A New Global Database of Mars River Dimensions

Edwin S. Kite[1,*] (kite@uchicago.edu), David P. Mayer[1,2], Casey J. Duncan[3], Deirdre Edward[1]

1. University of Chicago. 2. Now at USGS Astrogeology Center. 3. University of Utah. * poster author.

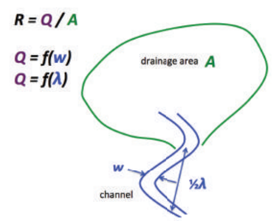
THE UNIVERSITY OF CHICAGO

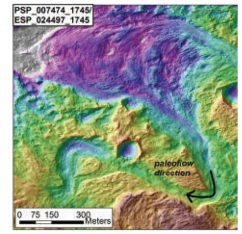
Motivations & Method:

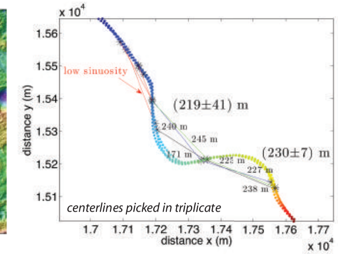
The scale of ancient Mars rivers – their paleochannel widths and meander wavelengths – is a proxy for past river discharge. Discharge, divided by drainage area, yields runoff production, which is a key parameter for selecting between climate models (e.g rain versus snowmelt).

Repeated ArcGIS traces are merged and analysed in MATLAB.
172 drainage areas are represented.
~83% of sites have HiRISE coverage
(~60% of those with HiRISE anaglyphs or HiRISE DTMs)
→ *an advance over the pioneering THEMIS study of Irwin et al., Geology, 2005*

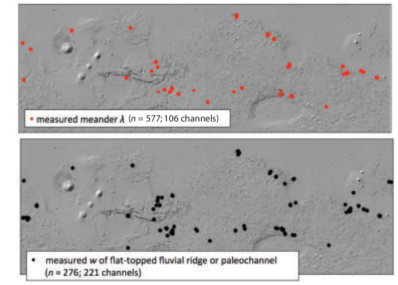
Two main biases in the database:
(1) Only well-preserved channels and drainage areas are included.
(2) We measured the largest visible channels in a catchment.



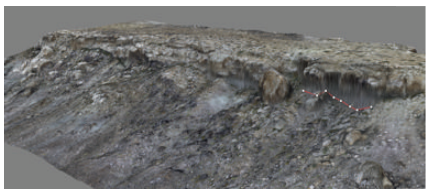




Automatic extraction from hand-picked traces (Kite et al., EPSL, 2015)



Exploiting preservation of river channel properties in river deposits

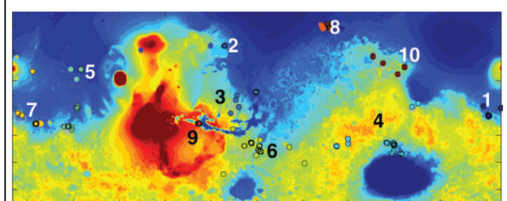


3D view of drone-derived Digital Terrain Model (DTM) of SE Utah inverted channel (Oct 2017). Flat top is ~20 m wide. No vertical exaggeration.

