CONSTRUCTING GEOLOGICAL CROSS-SECTIONS TO CONSTRAIN THE THREE-DIMENSIONAL STRATIGRAPHIC ARCHITECTURE OF THE JEZERO DELTA FRONT R Barnes[1*], S Gupta[1], G Paar[2], K M Stack[3], B Horgan[4], L Crumpler[5], M Tebolt[6], G Caravaca[7], S Alwmark[8], T Ortner[9], C Traxler[9], A Bechtold[10], H Kalucha[11], A Broz[12], C Tate[13], A Annex[11], J Bell[14], J Maki[3], O Kanine[11], J Nunez[15], S F Sholes[3], L Kah[16], N Schmitz[17], R Williams[18]. [1]Imperial College London, UK, *robert.barnes@imperial.ac.uk [2]Joanneum Research, Graz, Austria, [3]Jet Propulsion Laboratory, California Institute of Technology, USA, [4]Purdue University, USA, , [6]UT Austin, Austin, USA [7]IRAP, Toulouse, France, [8]Lund University, Lund, Sweden, [9]VRVis, Vienna, Austria, [10]University of Vienna, Austria, [11]Caltech, Pasadena, USA. [12]University of Oregon, USA [13]Cornell University, Ithaca, USA, [14]Arizona State University, USA, [15]Johns Hopkins Applied Physics Laboratory, USA, [16]Univ. Tennessee, Knoxville, USA, [17]DLR, Germany. [18]PSI, Tucson, USA.

Introduction: The NASA Mars2020 rover Perseverance has been traversing series that represent the transition from crater floor lithologies to deposits of the Jezero western delta since Sol 422 of rover operations [1]. During that time, the mission has explored the exposed stratigraphic succession at the delta front, named the *Shenandoah formation* [2]. Here we analyse Mastcam-Z mosaics and 3D data products derived from Planetary Robotics processing and viewing tools (PRoViP and PRo3D [3]) to map the 3D geometry of key stratigraphic boundaries and document the 3D stratigraphic architecture at the sub-km- to m-scale within the Shenandoah formation.

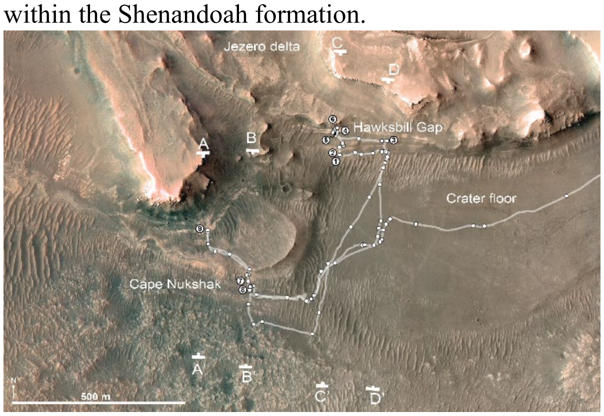

Fig. 1. *Map of the Jezero western delta front showing the locations of Perseverance's traverse, Hawksbill Gap and Cape Nukshak*

Data and methods: Four cross-sections were constructed across the lower delta stratigraphy at the base of Hawksbill Gap and Cape Nukshak (Fig. 2) using data collected from 3D reconstructions of Mastcam-Z data and HiRISE topography. Lithological observations made from Mastcam-Z image mosaics were used to inform interpretations of Digital Outcrop Models (DOM) comprised of multiple 3D reconstructions of stereo-image data. Stratigraphic boundaries based on team analyses [2, 4] and the key dip and dip azimuth measurements, were mapped on the DOMs in PRo3D and plotted on topographic profiles to visualise the depositional architecture. Stratigraphic thicknesses were corrected for dip where necessary, to build stratigraphic logs. The basal surfaces of the identified members which comprise the Shenandoah formation [2] were correlated between the lines of section to illustrate the architectural variations across the delta front.

