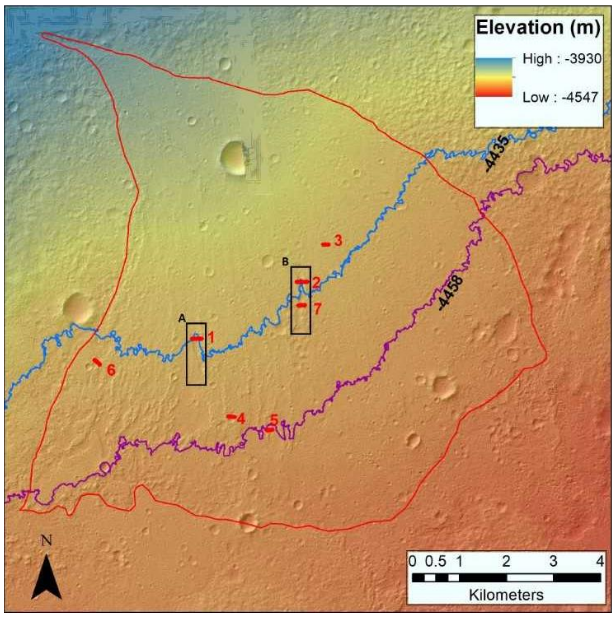

Figure 1. Orbital HiRISE DTM representation showing the Peace Vallis fan outlined in RED. The -4435 elevation contour is shown in BLUE. The groundwater sapping channel in Figure 1 is confined in box A, the other major channel is in box B. Cross-sections 1-7 in red.

RMI observations: The Peace Vallis campaign of the Mars Science Laboratory rover captured a texturally distinct feature ~11.5 km distant during the ChemCam RMI 20x1 raster CCAM04981 sequence [2]. Figure 2 shows the channel feature with white arrows showing the western scarp. The east scarp is obscured by an inverted channel ridge beside the feature. Additional processing of this image adjusted brightness, contrast, and corrected vignetting artifacts from the imaging system [3].

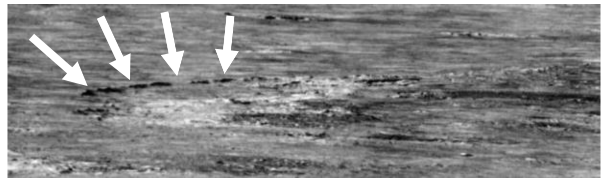

Figure 2. ChemCam RMI image of a groundwater sapping channel on the Peace Vallis fan (Figure 1 Box A & Figure 3 left). The white arrows indicate the western scarp of the channel.

Orbital data: Hillshaded HiRISE DTM data (1m/pxl) of the fan (Figure 3) illuminate features of the channels which are not readily apparent in imagery. Analysis of cross and down feature profiles of these channels reveals a self-similar morphology characterized by flat bottoms, steep parabolic sides, and an amphitheater-like headwall derived from backwasting and collapse. These groundwater springline channels at the -4435 elevation contour, represent a morphologic boundary similar to springlines observed on terrestrial fans (Figure 4).

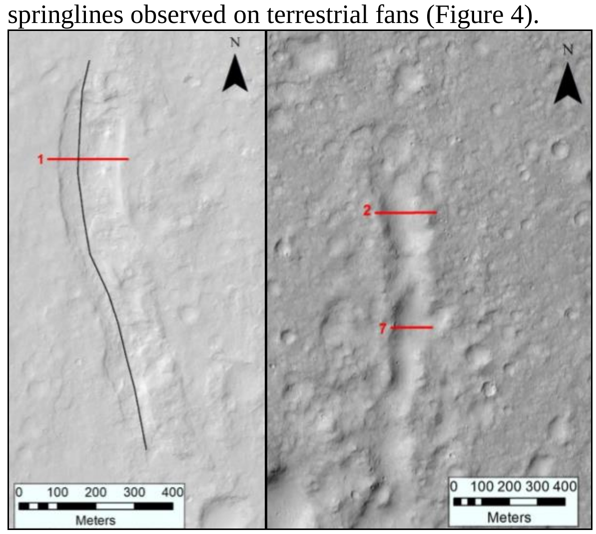

Figure 3. HiRISE DTM data showing the two features outlined in Box A and Box B in Figure 1. Red lines numbered 1, 2 & 7 indicate extrated cross-channel profiles shown in Figure 5. Black line is long profile.

