UPDATED GEOLOGIC MAPPING AND STRATIGRAPHIC ANALYSIS FOR NASA'S MARS 2020 ROVER LANDING SITE, JEZERO CRATER

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Abstract

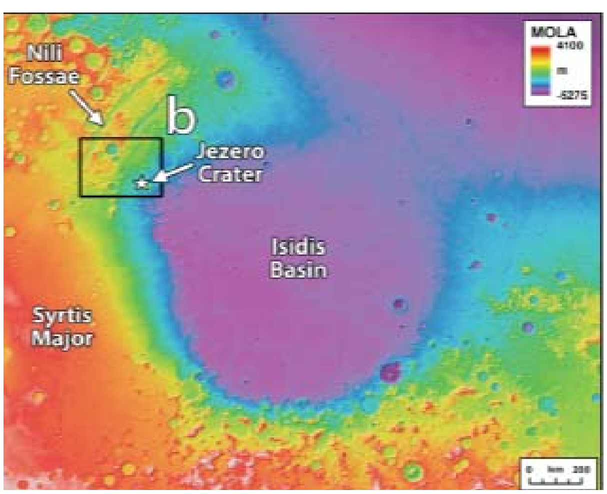
Jezero crater, Mars was selected in November 2018 as the landing site for the NASA Mars2020 rover. The site contains a ~45 km diameter impact crater located in the Nilli Fossae region of Mars. Delta deposits within Jezero crater have been interpreted ancient open-basin paleolake fed by two large inlet valleys connected to an extensive watershed and drained by an outlet valley. These delta units are of the utmost interest due to their potential to have preserved biosignatures, if ever present on Mars. This study expands upon the previously mapped region of the original landing ellipse in Jezero crater (Cofield and Stack, 2018). Additional engineering investigations have implemented a westward shift of the landing ellipse to include a larger portion of the delta front. This additional mapping effort seamlessly blends data from the original map by using the same ~25 cm/pixel images from the High-Resolution Imaging Science Experiment (HiRISE) at a scale of 1:5,000 to construct an orbital geologic map which encompasses a 10km radius from the center of the new landing ellipse. We provide two models for the stratigraphic relationship between the delta units and the crater floor units.

Introduction

NASA's Mars Exploration Program mission goals began in the early 2000s with the guidance of looking for features on the Martian surface which may indicate water was once present. Features such as fluvial channels and deltas were clearly observed from satellite imagery, and focused NASA's investigations on such features. Over the past decade, mission goals evolved to investigating potentially habitable environments with ground-based observations, such as Gale crater where NASA's Mars Science Laboratory (MSL) Curiosity rover continues revealing scientific clues about Mars paleoenvironment. NASA's next mission, the Mars 2020 rover, will be continuing the refinement of NASA's mission goals by seeking signs of paleo life. Mars 2020 will be tasked with searching for *in situ* evidence of ancient microbial life, collect and cache geologically diverse samples for future retrieval, future human exploration (, ip). Ultimately, the mission goal is to cache geologically significant samples which will be collected and returned to earth for further analysis in the future.

In November 2018, NASA announced the official Mars 2020 landing site will be Jezero crater, Mars. Jezero crater has been interpreted as an open-based paleolake with two inlet valleys coupled with expansive deltas, and one outlet valley (Fig.1a; Goudge et al., 2015). IT has been estimated that fluvial activity terminated around 3.8Ga (Fassett and Head, 2008a). Additionally, there has been a proposal of a hypothesized volcanic floor unit cross-cutting the front of the western delta units dated to ~3.45 Ga

