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Are sinuous ridges and channel networks in the equatorial Rahway Vallis region of Mars fluvioglacial in origin?

J. D. Ramsdale (1), M. R. Balme (1, 2), S. J. Conway (1), C. Gallagher (3).
(1) Dept. Physical Sciences, Open University, Walton Hall, Milton Keynes, MK7 6AA (jason.ramsdale@open.ac.uk). (2) Planetary Science Institute, Suite 106, 1700 East Fort Lowell, Tuscon, AZ, USA. (3) School of Geography, Planning & Environmental Policy, University College Dublin, Dublin, Ireland.

1. Introduction

We have studied a network of channels and ridges that are key to understanding the extremely flat (sloping at 0.02° south-east) geomorphology of Rahway Vallis, south-west of Orcus Patera, Mars. The branching pattern of the ridge and channel system is consistent with a fluvial origin, with cross sections of the channel and banks being reminiscent of fluvial v-shaped valleys. Possible fluvial explanations for the sinuous ridges include inverted fluvial channels [e.g., 1] and eskers (sub-glacial, sediment-filled channels, e.g. [2]). Here, we present observations on the system and test the fluvial and fluvioglacial hypotheses.

2. Sinuous ridges

A suite of elongate positive relief landforms (e.g. Fig. 1) has been observed around Rahway Vallis. These forms occur both individually and as part of complex systems incorporating various cross-cutting, anastomosing and branching patterns. Our preliminary mapping suggests that many ridges form convergent, contributory networks and have a spatial relationship with kilometre-wide channels found at elevations of around 3000m below datum. We have observed two distinct groups of ridges in Rahway Vallis: the first type form networks (e.g., Fig. 1) that appears to converge towards channels, but the second form long, lone, meandering ridges running down the centres of channels (Fig. 2). The lengths of the sinuous ridges range from tens of meters to tens of kilometres. Their widths are of the order of metres to tens of metres and their heights are a few meters, based on shadow measurements. The branching ridges displayed in Fig.1 are often sharp crested and lie within shallow curving depressions on the order of 100 metres wide, although many ridges lie on non-depressed ground and can cross depression divides. The depressions are generally isolated and rarely have emergent channels despite appearing arborescent. The networks appear to host up to three ridge orders (Fig.1).

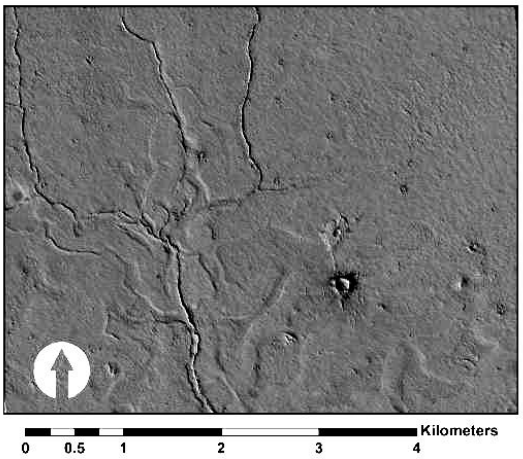

Fig. 1 HiRISE image PSP_003623_1900 showing an example of the branching sinuous ridge networks in Rahway Vallis.

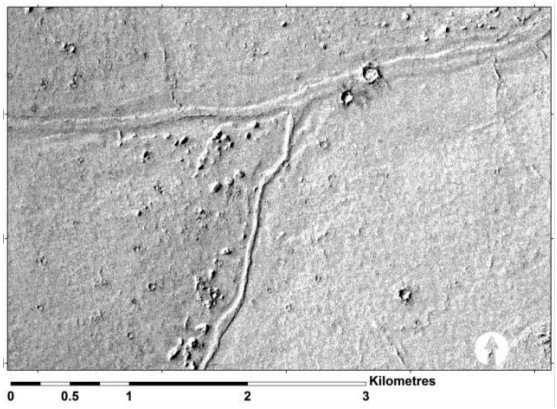

Fig. 2 CTX image P20_008897_1889_XN_08N184W displaying an example of lone channel parallel sinuous ridges in Rahway Vallis.

