MEGAFLOOD EROSION ON MARS — HOW A LAVA-FILLED CRATER BECAME A MESA.

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Introduction: Round mesas have previously been described on the floor of Ravi Vallis, along with alternative theories for their origin [1]. Here I examine a much larger round mesa in Elaver Vallis, east of Morella Crater (Fig. 1).

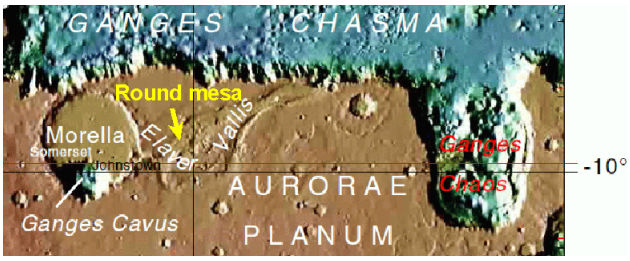

Fig. 1. Regional context for location of large round mesa on the floor of Elaver Vallis. Diameter of Morella Crater ~ 70 km. Map source: [2].

The round mesas are enigmatic because they occur in low areas of the outflow channels where the most intense megaflood erosion occurred. Hundreds of meters of basalts were stripped away. Why were the round mesas preserved and how do they differ from the geologic strata around them that were more easily eroded?

One theory suggests the Ravi Vallis mesas are mafic (doleritic) stocks that intruded the Noachian crust [1]. That could explain their resistance to fluvial erosion and their bright nighttime infrared signature when compared to the channel floor (see [1]). The Elaver Vallis mesa does *not* show a similar brightness in nighttime IR images (Fig. 2).

Mesa Characteristics: The round mesa in Elaver Vallis is 9 km wide, with well-developed longitudinal ridges on its upper surface, similar to the channel floor (Fig. 3). The top of the mesa is 100-150 m higher than the channel floor and lies >200 m below the pre-flood surface. This depth possibly represents Noachian-age crust. At least 200 m of layered basalts had to be stripped away by fluvial erosion to expose the top of the mesa. Fluvial erosion created a prominent moat around the upstream margin of the mesa (Fig. 3).

Landform Evolution: A proposed evolutionary sequence for the mesa is illustrated in Fig. 4. The crater elevation profile in this figure (black dotted line) is the MOLA profile of an unnamed crater at coordinates 7.34°S, 53.25°W. This crater is 600 m deep and similar in diameter to the round

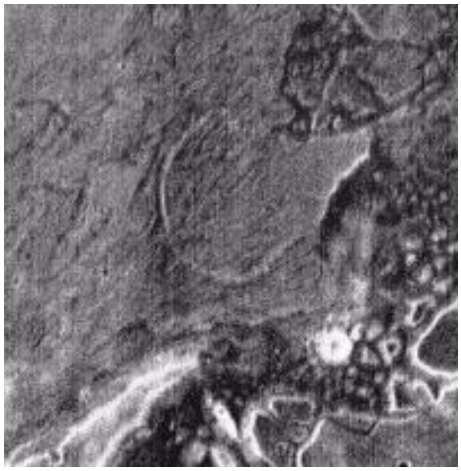

Fig. 2. Nighttime IR view of circular mesa. THEMIS image I33679005 (local time 3.30 hrs) [3].

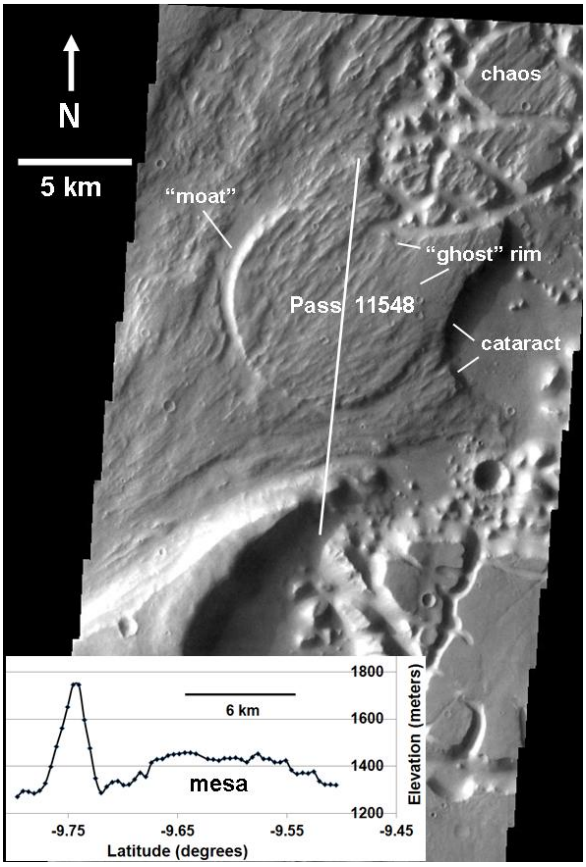

Fig. 3. Large round mesa on the floor of Elaver Vallis, east of Morella Crater. Megaflood flow direction was from lower left to upper right. THEMIS visible light image V05208001 [3]. Inset shows elevation profile from MOLA pass 11548.

mesa. This is a *minimum* depth for the pre-cursor crater in Elaver Vallis because post-impact visco-elastic relaxation may not yet have reduced its depth and flattened the crater floor. For example, a fresh crater 9 km wide would be expected to be 0.7-1 km deep, depending on whether it is simple or complex [4].

