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Landscape evolution on early Mars: insights from the Jezero western fan

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The modern surface of Mars does not sustain liquid water, however relict landforms observed on orbital images provide strong evidence of past aqueous activity. Nevertheless on-the-ground analysis of sedimentary strata are required to robustly characterise the specific nature of early Mars palaeoenvironments. The Mars 2020 Perseverance rover is exploring a prominent sedimentary fan deposit at the western margin of Jezero crater – the Western fan – which has been interpreted to be an river delta that prograded into an ancient lake basin during the Late Noachian-Early Hesperian epochs on Mars (~3.6-3.8 Ga). Perseverance's traverse across the fan in 2022-2023 provides a remarkable window into a fossilised sediment routing system on Mars with potential to understand how water and sediment were distributed across a Martian landscape under a markedly different climate to present day. Here we use the rover's cameras to characterise sedimentary geometries in a distal to proximal transect across the western fan and reconstruct sediment dynamics on the Western fan and infer past environmental change. The distal reaches of the preserved fan show a sedimentary succession that records a transition from distal alluvial fan into lacustrine and subsequently foreset delta deposits. This succession records the initiation of a martian lake system and lake level rise, though overlying delta stratal geometries suggest deposition during episodes of lake level fall. In the medial sector of the upper exhumed portion of the fan, complex stratal geometries are observed with a variety of scenarios for palaeoenvironmental interactions possible. In particular, the presence of large-scale foreset units preserved in this 'mid-fan' sector possibly suggests complex deltaic interfingering with fluvial strata during lake level fluctuations. In more

proximal and stratigraphically higher (and hence younger) sectors of the fan, we observe strata deposited by progradation of fluvial systems culminating in a sequence of rounded boulder-containing deposits that signal transition to a routing system characterised by high discharges. Misquoting Shakira "the sediments don't lie"; they record a history of sustained water transport and habitability on early Mars.