Analysis of channel profiles of these features shows that channel shape evolves in a regular self-similar manner, and on average conforms to modelled and measured seepage channel forms found on Earth (Figure 5).

Discussion: Topographic superposition of these seepage features, relative to a fluvially deposited thin and young fan unit dated by crater counting to <2 Ga [4], indicates that these erosional features formed shortly after surface flow and fluvial deposition of this mid-Amazonian fan unit. Persistent distant sourced groundwater flow, likely active over several hundred years, produced headward erosion that removed portions of this thin, upper-fan unit and produced these seepage features.

Physical mechanism. Environmental conditions late in Mars history producing both surface and groundwater flow were likely initiated by short-term climatic events, possibly the result of a large impact or obliquity variations late in the Amazonian.

Figure 4. Image of alluvial fan springline on a terrestrial fan in Fars province, Southern Iran showing extraction of water for irrigation ~1/2 down the fan from the apex. Surface roughness and dissection changes significantly at the springline feature.

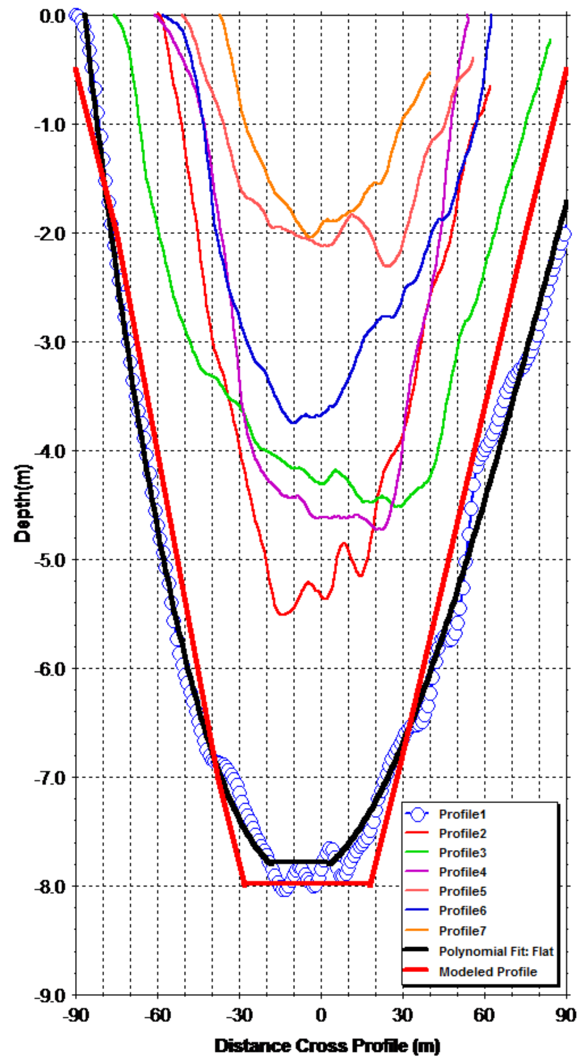

Figure 5. Cross profiles of seven seepage channels (20x vertical exaggeration) shown in Fig. 1. A 3rd order polynomial fit with a flat bottom (black line, adj. $R^2 = 0.993$) approximates channel shape. Modelled profile minus the short parabolic sections that join the flat bottom and nearly vertical sides is derived from [5] and is indicated by the heavy red line. Profiles 1-7 are similar in form suggesting seepage driven self-similar growth.

References: [1] Scuderi L. A. et al. (2019) *Science*, in submission. [2] Gallegos Z. G. et al. (2018) *LPSC XLIX*, Abstract #2965. [3] LeMoulic S. et al. (2019) LPSC *L*, Abstract #pending. [4] Grant J. A. and S. A. Wilson (2018) *LPSC XLIX*, Abstract #2012. [5] Lobkovsky, A.E., et al. (2007). J. Geophy. Res.: Earth Surface 112(F3).