ROUND MESAS ON THE FLOOR OF RAVI VALLIS, MARS – ARE THEY IGNEOUS INTRUSIVES?

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Introduction: Tear-drop shaped mesas are common on the floors of the Martian outflow channels. They often formed with craters at the rounded, upstream end where the high-standing crater rim caused flow separation and diversion of the flow. Circular mesas, a different kind of feature, have been discovered on the channel floor of Ravi Vallis (Fig. 1). These features are enigmatic because they occur in low parts of the channel where the greatest erosion occurred. How were these round mesas preserved and how do they differ from the geologic strata around them that were more easily eroded?

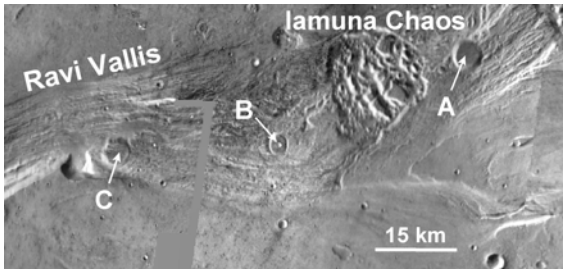

Fig. 1. Context image of Ravi Vallis showing three circular mesas (A-C) on the channel floor. See close-ups in figures below. Mesa at "B" is centered at 40.91ºW, 0.47 ºS. Flow in channel was from left to right. North is up.

Mesa Morphology: Three round mesas jut above the floor of Ravi Vallis (Fig. 1). Fig. 2 shows mesa "A" located about 5 km east of Iamuna Chaos. The mesa is 400 m high, 6 km wide at its base, and the flat top is 4 km wide with an elevation of -1025 m (Fig. 3). The mesa top is more than 200 m below the elevation of the pre-flood erosional surface. Figs. 4 and 5 show two other round mesas on the channel floor west of Iamuna Chaos. Mesa "B" is slightly smaller than "A" and "C" and has a superimposed crater that formed after the Ravi flooding.

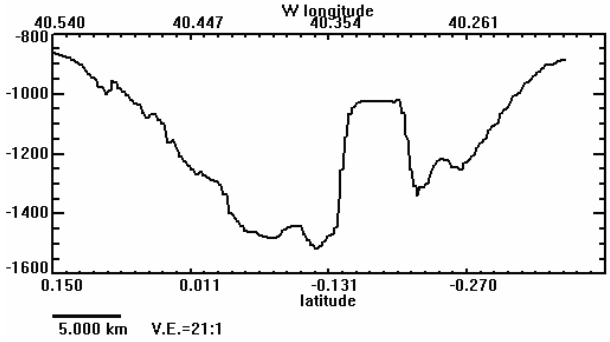

Fig. 3. MOLA topography across the Ravi channel and mesa "A" (Fig. 2a) from NNW to SSE. Vertical axis is elevation (m) and horizontal axes are in degrees.

The common features of the mesas include: (1) similar size and roughly circular shape; (2) relatively flat upper surfaces without well-developed longitudinal ridges like those on the adjacent channel floors; (3) flat tops that lie at least 200 m below the pre-flood surface in this area and therefore represent erosional surfaces; (3) eroded "moat" around the periphery of each mesa; (4) a higher elevation on the eastern (downstream) side of the mesas, indicating that the mesas protected these areas from erosion in the same manner as crater rims elsewhere associated with channel islands; (5) despite this partial protection from

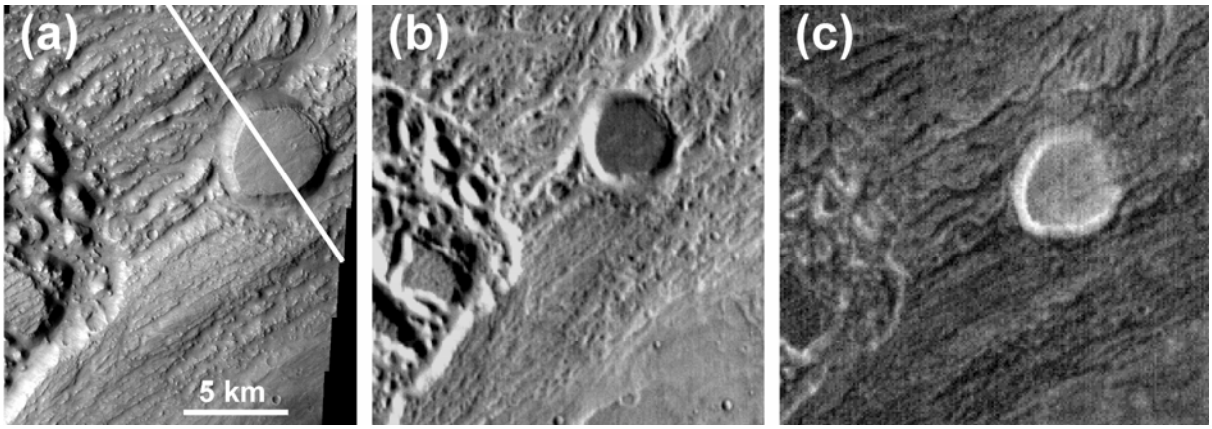

Fig. 2. THEMIS images of Mesa "A" on the floor of Ravi Vallis. A portion of Iamuna Chaos is visible at left side of each panel. (a) Visible light image V17887012 [1]. White line across mesa shows location of Fig. 3 profile. (b) Daytime IR image I17887011 (local time 16.25 hr) [1]. (c) Nighttime IR image I07398007 (local time 5.14 hr) [1]. Compare brightness of mesa "A" in nighttime image to the darker (dust covered) channel floor and mesa tops in Iamuna Chaos.

fluvial erosion, distinct longitudinal ridges were carved on the channel floor immediately downstream from two of the mesas; and (6) brightness of mesas in IR nighttime images, compared with darker channel floors.

