KECK GEOLOGY CONSORTIUM

PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

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Research Advisor: Patrick Spencer

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JULIA SIGNORELA**,** Franklin and Marshall College
Research Advisor: Andy De Wet

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ORIGINS OF SINUOUS AND BRAIDED CHANNELS ON ASCRAEUS MONS, MARS

ANDREW DE WET, Franklin & Marshall College
JAKE BLEACHER, NASA-GSFC
BRENT GARRY, Smithsonian Institution

INTRODUCTION

Water has clearly played an important part in the geological evolution of Mars. There are many features on Mars that were almost certainly formed by fluvial processes – for example, the Kasei Valles and Ares Vallis channels in the Chryse Planitia area of Mars are almost certainly fluvial features. On the other hand, there are many channel features that are much more difficult to interpret – and have been variously attributed to volcanic and fluvial processes (Bleacher et al., 2010; Murray et al., 2010). Unraveling the details of the role of water on Mars is extremely important, especially in the context of the search of extinct or extant life. In this project we built on recent work in determining the origin of one channel on the southwest rift apron of Ascraeus Mons (Fig. 1) (Bleacher et al., 2010). This project took advantage of recently available datasets to map and analyze similar features on Ascraeus Mons and some other areas of Mars. A better understanding of how these particular channel features formed might lead to the development of clear criteria to distinguish how other Martian channel features formed. Ultimately, this might provide us with a better understanding of the role of volcanic and fluvial processes in the geological evolution of Mars.

PREVIOUS WORK

The observations of sinuous channels on the Moon and Mars has led to a debate over their formation either as a result of fluvial or volcanic processes. This debate demonstrates the similar characteristics of fluvial and volcanic channels and their products (Leverington, 2009). Recently, evidence was presented that suggested that at least one channel system on Ascraeus Mons, previously interpreted to have formed by fluvial processes (Murray et al., 2010), was likely formed by flowing lava (Bleacher et al., 2010).
This study focuses on a channel exposed on the

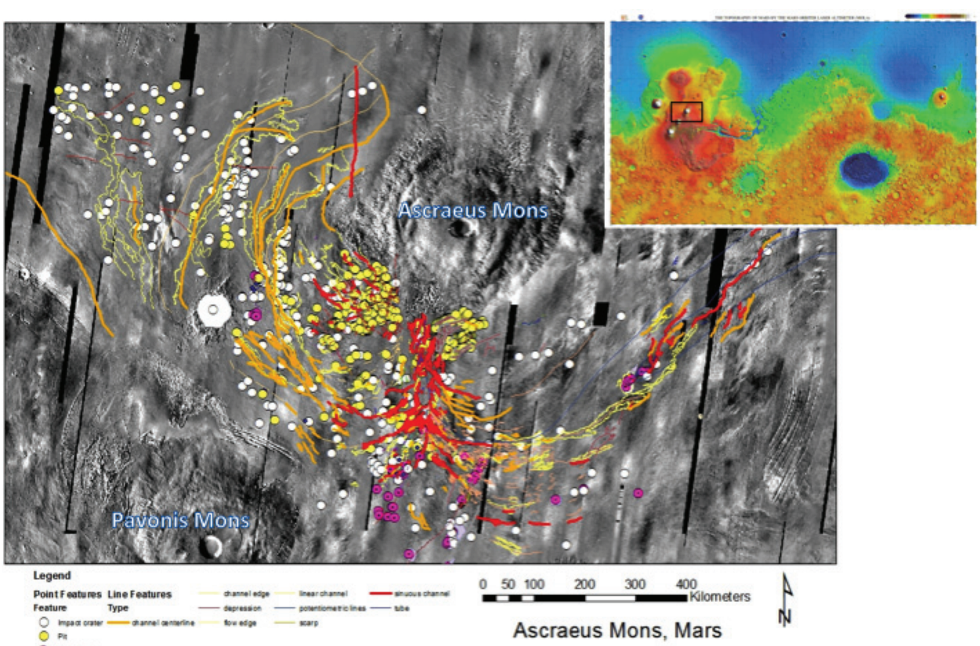

Figure 1 Map of the southern rift apron and surrounding areas of Ascraeus Mons showing the features mapped by the students.

east side of the southwest apron of Ascraeus Mons (Fig. 1). Earlier studies by us (Bleacher et al., 2007; Trumble et al., 2008) and other researchers (Mouginis-Mark and Christensen, 2005; Murray et al., 2010) had suggested that the channel resulted from fluvial erosion. These studies were hampered by the limited data available at the time which meant that only the proximal part of the feature could be studied. The channel originates from a NE trending fissure with a possible relationship to a larger rille to the north. The fissure does not display a topographic "cap" typical of nearby small volcanic vents. The channel is traceable for >270 km and we observe unique morphologies along the proximal, medial, and distal sections of the flow.

