SAMPLING OF JEZERO CRATER MÁAZ FORMATION BY MARS 2020 PERSEVERANCE ROVER.

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Introduction. Collection of samples that could be returned to Earth from the floor of Jezero crater is a major goal of the Mars 2020 mission. Laboratory analyses of these will expand exploration of Jezero, a Noachian crater on Mars characterized by a delta–lake system with high potential for habitability. The samples will also be used to test current ideas about the early planetary evolution of Mars. The *Perseverance* rover has collected samples from two members of the Máaz formation, mapped in orbital images as the Crater floor fractured rough unit by [1]. Type localities of the *Roubion* and *Rochette* members have been targeted and abraded prior to sample collection. Here we summarize these sampling activities and the potential of sampling the *Chal* member of Máaz. A similar summary for samples collected from the Séítah formation is described in Hickman-Lewis et al. (this meeting).

Geologic context. Prior to landing, Máaz was variously interpreted to be igneous (lava flow; also including volcanoclastic) or sedimentary (fluviolacustrine or aeolian). This question remains open, though outcrop evidence from the first target *Roubion* and second target *Rochette*, suggest that the Máaz formation is at least partially igneous [2,3], Schmidt et al.; Udry et al.; Wiens et al. (this meeting).

Samples obtained. The Montdenier and Montagnac cores, and their companion Bellegarde abraded patch, were acquired on a small tabular boulder (*Rochette*, ~40 cm across) arranged in a NW-SE-trending flat-lying band of boulders or outcrop (Fig. 1a) on the SW side of the Artuby ridge crest. These samples were absolutely oriented to ~1° in martian geographic coordinates, although the *Rochette* sample may have been differentially tilted with respect to the *Rochette* bedrock. Artuby forms a 2-3 m high NW facing scarp exposing Máaz stratigraphy that borders the edge of Séítah. *Rochette* was selected for coring primarily for its accessibility, limited relief, and perceived resistance to disaggregation during coring. Additionally, its position on Artuby ridge places it stratigraphically above and potentially younger than Séítah and other Máaz rocks including *Artuby* and *Roubion members*.

The Mars 2020 mission used a combination of instrument data to determine the composition, mineralogy, and texture of the sampled rock outcrop, including SuperCam/LIBS, PIXL, SHERLOC, and the close up cameras WATSON/ACI (Autofocus Context Imager) and PIXL/MCC (Micro Context Camera) on the abraded surfaces (Fig. 1b,c). These reveal that *Rochette* is holocrystalline with no intergranular porosity or evidence of cement. From elemental PIXL and SuperCAM/LIBS data the 0.2-0.5 mm, intergrown light and dark minerals are pyroxene and plagioclase consistent in composition and texture with an basalt (or microgabbro). Secondary features include brown iron-rich patches, especially evident around white patches that may reflect cavities filled by secondary minerals such as Ca-sulfate (occasionally hydrated) and phosphate. Carbonate and amorphous silicates were also identified by SHERLOC along with several types of aromatic organic signals, Scheller et al. (this meeting).

The *Perseverance* volume probe indicated that Montdenier and Montagnac are ~6 cm long with volumes of ~8.5 cm^3. When imaged with CacheCam, it was found that the texture and mineralogy seen at the abraded surface (Fig. 1c) are consistent with those observed at the bottom of each core (Fig. 1d,e).

Additional Máaz sample targets. Coring was attempted near the Guillaumes abraded patch (Fig. 1b), on a low relief outcrop of the *Roubion* member within the valley at the eastern end of Séítah selected largely to meet first-time sampling requirements. During coring, the *Roubion* sample disaggregated and was not recovered. The sealed tube includes martian atmosphere and minor ~10 μm-sized particles, most likely fragments of the failed core. Thus, the *Roubion* sample tube could be used to study martian atmosphere.

Nevertheless, because of its widespread occurrence and in particular its extensive secondary mineralogy, a compelling science case can be made to reattempt collection of outcrop of the *Roubion* member. Like *Rochette*, the dominant mineralogy of this member appears to be a relatively fine-grained gabbro or holocrystalline basalt. However, *Roubion* appears more altered (more reddish, and appearing to be more granulated and/or flaky) than most other examples of the Máaz formation, which may explain why it disaggregated during coring. Although this alteration poses a challenge for sampling, the greater extent and more extensive patches of secondary minerals (sulfate, perchlorate, and possibly halite and phosphate) provide clear evidence for aqueous interaction and a possible environment for potential astrobiology.

Returned Sample Science. The timing of volcanic rock crystallization will be quantifiable using laboratory-based, radio-isotopic geochronology of returned samples. Likewise, with knowledge of cosmogenic nuclide production rates in specific minerals on Mars, quantitative constraints on the sample's surface exposure age may also be possible. The timing of *Rochette*'s deposition will constrain the emplacement ages of other crater floor units. Furthermore, if the surface exposure and exhumation history of Máaz can be understood, then the geochronology of returned samples may quantify, or constrain, the duration of crater accumulation and retention at the exposed Jezero floor. Such information could then be used to test, and potentially quantify, fundamental parameters assumed in Mars crater chronology functions.

