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DELTAIC SYSTEM AT JEZERO CRATER, MARS. R. Barnes¹, S. Gupta¹, A. J. Jones¹, B. Horgan², B. Garzcynski³, G. Paar⁴, K. Stack⁵, J. Bell⁶, J. Maki⁵, S. Alwmark⁷, E. Ravanis⁸, E. L. Ives⁴, F. Calef⁴, L. Crumpler⁹, K. Williford¹⁰, A. Vaughan¹¹, J. I. Simon¹², S. Gwizd⁴, C. Tate¹³, A. Annex¹⁴, A. Klidas², K. Farley⁵, N. Randazzo¹⁵, R. Williams¹⁶, N. Schmitz¹⁶, L. Kah¹⁷, A. Brown¹⁹, G. Caravaca²⁰, O. Gasnault²⁰, R. Wiens², D. Flannery²¹, J. Nunez²².
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Introduction: The NASA rover *Perseverance* encountered a series of rocks deposited at the apex of the Jezero western fan system (~3.6–3.8 Ga) on Sols 959–1000 of the mission. Gnaraloo Bay (Fig. 1), with the erosional incision through key stratigraphic units, presents an opportunity to unravel the relative timing of the different emplacement processes acting in this area. Such information is essential in providing context to collected samples upon their return to Earth and aid the assessment of their astrobiological potential.

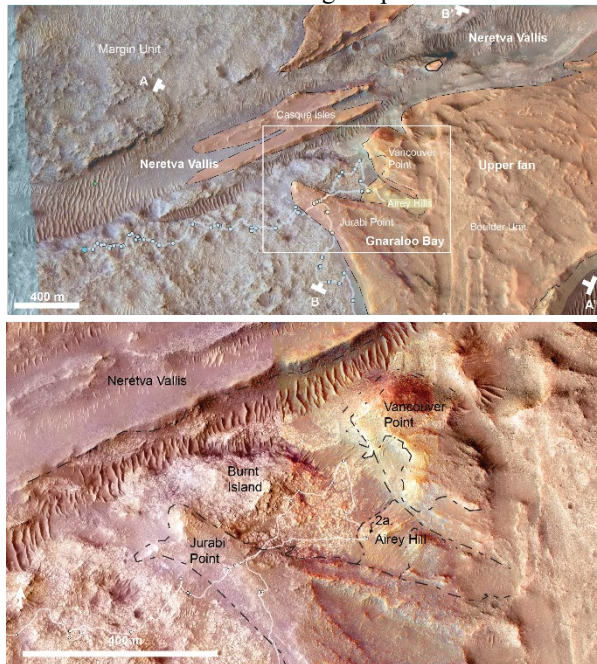


Figure 1. a. – Sketch map of the Jezero western fan apex showing the key features, as well as the locations of cross sections; b. – Detailed map of the key locations at Gnaraloo Bay

Data and methods: We present observations made from images collected by the Mastcam-Z stereo-camera system [1]. We characterized outcrops and bounding surface geometries from each major stratigraphic unit to visualize and better understand the variable depositional geometries at various points in the evolution of the Jezero western fan. Detailed interpretation of stratigraphic boundary relationships, variations in bedding style and visible textures as well as internal structures were made from image mosaics. Interpretations informed analyses of processed three-dimensional digital outcrop models generated from

Mastcam-Z stereo-images. We used the Planetary Robotics Vision Processing Tool (PRoViP) to create outcrop models analysed using tools in the Planetary Robotics 3D Viewer (PRo3D) [2][3] to measure the dimensions and orientations of geological elements preserved in outcrops, and record this information in maps, cross-sections and stratigraphic logs.