The lone ridges shown in Fig. 2 are largely rounded or flat topped and tend to lie within large continuous channels. The lone ridges tend to run parallel to the channels and do not leave their confines. The

identification of individual clasts in HiRISE images, and their branching nature suggest, that the ridge landforms are depositional sedimentary features with multiple or distributed sources.

3. The Channel Network

Rahway Vallis is remarkably flat, sloping around 0.02° towards the south-east, with the largest variation in slope direction occurring in shallow valleys that have a continuous channel in their centre (see Fig.3). This suggests that the channels are either a result of a process that can shape its own landscape or that the channels form preferentially in topographic lows, or even a combination of the two. Cross sections of the channel and valley show convex-up, shallow V-shaped profiles – a form consistent across the Rahway network. Despite being extremely shallow (around 15 metres vertically compared to several kilometres in the horizontal) the V-shape points towards a fluvial origin as opposed to the U-shape typical of glacial valleys or the flat bottomed form consistent with lava channels. Long profiles show the channels to be of consistent depth with bank height, and both channels and valley show a consistent downhill gradient from West to East. The channels typically widen downslope and increase in size at confluences, suggesting a contributory network with multiple sources. These measurements are consistent with the channels and ridges in Rahway Vallis forming a fluvial drainage network feeding into Marte Vallis to the North-East. We therefore adopt a glaciofluvial working hypothesis, in which the branching ridges formed sub-glacially, and the larger channels sub-aerially.

4. Hypothesis testing

We attempt to identify, classify and correlate any landform observations and other data that can test the fluvioglacial hypothesis. Importantly, other than possible thermokarst, no further geomorphological landforms diagnostic of fluvioglacial action have been identified. For the fluvioglacial hypothesis to strengthen, more fluvioglacial landforms must be identified. Future work will include identifying other formation hypotheses, including fluid lava flows emplaced over fluvial flood terrains [e.g., 3] or models where only effusive volcanism has created the landscape [e.g., 4]. Our preliminary conclusion is that the channels are fluvial in origin, but there is no strong evidence for glaciofluvial processes; the origin of the ridge networks is currently unknown.

References

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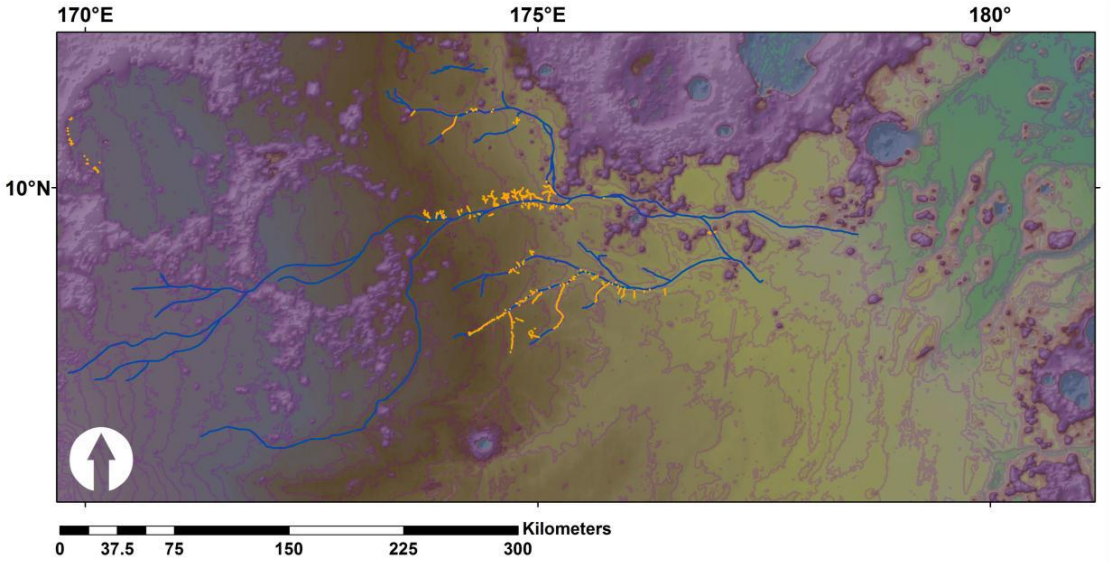

Fig.3 A topographic map based on MOLA data displaying the locations of identified ridges (orange lines) and channels (blues lines) in Rahway Vallis. The purple lines are 10 metre contours.