

STRATEGIC APPROACH AND FIRST RESULTS FROM THE JEZERO CRATER RIM CAMPAIGN. L.E. Mayhew¹, E. Ravanis², C. Quantin-Nataf³, K. M Stack⁴, K. Farley⁴, C.D.K. Herd⁵, R. Kronyak⁴, M. Minitti⁶, J.I. Simon⁷, B. Horgan⁸, D.L. Shuster⁹, S. Siljeström¹⁰, B. P. Weiss¹¹, C.C. Bedford⁸, F. Calef⁴, M. Deahn⁸ ¹Univ of Colorado Boulder, lisa.mayhew@colorado.edu, ²Univ. Hawaii, ³Univ Lyon, France, ⁴JPL/Caltech, ⁵Univ. Alberta, ⁶Framework, Silver Spring, MD, ⁷ARES, NASA Johnson Space Center, ⁸Purdue, ⁹Univ of California, Berkeley, ¹⁰RISE Research Institutes of Sweden, ¹¹MIT.

Introduction: The Mars 2020 mission has been conducting in-situ investigation of the geology, habitability, and biosignature preservation potential and collecting samples for return to Earth in Jezero crater, Mars for nearly 4 years [1]. After exploring the Jezero crater floor, the fan front and fan top, and the crater margin, in August 2024 the rover climbed up the inner crater rim, marking the beginning of the Crater Rim Campaign. Investigation and sampling of the diversity of crater rim rocks is imperative because they represent materials from Mars’ most ancient crust [2-3] that should record a diversity of geologic processes and potential ancient habitable environments that were not exposed in Jezero crater.

Scientific value of crater rim rocks: The unique rock units exposed within the crater rim are: (1) uplifted diverse ~4 Ga Noachian basement (NB) units deposited prior to the Isidis impact basin (3.9-4.1 Ga [2-3,4]) and the Jezero complex crater forming impact; (2) ~3.8 Ga regional olivine/carbonate-bearing unit [5]; and (3) ~3.8 Ga mafic capping unit [6,7]. Three key subunits of the Noachian basement were prioritized for investigation and sampling: (a) stratified Fe/Mg smectite, (b) low calcium pyroxene (LCP) rich rocks, and (c) megabreccia. Study of these rocks will address key science questions related to the earliest climate, weathering and alteration processes, and ancient habitable environments; early crustal evolution following accretion including timing of the Isidis impact which could provide critical constraints on the martian geologic timescale; and the earliest planetary evolution processes including crust formation, the strength and timing of the dynamo and whether its evolution drove the loss of early atmosphere [8]. Investigation of the regional olivine/carbonate and capping units may reveal connections to the broader geology of Nili Planum, Nili Fossae, and Syrtis Major and to similar units on the crater floor, thus addressing questions related to the emplacement mechanisms and timing of these units and more broadly to the geochronology derived from crater counting. The presence of carbonate associated with olivine is suggestive of water/rock interactions and may provide information about the loss of early martian surface water to weathering interactions with the crust [9]. On Earth, actively reacting olivine-rich rocks provide both nutrients and habitats for subsurface biospheres [e.g. 10].

Opportunistic investigation and possible sampling of impact melt and hydrothermal features could possibly inform the age of the Jezero impact and further constrain the chronology of Mars and record water/rock reaction processes and/or harbor biosignatures such as similar systems on Earth, respectively.

Strategic approach to crater rim exploration and sampling: The M2020 team studied the crater rim and surroundings to identify potential exploration and sampling targets for focused investigation. At this time, the team is concentrating its efforts on the northern crater rim traverse from the inception of the campaign south of Neretva Vallis through the *Singing Canyon* location (Fig. 1).

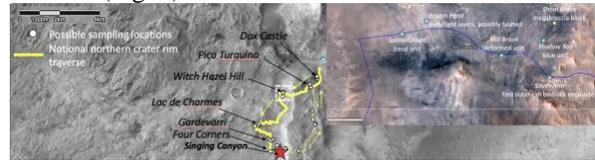


Figure 1. The first 7 focused investigation areas of the crater rim traverse. Inset shows 5 ROIs for focused exploration within the *Witch Hazel Hill* area.

The Crater Rim Campaign strategic planning identified 11 sampling opportunities with notional sample suites designed to address key science questions. The exact samples and sampling locations will differ depending on the path of the traverse. The composition of possible samples from the northern crater rim is largely unknown due to a lack of compositional orbital data from this region of the crater rim. The goal is to collect 4-5 samples of the most ancient layered Noachian basement rocks (e.g. at *Witch Hazel Hill*, *Lac de Charmes*), 3-4 samples of megabreccia that is likely to represent a wide diversity of the most ancient crustal rocks (e.g. at *Four Corners*), 1 sample of the regional olivine carbonate unit (e.g. at *Gardevarri*), and 2 opportunistic samples that could include hydrothermal or impact materials (Fig. 2). Regardless of exact sampling locations, the notional sample caches address the established campaign goals.

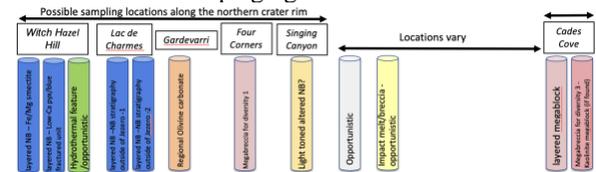


Figure 2. Notional sample cache from the crater rim traverse.

Campaign statistics: The Crater Rim Campaign officially commenced on sol 1252 of the mission as the rover began to climb the inner crater rim (Fig. 3). One hundred thirty sols of the campaign have been executed as of 6 January 2025 while covering 4.3 kms of terrain. Four natural surface proximity science targets and five abrasion targets have been investigated.

