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DEPOSITIONAL HYPOTHESES FOR THE EMPLACEMENT OF THE MARGIN UNIT, JEZERO CRATER, MARS. N. Randazzo¹, C.D.K. Herd¹, R. Barnes², K.C. Benison³, A. Brown⁴, T. Bosak⁵, G. Caravaca⁶, B. Horgan⁷, E. Ravanis⁸, and S. Siljeström⁹.

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Introduction: After 910 sols, the Mars 2020 Perseverance rover has begun exploring the margin unit, the region with the strongest and clearest orbital signature of carbonate minerals (Figure 1) [1, 2]. Stratigraphically, the margin unit is older than the Upper Delta/Fan Top units and lies unconformably below curved and inclined sandstone deposits, interpreted as fluvial deposits, and below the boulder-rich unit (Figure 2). On Mars, rovers and orbiters have only detected carbonates in trace amounts in only a few locations on the surface [3]; however, their sources are primarily unclear. Some carbonate material is also found in martian meteorites such as ALH 84001 and Nakhla [3]. The sources are aqueous alteration of igneous material, both in Comanche rock and ALH84001 [3]. Carbonates generally form due to aqueous processes in solutions that contain inorganic carbon. However, the meteorites do not preserve a record of specific surface processes in past habitable environments. Based on orbital detections, the carbonate material in Jezero is hypothesized to have precipitated from a lacustrine environment [1].

Here, we provide a detailed discussion about the depositional hypotheses, stratigraphy and paleoclimate implications of the margin unit and make a case for why samples from this unit should be returned to Earth via Mars Sample Return (MSR).

The margin unit is considered one of the most carbonate-rich deposits found on the martian surface [e.g., 1, 2]; alternatively, it is a location with the largest surface exposure. Comparison of geochemistry and sedimentology of the margin unit with what was previously found on the Jezero Upper Fan and Fan Front units provides insights into the relationship between these units. Notably, the Jezero fan was active during the Noachian (~3.8-4 Ga) [4-6], which is also the approximate period where life is hypothesized to have first occurred on Earth. The clastic material likely originated outside Jezero crater and provides valuable information about the outside Jezero region so an examination of this sample could also inform us about the environments outside of Jezero.

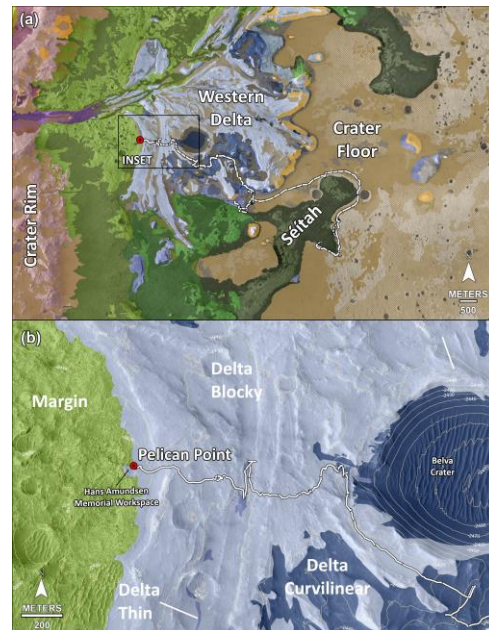


Figure 1. Bedrock geology detailing the location of the margin unit relative to the block unit of the delta top, the rim of Jezero crater, and the crater rim.

Formation Hypotheses: The location of the carbonate-rich margin unit relative to the crater rim suggests that the margin unit formed from an ancient shoreline deposit and that the carbonate material formed within a lacustrine environment [2]. However, the provenance of the margin unit sediments is unclear, as they could be sourced from reworked pyroclastic material deposited into a lake, or reworked volcanoclastic material from outside Jezero crater, or material eroded from the crater rim. Alternative formation hypotheses include fluvio-lacustrine or aeolian origins. The carbonates could have also formed via mineral carbonation, where silicate minerals react with the thick CO₂-rich atmosphere hypothesized to have existed on Mars during the Noachian. Therefore, any study of these martian carbonates offers a unique opportunity to learn about possible carbonate formation conditions on Mars.

Currently, two sample cores collected by Perseverance, *Pelican Point* and *Lefroy Bay*, contain margin material. Identifying the depositional environment of the

margin unit is important in the assessment of habitability during the time of deposition and the potential for organic preservation, especially because many carbonate grains, sedimentary structures, and even cement on Earth are biologically mediated (e.g., stromatolites, carbonate reefs, and perhaps tufa) [2].