The proximal section extends ~60 km from the fissure and displays anabranching, braided and hanging channels, terraced channel walls, no levees, "streamlined" islands, and flow margins that are difficult to detect or are embayed by younger materials. The medial section extends from 60-170 km. Here the channel is composed of one sinuous trench that also lacks clear levees. Generally this section of channel is surrounded by a smooth surface but sometimes shows minor leveed channels leading away from the main channel, probably due to overflow. Flow margins are difficult to determine and are sometimes embayed by younger materials. The distal section extends from 170 to >270 km and displays a significantly different morphology. At 170 km the slope decreases from 0.7- 1^{o} towards the fissure to 0.3-0.6^{o}. Here, the channel is located along the axis of a ridge that exceeds 40 m in height. In some locations the channel is roofed over. Furthermore, rootless vents are located along the axis of the ridge. These rootless vents display topographic "caps" up to 1 km in diameter and radiating flows, some extending for several kilometers.
Visual inspection of the Ascraeus channel's proximal section shows braided and hanging channels, terraced walls, and streamlined islands all of which have led many to suggest an origin involving fluvial activity based solely upon morphologic inferences. However, new image data enabled a complete view of the channel, including its distal portions, which display a topographic ridge, well defined flow margins, roofed channel sections, and rootless vents. We suggested that these features are indicative of a volcanic origin for the distal portion of this channel. And thus the whole feature is volcanic in origin (Bleacher et al., 2010). The Keck project expanded on this earlier study by examining other channels on Ascraeus Mons and in other locations on Mars (Fig 1).

GOALS AND SIGNIFICANCE

The focus of the Keck project is to study the entire southwest rift apron of Ascraeus Mons. We wanted to know if there are other channels that display similar features to the one we studied previously and whether these channels can be ascribed to volcanic or fluvial processes. As such, the objective is to understand the distribution of similar channel networks and their relative temporal relationship to other features. We hoped to be able to develop criteria that can be applied to Martian channel features in order to distinguish their mode of formation. Although we had previously concluded that one specific feature was attributed to fluvial activity, is actually volcanic, therefore it is important that we do not overextend our new inference to suggest that all features in the area might share a similar history without conducting the necessary mapping.

RESEARCH QUESTIONS

1) What are the characteristics and distribution of channels on Ascraeus? What are the characteristics of the proximal, medial and distal parts of each channel? 2) What are the similarities and differences between the channels - do all the channels have the same basic morphology? What are the differences? Is there a relationship between the morphology and age of the features? 3) What is the origin of the channels – volcanic or fluvial or some combination of both, or another completely different mechanism? 4) How do these channels compare to channels on similar volcanoes in the Tharsis area? What about other areas of Mars? 5) How do these channels compare to Martian channels that are generally agreed to be fluvial in origin? 6) Can we develop better criteria to distinguish volcanic from fluvial channels on Mars? 7) What do these channels tell us about the geological evolution of Ascraeus? The Tharsis Montes area? Mars generally? 8) If unique types of channels are identified, did they form at one specific period of time in Martian

history, or are they stratigraphically and temporally contemporaneous with other eruptions and channel forming events on Ascraeus Mons?

PROJECT DETAILS

The student projects were comprised of two components: Component 1 involved mapping the Ascraeus Mons rift apron (Fig 1). The students downloaded, georeferenced and assembled a dataset in ArcGIS. They then characterized and mapped the various morphological features associated with the channels. They measured various parameters such as aerial extent, cross-sectional morphology and channel gradients and described and interpreted these morphological features based on an understanding of plausible geological processes on Mars. Component 2 involved comparing the Mars features to analog features on the Earth including observations made during a five-day trip to Hawai'i (Fig. 2). The students were able to refine their interpretation of the origin of the Mars features informed by their observations of terrestrial features of known origin. They then attempted to develop criteria to distinguish fluvial and volcanic features. Finally the formation of these features was placed into the broader context of the geological evolution of Mars by mapping their boundaries to determine their relationship with other volcanic (and fluvial) deposits.

Figure 2 The Mars research group at Pohue Bay, Hawai'i. From left to right: Andrew de Wet, Zach Schierl, Julia Signorella, Ben Schwans, Jake Bleacher, and Andrew Collins.

