CHARACTERIZING THE FACIES AND STRATIGRAPHY OF THE ENCHANTED LAKE OUTCROP IN JEZERO CRATER, MARS. M. Tebolt[1,2], K. M. Stack[2], T. A. Goudge[1], S. Gupta[3], R. Barnes[3], G. Caravaca[4], A. J. Brown[5], [1]Department of Geological Sciences, Jackson School of Geosciences, University of Texas at Austin (mtebolt@utexas.edu), [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA [3]Imperial College London, [4]IRAP, Université Paul Sabatier Toulouse III, CNRS, CNES, Toulouse, France, [5]Plancius Research, MD

Background: Jezero crater once hosted an open lake system ~3.8 Ga when water is considered to have been abundant on the surface of Mars [1]. A sedimentary delta deposit formed at the western rim of the crater and remains well-preserved on the surface today [1,2]. Studying the stratigraphy of the Jezero delta can be used to better constrain the fluvial and climate history of early Mars [e.g., 2,3].

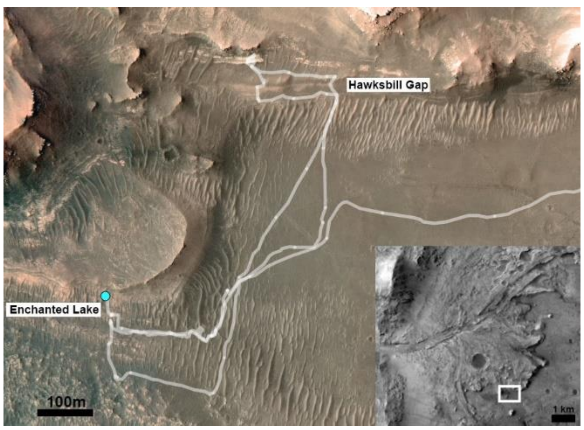

Fig. 1. *Enchanted Lake in context with the Jezero delta. Inset shows the Jezero delta with a white box outlining the area of exploration. The white line on the main figure shows the rover traverse. The blue dot at Enchanted Lake shows the rover position on sol 600*.

Here we present analysis of the Enchanted Lake outcrop, which is located on the eroded southern margin of the delta deposit (Fig. 1). This outcrop was the Mars 2020 *Perseverance* rover's first direct encounter with sedimentary rocks at the base of the delta deposit. Data of this outcrop were first collected from sols ~420-426 of the *Perseverance* mission. The rover then traversed to the northeast to explore the Hawksbill Gap area before returning to Enchanted Lake for sols ~565-600. This study identifies and characterizes the facies within the Enchanted Lake sedimentary succession, and interprets the paleoenvironment of the outcrop in context with the larger deltaic system.

Methods: We identified outcrop using images taken by the Navcam, Mastcam-Z, and SuperCam's RMI camera systems onboard *Perseverance*, and used these data to define facies and relative stratigraphic position. Facies were distinguished using physical lithologic differences, specifically grain size, bedding/lamination scale and type, degree of erosion/weathering, and sedimentary structures.

Facies Descriptions: Facies detailed below are in stratigraphic order from lowest to highest, with elevation used as a proxy for stratigraphic height.

Low angle cross-stratified medium sandstone: This facies has beds that are generally planar and sub-horizontal and exhibits low angle scour [4]. Layer thickness varies from very thin to thin beds (<1 cm - 4 cm). This facies includes the Kaguyak target (Fig. 2).

Curvilinear laminated sandstone: This facies is highly eroded and recessively weathered. A key feature are the curvilinear-to-chaotic patterns formed by the laminations. These structures include convolute laminations that appear sinuous with clear inflection points such as those around Trident Volcano (Fig. 2).

Planar thinly laminated siltstone: This facies is fine grained, on the scale of silts. Individual laminations appear to fine upwards. Laminations are highly regular with a thickness of ~0.7 cm as observed at the Amalik target (Fig. 2).

