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The internal sedimentary architecture of Terrestrial sinuous ridges: clues to understanding sinuous ridges on Mars

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Noachian-Hesperian terrains on Mars host multiple geomorphic and stratigraphic signatures of ancient water flow on early Mars. Sinuous, branching systems of ridges are one such geomorphic landform and have been interpreted as topographically-inverted ancient river channel systems. Characterising the internal sedimentary architecture of such systems is important to constraining the evolution and duration of ancient fluvial flows on early Mars. For example, such ridges are present at the Western delta at Jezero crater, the landing site for the NASA Mars 2020 rover mission. Some studies have used these ridges as time-frozen snapshots of ancient channels and focused on the distribution and geometries of these ridges. However, recent works have characterised these ridges as exhumed channel-belt deposits, composed of multiple channel deposits based on comparisons with similar deposits on Earth. Detailed sedimentary architectural analysis of Terrestrial ridges is needed to provide models for interpreting the earliest fluvial flows on Mars.

Here we present a fine-scale sedimentological analysis of sinuous ridges from the Caspe Formation, Ebro Basin, Spain as potential Terrestrial analogues for sinuous ridge networks on Mars. The Caspe Formation comprises of Oligo-Miocene fluvial deposits of the Guadalupe-Matarranya fan system deposited within the endorheic Ebro Basin. The sandstone ridges of the formation are dissected by a number of roads and recent road cuts present a unique opportunity to analyse the fluvial stratigraphy in cross-section. We used traditional field methods and photo-panel interpretations to identify the internal architecture of the ridges and the analysis was complemented with observations from sections parallel to the ridge axes and Unmanned Aerial Vehicles.

Our results provide identification of complete suite of elements preserved within an exhumed channel belt deposits such as channel scour surfaces, channel deposits in the form of lateral and downstream accreting bedforms and barforms, coarser gravel lags and finer-grained deposits from overbank and splay deposits. The ridges preserve a complex continuum of these elements suggesting deposition in an amalgamated channel-fill complex. We also record multi-storey depositional structures with stacked channel elements suggesting an aggrading fluvial system that experienced frequent local avulsion and reoccupation of previous channel positions. The internal architecture of these ridges suggests that Martian sinuous ridges are likely to comprise multiple

stacked channel units. If correct this would indicate long lived fluvial activity on early Mars as opposed to short episodes of water flow.