Western Fan and Margin Unit stratigraphy:

The stratigraphy in western Jezero crater records a transition from the igneous crater floor materials [4], to overlying distal deltaic deposits of the Shenandoah formation [5] which are then overlain by the upper fan series. A transition from distal deltaic to migrating fluvial or mouthbar bedforms [6] and periodic flood flow deposition is recorded in the upper fan series. The Tenby formation comprises well-bedded sandstones with a planform curvilinear geometry comparable to deposits from terrestrial migrating bedforms. A planar bedded coarse sandstone, called the Otis Peak formation overlies the Tenby formation. The Boulder Unit, a blocky unit of fans of boulder deposits, tops the fan, thicker and more laterally extensive closer to the apex. To the west and north, the upper fan succession overlies the carbonate/olivine bearing Margin Unit. The contacts between these units have been largely obscured for much of the traverse, precluding detailed assessment of their stratigraphic relationships.

Margin Unit at Gnaraloo Bay: Up to ~15 m of thickness of the Margin Unit (Fig. 1), the oldest stratigraphic unit in Gnaraloo Bay, was imaged. It comprises shallow dipping (< 10° dip) beds in packages dipping toward the crater rim, as well as packages dipping away from the crater rim separated by low-angle truncations, and showing variable thicknesses. There is no clear evidence that these subtle dip variations could be related to deformation. Numerous hypotheses are being investigated as to the processes represented in this area of the Margin Unit, such as shoreline deposits in smaller terrestrial lacustrine settings [7] and pyroclastic surge deposits.

Airey Hill – Tenby formation?: An arcuate, abrupt boundary striking ~NE-SW in SE Gnaraloo Bay separates an ~7 m thick outcrop at Airey Hill (Fig. 2), from the Margin Unit to the west. Dip directions in the Margin Unit adjacent to Airey Hill are to the northeast, north and southwest, and outcrop-scale surfaces at Airey Hill dip to the southeast, indicating the units are

separated by an angular unconformity. Airey Hill is comprised of arcuate packages of bedded sandstone, containing cobble conglomerate lenses. The lower 0.7 m is undulose-laminated, rough-textured, dark brown to buff material. The overlying outcrop contains packages of well-bedded sandstone with boundaries dipping less than 5° to the southeast. Packages up to ~0.3 m thick occupy the lower ~1 m of the outcrop and contain ~0.2-0.3 m thick beds with shallow (<12°) dips to the northeast. In the upper ~2 m, the beds between the sub-horizontal bounding surfaces form cross-sets that are up to 1.7 m thick, and contain 0.1 – 0.2 m beds that dip towards the south. The Airey Hill outcrop is interpreted to record an initial phase of upper stage flow directly on top of the Margin Unit, followed by deposition from migrating bedforms, initially to the north, then to the south, with an increasing flow thickness. Orbital characteristics of Airey Hill lead to initial interpretation of this deposit as equivalent to the Tenby formation observed on the fan top, but significantly shallower dips are observed here, compared to the Skrinkle Haven member [8], leading to the possibility that the Airey Hill rocks may be a different facies than observed in the wider Tenby formation.

Stratigraphic relationships at Vancouver Point

Point: Vancouver Point (Fig. 1b), a hill bounding eastern Gnaraloo Bay, is topped by olivine- and low calcium pyroxene-rich boulders, part of the Boulder Unit. The Boulder Unit here downcuts into planar stratified outcrops correlated with the Otis Peak formation. The basal contact of the Otis Peak sandstone at Vancouver Point strikes northwest-southeast through Gnaraloo Bay, cross-cutting and post-dating both the Margin Unit and Tenby formation.

Jurabi Point boulder ridge: The Jurabi Point ridge bounds Gnaraloo Bay to the south, and forms part of the western boundary of the current extent of the upper fan. The linear ridge of the Boulder Unit is one of

several such deposits identified around the fan top, interpreted to be one of the latest depositional events on the upper western fan [8]. The Jurabi Point boulder ridge is directly juxtaposed on the Margin Unit in the west, and overlies the contact with the Tenby formation at Airey Hill, with no observable change in elevation or orientation. The ridge provides a rare opportunity to analyse an outcrop of the boulder unit isolated from the underlying stratigraphy observed at previous imaging locations. The Otis Peak formation is absent at the Jurabi Point ridge, whereas it is commonly identifiable near other deposits of the boulder unit inside the fan. This observation may imply that the Otis Peak formation is not a facies associated with deposition of the boulder unit, and is a separate unit, unconformably underlying the boulder unit, and overlying the Margin Unit and Tenby formation.

