On the Hunt for Detectable Biosignatures in Jezero Crater: What to Look for and Where

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Introduction: The Perseverance rover, which is currently exploring Jezero crater on Mars, is equipped with seven instruments that allow for observation of textures, minerals, color, structure, and chemistry of rocks and sediments in order to search for signs of ancient life, understand the geologic history of the crater, and identify candidates for sample return (Farley et al. 2020). The first of these aims includes the direct detection of potential biosignatures, including textures, organic molecules, minerals, and elemental chemistries that are of biogenic origin (Mustard et al. 2013). The presence of these biosignatures will be constrained by the habitability of the local region, the preservation potential of the host rocks, and the sensitivity of the instrument suite, and their biogenicity will be investigated after return to Earth as part of the Mars Sample Return campaign. Here, we examine key targets on the three planned campaigns, potential biosignatures that may be present, and the capabilities of key rover instruments.

High Potential Biosignature Sites in Jezero: To date, measurements have been made on multiple sites that both contain minerals known in terrestrial settings to preserve biosignatures and likely were habitable settings (Williford et al. 2021). Two examples include the fine-grained rocks at the base of the delta fan and the NW inner margin of the crater.

Fine-grained Rocks at Base of Delta Fan. Fine-grained, clay-bearing rocks may have been deposited as muddy lake sediments that could have hosted life and preserved biosignatures settling out of the water column. The report of organic molecules by the Curiosity rover in the Sheepbed mudstone and Murray formation has highlighted this site in particular. Potential biosignatures in mudstones, especially those rich in silica (McMahon et al. 2018), microbialites, and complex organics.

NW Inner Margin of Crater. This unit, located along the inner margin of the crater, contains strong carbonate signatures and may have been the littoral zone of a lake (Horgan et al. 2020). The potential biosignatures here include microfossils, microbialites, biominerals, and complex organics.

Detectability of Biosignatures by the Mars 2020 Instrument Suite: The Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) instrument comprises a Deep UV spectrometer, context imager, and color camera to generate spatially resolved chemical maps (Bhartia et al. 2020). It is sensitive to trace organics as well as a range of minerals and can detect native fluorescence from aromatic organics; the WATSON and ACI cameras can be used to observe morphologies such as stromatolitic laminations or filaments ranging from the tens of micron to millimeter scale. SHERLOC can detect organics that may be present in either of the high potential biosignature targets, as well as detect carbonates in the latter. However, the presence of high amounts of iron, such as in iron-rich clays, would cause attenuation of spectral response through UV absorption.

The Planetary Instrument for X-ray Lithochemistry (PIXL) comprises an X-ray fluorescence spectrometer and camera that can scan rock surfaces to generate elemental maps (Allwood et al. 2020). PIXL can detect chemical biosignatures such as spatial variations of elemental abundances that may have resulted from biological activity. PIXL would be particularly useful in detecting fine textures and elemental chemistries in either high potential biosignature target, but cannot directly detect minerals such as carbonate.

The SuperCam instrument performs three types of spectroscopy, color imaging, and acoustic recording to remotely examine elemental composition, minerals, organics, and textures (Maurice et al. 2021). Using laser induced breakdown spectroscopy and time resolved luminescence spectroscopy, SuperCam can detect major elemental building blocks of organics (i.e., C, H, N, O, P, S) and conjugated organic structures, respectively, which may be found in either site. While in other contexts, luminescence is a useful tool for biosignature identification, luminescence generated by the 532 nm laser may obscure the Raman signal.

Conclusion: The three instruments discussed can be used collaboratively to establish the presence of potential biosignatures in samples. These high-priority samples may then be returned to Earth for detailed laboratory analysis.

References: Allwood, A. e t al. (2020) *Space Sci. Rev*. 216,134; Bhartia, R. et al. (2021) *Space Sci. Rev*. 217, 5.; Farley, K. et al. (2020) *Space Sci. Rev*. 217, 58; Horgan, B. et al. (2020) *Icarus*. 339, 113526; Maurice et al. (2021) *Space Sci. Rev*. 217, 47; McMahon et al. (2018) *JGR: Planets.* 123, 1012; Mustard et al. (2013) *Rep. of the Mars 2020 Sci. Def. Team;* Williford et al. (2021) *LPSC*, 1599.