Paleomagnetic studies of these samples can constrain the lifetime of the martian dynamo and test the hypothesis that loss of an early field drove atmospheric loss. If the samples are igneous, analyses could obtain precise estimates of the dynamo field strength at the time of crystallization. Furthermore, magnetic analyses of secondary ferromagnetic minerals (e.g., hematite) could provide younger records of the dynamo.

This rock has likely experienced interaction with one or more aqueous fluids, possibly groundwater that may or may not be related to Jezero lake. Although the extent of alteration in *Rochette* appears to be less than observed in *Roubion*, these water-rock interactions may record a habitable subsurface environment. Laboratory analyses of the secondary minerals will provide information on the chemistry and environmental conditions (e.g., pH, temperature, salinity, timing) of this aqueous activity. Organics, if preserved, would provide information on the martian carbon cycle.

Water-soluble salts (e.g., halite and/or perchlorate), apparently filling holes, suggests aqueous alteration and/or addition of secondary phases from an aqueous fluid in this rock at some point after deposition, almost by definition documenting the final aqueous interaction experienced by this rock. Similar salts on Earth are known to contain organic molecules and even fossilized microscopic life.

Summary of Máaz formation samples. Outcrop morphology and texture, as well as the appearance, composition and mineralogy observed at the Bellegarde abrasion suggest that the *Rochette* member is a fine-grained mafic igneous rock capping the sequence of lava flows that includes the *Roubion* and *Artuby* member stratigraphy. These rocks have experienced interaction with aqueous fluids.

Neither *Rochette* nor *Roubion* sample (or represent) material from the upper blocky expression that retains the crater record indicative of the Máaz formation. Therefore, there is interest in sampling the massive, erosion-resistant outcrop of the Chal member.

References: [1] Stack et al. (2020) *SSR* 216, 127, [2] Farley et al. (2022), [3] Liu et al. (2022), [4] Shahrzad et al. (2019) *GRL*, 46, 2408–2416.

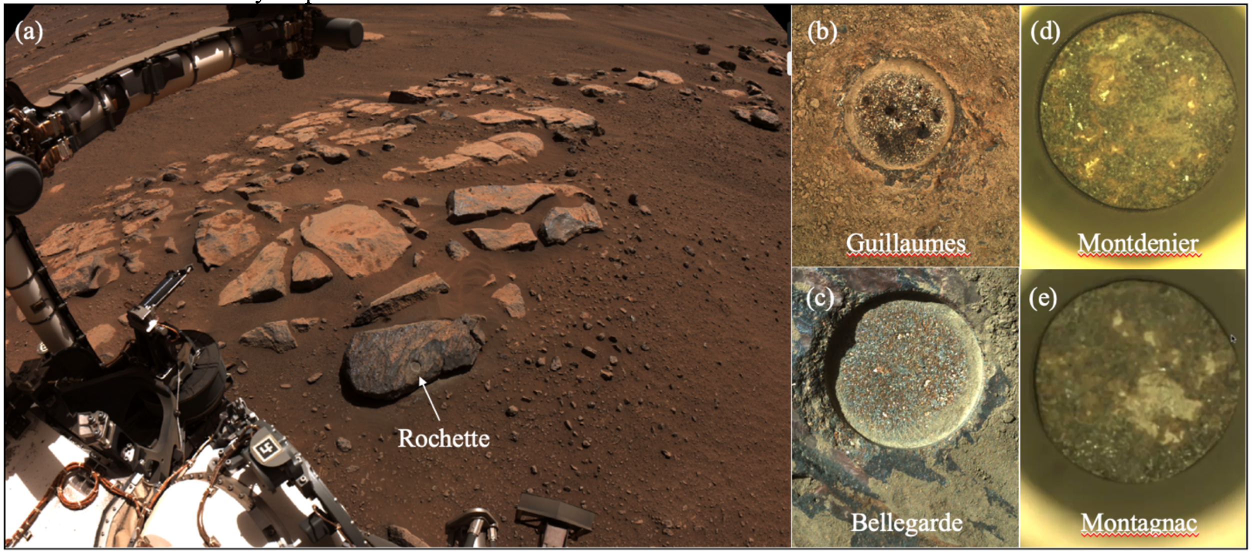

Figure 1. Máaz formation: (a) Mastcam-Z image of type locality of *Rochette* member on top of Artuby ridge. (b) Watson image of 5 cm *Roubion* abrasion. (c) Watson image of 5 cm *Rochette* abrasion. (d) Cachcam image of the bottom of 1.3x ~6 cm Montdenier core, (e) Cachcam image of the bottom of 1.3x ~6 cm Montagnac core.