JEZERO CRATER, MARS AS A COMPELLING SITE FOR FUTURE IN SITU EXPLORATION.
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Introduction: Jezero is a ~45 km diameter impact crater located in the Nili Fossae region of Mars. Jezero is an outstanding site to address key questions of ancient Mars climate, habitability, and volcanic history because: (a) It hosted an open-basin lake during the era of valley network formation [*1,2*], which ceased at approximately the Noachian-Hesperian boundary [*3*]. (b) It contains two delta deposits [*1,4*] with Fe/Mg-smectite and Mg-carbonate sediment [*4-7*] (the only exposure of lacustrine shoreline carbonates seen so far on Mars). (c) The depositional environment and mineral assemblage of the delta are promising for the concentration and preservation of organic matter [*5,8*]. (d) The diverse geologic units in Jezero are in clear stratigraphic context [*7*].

The Jezero paleolake system has been thoroughly investigated at a variety of scales, including work on: the mineralogy of the delta deposits [*4-6*] and watershed [*7*], as well as the morphology and sedimentology of the basin [*9*] and delta deposits [*1,4*]. The geologic context of Jezero is also well-studied given the broad suite of alteration minerals exposed in the ancient stratigraphies of the Nili Fossae region [e.g., *6,10-13*].

Here we present an overview of the units accessible for exploration in the Jezero basin, including questions and hypotheses that can be tested through analysis *in situ* and of returned samples. This is particularly timely given the upcoming Mars 2020 mission, for which Jezero is one of the final eight landing sites [*14*]. Primary science objectives for Mars 2020 are to: (1) characterize the geologic history of a site with "evidence of an astrobiologically-relevant ancient environment and geologic diversity"; (2) assess the habitability and "potential evidence of past life" in units with "high biosignature preservation potential"; and (3) cache scientifically compelling samples for potential return to Earth [*15*].

Units of Interest: Jezero crater contains three main geologic units of interest for *in situ* exploration, and each provides an interesting and unique scientific rationale for exploration. All three units are accessible within the notional Mars 2020 landing ellipse (**Fig. 1**).

Delta Deposit: The Jezero crater western delta deposit (**Figs. 2A,B**) records sedimentation in a likely habitable, circumneutral pH, fluvio-lacustrine setting [*1,4-7,9*]. The eroded front of the deposit exposes bottomset strata (**Fig. 2A**) [*4*], an ideal environment for both the preservation and concentration of organic matter [*5,8*]. Indeed, MSL has identified organic molecules in fine-grained, lacustrine sediment at Gale crater [*16*].

The delta hosts detrital sediment composed of Fe/Mg-smectite clays and Mg-carbonate derived from the ~12,000 km^2 watershed in the broader Nili Fossae region [*5-7*]. *In situ* analysis of the delta would provide access to sediment sourced from the altered crust of Mars, including materials likely uplifted from the Isidis basin-forming event [*6,10,11*].

The Jezero delta deposit also records fluid flow and sediment transport from a large valley network system [*1*]. Analysis of the deposit would provide a means to address several key questions for early martian climate and fluvial activity, including: How long were valley networks active? What were the magnitude and recurrence intervals of major flows? Were lakes ice-covered? What was the link between surface runoff and aqueous alteration? These questions are critical for understanding early martian aqueous environments, and for testing the major competing hypotheses for early martian climate: warm and wet [e.g., *17*] vs. cold and icy [e.g., *18*].

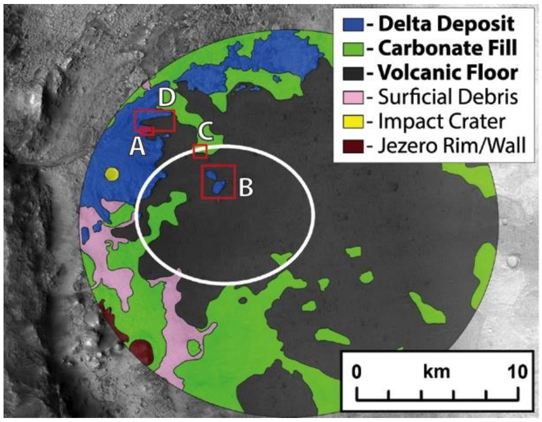

Fig. 1. *Geomorphic map of Jezero crater [7]. Notional ellipse for Mars 2020 shown in white. Location of parts in* ***Fig. 2*** *shown in red. Mosaic of CTX [19] images P04_002664_1988, P06_003376_1987, and P06_003521_1971*.

Carbonate Fill: Underlying the delta deposit is Mg-carbonate-bearing basin fill (**Fig. 2C**), which is similar to a regional carbonate unit found in Nili Fossae [*12,20*] that may host significant astrobiological potential [*12*]. This unit has been interpreted as either an exposure of the regional carbonate unit [*7*] or detrital lacustrine fill [*6,9*], hypotheses that could be directly tested *in situ.* Analysis of this unit would also provide insight into the origin of the regional carbonate, hypothesized to form from the alteration of an olivine-rich protolith [*6,11-13,20*], possibly involving serpentinization [*6,12,13*].

