TOPOGRAPHIC TRENDS OF THE GEOLOGIC UNITS IN JEZERO CRATER: LAKE LEVELS, POTENTIAL SHORELINES, AND THE CRATER FLOOR UNITS.

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Summary: The Mars2020 *Perseverance* rover continues to explore the crater floor of Jezero crater working to understand the origins of the different crater floor geological units. Here, we model and analyze the modern and paleo- topography of various facets of Jezero crater to better constrain the evolution and origins of the various units and features observed.

In general, we find that that *a*) the evidences for lake levels are largely unconstrained and are primarily supported by the outflow channel, western delta, and Kodiak, *b*) so far, no convincing evidence has been found for continuous lake terraces (i.e., shorelines), and *c*) the contact surface of the lobate Crater Floor Fractured Rough (Cf-fr) unit dips to the southeast.

Lake Levels: We present a preliminary diagram (Fig. 1) showing the orbital and *in situ* evidence constraining the different lake levels over time. The best constraints on past lake levels are the bottom of the NE outflow channel at -2.395 km [1] and the western delta fan which is at an average elevation of -2.45 km.

New *in situ* observations from the *Perseverance* rover mission include confirmation of classic deltaic clinoforms in Kodiak, suggesting that the delta extended out further in the past and had a water level at about -2.49 km [2]. The Santa Cruz butte, peaking at -2.52 km, has also been suggested to be a possible delta remnant [5], but rover observations have yet to find definitive evidence of any deltaic structures. Detection of salt crystals in the Bellegarde and Guillaumes abraded patches (on Sols 160 and 186 respectively, at an elevation of ~-2.57 km) suggests possible groundwater activity and provides a lower constraint on water level (but could be pre-, post-, or concurrent with a lake). Similarly, detection of inclined radargram reflectors underneath the rover by the RIMFAX instrument at the boundary of the Séítah unit *could* potentially be clinoforms which would provide additional constraints on lower lake levels [9].

These lake levels are also presented at their current elevation but, depending on the exact relative age of Jezero, the entire crater and its geologic units may have been tilted due to the rise of the Tharsis volcanic province and/or loading within the Isidis basin [4]. Thus, we have also applied these models to the elevation to get a “pre-Tharsis” digital elevation model which will be useful for correlating the different lake level evidences as we move up the delta and crater rim.

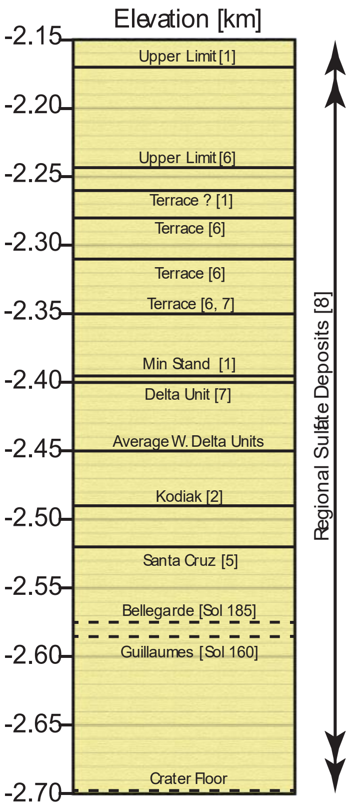

Figure 1: Summary of lake level evidence in Jezero crater. Upper limit corresponds to identified low points in the crater rim which did not form any outflow channels. A possible terrace is discussed in [1] as a slope break, while [6] shows 3 possible terraces in topographic profiles. Minimum stand is the bottom of the current outflow channel in the NE. Kodiak and Santa Cruz are possible delta extensions. Bellegarde and Guillaumes are abrasion patches where salts have been detected, possibly due to groundwater activity. Sulfate deposits were found in the Syrtis Major region and suggests subaqueous deposition [8], but have not been found in Jezero. Crater floor is around -2.70 km.

Potential Shorelines: Prior to landing, a few sites were suggested as potential candidates of erosional lacustrine terraces (i.e., shorelines). [1] suggested that break in the slope along the crater rim by the western delta fan could be evidence of a potential erosional lacustrine terrace. However, the errors associated with these slope measurements and lack of a consistent and traceable morphological feature casts doubt on the validity as a shoreline.

The age of Jezero suggests that *if* any shorelines were to form, they would likely be subdued and/or obliterated given billions of years of aeolian erosion and impact gardening. As seen in terrestrial paleoshorelines (e.g., Lake Bonneville, UT), some intermediate shorelines can be very subtle in their expressions both from orbital and *in situ* observations. Thus, we cast a wide net and test the entire crater rim using a CTX (Context Camera; 6 m/px) digital elevation model (DEM) for potential subtle erosional lacustrine terraces. We use the paleoshoreline detection toolkit developed by [3], which looks at specific changes in the residual topography between what observed topography and an ‘idealized’ slope.