Methods: We examined multiple sedimentary structures from the margin unit and compared them to terrestrial analogs. We also used data gathered from various instruments onboard the Perseverance Rover including the Radar Imager for Mars' Subsurface Exploration (RIMFAX), mineralogical data from Mastcam-Z, and geochemical data from SuperCam, and Planetary Instrument for X-ray Lithochemistry (PIXL) to infer the possible paleoenvironmental depositional conditions of the margin unit. Further details regarding the marginal unit are discussed in [7-12].

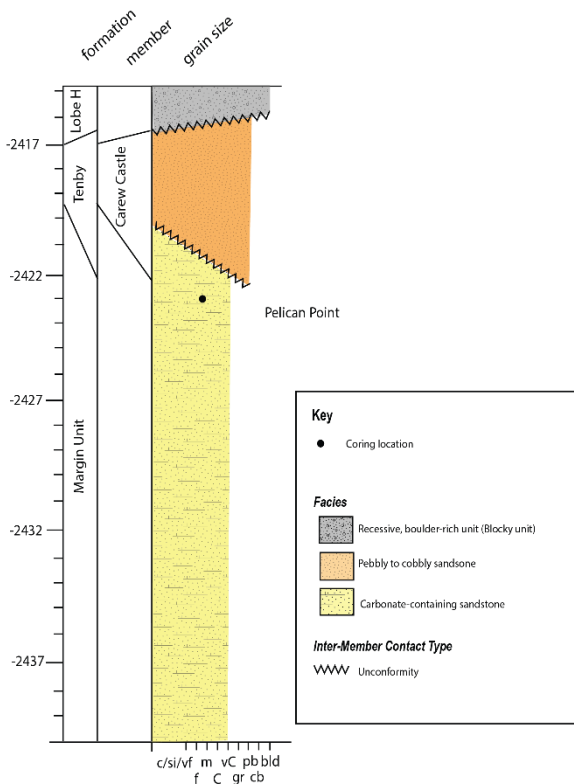


Figure 2: The Pelican Point sample location's Stratigraphic log shows that the margin unit lies below the curvilinear unit (Tenby) and the blocky units (Lobe H). Grain size categories include c/si/vf = clay/siltstone/very fine sandstone; f = fine sandstone; m = medium sandstone; C = coarse sandstone; vC = very coarse sandstone; gr = granule; Pb = pebble; cb = cobble; bld = boulder

Results: The margin unit lacks any evidence of igneous rocks and thus appears to be entirely sedimentary in origin. Examination of the clastic sedimentary rocks deposited in the margin unit so far has shown them to contain olivine grains, Fe/Mg-carbonates, hydrated silica deposits, and some carbonate-rich regolith [7,9]. The rocks of the margin unit appear to be finer than the sandstone deposits found in the Upper Fan and Fan Front and suggests that the fan units formed under a higher energy environment than the margin unit. Additionally, the margin unit has a larger concentration of carbonate material. Current sedimentological analysis using RIMFAX shows that the margin unit is characterized by gently sloping layers that dip rimward or towards the basin. The margin also lacks high angle cross-beds and ripples which may indicate an aeolian depositional environment but do show some evidence of fluvial and deltaic depositional features suggestive of accretion and erosion. However, mapping efforts have not identified potential inlets that could have created any braided or fluvial systems. Instead, the low-energy environment and the presence of carbonate and silica along with the aforementioned layers gently sloping rimward or basinward, suggest that the currently most plausible depositional environment is a lacustrine beach environment.

High Priority Science Objectives Through MSR:

Carbonates can also encapsulate organic matter during precipitation and are thereby crucial from an astrobiological perspective. Additionally, examining the diagenetic features also provides us with information about the post-depositional processes. While some information can be gleaned from targeted remote science, most of the necessary paleoclimatic/environmental/astrobiological information can only be obtained in laboratories on Earth. Laboratory analysis, such as fluid inclusion analyses, clumped isotope thermometry, and classic stable isotope analysis, can supply information, such as temperature and salinity, during which these carbonates were formed.

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References: [1] Horgan et al. (2020) *Icarus*, 339, 113536. [2] Ehlmann B.L. et al. (2008) *Science* 322, 1828. [3] Niles et al. *Space Science Reviews* 174(1-4), 301-328. [4] Kahn (1985) *Icarus*, 62, 175-190. [5] Pollack et al. (1987). *Icarus* 71, 203-224. [6] Ramirez and Craddock (2018). *Nat. Geosci.* 11, 230. [7] Siljeström S. et al. this meeting. [8] Wiens R.C. et al., (2024) LPSC LV (this meeting). [9] Jones et al., (2024) LPSC LV (this meeting). [10] Garczynski et al., (2024) LPSC LV (this meeting). [11] Horgan et al., (2024) LPSC LV (this meeting). [12] Ravanis et al., (2024) LPSC LV (this meeting).