JUSTIFYING MARTIAN FLUVIAL SINUOUS RIDGE MEASUREMENTS USING EARTH ANALOG STRATIGRAPHY. B. T. Cardenas1, T. A. Goudge1, C. M. Hughes1, J. S. Levy2, and D. Mohrig1, 1Jackson School of Geosciences, University of Texas at Austin, Austin, TX, 2Department of Geology, Colgate University, Hamilton, NY (Contact: benjamin.cardenas@utexas.edu)

Introduction: Topographically-inverted channel-filling deposits exist across the surface of Mars as sinuous ridges. Though the origin of these features is generally agreed to have occurred via fluvial sedimentation, widely varying interpretations of their stratigraphy have led to a variety of interpreted depositional settings [1-9].

We present results of field work on topographically-inverted fluvial channel deposits in the Cretaceous Cedar Mountain Formation located 13-km south of Green River, Utah, USA [10-11]. Stratigraphic measurements were related to high-resolution images and DEMs of a scale similar to that of HiRISE data. Our results provide a framework for further study of sinuous ridges on Mars.

Methods: UAV photosurveys were used to create high-resolution photomosaics and DEMs of two portions of a discontinuous sinuous ridge in the Cedar Mountain Fm., which contains 3 bends (Fig. 1). The aerial extent of dune cross-strata sets were mapped in the field, and measurements of foreset dip directions were collected as measures of local paleo-transport direction (Fig. 2). Laterally persistent stratigraphic surfaces were also mapped in the field.

Results: Stacked channel-fills: Channel-filling sandstones and conglomerates are separated by laterally-continuous mudstone layers of variable thickness (cm-m scale). Today, these exposed mudstone layers are relatively erodible and recessive, and are often associated with topographic breaks on ridge surfaces (Fig. 2). We interpret these mudstones as representing sedimentation during periods of inactivity within a channel due to flow diversion by an upstream avulsion. With time, the inactive channel transferred to a floodplain setting with associated overbank sedimentation and pedogenic processes [12-14]. At some later time this low area on the floodplain was re-occupied by a younger active channel, removing some mudstone thickness via channel-bottom erosion and depositing coarser-grained channel-filling deposits on top of this erosional surface (Fig. 2). We have identified a total of 3 stacked channel-fills within this ridge.

Preservation of channel-bottom topography: The upper-most channel-filling deposit on the ridge top preserves topography similar to a mid-channel bar [15] (Fig. 1). This topographic element is constructed of stacked sets of cross beds climbing up and then down topography in the downstream direction. The spread in paleo-transport direction measured from these cross-beds increases with local elevation on this element, which we interpret as recording the dispersion of flow and sediment around the highest portions of the bar (Fig. 3A). Preservation of a bar form requires the rapid cessation of sediment transport within the channel, likely associated with an upstream avulsion and subsequent burial in a floodplain setting.

Centerline preservation: To test the degree of preservation of the original channel centerline in these deposits, paleo-transport directions were compared to the local trend of a calculated ridge centerline (Fig. 4) with the value $\Delta AZ$ (local centerline azimuth − local paleo-transport azimuth). The normal distribution of $\Delta AZ$ around a near-zero mean of -12 degrees and a 35 degree standard deviation is within the range of an active river, and indicates the ridge centerline represents the centerline of the channel reasonably well. The non-zero mean may represent the lateral migration that is recorded, or the control of differential erosion of the ridge on centerline placement.

Discussion: The vertical stacking and lateral migration recorded by the ridge in the Cedar Mountain Fm. represents an integration of channel-fills associated with a succession of separate river channels. The dimensions of a single sinuous ridge thus do not represent the dimensions of the formative channel. However, based on our results, the centerline shape of re-occupied channels are preserved well enough for centerline analyses (Fig. 4) [1].

Topographic breaks have been shown to occur along channel-fill contacts, and such breaks can be observed as steps on the tops of martian sinuous ridges, distinguishing separate channel-fill deposits [e.g., 1].

The preservation of channel-bar topography (Fig. 1) supports the interpretation of a depositional environment characterized by avulsing river channels. This observation also indicates that channel-fill thickness may reasonably be equated to the thickness of a bar, a common proxy for channel depth [12]. Ongoing work is contrasting these results to nearby, exhumed channel-filling deposits in the Jurassic Morrison Fm., which seems dominated by lateral, rather than vertical, channel amalgamation.


Figure 1 – A: Contoured photomosaic of part of a Cedar Mountain Fm. ridge. D-D’ along the orange line shows the location of the topographic profile in C. B: Complete study area at the Cedar Mountain Fm., with photomosaics superimposed on Google Earth images. C: Topographic profile from D-D’ is similar to bar stoss and lee slopes.

Figure 2 – Thin, recessive, laterally-continuous mudstone separating two, coarser channel-filling deposits in the Cedar Mtn Fm. Top of the mudstone is marked by the bottom of the notebook.

Figure 3 – Paleo-transport direction vs. elevation in the bar-like topographic feature (Fig. 1).

Figure 4 – Top: Schematic of the $\Delta AZ$ measurement, and the distribution of $\Delta AZ$ with the fitted normal curve. Purple arrows represent the locations and azimuths of paleo-transport measurements. The black dots and blue arrows represent the centerline and its local tangent azimuth. Inside the inset, the pink angle between the centerline azimuth nearest a paleo-transport measurement is $\Delta AZ$. Bottom: Normal distribution of $\Delta AZ$ around a mean of -12 degrees with a standard deviation of 35 degrees.