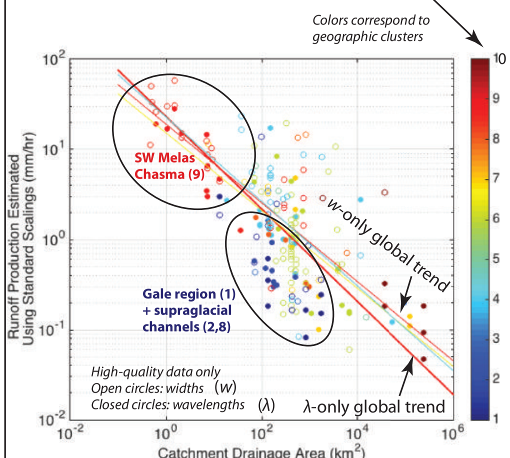
Do the flat tops of sinuous ridges measured from orbit correspond to channel-belt widths, or channel widths? Sinuous ridges near Green River in SE Utah preserve channel deposits and point-bar deposits. At this site, channel deposits preserved within sinuous ridges can be less than the width of the flat top of the ridge, and in some interpretations the width of the flat top of the ridge corresponds to channel-belt width, not a channel width. These Earth-analog data are a warning against over-interpreting HiRISE DTMs, because the decisive grain-size and bedset-thickness measurements are very difficult from orbit. For many Mars river deposits, the simplest interpretation of sinuous-ridge width is nevertheless that ridge-top width corresponds to inverted channel width. This is because (1) sandblasting-away of floodplain deposits allows diagnostic bedforms, e.g. lateral-accretion deposits, to be recognized from orbit; (2) agreement between meander-wavelengths and paleochannel widths allows cross-checking; (3) rivers can transition from negative-relief valley floors to positive-relief channel floors, which decreases the likelihood that either is an artifact.

Findings:

Evidence for regional variations

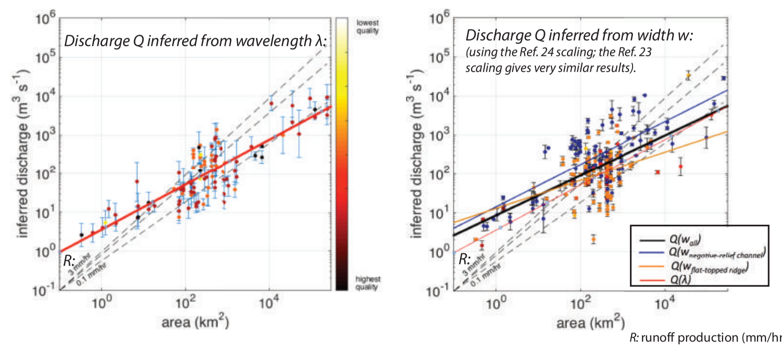


k-means clustering of geographic distribution of measured rivers



yellow trend-line: all-data fit, high quality only
cyan trend-line: all-data fit, all qualities

Rivers on Mars were wider than rivers on Earth for the same drainage area



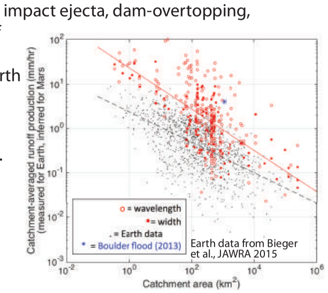
The main surprise so far: Channels are frequently too big (relative to their drainage area) to be easily reconciled with a seasonal-snowmelt climate. As expected from Earth data, scatter is high. At Earth sites, the width of flat-topped ridges can record channel-belt width (not channel width). On Mars, width-inferred and wavelength-inferred paleodischarges agree, consistent with the interpretation that well-preserved flat-topped sinuous ridges record channel width.

Fine grain sizes, or extreme runoff production on Early Mars?

We have ruled out the possibilities that my observations result from limited image resolution, postfluvial modification, flash-snowmelt due to reentry heating from distal impact ejecta, dam-overtopping, karst-like modification of paleochannels, or misinterpretation of debris-flow deposits. We might be measuring strath terraces or channel belts at some sites, but not most. Published work on Earth permafrost-river hydraulic geometry does not support a large permafrost correction. Two possibilities remain:

(1) Rivers on Earth adjust their depths to just mobilize sediment. Therefore, if grainsize on Mars was small, then modest river depths could transport sediment, so discharge could be small (consistent with snowmelt) for a given width.

(2) Extremely high runoff production (rainfall?) on Early Mars.



Author contributions. E.S.K. analysed Mars data and supervised fieldwork. D.P.M. built the Mars GIS, and the Mars DTMs, for the project. C.J.D. collected the drone data and built the Earth DTMs. D.E. analysed drone data.

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