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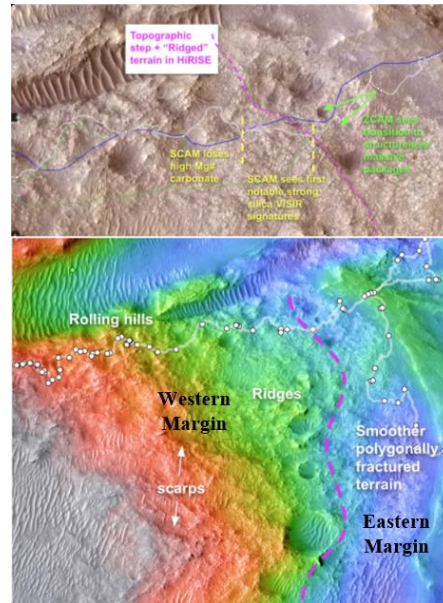
## DEPOSITIONAL HYPOTHESES FOR THE EMPLACEMENT OF THE MARGIN UNIT, JEZERO CRATER, MARS, AND THE IMPLICATIONS FOR HABITABILITY AND ORGANIC PRESERVATION.

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**Introduction:** After 910 sols, the Mars 2020 Perseverance rover has begun exploring the Margin unit, a region with the strongest and clearest orbital signatures of carbonate minerals [1, 2]. Based on orbital detections, outcrop observations, and abrasion patch analyses, the carbonate material in the Eastern Margin unit of Jezero is hypothesized to have precipitated from a lacustrine environment [1], the Western Margin unit; however, based on outcrop observations and chemical data, may have formed from separate processes (Figure 1). Stratigraphically, the Margin unit is younger than the Upper Delta/Fan Top units, which lie unconformably above the Margin unit 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. Here, we provide a detailed discussion of the depositional hypotheses, stratigraphy, and paleoclimate implications of the Margin unit. We further make the case about the importance of returning such samples to Earth via Mars Sample Return (MSR).

The Margin unit is considered one of the most carbonate-rich deposits on the martian surface [e.g., 1, 2]. A comparison of the geochemistry and sedimentology of the Margin unit with what was previously found in 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], the approximate period when life is hypothesized to have first occurred on Earth. The clastic material likely originated outside Jezero crater. It might provide valuable information about the surface environments beyond Jezero.



**Figure 1.** Eastern and Western Margins within Jezero crater

**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 reworked from pyroclastic material deposited into a lake, sourced from igneous or volcanoclastic material from outside Jezero crater or even from the watershed, or material eroded from or within 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 CO<sub>2</sub>-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.

Three sample cores collected by Perseverance, Pelican Point, Lefroy Bay, and Comet Geyser contain Margin material. *Comet Geyser*, from the Western Margin unit, appears to have a higher concentration of silicate

cemented Mg-carbonate and some possible serpentine. 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, compared them to terrestrial analogs, and used data gathered from various instruments onboard the Perseverance to infer the possible paleoenvironmental depositional conditions of the Margin unit as well as the preservation potential [7-11].

**Results:** The Margin unit as a whole appears chemically altered, and the eastern Margin unit lacks any evidence of igneous rocks, which may be sedimentary in origin and locally sourced. 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, some detections of hydrated carbonate, and some carbonate-rich regolith [7,9,12]. The Margin unit has a larger concentration of carbonate material. Current sedimentological analysis using RIMFAX and Mastcam-Z stereo-imagery shows that the Eastern Margin unit is characterized by gently sloping layers that dip rimward or towards the basin, and the diverse grain compositions observed in abrasion analyses indicate a sedimentary origin [9, 13]. The Eastern Margin unit also lacks high-angle cross-beds and ripples but shows some evidence of fluvial and deltaic depositional features suggestive of accretion and erosion. However, no potential inlets that could have created braided or fluvial systems have been identified. The Western Margin unit has traceable layers of well and poorly-layered possible sub-units [14] and could be

magmatic/pyroclastic/sedimentary emplacement; however, the relatively low chemical diversity (e.g., Ca, Na, Al) puts constraints on the origin and travel distance if these rocks are sedimentary.

**High-Priority Science Objectives Through MSR:**

Carbonates can also encapsulate organic matter during precipitation [ref] 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. (2024) LPSC LV. [8] Wiens R.C. et al., (2024) LPSC LV. [9] Jones et al., (2024) LPSC LV. [10] Garczynski et al., (2024) LPSC LV. [11] Horgan et al., (2024) LPSC LV. [12] Srivastava, this meeting. [13] Williams et al. (2024) LPSC LV. [14] ones et al., this meeting.

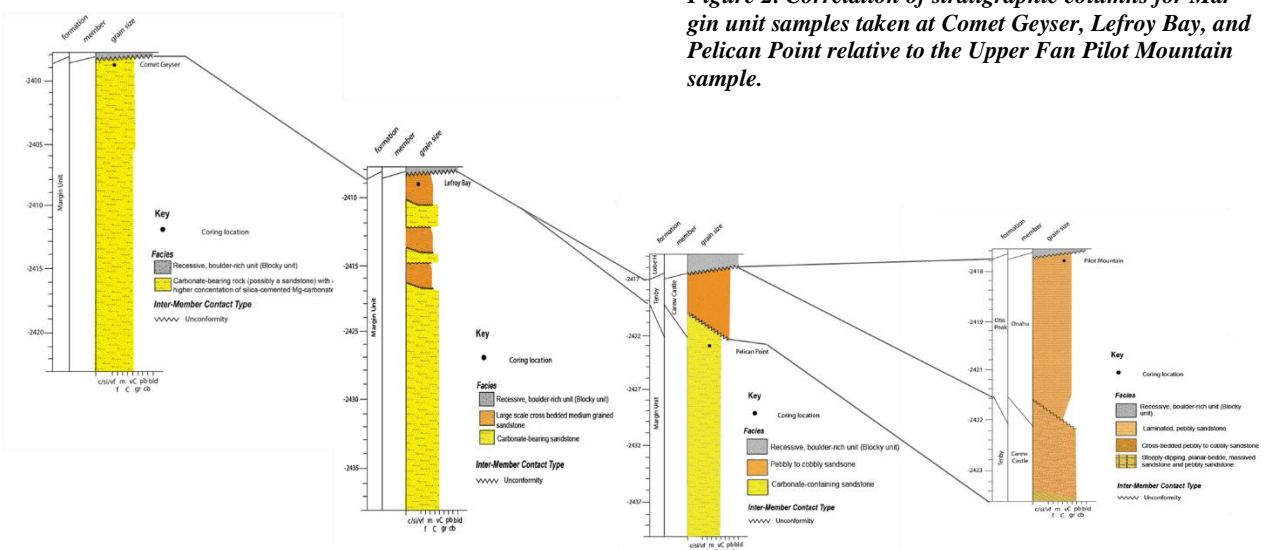


Figure 2. Correlation of stratigraphic columns for Margin unit samples taken at Comet Geyser, Lefroy Bay, and Pelican Point relative to the Upper Fan Pilot Mountain sample.