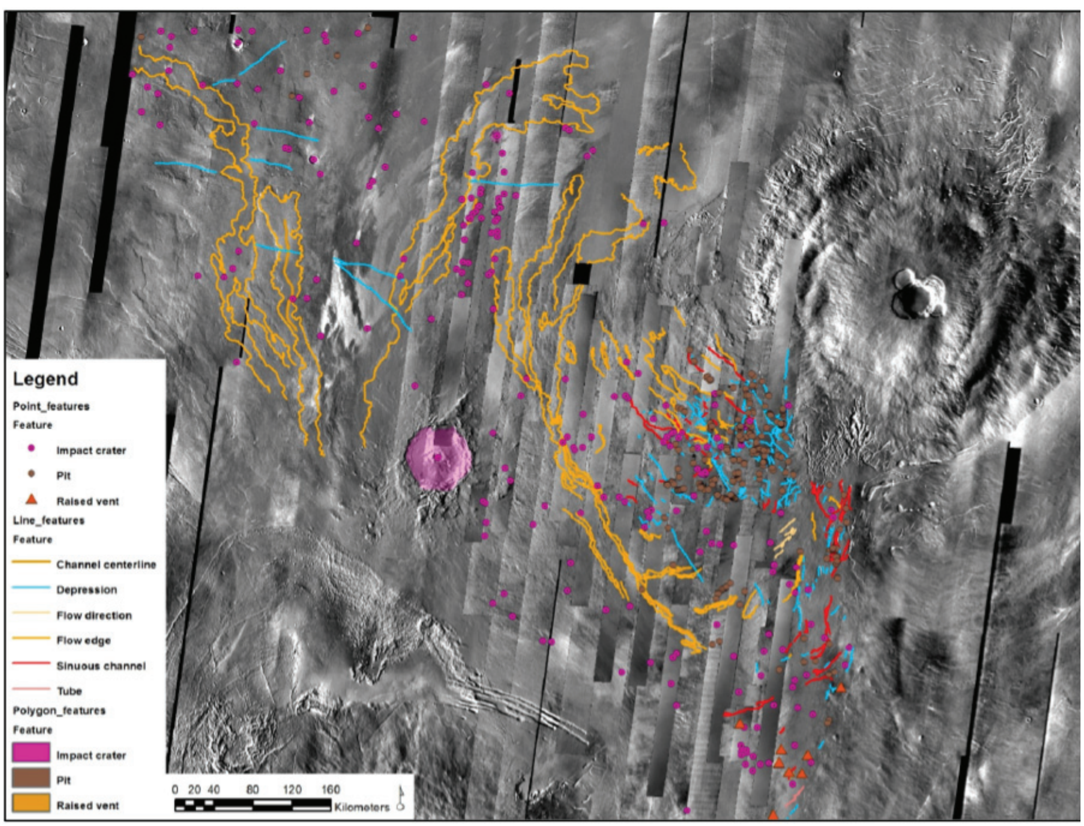

Figure 3 Map of Andrew Collins' study area showing features on and extending from the southwest rift apron of Ascraeus. The image uses a THEMIS base map and THEMIS and HRSC high-resolution imagery patches with the GCS_Mars_2000_Sphere coordinate system on a cylindrical equilateral projection.