Recessively weathering siltstone: The grains of this facies are not resolvable with SuperCam RMI (~100 μm/pixel [5]), indicating a grain size finer than very fine sand. The most distinguishing characteristic of this unit is its highly eroded, slope-forming nature. The rocks are fissile and erode to form small thin plates. This is seen at the Knife Creek target (Fig. 2).

Coarse-grained sandstone: This facies consists of coarser grains on the scale of coarse sand to granules. It is characterized by planar to low angle cross-stratified bedding with layer thickness on the scale of ~3-10 cm. This includes the Alagnak target (Fig. 2).

Discussion: We interpret this outcrop as a turbidite, part of an unconfined, submarine fan lobe, formed when a subaqueous gravity flow traveled down the slope of the delta and deposited sediment distally on the lake floor [6]. The facies observed at Enchanted Lake are consistent with portions of a Bouma sequence, the classic presentation of turbidite facies [7,8]. This includes cross-stratified and convoluted laminations, parallel laminae, and hemipelagic sediment. While the Enchanted Lake outcrop does not preserve a full Bouma sequence, it is uncommon to find a fully intact Bouma sequence in nature, and partial sequences are much more common.

Additionally, the convolute lamination pattern from the curvilinear laminated sandstone is interpreted as soft sediment deformation, a common feature found in turbidites [7]. Soft sediment deformation occurs during

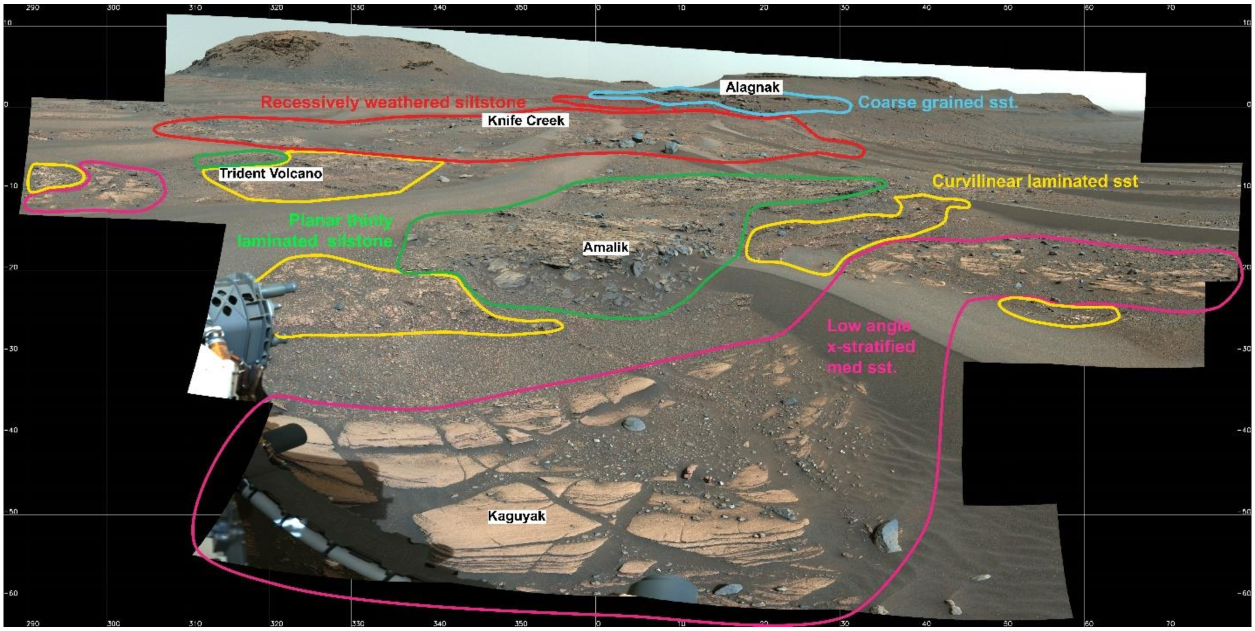

Fig. 2. Map of observed facies at Enchanted Lake. The rover is facing North. Facies exposures are indicated by colored outlines (see text for complete descriptions). Notable outcrops are also labeled. The background image is Mastcam-Z mosaic QZCAM_SOL0425P_ZCAM08450_Z034_L0E_ENCHANTED_LAKE

or shortly after deposition (before significant diagenesis) from rapid loading (e.g., burial). This loading creates excess pore fluid pressure that can mobilize a less dense layer, creating various deformation structures [9,10].

