

A COMPARISON AND ANALOG-BASED ANALYSIS OF SINUOUS CHANNELS ON THE RIFT APRONS OF ASCRAEUS MONS AND PAVONIS MONS VOLCANOES, MARS

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Introduction: The origin of sinuous channels on the flanks of the Tharsis volcanoes on Mars is debated among planetary scientists. Some argue a volcanic genesis [1] while others have suggested a fluvial basis [2-4]. The majority of the studies thus far have focused on channels on the rift apron of Ascraeus Mons. Here, however, we broadly examine the channels on the rift apron of Pavonis Mons and compare them with those studied channels around Ascraeus. We compare the morphologies of features from both of these volcanoes with similar features of known volcanic origin on the island of Hawai'i. We show that the morphologies between these two volcanoes in the Tharsis province are very similar and were likely formed by comparable processes, as previous authors have suggested [5]. We show that, although the morphologies of many of the channels around these volcanoes show some parallels to terrestrial fluvial systems, these morphologies can also be formed by volcanic processes. The context of these features suggests that volcanic processes were the more likely cause of these channels.

Research Methods: Using ArcGIS we created a composite photographic base layer using low-resolution THEMIS infrared images and overlaying high-resolution data from THEMIS and CTX. We first mapped features suggestive of fluvial activity on the southwest rift apron of Ascraeus, and then mapped similar features on the southwest rift apron of Pavonis. We visually compared the features and, using 3D Analyst in ArcGIS and digital elevation models from MOLA data, compared their dimensions and profiles. We conducted field work on Hawai'i, examining the recent Mauna Ulu flow, the 1907 and 1859 Mauna Loa flows, the 1801 Hualalai flow, the Pauahi crater, and other features. We used field observations, ArcGIS, and Google Earth to quantitatively and qualitatively compare these features with some of the morphologies found on Mars and attempt to evaluate their origins.

Results: Channel features on Ascraeus Mons and Pavonis Mons are very similar. The morphologies in question, sinuous channels, appear in both locations (Fig. 1). Their scales are similar and they display the same characteristics: relatively high sinuosity, hanging walls, and no levees. Though braids appear to be fewer on the rift apron of Pavonis than on Ascraeus, streamlined islands (initially interpreted as evidence for fluvial processes) can be found in relative abundance in the Pavonis Mons channels.

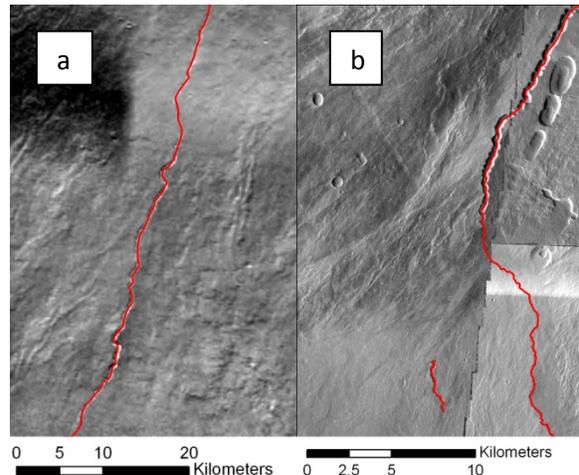


Figure 1. Sinuous channels on the rift aprons of volcanoes in the Tharsis Province: (a) a 270 km extending east from Ascraeus Mons; (b) a 120 km channel extending southwest from Pavonis Mons

More importantly, however, streamlined islands were also found in known volcanic channels—that is, leveed channels whose origins are generally accepted as volcanic—around Pavonis (Fig. 2). These are small (>200 m in length) and clearly indicated where the channel banks migrate outward, accommodating the disruption in flow. Unlike the Ascraeus channels, which tended to be surrounded by a smooth surface embayed by younger materials [1], the Pavonis channels have distinct downslope-oriented, low-angle levee-forming, overflow margins emanating from the main channel and superposing existing features.

Features on Hawai'i are similar in proportion, though much smaller in dimensions. On Hawai'i we observed multiple leveed channels both close to (<100 m) and far from (>1 km) vents. We also observed a number of channels without levees, most of which were collapsed lava tubes (Fig. 3). These varied in depth, with some (e.g. the 1801 Hualalai tube; Fig. 3) occurring just below the surface and others (e.g. the historic 750-1500 BP Mauna Loa tube) flowing much deeper. Some of the collapses left hanging walls and many displayed streamlined islands on their margins or in the center of the tube channel itself.

