FROM LAKE DEPOSITS TO FLUVIAL FLOODS AT THE EASTERN DELTA FRONT OF JEZERO CRATER, MARS.

N. Mangold[1*], S. Gupta[2], G. Caravaca[3], G. Dromart[4], O. Gasnault[3], S. Le Mouélic[1], C. Quantin-Nataf[4], B. Horgan[5], J. F. Bell[6], O. Beyssac[7], S. Maurice[3], J. I. Nuñez[8], D. L. Shuster[9], K. M. Stack[10], B. P. Weiss[11], R. C. Wiens[5]. [1]LPG Nantes, France. [2]Department of Earth Science and Engineering, London, UK [3]IRAP, Université de Toulouse, France. [4]LGL, Lyon, France. [5]Purdue University, USA. USA. [6]ASU, Tempe, USA. [7]IMPMC, Paris, France. [8]JHUAPL, Laurel, USA. [9]Dept. Earth and Planetary Science, University of California, Berkeley, USA. [10]JPL, CalTech, Pasadena, USA. [11]MIT, USA. *nicolas.mangold@univ-nantes.fr

Introduction: The Perseverance rover landed on the floor of Jezero crater on 18 February 2021. The landing site is located ~2.2 km from the SE-facing erosional scarp of the western fan deposits. Images obtained using the Mastcam-Z camera and the Remote Micro-Imager (RMI) of the SuperCam instrument provided the first Mars ground-based observations of this western fan. These images show a deltaic architecture consistent with a paleolake, but at a level ~100 m lower than expected, suggestive of a closed system [1]. Here we report new observations made during the "rapid traverse" in March-April 2022, a period during which the rover traveled fast along the eastern and southeastern side of Jezero fan taking only a few remote sensing observations on the way.

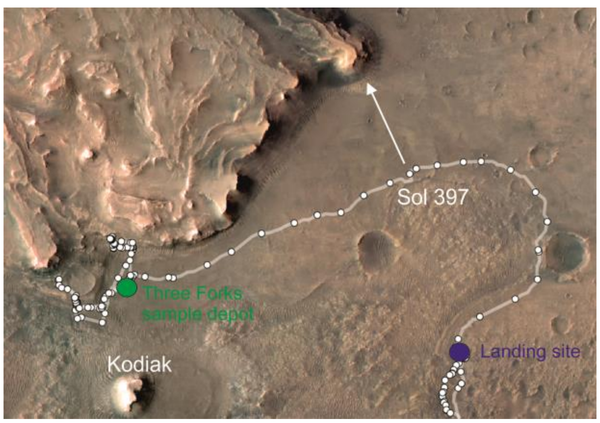

Figure 1: Orbital view (HiRISE color image) of Perseverance rover traverse along the SW side of the delta front. Data studied were acquired on sol 397 over the scarp indicated by the white arrow.

Observations and interpretations: The studied scarp is 70 m high and corresponds to the easternmost lobes of the fan. Observations were taken from ~890 m away on sol 397 and consist of Mastcam-Z and SuperCam RMI data (Fig. 1). At this distance, RMI images are ~0.9 cm/pixel of pixel size enabling us to resolve objects of ~3-4 cm large at best. Apart from slopes covered by scree, four main sets of strata are observed from bottom to top (A0-A3)(Fig. 2).

A 25 m thick basal unit A0 contains thin beds. Individual beds are 5-30 cm in thickness and contain no pebbles. The texture seems dominated by sandstones or finer-grained sediments. At the top of the sequence, beds seems relatively planar while they are inclined in the direction of the slope immediately below. These beds dip toward SE (toward the rover) in the left of the outcrop and toward ESE at the right edge of the image. At this location, beds display an asymptotic shape (from ~35° to ~20° of apparent dip, Fig. 2b).

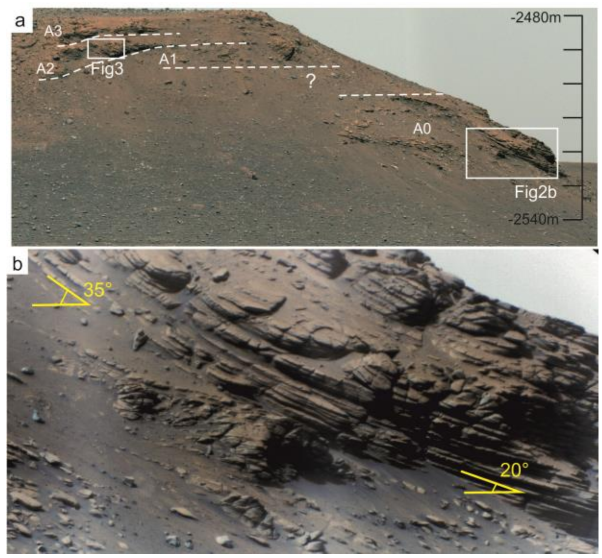

Figure 2: (a) Mastcam_Z image of the scarp of the delta with four main units visible (A0 to A3). Approximate elevation indicated on scale to the right. (b) Close-up on the RMI image on unit A0 showing inclined sandstone bedsets with decreasing dip from 35 to 20°. Each bed is a few cm thick.

