# A TOUR OF ANCIENT HABITABLE ENVIRONMENTS IN AND AROUND JEZERO CRATER, MARS.

K. H. Williford[1*], K. A. Farley[2], K. M. Stack[1], T. Bosak[3], D. T. Flannery[4], Gupta, S.[5], Sun, V.[1], Brown, A. J.[6], [1]Jet Propulsion Laboratory, California Institute of Technology, USA, [2]Division of Geological and Planetary Sciences, California Institute of Technology, [3]Department of Earth, Atmospheric and Planetary Sciences, Cambridge, USA, [4]School of Earth and Atmospheric Sciences, Queensland University of Technology, Queensland, Australia, [5]Imperial College London, UK, [6]Plancius Research, Severna Park, MD. [*]kenneth.h.williford@jpl.nasa.gov

**Introduction:** The Mars 2020 team plans to explore and collect samples from diverse ancient environments preserved in the rocks in and around Jezero crater. The *Perseverance* rover payload will be used to understand the formation and evolution of those environments and establish field context for a set of about thirty rock and regolith samples envisioned for return to Earth in the early 2030's for further study. Analysis of samples collected by *Perseverance* with the benefit of powerful techniques only available in Earth-based laboratories would provide extraordinary opportunities to understand the ubiquity of life, among other fundamental questions about the origin and evolution of terrestrial planets.

At the final landing site selection workshop in late 2018, the Mars 2020 science team presented an ambitious "traverse mission" scenario responding to a rich, multi-year scientific debate about the merits of surface and subsurface environments on early Mars for habitability and biosignature preservation. The traverse mission links an ancient, open system lake with deltaic and carbonate-containing deposits inside the crater with potential impact-generated habitable environments in the crater rim and an extremely ancient crustal sequence outside the crater, that may preserve formerly habitable subsurface environments. In the time since landing site selection, the Mars 2020 science team has further developed this mission scenario. These efforts have generated a detailed geologic map [1], selected and prioritized exploration and sampling targets with strong potential to preserve signs of ancient life and planetary evolution [2]. Favored targets were linked into a strategic traverse to facilitate the *in situ* investigations and the assembly of a diverse cache of rock and regolith samples whose scientific value is commensurate with the extraordinary investment required to return them safely to Earth. Here we use the team-generated map and strategic plan to offer a tour of diverse, ancient habitable environments planned for exploration and sampling.

**Geologic and Astrobiologic Context:** Potential ancient habitats in likely order of exploration and sampling by Mars 2020 include the following:

1) fracture systems in an olivine (and possibly carbonate and clay)-bearing rock unit, and a crater-retaining unit with mafic composition on the crater floor that could have supported water-rock interactions and chemical gradients favorable to biology,
2) fine-grained, clay-bearing rocks (e.g. mudstones) and any potential chemical precipitates therein at the base of the delta fan that were once muddy, lake bottom sediments,
3) coarse-grained rocks (e.g. sandstones) higher in the delta representing higher energy river-influenced environments with strong potential for habitable surface and subsurface microenvironments on and between sand and pebbles that have the added benefit of concentrating the high geologic diversity of the watershed outside the crater,
4) carbonate-bearing rocks just inside the crater rim – the so called "marginal carbonates" that appear spectrally distinct from other carbonate-bearing rocks in and around Jezero [3] – where microbial mats in shallow water may have interacted with ions and sediments to form structures such as stromatolites (the most abundant macroscopic biosignatures in Earth's early geologic record),
5) complex, fractured, and aqueously altered rocks of the crater rim potentially preserving ancient, impact-generated hydrothermal systems [e.g. 4] that may have been the earliest habitable environments in the Jezero system,
6) a sequence of aqueously altered igneous and sedimentary rocks outside the crater much of which likely predates the Jezero impact event and could preserve habitable subsurface environments and with the potential to test hypotheses about the evolution of the martian magnetic field, atmosphere and habitability.
7) aqueously altered megabreccia blocks emplaced by – and preserving conditions predating – the Isidis impact; with perhaps the best potential to test hypotheses about the evolution of martian magnetic field, atmosphere and habitability in the earliest and interval of Mars history.

**Acknowledgments:** Work at the Jet Propulsion Laboratory, California Institute of Technology, was performed under contract with the National Aeronautics and Space Administration.

**References:** [1] Stack K. M. et al. (2020) *Space Science Rev* **216** 127. [2] Herd et al. (2020) LPSC 2021. [3] Horgan, B. et al. (2020) *Icarus* **339** 113526. [4] Osinski, G. R. et al. (2012) *Icarus* **224** 347-363.