The Complex Exhumation History of Jezero Crater Floor Unit. C. Quantin-Nataf[1], S. Holm-Alwmark [2], J. Lasue[3], F.J. Calef[4], D. Shuster[5], K.M. Kinch[2], K.M. Stack[4], V. Sun[4], N.R. Williams[4], E. Dehouck[1], A. Brown[6], [1]University of Lyon, LGL-TPE (CNRS-ENS-Lyon-Université lyon1), France, cathy.quantin@univ-lyon1.fr, [2] Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark, [3]IRAP, Toulouse, France, [4]JPL-Caltech, Pasadena, USA, [5]Dept. Earth and Planetary Science, University of California, Berkeley, USA; [6]Plancius Research, MD, USA.

Introduction: On February 18, 2021, NASA's Mars 2020 *Perseverance* rover will land in Jezero crater, a 50 km crater located on the margin of the Isidis basin on Mars. The Mars 2020 mission will be the first step of a Mars sample return campaign, as *Perseverance* has the capability of collecting and caching samples.

Several geological units are observed within Jezero crater [1]: a pyroxene-bearing cratered dark floor unit, an olivine bearing unit exposed in erosional windows below the dark floor unit, a deltaic complex and marginal carbonate bearing unit [2]. The leading theory (e.g., [3]) for the sequence of events in Jezero crater is: 1) the formation of Jezero, 2) the filling of Jezero crater by the regional olivine bearing unit at about 3.8 Ga, 3) the emplacement of the delta and the marginal carbonate during a lacustrine phase and the final emplacement of the unaltered mafic floor unit.

Returning an igneous sample of a crater-retaining surface on Mars is of utmost importance to accomplish the science objectives of Mars Sample Return [4]. It would establish a link between an absolute age and a crater density distribution and consequently the calibration of the Martian cratering chronology widely used to date geological features and surfaces on Mars. The crater floor unit is relatively flat and cratered and has been interpreted as an extrusive igneous rock emplaced after the cessation of the fluvio-deltaic activity [3], but a sedimentary origin has also been proposed [5, 6]. If of igneous origin and unaltered, the mafic crater floor unit is promising if the age of crystallization can be assumed to represent the duration of subsequent crater accumulation. The crater size distribution of this unit is consistent with an accumulation of crater with no significant erosion since 2.4+-0.5 Ga (crater based age model) [6], while the deltaic deposit has a crater size distribution that has been interpreted to have a model crater retention age >3.2 Ga with subsequent erosion evidenced by the paucity of small craters [7].

However, high resolution investigation of the stratigraphic relationships between the deltaic deposits and possible distal delta remnants and the youngest crater floor unit(s) questions this succession of events [8]. In alternative models, the deltaic deposits may overlie the floor unit, making the floor unit older than Jezero's fluvio-deltaic deposits [8].

In this contribution, we investigate the cratering density distribution across the floor unit, to help reconcile these stratigraphic relationships and the apparent crater size distribution.

Method: - Orbital data analysis: We used HiRISE visible image mosaic basemap and derived digital elevation models (DEMs; 1 m/px) available in CAMP, a web-GIS service develop for the use by the Mars 2020 science team (see [1] for details with source files available [9]). The topographic profiles were derived from this data set [10]. In parallel, we used CTX image mosaics from [11], and HiRISE color images in an ArcGIS GIS project.

- Crater density map: We mapped all craters larger than 170 m of the floor unit (> 200 craters). All craters were then converted into a central point location from which we computed their spatial density using the kernel density function in ArcGIS. This function calculates a magnitude-per-unit area from points or using a kernel function from [12] to fit a smoothly tapered surface to each point.

- Impact crater modeling: In the philosophy of the impact cratering model developed by [13] to reproduce cratering with crater obliteration, we developed a model of impact cratering of a surface under exhumation due to the erosional retreat of a capping unit of a certain thickness. The parameters of the model are the starting age of the capping unit removal and the thickness of the capping unit.