A0 was not discussed in [1] because imaging available was too ambiguous to conclude whether the inclined layers were in place or modified by mass wasting. From new data, it appears clear that this outcrop is in place. From orbital images, we can determine that this outcrop continues over 150 m toward the north (not visible on rover images). Two interpretations are possible: (i) From the asymptotic shape of layers, their dip and thickness, this basal unit could be part of the foresets of a deltaic architecture or (ii) Inclined strata could correspond to fluvial bars. This second hypothesis would require a giant river. Fluvial bars on Earth are lower than 25 m in height. The corresponding river would have an equivalent depth > 25 m. Thus, it seems unlikely that this thick stack of layers could have been deposited by such a deep and wide river. In contrast, the variability in individual layers thickness and their dip are both consistent with turbidity currents on the delta slope. We thus favor an interpretation as foresets, in agreement with interpretations from orbital data north of this location (although dip measured from orbit are much lower) [2]. In contrast to the Kodiak butte, the full sequence (from topsets to bottomsets) is not visible here due to the density of scree, but the dip direction is consistent with the eastern direction of this lobe. Assuming the relatively flat layers at the top of A0 being topsets, this location would highlight a lake level at an elevation between -2500 m and -2510m.

A 7 m thick sequence A1 composed of <20 cm thick tabular strata is observed in the upper part of the slope. The northern margin is marked by steeply inclined bedsets (up to 30° to the SW). No pebbles are observed, suggesting sandstones or finer-grained deposits. We favor the formation of these inclined beds by lateral accretion of fluvial bars.

A coarse-grained lenticular unit A2 overlies A1. It shows an asymmetry with up to 9 m in thickness. This sequence contains clast-supported conglomerates with rounded cobbles and boulders. The largest boulder, up to 1.5 m long is embedded within the outcrop. In addition to descriptions of this unit made in [1], the higher resolved images enable us to identify (Figure 3): (i) Imbricated pebbles and cobbles; (ii) A large number of well-rounded cobbles; (iii) Well-visible beds, which appeared faint in previous images. Several beds display basal cobbles highlighting fining up sequences over 50 cm to 1 m thickness (Figure 2), as expected for fluvial bars with decreasing intensity, starting the deposition with bed load and finishing with suspended load. These new observations confirm the fluvial origin of these deposits as high-energy floods, discarding any formation by debris flows or megafloods.

Lastly, A3 at the top of the sequence is up to 10 m thick and shows parallel bedding with local cross-stratification. A3 is generally finer-grained than A2 but contains isolated pebbles and cobbles, suggesting a pebbly sandstone common in river deposits. The lack of an obvious boundary between A2 and A3 suggests a gradational transition. Therefore, these units may be part of the same depositional sequence and A3 would record the waning stage of floods. Atop of A3 on the plateau lie many boulders and cobbles (up to 2 m) with many of them being rounded. Their presence means that the delta top is covered by a lag of boulders previously embedded in fluvial conglomerates and now lying on the delta top.

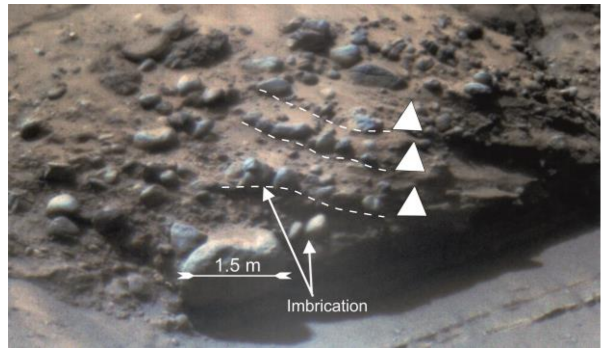

Figure 3: Close-up on the SuperCam RMI image (sol 397) showing rounded cobbles, imbrication of cobbles and fining up sequences in individual beds of 50 cm to 1 m thick beds indicated by the dashed lines.

Conclusions and implications: The basal layers are part of a 25 m thick, 150 m long unit with inclined beds of sandstones that are interpreted as forests from deltaic deposits. Their top elevation between -2500 m and -2510 m is consistent with that deduced at Kodiak and the main delta front [3, 4], in a closed lake system [1]. Corresponding bottomsets are eroded suggesting that the delta front has recessed backward substantially.

The boulder-rich conglomerates observed ontop of the sequence consist of high-energy floods of still undetermined origin (glacial melting, dam break, etc.). The rounding of many clasts indicates that they have undergone strong abrasion by river transport. Their rounding and their lack of apparent internal bedding suggests an igneous lithology. Observations on the south of the delta front show similar packages of layers including boulder conglomerates, but also finer-grained layers that are under assessment [3]. The rover traverse in 2023 includes an access to the top of the delta where it should cross the transition from topsets toward conglomerates. Boulders present an opportunity to analyze and sample crustal rocks sourced from far outside Jezero crater.

Acknowledgments: The authors acknowledge the M2020 project's management, engineering and scientific teams for their diligent efforts in making this mission as effective as possible. The authors are grateful to M2020 team members who participated in tactical and strategic science operations.

References: [1] N. Mangold, et al., *Science*, 374, 711-717, 2021. [2] T. A. Goudge et al., *EPSL*, 458, 357-365, 2017. [3] Gupta et al., this conference. [4] Caravaca et al., this conference.