
Introduction: In the crater rim and region surrounding Jezero crater, remote sensing observations indicate Fe/Mg-smectites close to pyroxene-rich Noachian basement, with Fe/Mg-smectites in places overlain by Al-rich clay minerals (Figure 1; [1]). These relationships, potentially representing transitions between parent material and pedogenic weathering products[2], are distributed globally, indicating that the process(es) that formed them were once widespread.

Figure 1. CRISM band parameter maps from the Capitol Reef area near Jezero crater processed as described in [3], indicating an area where pyroxene-rich Noachian basement is close to Fe/Mg-smectite, suggesting the potential for reaction fronts.

On Earth, transitions between parent material and weathering products such as clay minerals, or reaction fronts, are habitable environments with a high potential for preservation of biosignatures. These characteristics make them excellent targets for collection by Perseverance for the Mars Sample Return program.

Habitability: Habitability can be defined as the presence of liquid water, building blocks of life, energy sources, and sufficiently element conditions for life [4, 5] (Figure 2). Reaction fronts form by aqueous alteration of the parent material to the weathering products, and therefore inherently preserve evidence of past water activity. As the water reacts with fresh minerals in the parent material at the reaction front, newly available nutrients that can be utilized by biota are released [e.g. 6, 7].

Figure 2. Habitability (H), with the conditions that are available in the reaction front indicated in bold. Figure modified after [4] and [5].

Energy gradients that can support life may result from the interaction of parent materials that may contain reduced elements such as iron with water that may contain oxidants. Studies of the habitability implications of redox stratifications have been performed at Gale crater by the Curiosity rover [8].

Life: On Earth, these transition zones contain life in a variety of environments from soils [6] to oceanic crust [9] (Figure 3). For example, indicators of microbial activity such as colony-forming units (A) or Fe-oxidizing species (B) show increases near the bedrock, and Fe²⁺ that can act as an energy source is also present (Figure 3). Terrestrial weathering profiles in areas such as the Amazon basin, the Pilbara and Yilgarn cratons of Australia, and Hawaii, potentially resulting from more than one weathering event, can also reach 100 to >500m in thickness [10-12].
clay minerals may include incorporation of the inorganic elemental content, or metallome, of microbial cells (Figure 4, [15]). In addition, microbial uptake can fractionate the stable isotopes of elements such as Fe and Mg (e.g., [22]). Current ongoing work is exploring the preservation of elemental, isotopic, and mineralogical biosignatures in clay minerals relevant to samples from Jezero crater and beyond [23, 24].

**Identification of Potential Reaction Fronts:** Interfaces between pyroxene-rich materials and smectite minerals observed near Jezero crater (Figure 1) may be reaction fronts containing past habitable conditions and having a high biosignature preservation potential. Evidence supporting the presence of these potential reaction fronts is observed from orbit, including pyroxene-rich Noachian basement and clay minerals close to each other and on steep slopes [3]. LIBS measurements and VISIR, which along with Raman are present on *Perseverance*, have also been used to detect altered zones in Gale crater [25], and oxidation state changes [26] that could indicate reaction fronts near Jezero crater.

**Conclusions and Implications for Sampling:** One of the driving goals of Mars Sample Return is to search for signs of past life. Locations that contain reaction fronts between primary minerals and water: 1) represent potentially habitable past environments, 2) are inhabited on Earth, and 3) have a high biosignature preservation potential due to the presence of minerals such as smectites. Therefore, reaction fronts near Jezero crater represent prime locations for future sampling. The *Perseverance* instrument payload can collect data to inform the locations of promising targets, and sampling these locations is an exciting opportunity to collect evidence of past life on Mars if it was ever present.

**References:**