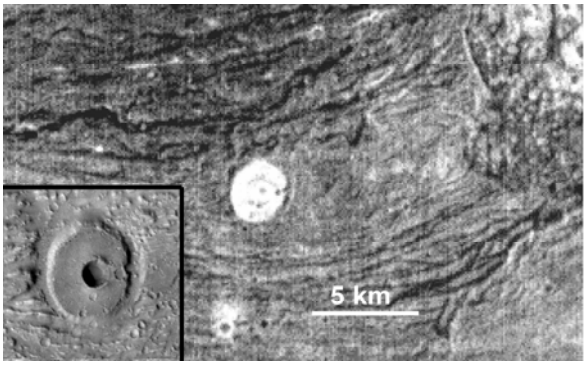

Fig. 4. Mesa "B" on the channel floor west of Iamuna Chaos. THEMIS nighttime IR image I18056016 (local time 4.25 hr) [1]. Inset at lower left shows mesa in visible light (THEMIS V16976018) [1].

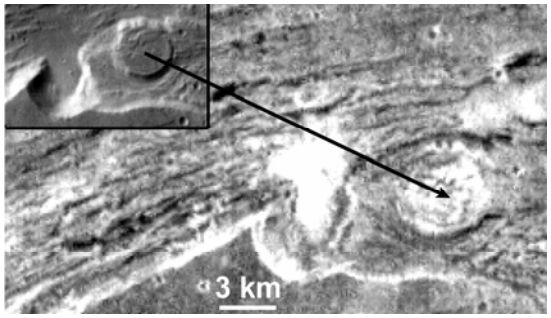

Fig. 5. Mesa "C" on the floor of Ravi Vallis, just east of an eroded crater. The crater floor and mesa top are brighter (more rock rich) than the dusty channel floor. THEMIS nighttime IR image I14387006 (local time 5.67 hr) [1]. Inset is daylight IR image I11773001 [1].

Discussion: Circular mesas exist elsewhere on Mars away from channels, where they appear to represent former craters that filled with eolian sediments (Fig. 6a). The material within the crater then became partially indurated, perhaps from diagenetic cementation, and was therefore more resistant to erosion than surrounding areas. Another possibility is that lava erupted through the crater floor, filling the basin. Over a long time span, eolian processes eroded the area around the crater more than the sediments within, producing a reversed topography where the former crater basin is now topographically high (Fig. 6a). The round mesas on the floor of Ravi Vallis did not form this way because they were flood-carved.

I propose two possible origins of the round mesas in Ravi Vallis. First, they may be an evolved form of the mesas seen in all of the outflow channels, except here the distinct streamlined "tails" have mostly been removed. Fig. 6b shows streamlined "islands" near the mouth of Kasei Valles. The islands are highly degraded – the upper one has nearly lost its "tail" and the lower one is highly dissected. However, unlike the round, "bright" mesas in Ravi Vallis, these mesa tops are dark in nighttime IR (see THEMIS I01294003). In the outflow channels, most mesa and island tops are dark, while exposed rocks on their flanks are bright.

Second, the mesas are similar in diameter and may have a unique, alternate origin. They may be remnants of igneous intrusive bodies (i.e., stocks within the Noachian crust) that were less fractured and more massive than the surrounding basalts. They would therefore have been more resistant to the intense hydrodynamic erosion that stripped away layered basalt flows and carved the Ravi channels. Erosion of the intrusives would have formed features of positive relief, like the mesas. This could also explain why the upper surfaces of the mesas do not have well-defined longitudinal ridges like those on the adjacent channel floors. This is evidence that the mesas have different physical properties from the channel floors. The mesas also are brighter than most channel surfaces in nighttime IR images (Figs. 2c, 4, and 5). This brightness suggests the mesas consist of massive rock with minimal dust cover. If the mesas are igneous intrusives, they may reveal a different spectral signature from basalt flows because intrusives typically have coarser mineral grains.

Finally, if the mesas are stocks, then their abundance along Ravi Vallis (3 over a distance of 65 km) may be a clue to the relative abundance of these features in the crust in this region of Xanthe Terra.

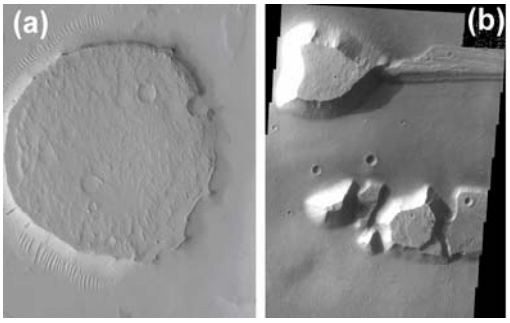

Fig. 6. (a) Circular mesa in NE Arabia Terra, near 23.7°N, 319.0°W. Image is 3 km wide [MOC Release No. MOC2-538, 8 Nov. 2003]. (b) Mesas in channel near the mouth of Kasei Valles. Flow in channel was from left to right. THEMIS image V21307008 [1] is 18 km wide.

Reference: [1] Christensen et al., THEMIS public releases, http://themis-data.asu.edu/. This article was prepared by an employee of the US NRC on his own time apart from regular duties.