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Complex history of Jezero crater as observed with the Perseverance Mars rover, and implications for habitability and astrobiology

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Jezero crater was selected as the site for the NASA's Mars 2020 Perseverance rover and Mars Sample Return missions based on orbitally observed sedimentary deposits inferred to record fluvial and deltaic processes in an open basin setting. In addition to Jezero's deltas/fans, observation from orbit of hydrated silica, clay, and carbonate absorptions in infrared spectra provided further rationale, showing that elements needed for the support and preservation of life were present in abundance. Following the discovery from the Curiosity rover in Gale crater of > 400 meters of predominantly fine-grained lacustrine strata, Jezero was anticipated to also host fine-grained phyllosilicate-rich strata such as are conducive for accumulation and preservation of organic materials on Earth.

In contrast to Gale, Jezero crater's floor was found to consist of two types of igneous rocks: an olivine-rich unit (Séítah) and a less mafic flow or series of flows (Máaz). Limited aqueous alteration resulted in minor carbonates, phyllosilicates, sulfates, and perchlorates. These igneous units pre-dated the sedimentary deposition of the western delta, which has eroded from its original extent leaving an exposed 25 m scarp (front) and remnant buttes.

The current delta front and top are composed of pebble conglomerates and sandstone with siltstone in intervals traceable along the front. This sequence shows evidence of pervasive aqueous alteration and diagenesis, with no remaining original igneous signatures in the IR spectra in the siltstone, which contains sulfates, indicating that the closed lake experienced significant evaporation. Based on grain size and cement composition, samples collected from Hogwallow Flats are among the most valuable for habitability and taphonomy that Perseverance has collected.

In late 2023 to 2024 Perseverance has been exploring the carbonate-rich margin unit situated between the delta and the crater rim, and found it abundant in silica, which is expected together with carbonates as a product of olivine alteration. In places, carbonates appeared as rounded pebbles weathering out of bedrock. Samples of this possible ancient beach deposit will be important for Earth return based on astrobiological potential.