(Goudge et al., 2017; Goudge et al., 2012b; Schon et al., 2012). The primary delta (Fig. 1b, 2) exposes contacts between the delta units, crater floor units, and some carbonate-bearing basin fill. These contacts may provide vital clues regarding the stratigraphic relationship between the delta and the crater floor units. A detailed orbital geologic map and stratigraphic analysis of the Jezero landing ellipse mapped on High Resolution Imaging Science Experiment (HiRISE) at 1:5,000 provided two contrasting models of the age relationship between the delta and the crater floor units (Cofield and Stack, 2018). One model suggests the crater floor units are younger than the delta and the contrasting model suggests they could be interpreted as older than the crater floor unit. This study will present an expansion of the previous Jezero crater landing ellipse orbital geologic map, and a further investigation of the two stratigraphic models. Understanding the age relationship between the delta and the crater floor units will be fundamental to paleoenvironment interpretations of Jezero crater.



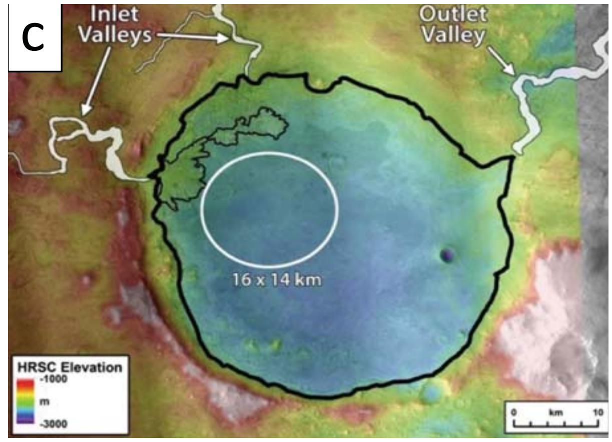


Figure 1. Jezero crater location. (A) Jezero crater is located in the Nili Fossae, and (b) has been interpreted as an open-basin paleolake with an extensive watershed, two large inlet valleys with prominent deltas, and an outlet valley (Goudge et al., 2015). Jezero crater landing ellipse outlined in white oval.

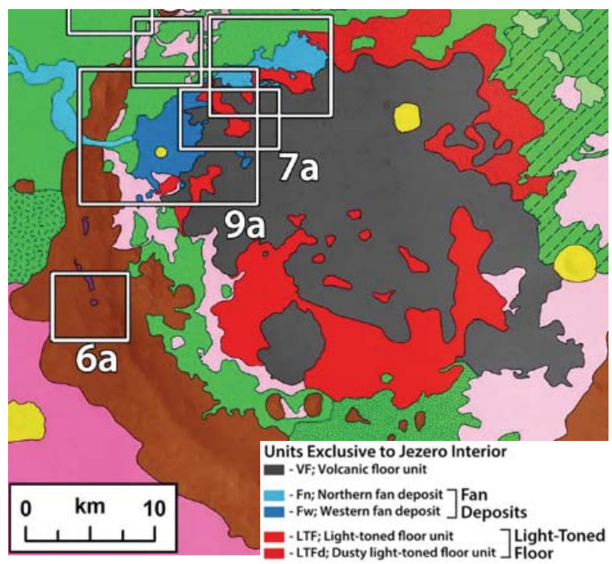


Figure 2. Existing Jezero crater map. Orbital geologic map constructed at a scale of ~1:30,000 (Goudge et al., 2015) with candidate landing ellipse (yellow oval).

Methods

The study area encompasses an expansion to a 10km radius from the center of the original 87 km^2 Jezero crater landing ellipse (Fig.3). Orbital geologic maps of Jezero Crater were constructed using basemaps of mosaicked HiRISE images at a resolution of ~0.25m/ pixel) An existing Digital Elevation Model (DEM) produced by the USGS from stereo HiRISE images provided topography data. The 10km radius map expansion was mapped at the same scale as the original landing ellipse map (1:5,000) in order to seamlessly combine the two maps.

Orbital geologic units were distinguished by differences in surface texture, brightness, relative tone, and observed geologic contacts or layering. Mapping was completed using ESRI's ArcMap GIS following the USGS planetary mapping guidelines.

