Geophysical Research Abstracts
Vol. 20, EGU2018-6049, 2018
EGU General Assembly 2018

Fluvial regime, age and duration of the Jezero crater paleolake, Mars

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The Jezero crater is on the short list of the three last landing sites proposed for the NASA2020 rover, and the only one to associate a system of fluvial valleys, delta fan and paleolake with alteration minerals (phyllosilicates and carbonates) identified in VNIR spectroscopy and suspected to be an example of the intense fluvial activity of the Noachian period. However, the duration of the paleolake is not well constrained (episodic or long-term). While there are clear morphological evidence for the presence of a paleolake, through the presence of two fans and an outlet valley, there is no evidence that the altered minerals formed during the period the paleolake was active. To provide some input to these questions, we studied the topography and flow regimes of the feeding valleys, the geometry of the fan deposit and stratigraphic relationships with surrounding geological units. Cross-cutting relationships do not allow concluding for a definitive age for the fluvial activity, being formed after the olivine-rich unit emplacement (ca. 3.7-3.8 Gy) and before the volcanic floor of the crater (3.45 Gy), thus pointing toward a Late Noachian or Hesperian age. From the geomorphologic and morphometric analysis of the 190 km long fluvial valley we have determined that the upper section of the valley system (first 120 km) is distinct in style and 10 times more eroded than the lower section of these valleys (last 70 km). The lack of significant incision in the lower system is also coupled with the presence of braided, locally divergent, channels with local fluvial bars, that are features absent in the upper section of the valley. Channels indicate high discharge rates in this lower section estimated as 1,000 to 10,000 m3/s. These observations point towards a two-stage scenario for the formation of these valleys. The delta fan in Jezero crater has been formed as the last episode of this fluvial activity, thus implying that it formed through the second-stage under relative high discharge rates. From the volume of the fan deposit and of the channel discharge rates, we estimate that the minimum time needed to form the ∼4-5 km3 of volume of the fan delta is from 100 to 10,000 years, suggesting a relative short-term episode, in agreement with terrestrial comparisons for fan delta of similar volume. These results suggest that the alteration minerals inside Jezero crater are formed either by detrital accumulation of the altered bedrock upstream, or by in-situ alteration in a former period of lake activity predating the formation of the observed delta fan. Even with a short-term paleolake episode, Jezero provides a unique location for sample return with the coupled presence of igneous bedrock clasts, carbonates and clay-bearing lacustrine deposits.