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Sedimentary and stratigraphic observations at the Jezero western delta front using Perseverance cameras: initial constraints on palaeoenvironments

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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 key exploration target for the mission is a prominent sedimentary fan deposit at the western margin of Jezero crater that 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]. Long distance observations of a remnant butte (informally named Kodiak) related to the western fan demonstrated that it comprised two distinct Gilbert-type delta units [2, 3].

In her approach to the western fan, Perseverance drove alongside the east-facing scarp of the western fan and arrived at a key location called Three Forks - a setting off point for delta exploration - in April 2022. Images from the Mastcam-Z and SuperCam Remote Micro-Imager instruments 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. These observations provide the first direct evidence of delta geometries in the main western fan deposit. Here, we report its stratigraphy and sedimentology, which provide new constraints on the nature of the fan deposits, and therefore paleoenvironmental implications.

A Mastcam-Z mosaic of basal delta strata acquired on sol 411 in the vicinity of Three Forks and at an approximate distance of 250 m from the scarp provides a spectacular view of a prominent embayment in the delta scarp that has been informally named Hawksbill Gap. Hawksbill Gap is the proposed ascent route for Perseverance in her investigation and sampling of delta front strata. Prominent cliffs that make up the eastern and western margin of Hawksbill Gap show stratal patterns similar to those observed at Kodiak. The mid-sections of the scarps are characterized by decametre-scale inclined strata interpreted as foreset strata of a Gilbert-type delta succession. Internally these comprise stacked tabular beds that are locally conglomeratic but predominantly comprise finer-than-conglomerate lithologies, likely pebbly sandstones. Units with variable dips are present, together with some evidence of over-steepened dips suggestive of possible slumping or synsedimentary deformation. On the eastern side of Hawksbill Gap, the inclined strata are overlain across a sharp truncation surface by generally planar parallel thin-bedded horizontal strata that we interpret as topset beds deposited by fluvial processes in a delta top environment. The prominent

erosion surface separating the foresets from the topsets indicates that these are oblique prograding clinoforms, which suggests delta progradation here during lake level fall based on Earth field examples and experimental studies. Conglomerate beds containing boulders are observed within the topset strata indicating sediment-transport on the delta top by episodic high-discharge floods. Their relationship to the delta-capping boulder conglomerates described by Mangold et al. 2021 that were interpreted as evidence for major post-delta flood episodes remains to be determined. Foreset beds capped by sub-horizontal topsets are also observed on the western flank of Hawksbill Gap. Observations of the western flank of Hawksbill Gap, interpreted to be a promontory of a preserved channel body show complex bivergent inclined stratification indicative of a complex delta geometry, possibly a very narrow (~200 m wide) lobe distinct from other lobes of the delta. Detailed analysis of such stratigraphic patterns will permit reconstruction of fine-scale depositional processes and preservation here.

The Sol 411 Mastcam-Z mosaic from Three Forks also revealed the basal stratigraphy of the Jezero western delta for the first time showing low relief, recessive strata separated by laterally continuous at 100 m scale, thin tabular resistant beds that provide useful local marker horizons to sub-divide the stratigraphy. On a ledge at the top of lowermost strata, a distinct very light-toned layer that is laterally continuous for tens of metres is observed in the Mastcam-Z mosaic (and also in HiRISE imagery). This distinct unit has been informally named at two locations as Hogwallow Flats and White Rocks. Above Hogwallow Flats a prominent resistant planar unit that forms a distinct planar unit named Rocky Top is visible in Mastcam-Z and HiRISE imagery. This unit in vertical section has thin-bedded strata in its lower part and more thickly bedded at its top which may represent a thickening-up succession typical of lobe progradation in delta toe settings. This unit is laterally discontinuous clearly pinching out to the east and disappearing within less resistant beds.

In the light of the occurrence of horizontally bedded strata at the base of the delta scarp and also located below, the horizontally bedded basal strata below the large-scale inclined strata interpreted as foreset beds may represent bottomset and delta toset beds. In this scenario, the more resistant beds may represent coarser-grained turbidite flow deposits, with the less resistant strata perhaps representing finer-grained rocks that weather more recessively. The latter may have formed from either fine-grained turbidity currents or decantation processes in a prodelta environment. Close range observations are required to test these hypotheses.

Interrogation of the stratal geometry and sedimentary facies of the western delta succession will provide 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.

References: [1] Goudge et al. (2017) *EPSL* doi:10.1016/j.epsl.2016.10.056

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