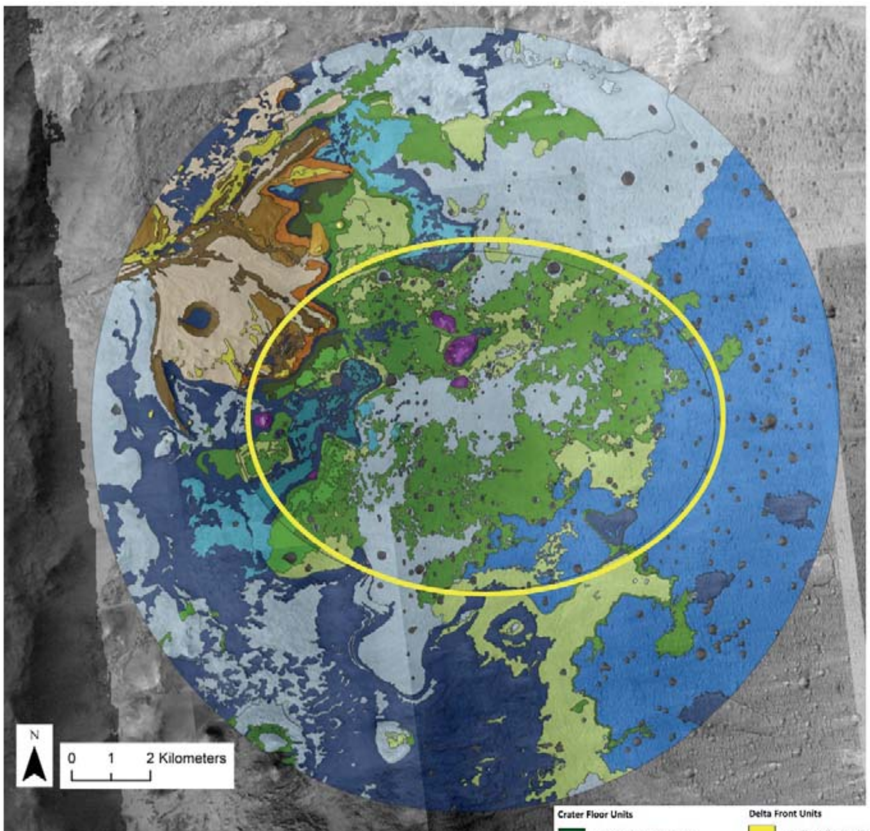


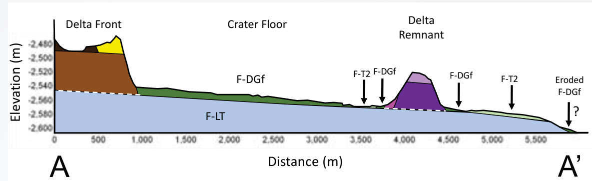
Figure 3. Expanded Jezero crater map. Orbital geologic map constructed at a scale of ~1:5,000 using HiRISE mosaics. This map was expanded beyond the original Mars 2020 landing ellipse (yellow oval) to a 10km radius from the center of the original landing ellipse.

Results

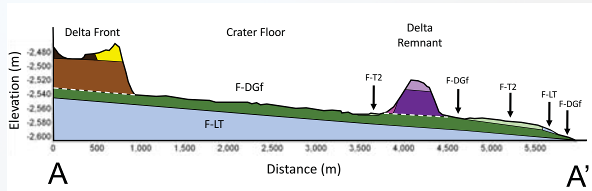
Within the Jezero crater landing ellipse, orbital geologic units were the delta front the crater floor, and the carbonate-bearing units (Fig.3). The geologic units were combined from the original landing ellipse map (Cofield and Stack, 2018). The delta front units are easily distinguished with the DEM by a rise in elevation >80m above the crater floor units.

