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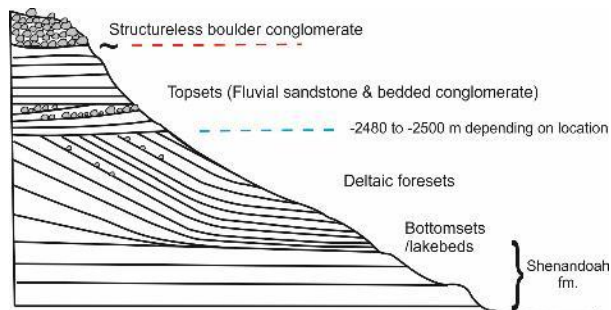
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**CONSTRAINTS ON JEZERO PALEOLAKE HISTORY FROM ITS FLUVIAL INPUT.** N. Mangold<sup>1,\*</sup>, G. Caravaca<sup>2</sup>, S. Gupta<sup>3</sup>, R.M.E. Williams<sup>4</sup>, O. Gasnault<sup>2</sup>, S. Le Mouélic<sup>1</sup>, E. Dehouck<sup>5</sup>, G. Dromart<sup>5</sup>, A. Annex<sup>6</sup>, J. Hurowitz<sup>7</sup>, L.R.W. Ives<sup>6</sup>, L. C. Kah<sup>8</sup>, N. Randazzo<sup>9</sup>, K. L. Siebach<sup>10</sup>, J. I. Simon<sup>11</sup>, K. Stack<sup>6</sup>, M.M. Tice<sup>12</sup>, J.F. Bell III<sup>13</sup>, A. Cousin<sup>2</sup>, S. Maurice<sup>2</sup>, R.C. Wiens<sup>14</sup>. <sup>1</sup>LPG, Nantes Univ, CNRS, France; <sup>2</sup>IRAP, CNRS, CNES, Univ. Toulouse, France; <sup>3</sup>Imperial College, London, UK; <sup>4</sup>PSI, Tucson, AZ, USA; <sup>5</sup>LGL-TPE, Univ. Lyon 1, France; <sup>6</sup>SETI Institute/NASA Ames Research Center, Mountain View, CA ; <sup>7</sup>Stony Brook University, Stony Brook, NY, USA; <sup>8</sup>Earth and Planetary Sciences, University of Tennessee, <sup>9</sup>Univ Alberta, Edmonton, AB, Canada, <sup>10</sup>Rice University, USA, <sup>11</sup>NASA Johnson Space Center, Houston, TX, USA <sup>12</sup>Texas A&M, College Station, TX, USA; <sup>13</sup>ASU, Tempe, AZ, USA ; <sup>14</sup>Purdue Univ. West Lafayette, IN, USA. \*nicolas.mangold@univ-nantes.fr

**Introduction:** The western fan of Jezero crater displays features interpreted as fluvial and deltaic sedimentary rocks from orbital data [1,2]. Images obtained using the SuperCam Remote Micro-Imager (RMI) and the Mastcam-Z camera provide in-situ observations of Jezero crater's western fan in various locations along the Perseverance traverse. In the last two years, the rover analyzed the fan front before that it crossed the top of the fan. Here we summarize the fluvial and deltaic stratigraphy observed throughout the delta and discuss further the variability in the fluvial input and its implication on the history of Jezero lake.



**Fig. 1:** Synthetic sketch of the observations made on the fan front [3].

**Stratigraphy:** The stratigraphy of the western fan has been examined using distant imaging on several hillslopes, along its eastern and southern sides, along Kodiak butte, and on outcrops of the fan top. Our observations highlight a systematic stratigraphy (Fig. 1) [3,4]: (1) The bottom of hillslopes of the fan front displays recessive, light-toned deposits that are best explained as lacustrine deposits at the delta toe, as part of the Shenandoah fm. [5]. (2) The central part of the fan front hillslopes corresponds to steeply dipping beds with a sigmoidal geometry over 20-25 m sequences. The same sigmoidal bodies are observed within the fan in various places, such as in Pinestand Mountain, which displays two ~14 and ~22 m bed sets with up to ~30° dipping sigmoid strata. We interpret these beds as due to gravity-induced avalanches of material deposited

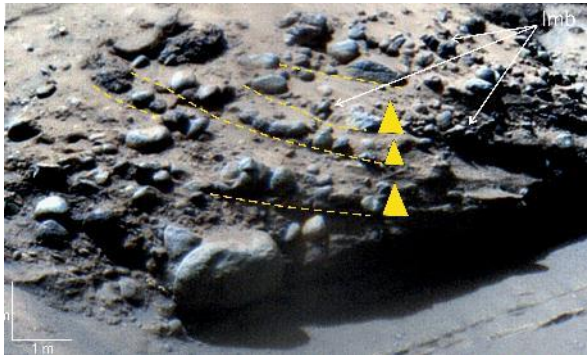
onto the slope of a delta, namely foresets. The transition between topsets and foresets correspond to a former lake level. This transition varies from -2410 to -2500 m as recorded from outcrops on the delta front and top. This evolution is interpreted as a progradation from top to bottom during forced regression (lake level fall) [6], in agreement with the downlap geometry observed in several locations. (3) Above the foresets various types of fluvial deposits (sandstones and conglomerates) are present, with a facies distinct from the steeply dipping beds, showing especially internal cross-beddings or channel structures. These deposits are interpreted as topset beds deposited by rivers feeding Jezero Lake. (4) Above all these bedded sedimentary rocks are massive, poorly-sorted boulder conglomerates that truncate all the underlying strata.