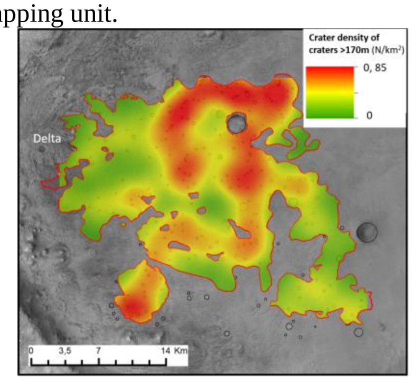

Fig. 1: Density of craters larger than 170 m on the youngest crater floor unit in Jezero crater. The contour of the floor unit is from [6]. The crater density is in N/km²

Results: The crater floor unit has an unusual, inhomogeneous crater density (Fig. 1). The density of craters larger than 170 m is close to zero at the foot of the delta while it is as large as 0.85 craters/km² in the NE parts of the floor unit. The near lack of observed craters nearest to the delta suggests a reduced exposure to recent bombardment. In contrast, the crater floor unit sections to the northeast and south have a crater density that corresponds to a model surface retention greater than 3 Ga. These results suggest that the floor unit has experienced differential exposition over 3 Ga of bombardment to today. It seems inconceivable that a geologic unit could be emplaced systematically over the past 3 Ga when all adjacent units point towards a long lasting erosional environment versus a depositional one. We offer a more plausible hypothesis that the floor unit was buried and subsequently exhumed both gradually and unevenly away from the crater center.

Burying Evidence: The largest crater of the floor unit, Hartwell crater, is diameter (D) ~ 2 km. The ejecta blanket of this crater has clearly been eroded, likely by aeolian processes, and is morphologically different compared to what would be expected, therefore excluded from the crater counting effort of [6], as it may predate the floor unit emplacement. However, observed at high resolution, the rim height is abnormal for a crater this size (about twice as expected from D). HiRISE DTM- derived topographic profile and color images reveal that the crater rim is composed of 2 distinct layers: The basal layer is about 40 m thick, finely grained and layered, while a second upper layer is blocky, as is expected for a proximal ejecta blanket. We interpret this as evidence for a partially eroded crater, originally emplaced on a unit that overlies the now-exposed floor unit. This unit is now completely eroded in the vicinity of the crater, except just underneath the remnant ejecta blanket from this large crater, suggesting the ejecta blanket armored the capping unit locally from erosion.

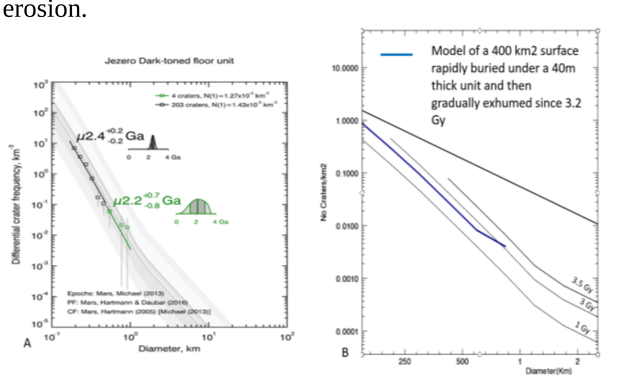

Figure 2 : Left] Crater size distribution of the floor unit from [6]. Right] Synthetic crater size distribution of a 400 km2 surface rapidly buried under 40 m thick unit and then gradually exposed to bombardment since 3.2 Ga, using the crater production function of [14] and the time dependency from [15].

We tested this scenario with an impact crater model assuming the crater floor unit was buried shortly after emplacement (i.e., without any exposure to bombardment), by a 40 m thick layer that deflated with time due to horizontal erosional retreat. The simulated crater size distribution (Fig. 2, right) reproduces the observed one [6] with craters smaller than D 700 m following the 2.4 Ga model isochrons and craters larger than D 700 m with higher density. The largest craters would also affect the underlying floor unit. The apparent model crater retention age of 2.4 Ga would be an average exhumation age between the first parts of the floor that were exposed 3 Ga ago and others that were only recently exhumed. The exhumation started in northeast Jezero with the erosional front moving toward the Western delta. It is in agreement with the dominant wind direction deduced from wind related morphologies in Jezero [16]. The Undifferentiated Surface unit (Us [1]) may represent a regolith derived from the western delta front's continued retreat or the last capping unit remnants, either possibility we can confirm with in situ measurements.

Conclusion/Discussion: While others have suggested the crater floor unit in Jezero crater has an apparently young age [6], overlying and onlapping all other emplaced units (e.g., [1, 8]), we present here evidence showing this unit is stratigraphically below the delta and >3 Ga old. Several contradictory observations about emplacement history of the crater floor unit in Jezero crater can be resolved if it is resistant to erosion, initially buried below a few tens of meters thick unit that gradually eroded away by aeolian processes from the northeast to west, resulting in uneven exposure to impact bombardment over 3 Ga. In this scenario, we maintain the floor unit regions with highest crater density are the most important for estimating a minimum floor unit emplacement age. This scenario also has consequences for Mars sample return. Due to the apparent complexity of its exposure history, the Jezero dark crater floor unit would not provide the simplest scenario for crater chronology calibration using return sample geochronology.

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