Some of the facies present in Enchanted Lake are also consistent with what might be expected for a fluvial or beach margin setting. However, the rocks at Enchanted Lake are missing abundant cross-stratification (e.g., ripples and/or dunes), which are typical features of channelized fluvial sediment bodies [11]. Due to this lack of cross-stratification and any other features to indicate subaerial exposure (e.g., mudcracks), we suggest the outcrop facies are most consistent with subaqueous unconfined gravity flows (i.e., a turbidite). As an unconfined distal deposit, Enchanted Lake would represent part of the delta system building out as bottomsets

References: [1] Fassett and Head, (2005) *Geophys. Res. Lett.*, vol. 32, no. 14. [2] Goudge et al., (2018) *Icarus*, vol. 301, pp. 58–75. [3] Edgar et al., (2017) *Sedimentology*, vol. 65, no. 1, pp. 96–122. [4] Olariu et al., (2021) *Sedimentology*, vol. 68, no. 5, pp. 1941–1963. [5] Gasnault et al., (2021) LPSC 2021 #2548. [6] E. Mutti, (1985) *Provenance of Arenites*, pp. 65–93. [7] Talling, et al., (2012) *Sedimentology*, *59*(7), pp.1937-2003. [8] Sumner, et al., (2008) *Journal of Sedimentary Research*, *78*(8), pp.529-547. [9] Allen (1981) *Proceedings of the Geologists' Association*, vol. 92, no. 1, pp. 75–77. [10] Owen et al., (2011) *Sedimentary Geology*, vol. 235, no. 3, pp. 133–140. [11] Aitken and Flint (1993) *AAPG Bulletin* 77 (1993): no. 51

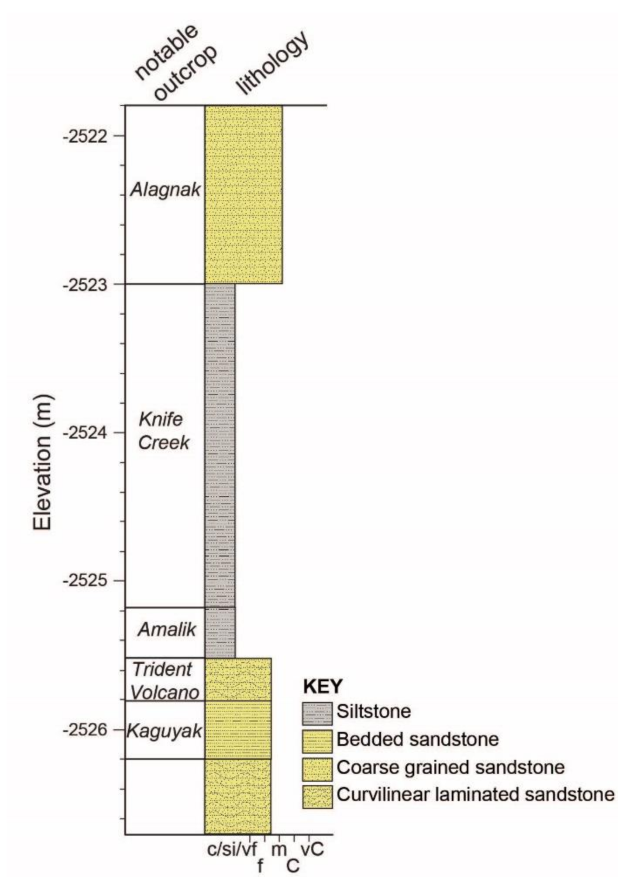

Fig. 3. Stratigraphic column of Enchanted Lake using elevation as a proxy for stratigraphic height.