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New insights into the hydrologic history of western Valles Marineris, Mars

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Abstract

Using Mars Reconnaissance Orbiter (MRO) Context (CTX) and High Resolution Imaging Science Experiment (HiRISE) image data in tandem with Mars Orbiter Laser Altimeter (MOLA) surface topography, we have characterized and mapped the remnants of an extensive flow feature that we interpret to be a debris flow within the floors of Tithonium Chasma and an adjacent canyon system in western Valles Marineris. The deposit appears highly modified by collapse and tectonic deformation consistent with a freezing and devolatization history, but shows no signs of resurfacing by catastrophic floods. Preliminary impact crater count statistics indicate the deposit was emplaced during the Early Hesperian, thereby defining a stratigraphic marker that constrains any major surface water discharges from Noctis Labyrinthus to the Noachian period.

1. Introduction

Noctis Labyrinthus and Valles Marineris form a vast network of canyons, ~4000 km in length, which are mostly (but not always) interconnected [1,2] (Fig. 1a). Ground-water circulation from aquifers located in the Tharsis Montes to Valles Marineris via Noctis Labyrinthus [3-5] may have led to development of the aquifers further east in circum-Chryse, which underwent collapse to form extensive outflow channels and chaotic terrains [3].

2. Geomorphologic analysis

Tithonium Chasma (Fig. 1b) comprises the largest undivided canyon in western Valles Marineris (Fig. 1a). We have identified an extensive sedimentary deposit that covers most of the chasma's surface, and terminates within two canyons in western Valles Marineris (Fig. 1b). The eastern part of the deposit is extensively modified and exhibits morphology suggestive of surface collapse and fracturing (Fig. 1b). However, its eastern and most distal parts exhibit a well-preserved lobate morphology (Fig. 2a). Examination of decameter-scale surface features reveals an extensive system of polygonal fractures (Fig. 2b), coarsely layered-boundary outcrops (Fig. 2c), and channeled surfaces (Fig. 2d). Our preliminary crater counts of this deposit indicate emplacement during the Early Hesperian, but this result needs to be confirmed.

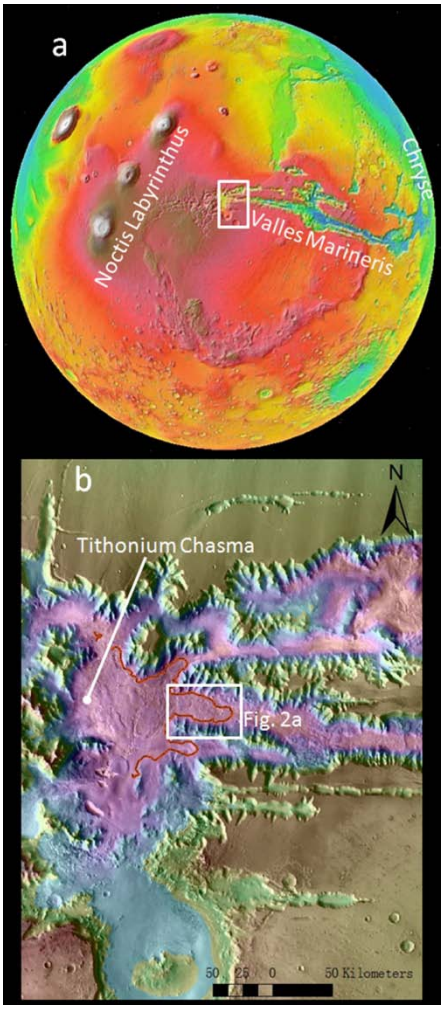

Figure 1: (a) MOLA context and location for the study region. (b) Map showing the eastern margins of the flow deposit.

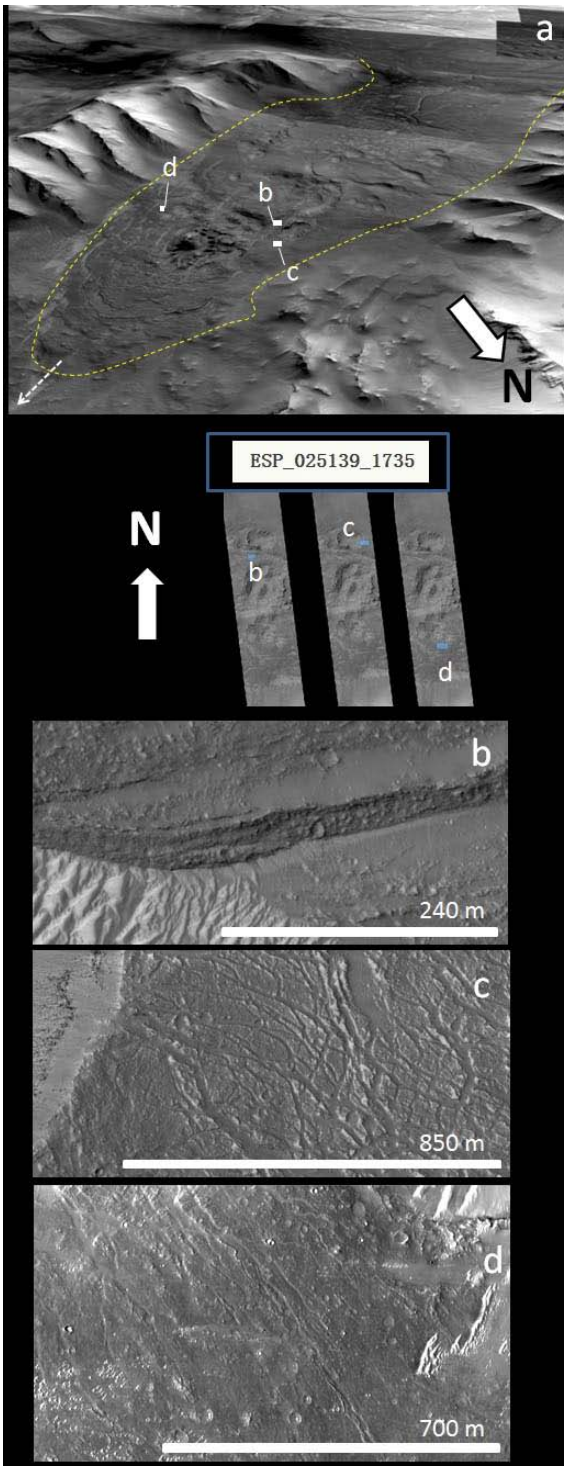

Figure 2: (a) CTX mosaic showing a perspective view of lobated flow front within a canyon. (b, c and d show HiRISE views of the deposit). (b) Scarp that exhibits coarse layering and matrix supported boulders. (b) Part of fractured surface. (c) Part of channeled surface, including localized meanders and bouldery deposits exposed within inverted channels.

3. Interpretations

Our findings indicate that during the Early Hesperian, large volumes of water-saturated sediments were discharged from Noctis Labyrinthus. The polygonal fractures are indicative of extensively tectonic resurfacing, perhaps consequential of freezing and d expansion, and/or volume loss and subsidence. The outcrops are layered and approximately horizontal suggesting that the debris flow velocities were not turbulent, however these could have been emplaced by magmatic or sedimentary volcanism eruptions within the deposit. The channels are indicative a ground-water release history and the inverted channels show that outstripping of surficial layers has been modest flowing fluvial activity. We see no evidence for a history of major catastrophic flooding or debris flow from this region following emplacement of the mapped deposit.

Acknowledgements

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