MORPHOLOGY AND EMPLACEMENT PROCESSES AT THE DISTAL END OF THE CARRIZOZO LAVA FLOW, NEW MEXICO: IMPLICATIONS FOR MARTIAN SHEET FLOWS.
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Introduction: The Carrizozo lava flow is a 75-km-long, tube-fed, basaltic sheet flow erupted along the Rio Grande Rift in south-central New Mexico [Fig. 1a] [1]. A diverse morphology is observed along the flow length indicating various emplacement processes for each segment. The proximal area has a low-shield topographic profile with a centrally located cinder cone (Little Black Peak) surrounded by inflated platforms and tumuli [2]. The medial section, a narrow neck of brecciated pahoehoe only a few hundred meters wide in some sections, served as a conduit for lava flowing to the distal end [3]. The distal end is comprised of a series of abutting, inflated lobes with associated breakout features and terraced margins [Fig. 1b, c]. Here, we discuss the morphology and flow processes associated with the distal section of the Carrizozo lava flow and applications to interpreted sheet flows on Mars.

Background and Previous Work: The Carrizozo flow is ~5000 years old [4, 5] and is one of the longest lava flows in the United States. Located in the Tularosa Basin, the current underlying slopes are 0.2 to 0.4° [1]. No topographic barriers confine the flow margins, suggesting eruption duration and available volume contributed to the length of the flow [1]. The flow covers an area of ~330 km^2, has thicknesses of ~10 to 15 m, and an estimated flow volume of ~4.3 km^3 [6]. Pahoehoe-like surface textures in the proximal section and the lack of a central, open channel suggests a low effusion rate (< 5 to 20 m^3/s), based on observations of active Hawaiian pahoehoe flows [1, 7], which implies emplacement durations on the order of decades [1]. The formation of the narrow centralized tube with a jumbled, slabby surface texture in the medial section means the lava was confined and traveling at a higher flow rate, suggesting a maximum effusion rate of 800 m^3/s and an eruption duration of a few months [8].

Data and Methods: We conducted a preliminary field survey of the distal flow section in April 2007 to provide context to observations of USGS digital orthophoto quadrangles. We obtained topographic profiles using a Trimble R8 Total Station, a carrier-phase Differential Global Positioning System (DGPS), in October 2007. The DGPS has a vertical accuracy of ~2 to 4 cm and a horizontal accuracy of ~1 to 2 cm. We completed topographic profile traverses perpendicular [Fig. 1c] and parallel to flow directions.

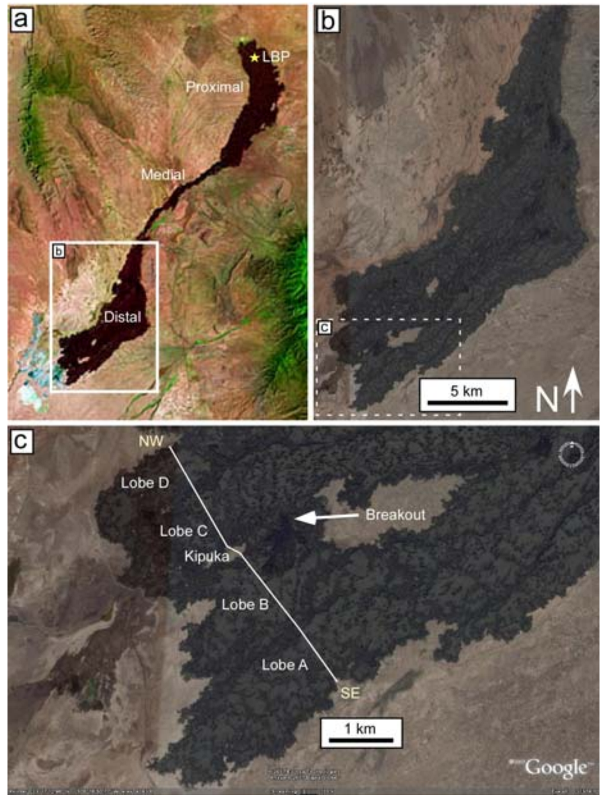

Figure 1. (a) Landsat image of Carrizozo flow. Star marks location of Little Black Peak (LBP) cinder cone. (b) Distal end of the Carrizozo flow. (c) Traverse for topographic profile across four lobes shown in Fig. 2.

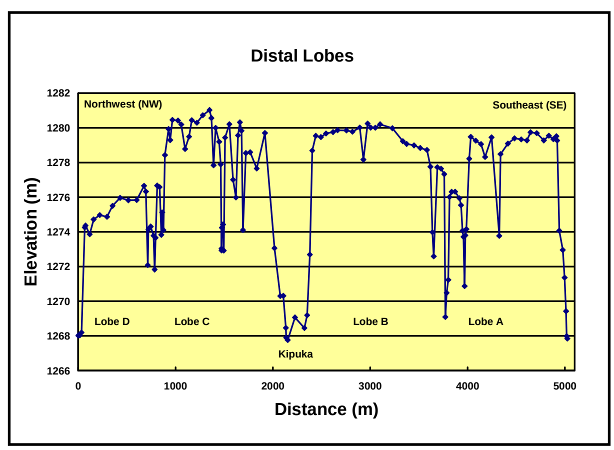

Figure 2. Topographic cross-section across four of the distal lobes from DGPS data.

