FINE-SCALE SEDIMENTARY ARCHITECTURE OF THE UPPER PART OF THE JEZERO WESTERN DELTA FRONT.

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Introduction: Orbital and rover observations of relict geomorphic features and stratigraphic architectures indicate Mars once had a warmer, wetter climate. Constraining the character, relative timing and persistence of ancient aqueous activity on Mars is possible through detailed interrogation of the stratal geometry of aqueously deposited sedimentary bodies. Such analyses inform interpretations of Martian climate evolution, potential habitability, and search strategies for rocks that might contain potential biosignatures. NASA's Mars 2020 Perseverance rover mission is seeking signs of ancient life in Jezero crater and is collecting a cache of Martian rock and soil samples for planned return to Earth by a future mission.

A prominent sedimentary fan deposit at the western margin of Jezero crater has been interpreted to be a river delta that built into an ancient lake basin during the Late Noachian-Early Hesperian epochs on Mars (~3.6-3.8 Ga) [1, 2]. The Perseverance rover landed on 18 February 2021 ~2.2 km from the western fan. In March-April 2022, the rover conducted a rapid traverse along the eastern and southeastern side of Jezero fan only obtaining a few remote sensing observations along the way. In April 2022, the rover arrived at the base of the ancient delta in the *Three Forks* region of the crater floor adjacent to the delta front (Fig. 1). During the 'rapid traverse' and the exploration of two sections at the delta front - Cape Nukshak and Hawksbill Gap – Perseverance obtained striking images from the Mastcam-Z and SuperCam's Remote Micro-Imager instruments of the stratigraphy exposed stratigraphically higher up in the fan's erosional front [3]. Images provide new views of the stratigraphy exposed in the erosional front of the western Jezero delta; in particular, showing sections of the delta previously not visible from long distance observations and at much higher resolution. Here, we report its stratigraphy and sedimentology, which provide new constraints on the nature of the fan deposits, and therefore paleoenvironmental implications.

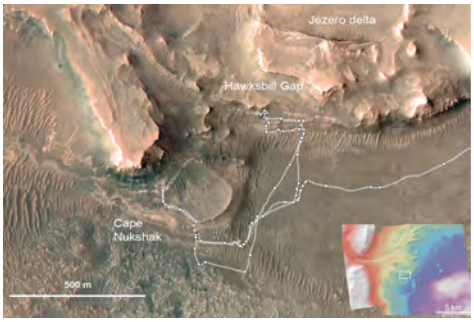

Fig. 1 Map of the Hawksbill Gap and Cape Nukshak in the Three Forks region.

Hawksbill Gap: Multiple Mastcam-Z mosaics show spectacular views of the stratigraphy of a prominent embayment in the delta scarp that has been informally named Hawksbill Gap, the lower section of which the rover investigated and sampled in 2022 (Fig. 1). The prominent cliffs of the eastern and western margin of Hawksbill Gap show distinctive stratal geometries with complex stratigraphic relations. The basal succession comprises poorly exposed thinly bedded, planar laminated sandstones that are interpreted as the deposits of low-density turbidity currents [4, 5]. A locally prominent, resistant unit named Rocky Top member comprises planar stratified pebbly sandstones also likely to be high-density turbidite deposits. The Rocky Top outcrop is laterally discontinuous over a tens of meters scale and shows a plano-convex cross-section shape pinching out to its eastern and western margins. The geometry of the body suggests it may represent a cross-section through a lobe deposit formed by sediment gravity flows.