Summary: We interpret the stratigraphy at Gnaraloo Bay to record the initial deposition of fluvial deposits on top of marginal beach/shoreline deposits. This was followed by deposition of sheets of coarse sandstone which appear to have been shielded from erosion by the late episode of channelized flood flow boulder deposition sourced from the Neretva Vallis inlet valley.

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References: [1] Bell *et al.*, (2022). [2] Paar *et al.*, (2023). *Journal of Geophysical Research*. [3] Barnes *et al.*, (2018). *Earth and Space Sci.* 5(7), 285-307. [4] Farley *et al.*, (2022) *Science* [5] Stack. *et al.* (2024) *Journal of Geophysical Research* . [6] Caravaca *et al.* (2023) *LPS LV* [7] Jones *et al.*, 2024. This conference. [8] Ives *et al.*, (2023) *LPS LIV*. [8] Gwizd *et al.*, 2024 *LPS LV*.

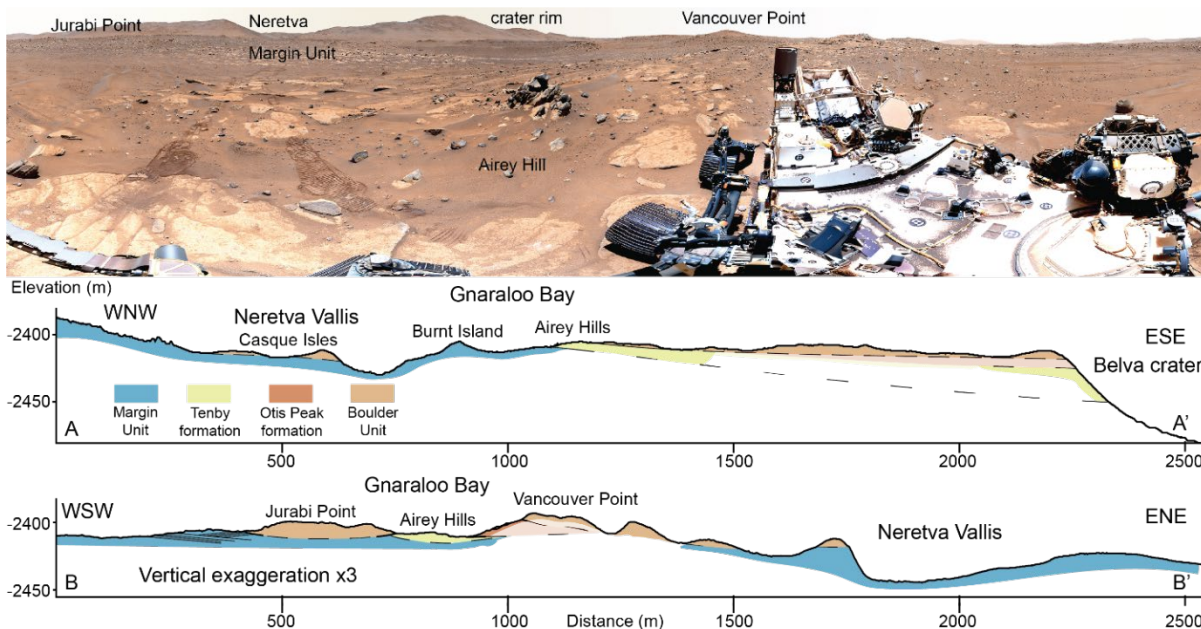


Figure 2. The 110 mm focal length 360° gigapan taken at Airey Hill on Sol 963 showing the key geographic features in Gnaraloo Bay. Cross-sections A-A' and B-B' (locations in Fig. 1a) are shown below.