Observations: The distal end is <9 km wide, comprises ~22 km of the flow length, and covers an area of ~140 km^2 [Fig. 1b]. The maximum flow thickness is 14 m on Lobe C, measured from the topographic profiles [Fig. 2]. Individual lobes have nearly flat tops, creating a platform surface, and are divided by transitional zones of tumuli and kipukas. Three flow features in the distal area are: 1) inflated platforms 2) terraced margins, and 3) surface expressions of breakouts.

Inflated Platforms. The topographic levels of each lobe only vary by 1 to 2 m over the width of each lobe, disregarding inflation/deflation pits [9], collapse pits, and transition zones between lobes. For example, the surface of Lobe B changes by less than 1 m over 1 km [Fig. 2]. The margins of the plateaus have nearly vertical tilted slabs of crust with textures (i.e. pahoehoe ropes and lineated crust) that had to have formed on level flow surfaces. Significant inflation has occurred and the consistent topography across each lobe surface suggests a slow and homogenous rise of each lobe.

Terraced Margins. The flow margins exhibit a 'staircase' or 'terraced' topographic profile with distinct flow surfaces getting relatively lower closer to the flow margin. Three scenarios can describe the formation of the terraced margins [Fig. 3]. The first model shows inflation of the primary (oldest) lobe and then subsequent breakouts of lava at different levels [Fig. 3a]. Other scenarios suggest the emplacement of inflated lobes over a thinner, non-inflated, underlying lobe [Fig. 3b] or a coeval process during inflation of the lobe [Fig. 3c].

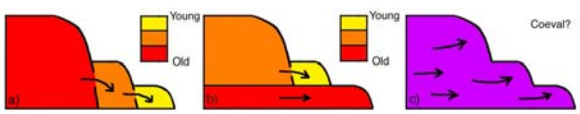

Figure 3. Schematic models of how terraces observed at the flow margin could have formed.

Breakouts and Jumbled Sheet Textures. Along the margin of Lobe C, a darker toned, fan-shaped, surface feature is observed [Fig. 1c]. Ground observations show that the surface texture in this area is jumbled, imbricate, slabs of pahoehoe crust piled up to ~1 m thick over a massive interior. We interpret this particular flow feature to be the near-source surface expression for a breakout from the margin of Lobe C that fed lava to form Lobe B [Fig. 1c]. Additional breakout features are observed along lobe margins and at the transition from the medial to the distal end [Fig. 1b].

Implications for Mars: Lava flows with similar flat, plateau surfaces, kipukas, and lobate margins have been imaged on Mars [Fig. 4] [10]. The example shown here, located near Pavonis Mons, has a flow width of ~16 km and a thickness of ~25 to 30 m measured from MOLA gridded data. The surface features suggest the emplacement style could be similar to the distal end of the Carrizozo flow, with inflation of central lobes and breakouts at the margins. We will present an analysis of the two lava flows comparing emplacement processes.

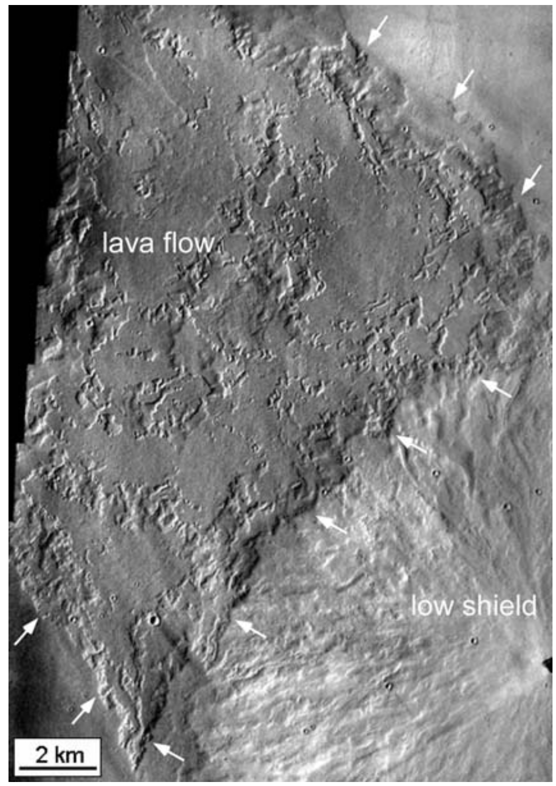

Figure 4. An inflated sheet flow on Mars embays the lower flank of a low shield volcano. Arrows point to the flow margin. THEMIS visible image V19126002. Image courtesy of NASA, JPL, ASU.

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