The stratigraphic mid- to upper-sections of the scarps – above the outcrops of the Shenandoah formation are characterized by packages of decameter-scale inclined tabular strata, with variable inclinations and geometries. On the eastern flank of Hawksbill Gap, the Franklin Cliffs outcrop (Fig. 2) shows stratal units comprising (1) poorly sorted matrix-supported conglomerates interpreted to be debris flow deposits, (2) gently inclined pebbly sandstone bedsets, and (3) tabular large-scale inclined bedsets that are locally conglomeratic but predominantly comprise finer-than-conglomerate lithologies, likely pebbly sandstones. The inclined strata show multiple laterally stacked bedsets indicating episodic deposition from multiple flow events (Fig. 2). These are interpreted as delta foreset strata similar to those observed in Kodiak formed by sediment avalanching down the delta front of relatively steep coarse-grained deltas [7]. The inclined strata are overlain across a sharp truncation surface by generally planar parallel thin-bedded horizontal strata that we interpret as topset beds (Fig. 2). Conglomerate beds containing rounded boulders and up to ~1-2 m in diameter occur interstratified within finer-grained topset strata. The topset strata are interpreted to represent deposition from fluvial depositional processes in a delta top setting. The presence of the large cobble and boulder clasts indicates that episodic high discharge flood processes were important in sediment transport in this setting. The stratal patterns are broadly consistent with deposition in a Gilbert-type delta setting with basal strata representing deposition from sediment gravity flows, inclined strata representing avalanching foreset beds, and overlying topset beds deposition from fluvial processes in a delta top environment [7, 8]. At Franklin Cliffs, a prominent sub-horizontal erosion surface separates the foreset strata and inclined debris flow deposits from the topsets (Fig. 2); rollover of topsets into foresets is not observed. This indicates that these are oblique prograding clinoforms, which suggests delta progradation here during lake level fall based on Earth field examples and experimental studies.

Western side of Hawksbill Gap and Cape Nukshak: Observations of the western flank of Hawksbill Gap, above Cape Nukshak show similar large-scale inclined stratification that downlaps onto flat-lying strata of the lower part of the western fan succession (Shenandoah formation) within a narrow elongate (~200 m wide) promontory. Observations of the snout of this promontory above Cape Nukshak – a target called Whale Mountain – show highly complex geometries in strike section (Fig. 3). An ~13 m thick section, shows bivergent large-scale inclined stratification with beds inclined to either side of the promontory (Fig. 3). Locally, conglomerate beds are observed interstratified. Whilst the inclined stratification is typical of foreset strata, the cross-sectional geometries are unusual. The bivergent geometries may represent cross-sections through narrow finger-like lobes indicating a highly rugose planform geometry. However, alternatives should be explored. Similar to at Franklin Cliffs, the inclined strata are overlain by rounded cobble- to boulder-conglomerates suggestive of sediment transport and deposition by flood events.

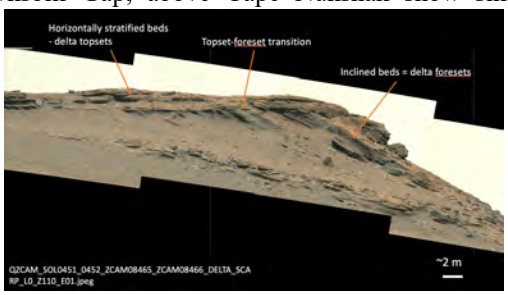

Fig. 2 Franklin Cliffs (Sols 451 and 452, sequences zcam08465 and 08466)

Summary: Interrogation of the stratal geometry and sedimentary facies of the western delta succession provides constraints on the character, relative timing and persistence of ancient aqueous activity at Jezero. Such analyses inform interpretations of Martian climate evolution, potential habitability, and search strategies for rocks that might contain potential biosignatures and organic matter.

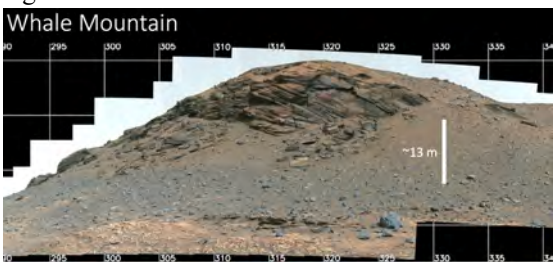

Fig 3 Complex bivergent geometries of inclined strata in Whale Mountain above Cape Nukshak. (Sol 610, sequence zcam08618

References: [1] Fassett & Head. (2005) GRL 32 L14201. [2] Goudge et al. (2017) EPSL 458. [3] Mangold LPSC23 [4] Stack LPSC 23; [6] Tebolt, LPSC 23, [7] N. Mangold, et al., (2021) *Science*, 10.1126/science.abl4051. [8] Caravaca et al, LPSC23. [9] Kanine et al. LPSC23.