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Hydrological History of a Complex Lake and Valley System in Western Arabia Terra, Mars

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Abstract

We present a detailed geomorphological study of an area in western Arabia Terra that shows evidence for fluvial processes. Sedimentary fan deposits and palaeolake extents inferred from outlet channel elevations serve to reconstruct the hydrological setting at the time of formation, and reveal two valley and lake systems with no surface connection. The close proximity of the two systems, their shared surface elevation, and the limited potential watershed of the smaller system suggests groundwater connectivity and filling. Palaeolake and channel topographies inconsistent with inferred flow directions also suggest significant subsidence and collapse that could be linked to groundwater drawdown or base level change.

1. Background

Arabia Terra hosts diverse landforms indicative of hydrological processes including: fluvial channels [1], deltas [2], palaeolakes [3], ocean shorelines [4], and groundwater upwelling [5]. However, there is little consensus on the timing, duration or interaction of hydrological processes, and detailed study is often limited by the resolution of topographic data. This study focuses on a small area in western Arabia Terra of middle Noachian age [6] situated near the crustal dichotomy that hosts discontinuous channels and sedimentary fans. The goal of this study is to reconstruct the past hydrological system in this region.

2. Data and Methods

This study utilised CTX, HiRISE and THEMIS images to map geomorphological features. Topographic data was obtained by producing a 20 m/pixel DTM mosaic from CTX stereo imagery with SOCET SET, and supplemented by 200 m/pixel HRSC MOLA Blended DEM data.

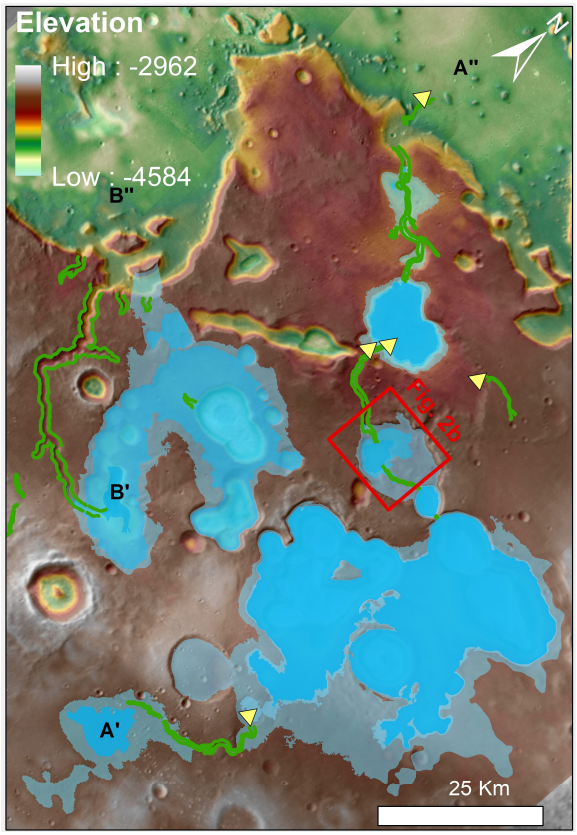

Figure 1 – Topographic map of study area, with channels (green outlines), sedimentary fans (yellow triangles), and palaeolakes inferred from outlet channel start (dark blue), channel spillover (blue), and bank spillover (pale blue). The beginnings and ends of two valley systems are marked as A'/B' to A''/B'' respectively. (CTX DTM and HRSC MOLA Blended DEM over THEMIS IR Day mosaic, top left corner of map at 16°W 31°N)

3. Observations

A combined ~166 km of channels were mapped in the study area with the longest section being ~43 km long (Fig.1). Seven distinct basins were identified and palaeolake extents in each were inferred from

three different outlet channel elevations (Fig.2). The total maximum surface area of all inferred palaeolakes is 2187 km^2, with the largest individual body being 1045 km^2. Two sedimentary fans empty into closed basins at elevations similar to outlet channels in the same basins. Three other sedimentary fans occur at locations and elevations open to the northern lowlands, at -3430 m, -3560 m and -3860 m.

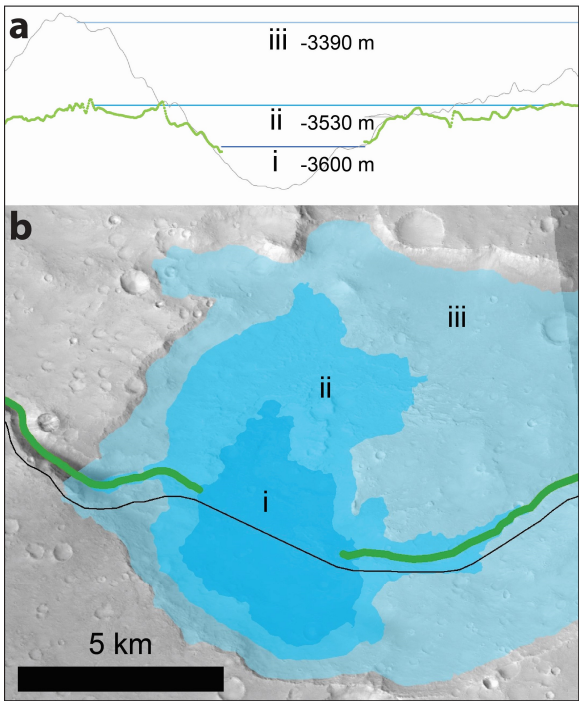

Figure 2 – Detail of inferred palaeolake (a) levels and (b) extents derived from outlet elevations at (i) start of outlet channel (dark blue), (ii) spillover at channel base (blue), and (iii) spillover at channel bank (pale blue) with topography (black line) and channel base (green line). Inferred direction of flow is right to left. (CTX image D16_033549_2114_XI_31N014W)

4. Discussion

Bank spillover elevations are interpreted as representing earlier palaeolake extents, while channel base and outlet start elevations represent progressively later post-incision extents. The locations and elevations of inferred palaeolakes link the majority of discontinuous channel segments into connected valley and palaeolake systems (Fig. 1). Two separate valley systems are identified that do not appear to be connected at surface level, and drain into the northern lowlands through different channels. The surfaces of the largest palaeolakes in both systems share an elevation (-3390 m), and based on current topography are only separated laterally by ~1.5 km. These correlations along with the observation that the smaller system has a limited watershed may suggest groundwater connectivity between the bodies. One palaeolake in valley system B (Fig. 1) inferred by bank spillover did not describe a closed basin on current topography, and so its extent was artificially truncated to be isolated from the northern lowlands. This inconsistent open basin can be described as a result of raising the bank or by lowering or removal of a bounding basin edge. The narrow areas in which the basin opens to the lowlands are steep-sided asymmetrical depressions, and may be the result of collapse at a time after the palaeolake existed. In basins where inlet and outlet channel were not connected, the elevations at the start of the outlet and the end of the inlet were a good match (Fig.2,i), supporting the existence of a standing water body. However, all outflow channels beginning in palaeolake basins are lower (up to 270 m) than the channel base spillover elevation (Fig.2,i&ii). These upslope channels in the downstream direction suggest topographic changes to the channel that may be the result of groundwater subsidence towards the basin centre.

Acknowledgements

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