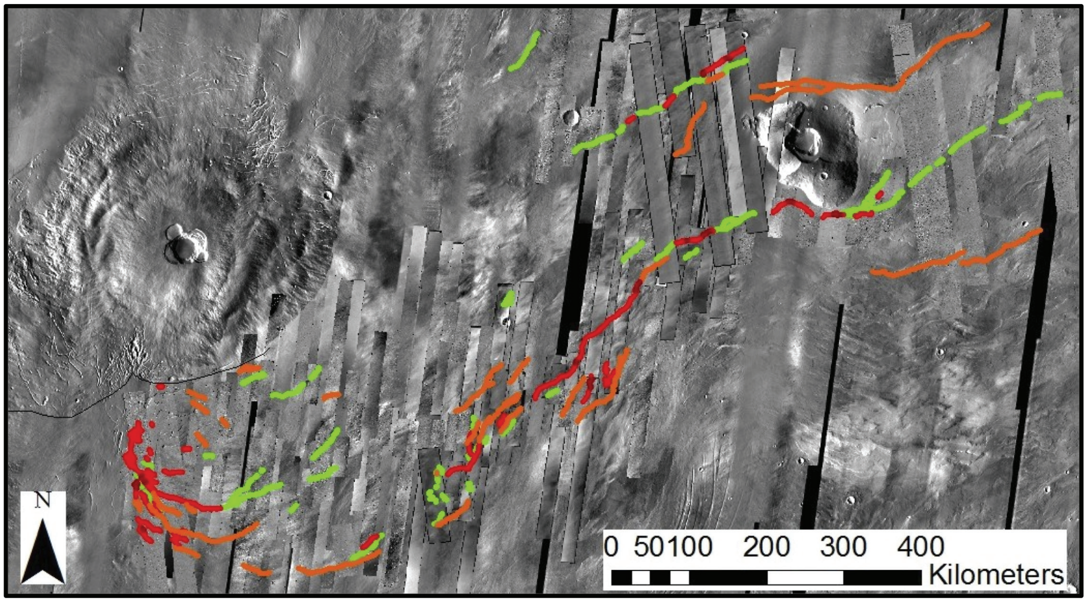

Figure 4. This map shows the distribution of sinuous channels (red), collapsed lava tubes (green), and lava flow channels (orange) on the Ascraeus Mons rift apron and surrounding plains extending east to Tharsis Tholus (shield at upper right) as mapped by Zach Schierl.

STUDENT PROJECTS

Andrew Collins (The College of Wooster) mapped and analyzed sinuous channels on the north-western part of the SW rift apron of Ascraeus Mons and then compared them to similar channels on the Pavonis Mons volcano, Mars. Field observations of similar features of known volcanic origin on the island of Hawai'i provided terrestrial analogs for these Mars features. Andrew was able to show that the morphologies between these two volcanoes in the Tharsis province are very similar and likely formed by comparable processes, as previous authors have suggested (Bleacher et al., 2007). Although the morphology of many of the channels around both of these volcanoes show some similarities 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 (Fig. 3).

Zachary Schierl (Whitman College) focused on the origin and morphology of sinuous channels extending from the south-eastern part of the SW rift apron of Ascraeus Mons onto the surrounding plains surrounding Tharsis Tholus (Fig. 4). Zach argued that the sinuous channel features were produced by volcanic processes since a large number of the sinuous channels, both on the apron and on the surrounding plain, transition into lava tubes or channels that are clearly associated with discrete lava flows. The difference in morphology between the simple and complex channels is likely tied to the observed difference in slope rather than the mode of formation. The preponderance of lava tubes over channels on the surfaces with shallower slopes, is likely the result of lava tubes being more likely to form on shallower slopes where the flow velocity is reduced (Sakimoto et al., 1997).

Ben Schwans (Trinity University) mapped the sinuous channels on the south-western part of the SW apron of Ascraeus Mons.

Julia Signorella (Franklin & Marshall College) focused on sinuous channels on the south-eastern part of the southern rift apron of Ascraeus Mons (Fig. 5). Julia was able to show that most of the sinuous channels had their origin in elongate depressions (fissures) or pits (vents) that postdated the numerous isolated low shield volcanoes in the area. The low shield volcanoes with associated summit vents were probably formed by numerous small relatively intermittent eruptions that produce the topographically positive features whereas the depressions were likely the source of continuous eruptions of very large volumes of material producing the associated sinuous channels. These depressions are similar to those produced by fissure eruptions as seen on Hawai'i. The sinuous channels transition from incised features in the proximal section; to tubes, roofed over sections, and collapsed pits in the medial section; to topographically positive features in the distal section. Analogous features were observed at Pohue Bay and Mauna Ulu on Hawai'i suggesting that the Mars channels are volcanic in origin.

Several of the students presented their results at the LPSC meeting in Houston in March, 2012 (Collins et al., 2012; Schierl et al., 2012; Signorella et al., 2012).

CONCLUSIONS

1) Numerous sinuous and braided channels previously interpreted as either volcanic or fluvial in origin, occur on the SW apron of Ascraeus Mons.
2) Most of the sinuous channels originate from elongate, structurally controlled pits on the apron. Other sinuous channels occur away from the apron but are