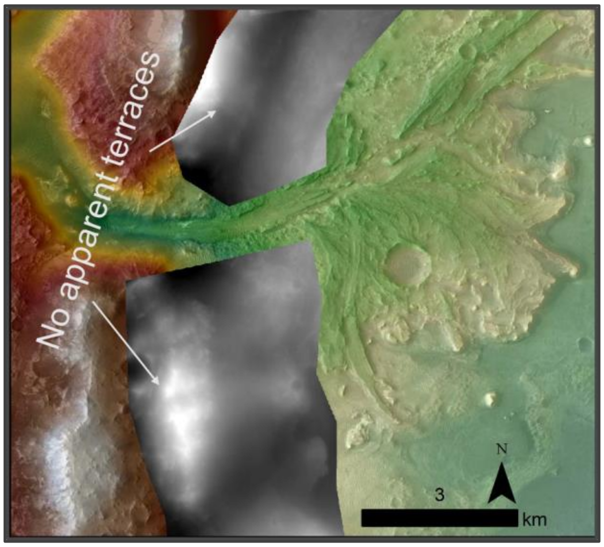

Figure 2: Application of the paleoshoreline detection toolkit (white/black inlay) [3] along the crater wall by the western delta. Candidate shorelines should appear as alternating dark/light lines, the lack of these features suggest no apparent terraces in this location (from [1]).

Applications of this method to the crater rim directly adjacent to the western delta (Figure 2) where the possible terrace was suggested from [1] show no signs of candidate terraces. Furthermore, we have identified other curvilinear features along the crater floor reminiscent of lake shorelines or strandlines, but we interpret these as stratigraphic layering within the crater, rather than erosional terraces. We also test several possible terraces near the outflow channel [6], which were only identified via a single topographic profile.

Crater Floor Units: To better understand the different crater floor units the rover has been traversing, we model their potential surfaces by tracing out their contacts and fitting planes to the data. We do this for both the contact between the lobate Cf-fr unit and the underlying crater floor surface along with the contact between the Cf-fr and the Crater Floor Fractured 1 (Cf-f-1, which includes Séítah) unit.

Figure 3 shows both the surface topography of the lobate Cf-fr unit and a simple 4th-degree polyfit to the unit contact with the underlying crater floor unit. We also test other surface-fitting techniques, including other degree polynomials, interpolants, and Lowess fits, which all have a general S/SE slope in the surface. We also note that the 'thumb' of Séítah is significantly lower than the rest of mapped Cf-f-1 contact (as is the surface topography). However, even with this segment removed the overall trend of the Cf-fr/Cf-f-1 contact is to the SE.

This S-to-SE trend is seen in both the Cf-fr and Cf-f-1 unit contact surfaces. This suggests that either the unit was deposited at an angle dipping <~1° to the SE, or has since been deformed through other processes, e.g., Isidis loading or Tharsis-induced deformation [4].

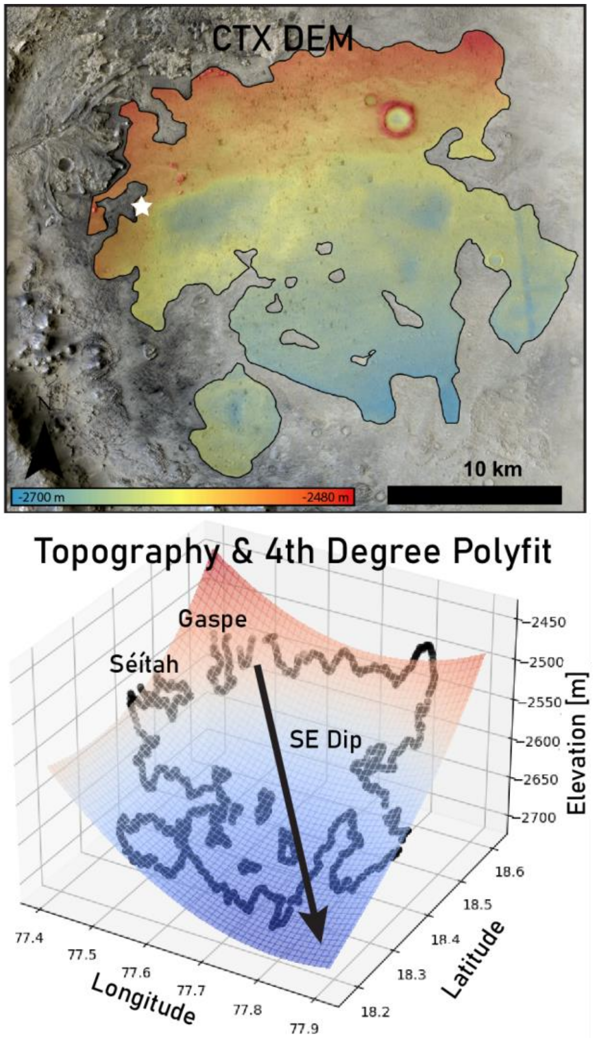

Figure 3: *top*) CTX mosaic map of the lobate Crater Floor Fractured Rough (Cf-fr) unit with overlain colorized CTX DEM. *bottom*) A 4th degree polynomial surface fit to the contact boundary showing an apparent dip to the southeast.

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References: [1] Fassett and Head (2005) *GRL* 32, doi: 10.1029/2005GL023456. [2] Mangold et al. (2021) *Science* 374, doi: 10.1126/science.abl4051. [3] Sholes et al. (2019) *JGR:Planets* 124, doi: 10.1029/2018JE005837. [4] Citron et al. (2021) *LPSC LII*, Abstract #1605. [5] Schon et al. (2012) *PSS* 67, doi: 10.1016/j.pss.2012.02.003. [6] Salese et al. (2020) *Astrobiology* 20, doi: 10.1089/ast.2020.2228. [7] Mangold et al. (2020) *Astrobiology* 20, doi: 10.1089/ast.2019.2132. [8] Quinn and Ehlmann (2019) *124*, doi: 10.1029/2018JE005706. [9] Russell et al. (2022), this conference.