I theorize that flood basalts poured into and filled a crater, cooling over an extended time. In essence, the crater acted as a lava trap. Subsequent flood basalts overran and buried the crater. Eventually the Elaver Vallis megaflood exhumed and eroded the lava-filled crater. For comparison, flood basalts of the Columbia Plateau are 10-100 m thick. A lava-filled crater ≥ 600 m deep would require much more time to cool. Equation 1 [5, 6] gives solidification times for sheet-like lava flows and approximates the time needed to solidify the core of a lava-filled crater,

$$t = 0.694 \frac{L^2}{K} \qquad (1)$$

where t = lava solidification time (sec), L = half thickness of an extrusive sheet (cm), and κ = thermal diffusivity (~10^{-2} cm^2 s^{-1}). This equation includes the effect of latent heat. The solidification time for a lava flow 50 m thick would be ~14 years, while that for a lava-filled crater 600 m deep would be nearly 2000 years. The much longer cooling time for the lava-filled crater would have led to a coarse, doleritic mineral texture and reduced numbers of cooling joints, significantly increasing the bulk rock strength and resistance to subsequent hydrodynamic erosion. Thus the legacy of an ancient, lava-filled, buried crater is a high mesa on the floor of Elaver Vallis.

References: [1] Coleman, N. (2008) *LPSC 39*, http://www.lpi.usra.edu/meetings/lpsc2008/pdf/2154.pdf. [2] http://planetarynames.wr.usgs.gov/images/mc18_mola.pdf. [3] Christensen et al., *THEMIS public data releases*, ASU, http://themis-data.asu.edu/. [4] Garvin, J. and J. Frawley (1998) *GRL* **25**, 4405-4408. [5] Zieg, M. and B. Marsh (2005) *GSA Bull.*, doi: 10.1130/B25579.1. [6] Marsh, B. (2007) in *Treatise on Geophysics*, v. 6, ch. 6.07, p. 301, Elsevier.

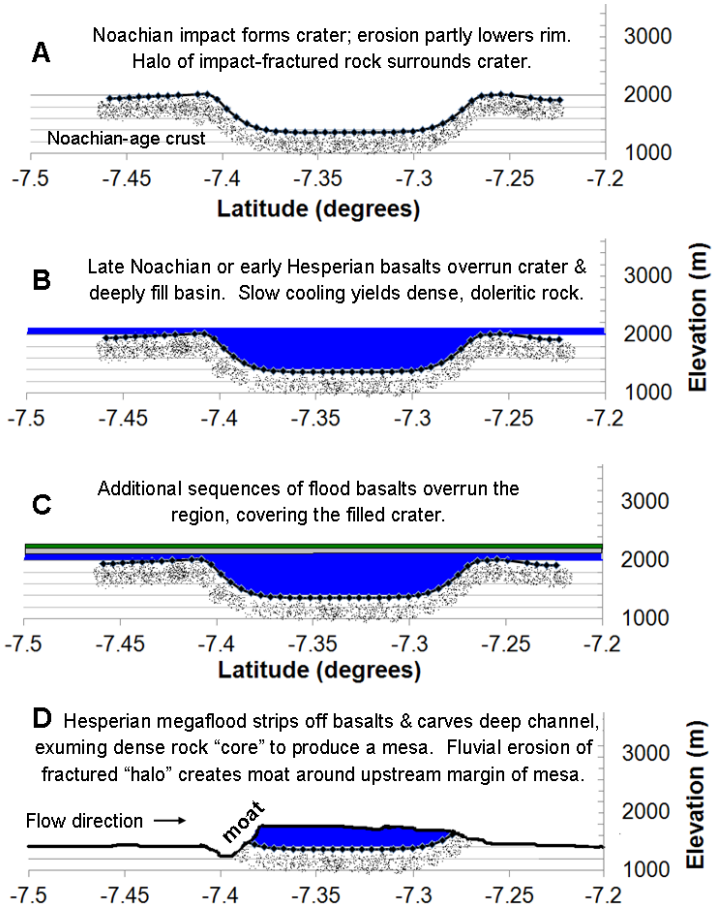

Fig. 4. Evolutionary sequence (A to D) to create a round mesa on the floor of Elaver Vallis.