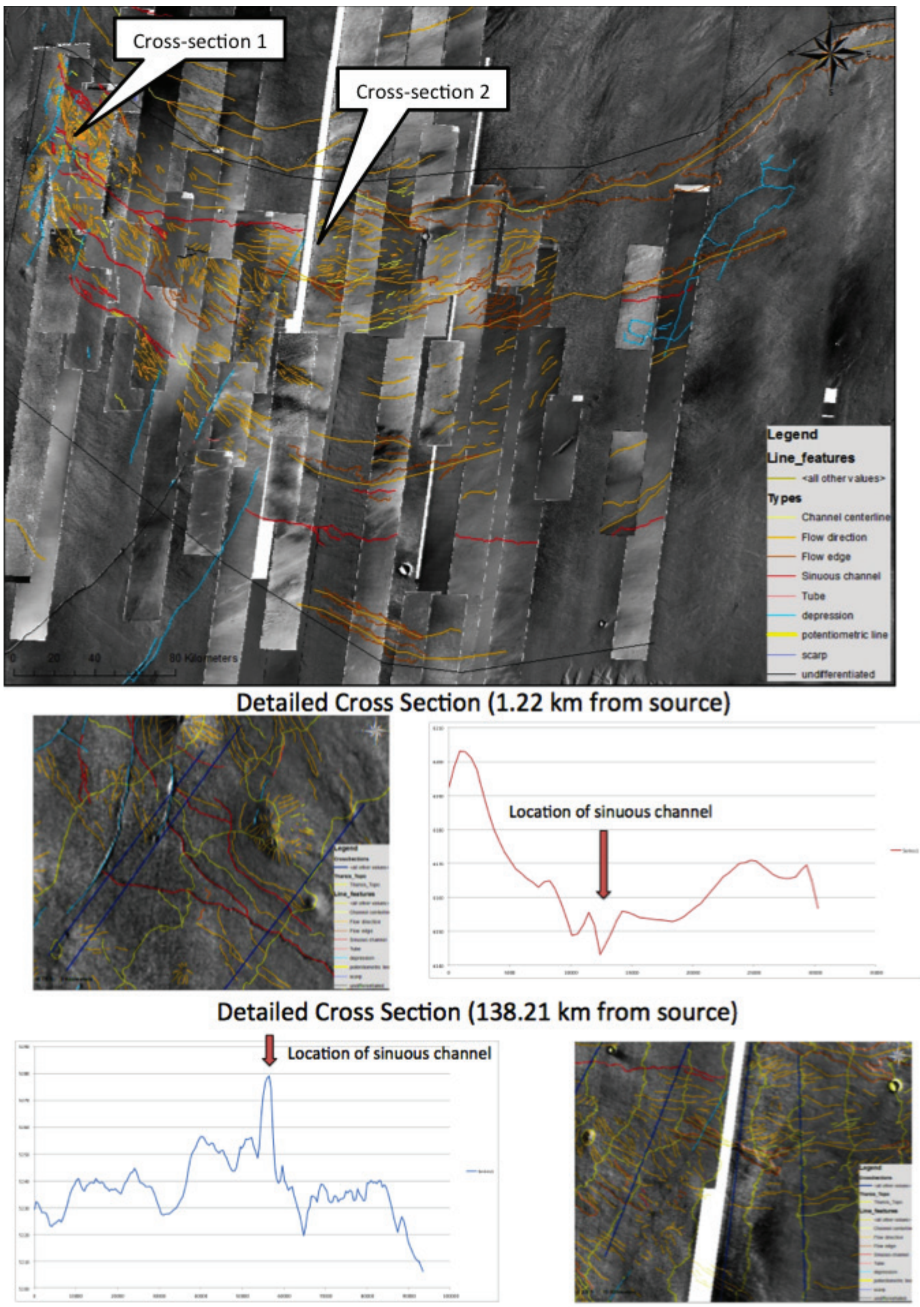

Figure 5. This map of Julia Signorella's study area shows part of the SW rift apron of Acraeus Mons. The study area starts on the SE part of the apron and extends out onto the adjacent plain. Two cross-sections show that the sinuous channels are topographically low in the proximal sections and occur on broad raised areas towards the medial and distal sections.

continuous with broader flows that originate on the SW apron of Ascraeus Mons.
3) The sinuous and braided channels are continuous with (grade from or into) broader channels, roofed over channels, aligned pits, and isolated vent features.
4) While some sinuous channels appear to have morphologies similar to features formed by fluvial processes, all the features observed could reasonably be formed by volcanic processes.
5) Some features (tubes, isolated vents, collapsed channels) can plausibly only be formed by volcanic processes. Analogous features formed by volcanic processes are observed in numerous terrestrial volcanic areas, most notably Hawai'i.
6) The sinuous and braided channels on the SW rift apron of Ascraeus Mons grade into volcanic features and are thus interpreted as volcanic in origin.

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