Stratigraphic Models

Two models were developed based on the landing ellipse orbital geologic map for the stratigraphic relationship between the delta and the crater floor units (Cofield and Stack, 2018). One model suggests the crater floor units (F-DGf) do not project under the delta front; therefore, the delta would be older than the younger crater floor units. A contrasting model suggests the delta is stratigraphically higher than the crater floor units, or the crater floor units can be projected under the delta. This model would indicate the crater floor units are older than the younger delta.



Crater floor unit F-DGf stratigraphically younger than delta and remnants in agreement with Goudge et al., 2015



Plausible to project F-DGf beneath delta and remnants; therefore, stratigraphically older

Figure 4. Jezero stratigraphic models. Two contrasting models were proposed for the stratigraphic relationship (relative age) between the delta and the crater floor units (F-DGf). The top figure suggests the crater floor units do not project under the delta and are older than the delta units. The bottom figure projects the crater floor units under the delta; therefore, suggesting the delta is younger than the crater floor units (Cofield and Stack, 2018).

Supporting Evidence

To the east of the delta front, the large carbonate-bearing unit (or lobe) provides a distinct geologic contact with surrounding crater floor units. The carbonate-bearing lobe has troughs along the majority of the boundary with nearby geologic units. The lobe-like nature of this unit and the edge troughs may suggest this was some sort of flowing unit into the existing crater floor units. In contrast, the delta front does not show this distinct trough-feature in a topographic cross section (Fig. 5). If these troughs indicate some sort of flowing processes, and the delta formed after the crater floor units, the delta front may also have a similar trough. The lack of a trough may suggest the delta was not in place during the time of the carbonate-bearing unit formation. This would indicate the delta is younger than the crater floor units.

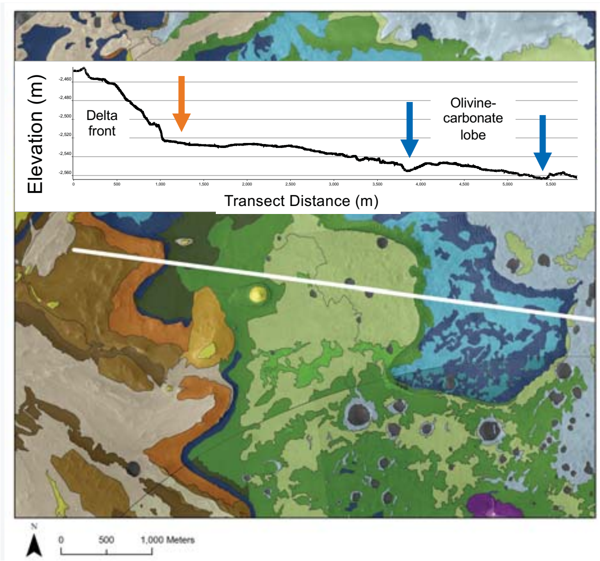


Figure 5. Delta and carbonate-bearing unit topographic profile. The delta front shows a gradual transition (orange arrow) to the crater floor units while the carbonate-bearing lobe has distinct troughs along the contact with nearby geologic units (blue arrows).

Further investigation of the map in this study shows the delta might be cross-cutting the carbonate-bearing units (Fig.6). According to the mapped units, the delta would be younger than the carbonate-bearing units.