**Fluvial beds:** The fluvial deposits observed at the top of the sequence (points 3 and 4 in the previous section) deserve a closer look to evaluate their regime.

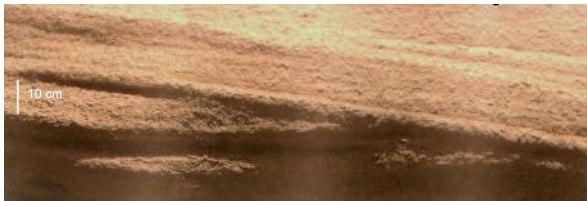
The Miners Castle outcrop on the Eastern side of the fan front, displays a cobble- and boulder-rich conglomerate (Fig. 2). The boulder-rich section of the outcrop presents an asymmetric geometry, reaching 4.5 m high in the thickest portion, and thinning gradually to the north. Clear bedding is observed characterized by beds of ~50 cm to ~1 m in thickness (Fig. 2). In the central area, individual beds contain cobbles at their base that transition sharply into finer grains in their upper part. Such a fining upward sequence (i.e., normal grading) with size-sorted clasts is typical of a decrease of fluid velocity and a change from bedload transport at the base to suspension load in the upper part of a flow. Many of the clasts here appear significantly rounded, suggesting a substantial transport distance. When pebbles are elongated, they display clast imbrication (labelled Imb in Figure 2), a geometry also typical of bedload transport in fluvial flows.

The values of discharge rates estimated for this flow vary from 126 to 521 m<sup>3</sup>.s<sup>-1</sup> [3]. These values still represent a relatively large range of estimations, but with a smaller upper bound compared to previous estimations [7]. This difference is due in large part to

the refinement in channel shape thanks to better resolved images, and for a small part to the slightly smaller grain size distribution.



**Fig. 2:** Detailed view of Miners Castle outcrop on the eastern side delta front. The cobble and boulder-rich section of conglomerates displaying imbricated cobbles that bound individual beds (yellow dashed lines) with fining upward texture (yellow triangles). Imb indicates imbrication of clasts (SuperCam image sol 397).



**Fig. 3:** Detailed view (50 cm high outcrop) of cross-bedded, pebbly sandstones at Carew Castle on the delta top (SuperCam image sol 754).

On the delta top, Carew Castle displays coarse-grained beds (both sandstone and pebble conglomerate), which are subhorizontal and heavily cross-stratified, deposited within an energetic setting, typically braided river system [8]. Their vertical extension of 5 to 10 m is similar to that of the cross-bedded topsets observed at Kodiak [7,9,10], and several locations of the Eastern delta side [3]. Further West, similar cross-bedded, fluvial deposits have been observed in locations such as Onahu, where a facies of coarse-grained sandstone was observed locally.

Lastly, poorly-sorted boulder conglomerates are observed all over the place from the Kodiak butte [7,9], to the delta front (above Miners Castle) [3], and in many locations on top of the fan where they correspond to the unit defined as Blocky Deposits in previous mapping efforts [1]. These structureless deposits contain many boulders up to 2 m in length. They represent an energetic last stage of fluvial floods, which truncates underlying beds. Their relationships to the Jezero Lake is not clear yet, i.e., they could have been deposited

subsequently and without any link to the paleolake. The morphology of Neretva Vallis upstream infers intense late stages of activity with discharge rates estimated in the  $10^3$ - $10^4$   $\text{m}^3\cdot\text{s}^{-1}$  range [11], which could correspond to the fluvial episodes represented on the delta by boulder deposits.

**Discussion and conclusion:** In summary, the scarps of Kodiak butte, delta front and fan top display a similar sequence of deposition: steeply dipping beds interpreted as deltaic foreset beds capped by subhorizontal fluvial topsets that most frequently truncate their underlying layers, themselves truncated by boulder-rich structureless deposits. The variations of the lake level inferred from the topset-foresets transitions are consistent with a progressive fall of the lake level, i.e., forced regression [6]. Such an evolution means that the delta formed in a closed lake system for most of its history. This conclusion is consistent with the irregular topography of Pliva Valles, which is better explained by a series of overflows than by a steady-state river flow [12], suggesting that the period during which Jezero Lake was an open system was much shorter in time than the subsequent period during which the delta formed.

Such a scenario also means that the fluvial input was not sufficient to preserve a lake level high enough for an open lake system. The high variability of fluvial deposits observed, their relative limitation in thickness (5-10 m thick are preserved for most of them) and their overall coarse grain size, suggest an irregular fluvial regime with flooding events and waning stages of deposition. This variability can explain the fluctuations reported from depositional stages at Kodiak [10]. This variability needs also to be taken into account for the type of environment expected for the deposition (e.g.; glacial meltwater, desert floods, etc.) as well as in future estimations of Jezero Lake timescale.

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