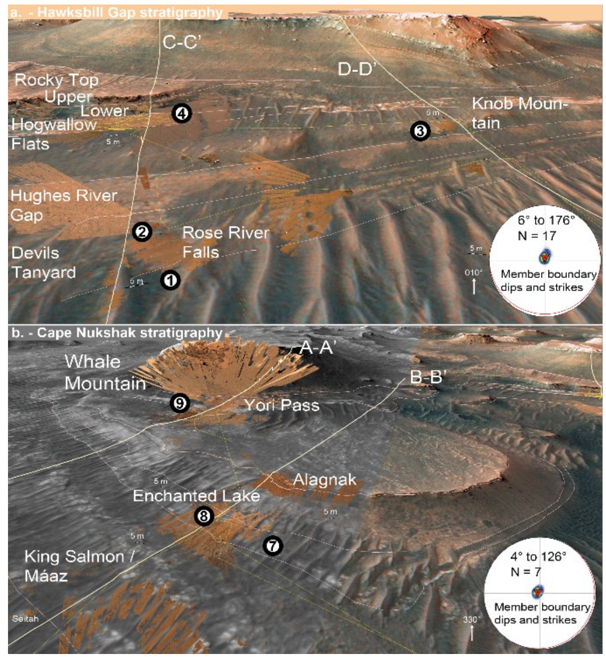

Fig. 2*: 3D views of Hawksbill Gap (a.) and Cape Nukshak (b.) showing the topographic profiles used for creating the cross-sections, as well as the locations of 3D reconstructions of Mastcam-Z stereo images.*

Stratigraphy: The fine-medium-grained Devils Tanyard member sandstone is the lowest sedimentary delta member, with ~2 - 4.5 m total thickness of alternating resistant and weathered out bedsets concordantly overlain by the <5 m thick Hughes River Gap member, which lacks recessive interlayers [2]. Facies in the Knob Mountain member vary along-strike between the Boston and Kibler Knob outcrops in western Hawksbill Gap and Knob Mountain in eastern Hawksbill Gap. We have classified them collectively here [2], yielding a 1.5 – 6.5 m thickness. The Knob Mountain member is overlain by the ~2.2 – 4 m thick Hogwallow Flats member, a sulfate-cemented siltstone comprised of alternating sub-members of more massive and more platy bedding. The Rocky Top member has been subdivided into a more recessive weathering lower member, and an upper cliff forming member [2] and is up to 10 m thick collectively, pinching out laterally to the east and west. The stratigraphy at Enchanted Lake at the Kaguyak, Amalik and Trident Volcano outcrops show alternating bedsets of weathered out and weathering resistant well-bedded very fine to medium sandstones [2, 4] which are comparable to the Devils