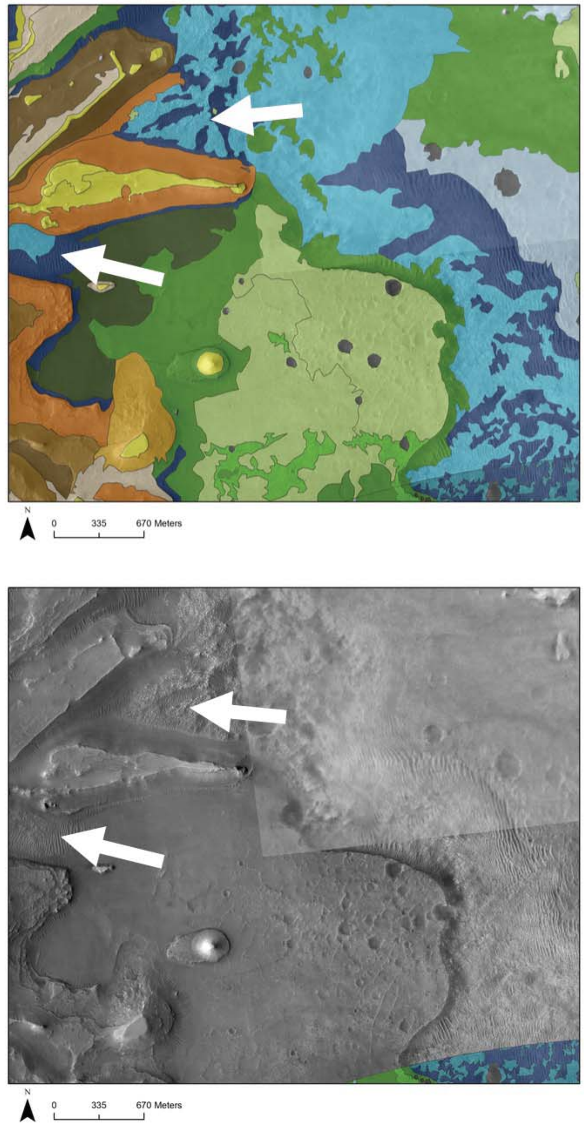


Figure 6. Delta and carbonate-bearing unit. Based on the map in this study (top figure), it appears that the delta is cross-cutting the carbonate-bearing unit (bottom figure, white arrows). This would suggest the delta is younger than this unit and the crater floor units.

Discussion

The expansion of the original Jezero crater landing ellipse map constructed in this study has revealed additional details and potential constraints of the stratigraphic relationship between the delta and the crater floor units. Two previous models proposed contrasting stratigraphic relationships between these units. If the carbonate-bearing lobes were formed through from a flowing process, the delta front might also have the same troughs along the unit boundary. The delta front shows a gradual slope at the contact of the crater floor units. However, the delta front could be eroding material which is covering the potential troughs, so this stratigraphic constraint should be interpreted with caution. As mapped, the delta front appears to cross-cut the carbonate-bearing unit, which would suggest the delta is younger than the carbonate-bearing unit. One of the criteria for the Mars 2020 landing site was the presence of datable (igneous material). While the crater floor units have been interpreted to be volcanic in origin (Goudge et al., 2017; Goudge et al., 2012b; Schon et al., 2012), their stratigraphic relationship may further constrain their age. As proposed (Goudge et al., 2012b), the volcanic floor units are ~3.45Ga and the fluvial activity terminated 3.8Ga (Fassett and Head, 2008a). If the examples outlined in this study prove factual, the crater floor units would be older than the delta; therefore, they would have been in place >3.8Ga. Constraining relative ages of the sedimentary units within Jezero crater will help support the validity of future *in situ* absolute dating techniques.

Conclusion

In this study, we expanded our previous 1:5,000 orbital geologic map for the Mars 2020 rover landing ellipse in Jezero crater. An expanded investigation has provided clues to refine the stratigraphic relationship between the delta units and the crater floor units. The presence of troughs around a carbonate-bearing unit may suggest it formed through some type of flow. However, the lack of this distinct trough at the base of the delta front might suggest the delta is a younger feature than the crater floor units. Likewise, the map indicates the delta cross-cuts the carbonate-bearing units, which would also suggest the delta is younger than the crater floor units. These stratigraphic constraints contrast previous hypotheses which have suggested the delta is older than the crater floor units. Absolute dating provided by the Mars 2020 rover will provide in situ ages for the crater floor unit and will provide increased stratigraphic relationship constraints for the geologic units at Jezero crater, Mars.

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