Carbonate-bearing units are relatively rare on Mars, but they provide critical information on atmospheric evolution, carbon reservoirs, past fluid geochemistry [*21*], and aqueous temperatures at formation [*22*]. Analysis of martian carbonate – both *in situ* and as returned samples – would provide a unique opportunity to study these crucial aspects of the early martian environment and reservoirs of the ancient martian atmosphere.

Volcanic Floor: Jezero crater is resurfaced by a volcanic unit that embays both delta deposits (**Fig. 2D**) [*7,9*]. This unit has a spectral signature consistent with other martian volcanic units [*23*], and was emplaced in the Late Hesperian or Early Amazonian [*9,23*]. *In situ* analysis would establish a baseline for understanding the nature of these crater-filling volcanics. Additionally, while no evidence for lava-water interaction is observed from orbit [*23*], *in situ* analyses can test this hypothesis to provide improved constraints on the relative timing of martian volcanic and fluvial activity. Finally, the volcanic unit is sufficiently large to crater count [*9,23*], and radiometric age dating of returned samples would establish a key data point to help constrain the absolute timing of martian production functions [e.g., *24*].

Summary: Jezero crater contains a diverse set of geologic units that provide an opportunity to address the objectives of the Mars 2020 rover [*15*] and numerous high-priority scientific questions for Mars exploration [e.g., *25*]. Orbital evidence suggests that the Jezero delta records a habitable environment [*4,5*], and lacustrine clay/carbonate-bearing sediment is an optimal location for concentrating and preserving organic matter [*5,8*].

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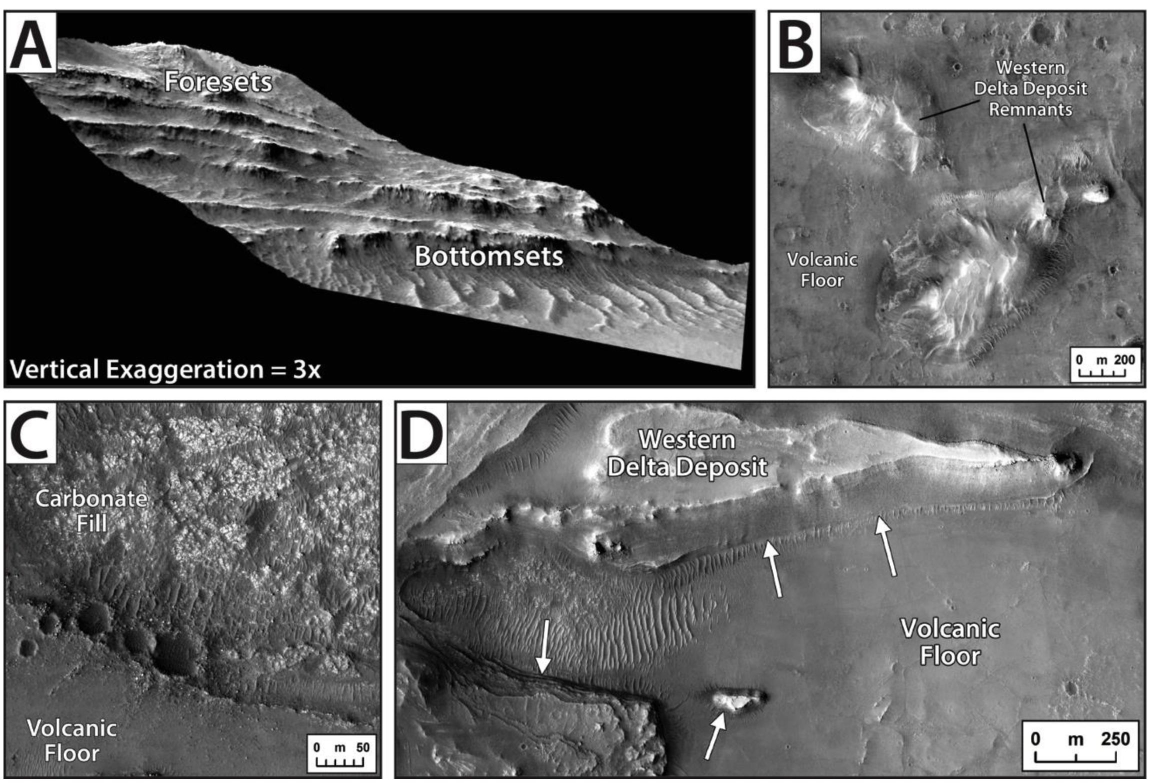

Fig. 2. *Units of interest in Jezero crater.* ***(A)*** *Foreset and bottomset strata exposed along the eroded delta front. Figure modified from [4]. Portions of HiRISE [26] image PSP_003798_1985 draped over a NASA ASP [27] HiRISE-derived DEM from stereo-pair images PSP_003798_1985 and PSP_002387_1985.* ***(B)*** *Remnants of the delta deposit within the Mars 2020 notional landing ellipse. Figure modified from [7]. Portion of HiRISE image ESP_023379_1985.* ***(C)*** *Carbonate-bearing basin fill. Figure modified from [7]. Portion of HiRISE image PSP_002743_1985.* ***(D)*** *Volcanic floor unit, which embays the western delta deposit (white arrows). Figure modified from [7]. Mosaic of HiRISE images PSP_003798_1985 and PSP_002387_1985.*