First results: First results from the inner crater rim exploration (*Dox Castle* through *Lookout Hill*) indicated that the rover was traversing across olivine-dominated rocks similar to those observed during the prior Margin Campaign [Fig. 3; 11-14]. Results from abrasion proximity science at *Eremita Mesa* and natural surface proximity science at *Tahoma Glacier* and *Goat Island Rock* provided further documentation of the continuation of this rock type [Fig. 3; 15, 16].

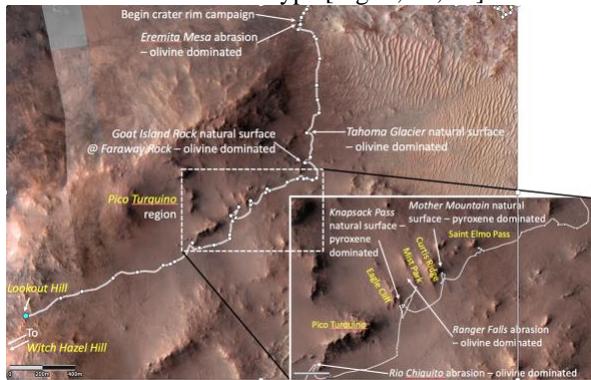


Figure 3. Crater rim traverse through sol 1356 showing the positions of abrasion and natural surface proximity science investigations. Inset map of the inner crater rim where a diversity of rock types was discovered.

Investigations at the first two strategic locations of the campaign, *Dox Castle* and *Pico Turquino*, have been completed. The *Dox Castle* outcrop is consistent with previous margin unit rocks [11] as were targets along the traverse between *Dox Castle* and *Faraway Rock* [12-14]. Definitive ‘crater rim’ rocks, those defined as being markedly different from the margin unit and dominated by low Ca-pyroxene, including unaltered pyroxenites, were first detected at *St. Elmo Pass* [Fig. 3; 11-14, 17, 18]. Further exploration of this region led to the discovery of significant lithologic diversity including low Ca-pyroxene rocks with varying abundances of feldspar minerals and/or alteration phases (e.g. at *Mother Mountain* and *Knapsack Pass* natural surface proximity targets) and olivine-dominated rocks reminiscent of those found in the margin unit (e.g. at the *Ranger Falls* and *Rio Chiquito* abrasion patches) [Fig. 4; 11-16]. It was not possible to definitively determine if rocks in the inner crater rim represent Noachian basement or to determine if the prominent ridges were associated with a later event such as the Jezero or Isidis

impact and/or volcanism. Studies are ongoing to constrain the origin of these rocks and sampling of these or similar rocks may be reconsidered with additional contextual information.

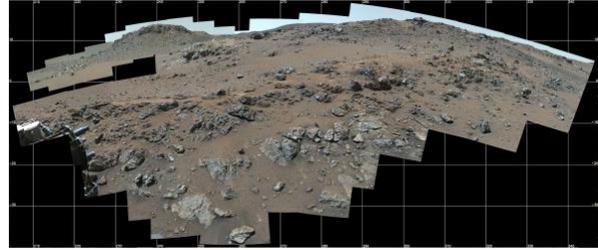


Fig 4. MastcamZ mosaic of Eagle Cliff (foreground), including the Knapsack Pass natural surface proximity science target, and Pico Turquino (background, 240 azimuth) area. This mosaic combines observations zcam09368 and zcam09370 on sol 1309 and zcam09374 on sol 1311. Image credit: NASA/JPL-Caltech/ASU/MSSS.

Next steps: As of December 2024, the rover has crested the high point of the crater rim and begun to descend the outer crater rim to the west. This marks the beginning of exploration of the complex terrain of the *Witch Hazel Hill* region (Fig. 1). Here the team expects to encounter an even greater diversity of rock types that have not yet been investigated during the mission. These include a first look at layered Noachian basement rocks in stratigraphic context. Five ROIs for focused investigation have been identified. The ROIs span the ~200m of vertical relief from the top of the crater rim to the base of the outer rim. From *Witch Hazel Hill* the rover will continue south and west to *Lac de Charmes* where we expect to encounter Noachian basement rocks in stratigraphic context and unaffected by Jezero impact processes. Rocks at *Gardevarri* will be our first encounter with the regional olivine-carbonate unit outside of the crater. Megabreccia and altered Noachian basement rocks will be investigated at the *Four Corners* and *Singing Canyon* locations. The wide diversity of these rocks will provide unique insights into the ancient history of Mars.

References: [1] Farley et al. (2020) *SSR* 216. [2] Simon et al. (2021) *LPSC* LII #2548. [3] Scheller et al. (2024) *LPSC*. [4] Scheller and Ehlmann (2020) *JGR Planets* 125. [5] Mandon et al. (2020) *JGR: Planets*. [6] Hundal et al. (2022) *GRL*, 49. [7] Sun and Stack (2020) *USGS Map #3464*. [8] Weiss, et al. (2025) *PNAS*. [9] Wernicke and Jakosky (2021). *JGR Planets*. [10] Templeton et al. (2021) *JGR Biogeosciences* 126. [11] Ravanis et al., *this meeting*. [12] Quantin-Nataf et al., *this meeting*. [13] Udry et al., *this meeting*. [14] Bedford et al., *this meeting*. [15] Moreland et al., *this meeting*. [16] Uckert et al., *this meeting*. [17] Vaughan et al., *this meeting*. [18] Horgan et al., *this meeting*.