Discussion and Conclusions: Because the morphologies of the channels and surrounding features on Ascraeus Mons and Pavonis Mons are so similar, it is logical to conclude that they were formed in

comparable ways. However, some of the Pavonis channels display diagnostic features that those on Ascræus Mons do not. This provides us with an effective point of comparison in determining the origin of the channels. For example: we find streamlined islands in the sinuous channels on Ascræus Mons. On Pavonis Mons, we find them in both the ambiguous sinuous channels and known volcanic channels.

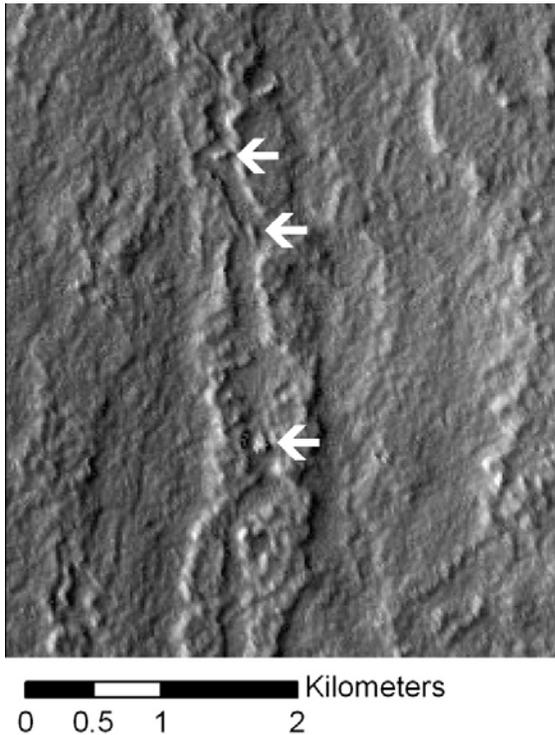


Figure 2. Streamlined islands in a volcanic channel on Pavonis Mons. The levees are clearly distinguishable and the islands are readily identifiable where the channel banks migrated to accommodate them.

When correlated with data from Hawai'i, in which similar features, known to be volcanic in origin, can be found, it can be established that lava can, in fact, form these islands, thereby strengthening the argument that these islands on Ascræus Mons and Pavonis Mons may have been produced by lava rather than fluvial processes. Additionally, unlike on Ascræus, the channels descending from Pavonis show distinct overflow deposits that are sufficiently thick and textured as to represent lava rather than mud or fluvial overbank. Whereas almost all of the Ascræus channels are embayed by younger materials, some of the Pavonis channels actually display the flow materials that, on Ascræus, are simply not detected [1].

Though the features we observed in Hawai'i are significantly different in size, their dimensions are proportional to those of the features found on the Tharsis Plateau. Additionally, the Tharsis volcanoes

erupted in the same general style (Hawaiian style effusive eruptions) as those on Hawai'i [5,6]. We can therefore make the supposition that similar-looking features in these two environments may have originated in a comparable manner. For example, the 1801 Hualalai lava tube-fed flow (Fig. 3) in Hawai'i is very similar to observed channels on Ascræus and Pavonis in that it is sinuous, it is not necessarily continuous on the surface, and it occurs in rock of assumed similar composition and rheological properties [5]. Additional features can be encompassed by this comparison as well. Pauahi Crater on Hawai'i has many properties of some of the pits we see on Ascræus and Pavonis: it is actually two connected pits, it has a flat bottom surface, it is very deep, and, again, it presumably occurred under similar conditions to those pits formed in the vicinity of Ascræus and Pavonis Montes.



Figure 3. A collapsed lava tube, traceable to 2.3 km, in the 1801 Hualalai Lava Flow, Hawai'i. This feature may be comparable to channels found around the Tharsis Montes

We conclude that these channels were formed by volcanic processes. Though evidence is not overly abundant (e.g. we do not seem to find as many braided channels on Pavonis Mons as on Ascræus), the comparisons that can be made are suggestive of volcanic processes as the chief mechanism in the formation of these channels. However, in order to more effectively evaluate this conclusion, broader coverage of higher resolution imagery will be necessary.

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References: [1] Bleacher et al. (2010) LPSC, #1612. [2] Murray et al. (2010) EPSL, doi:10.1016/j.epsl.2009.06.020. [3] Bleacher et al. (2008) JGRE doi:10.1029/2006JE002873. [4] Mouginiis-Mark and Christensen (2005) JGRE, doi:10.1029/2005JE002421. [5] Bleacher et al. (2007) JGRE, doi:10.1029/2006JE002873. [7] Hauber et al. (2009) JVGR, doi:10.1016/j.jvolgeores.2009.04.015.