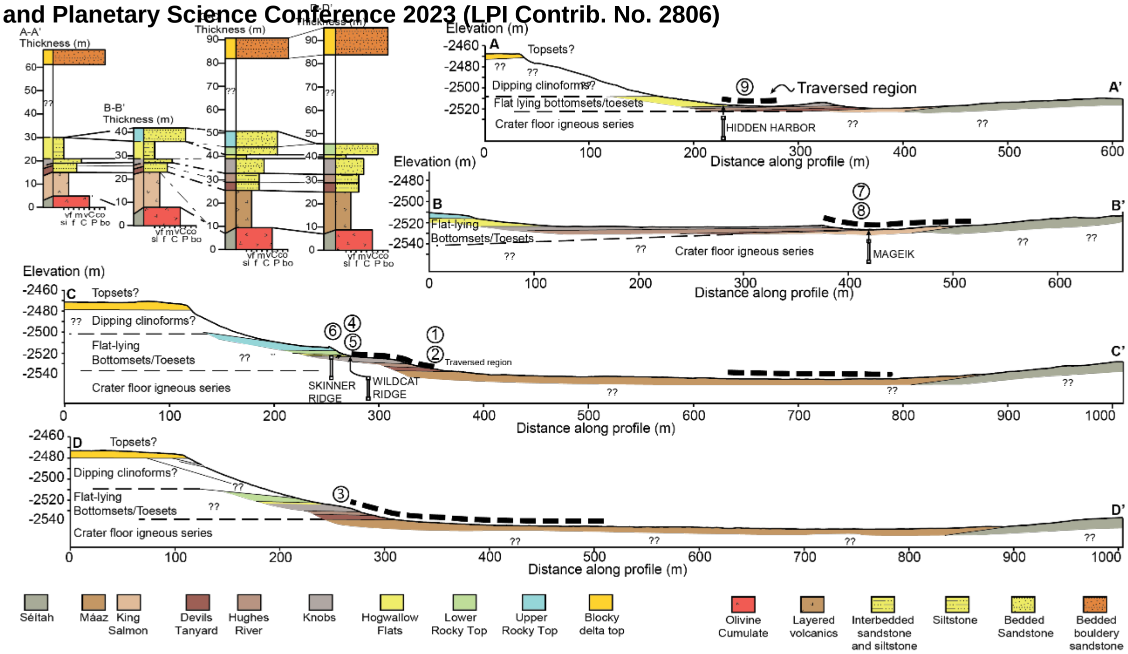

Fig. 3: *Cross-sections A-A' to D-D' constructed using 3D reconstructions of Mastcam-Z stereo-images, together with the stratigraphic correlation charts* created *from the sections.*

Tanyard member. This unit is overlain by light-toned rocks at Knife Creek which are a fine-medium sandstone and lack recessive interlayered bedsets, comparable to the Hughes River Gap member. The Alagnak outcrop [5], overlying Knife Creek (Fig, 2b) at a similar stratigraphic elevation to Knob Mountain, is a coarse-grained pebbly sandstone unit with locally inclined beds comparable in geometry and texture to those at Knob Mountain. A light-toned siltstone to very-fine sandstone unit overlies the Alagnak outcrop at Yori Pass, which has a comparable appearance to the Hogwallow Flats member at Hawksbill Gap, with the same alternating sub-members. The Rocky Top member is absent at Yori Pass, where a 1.3-3 m thick unit of darker toned cross-stratified sandstones overlie the light toned unit and are overlain by ~25 m of south dipping foreset units, largely obscured by regolith. The Whale Mountain outcrop, comprises ~ 22 m of divergently dipping layers with numerous erosional surfaces, and forms the upper section of exposed stratigraphy at Cape Nukshak. The members of the Shenandoah formation have been correlated to show a southwesterly decrease in thickness of the overall sedimentary succession at Cape Nukshak compared to Hawksbill Gap (Fig. 3).

Key structures observed at the Jezero delta front: Member boundaries are sub-horizontal, dipping <8° at the delta base shallowing to ~3° up-section, consistently towards 165° – 175° (Fig. 3). Internal beds and laminations within Devils Tanyard, Hughes River Gap and Hogwallow Flats members commonly dip shallowly to the north, with curvilinear laminations in Devils Tanyard and Hughes River Gap with up to 80° of variation in dip and strike, evidencing possible convolute folding of layers ~5 – 20 cm thick. Similar structures are found in the ~80 cm thick basal layer of the Hogwallow Flats outcrop, with evidence of ~4 m wavelength folding with up to 25° of rotation and erosion of fold crests. The 65 cm thick middle sub-member of Hogwallow Flats shows low-amplitude undulations 3 – 4 m in wavelength in the interlayered resistant platy laminations and recessive intervals. At the HiRISE scale, the lower and upper boundaries at Cape Nukshak are sub-horizontal, but the Devils Tanyard equivalent at the Enchanted Lake outcrop shows high variability in dip and strike where it outcrops, containing layers which dip up to 45°, and areas with chaotic bedding orientations.

Summary: The structural and stratigraphic architecture is consistent with deposition of variable grain size fractions in delta bottomsets, from the Devils Tanyard to Knob Mountain members, and a change in sediment input is evidenced by siltstones at Hogwallow Flats. A transition to relatively coarser-grained pebbly sandstones likely deposited as turbidity current event-beds is observed at Rocky Top. Folding is the predominant deformation mechanism observed and shows more intensity within the lower members of the succession observed, with localised areas of tight folding sandwiched between the sub-horizontal member boundaries. Absence of consistent fold vergence and the flat lying member boundaries are used infer that the folds are soft sediment deformation features caused by vertical loading.

Acknowledgments: We are grateful to the many engineers and scientists for their efforts in the Perseverance mission, and to M2020 team members who participated in tactical and strategic science operations.

References: [1] Williams A. et al. (2023) LPS LIV. [2] Stack. et al. (2023) *LPS LIV*. [3] Barnes et al., (2018). *Earth and Space Sci. 5(7), 285-307.* [4] Tebolt at al., (2023) *LPS LIV*. [5] Ives et al., (2023) *LPS LIV*.