

The Icebreaker Mission to Mars: Habitable Conditions on Modern Mars Warrants a Search for Life. C.P. McKay, C.R. Stoker, B.J. Glass, A. Davila, NASA Ames Research Center, Moffett Field CA & the IcebreakerTeam
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Introduction: The 2008 Phoenix Mars lander mission sampled ground ice at 68°N latitude. Mission results, considered along with climate modeling studies, suggest that high latitude ice-rich regolith at low elevations is habitable for life [1]. This talk will review the evidence and describe a low cost life search mission to search for modern life on Mars.

Habitable Conditions Evidence from Phoenix: Digging with a robotic arm revealed an ice table within 3-5 cm of the surface. Evidence for liquid water processes was observed including: 1) beneath 3 -5 cm of dry soil, segregated pure ice was discovered in patches covering 10% of the area explored, 2) pure calcite mineral, which forms under aqueous conditions, was detected in the soil, 3) perchlorate salt, highly soluble in liquid water, was observed at varying concentrations with higher concentrations seen in soil clods [2]. Carbon and nitrogen sources are available to support chemoautotrophic metabolism. The Thermal Evolved Gas Analysis (TEGA) instrument searched for soil organics but perchlorate was discovered in the soil [3]; any organic carbon in the soil would not have been detectable due to reaction with perchlorate during the heating step used for releasing volatiles. While current climate conditions are too cold to support metabolism, climate modeling studies [4] show that variations in solar insolation associated with changes in the season of perihelion occurring on 25kyr timescales and obliquity variations on 125kyr timescales [5] cause warmer and colder periods to occur in the N. polar region. The current epoch is cold because orbital tilt is low and summer occurs at aphelion. As recently as 17kyr ago, when summer solstice was at perihelion, temperatures were warm enough to allow pure liquid water to form at the surface [4]. At orbital tilts > 35°, insolation is equivalent to levels experienced in Earth's polar regions at the present time. At 45° temperatures allowing microbial growth persist to 75 cm depth [6].

Terrestrial permafrost communities are an example of possible life in the ice-rich regolith. Studies in permafrost have shown that microorganisms can function in ice-soil mixtures at temperatures as low as -20°C, living in the thin films of interfacial water [7]. In addition, it is well established that ground ice preserves living cells, biological material, and organic compounds for long periods of time, and living microorganisms have been preserved under frozen conditions for thousands and sometimes millions of years [8]. If life survives in these areas, growing when conditions allow, biomolecular evidence of life should accumulate in the soils.

The presence of habitable conditions on Mars

that persist over geological timescales to the present suggests that searching for biochemical evidence of modern life is warranted. The Mars Icebreaker Life mission [9] was proposed with that goal to the NASA Discovery call in 2015 and a future proposal is planned. The mission plans to land in the same region as Phoenix with a payload designed to address the following science goals: (1) search for biomolecular evidence of life; (2) search for organic matter from either exogenous or endogenous sources using methods not impacted by the presence of perchlorate; (3) assess the habitability of the ice bearing soils. The Icebreaker Life payload features a 1-m drill to auger subsurface material to the surface where it is delivered to payload instruments. Three instruments were proposed for the mission: The Signs of Life Detector (SOLID) [10] uses immunoassay to search for up to 300 biomolecules that are universally present and deeply rooted in the tree of Earth life. The Laser Desorption Mass Spectrometer (LDMS) [11] performs a broad search for organic compounds of low to moderate molecular weight that may be cosmogenic in origin or degraded biomolecules. The results are not impacted by the presence of perchlorate. The Wet Chemistry Laboratory (WCL) [3] detects soluble species of potential nutrients and reactive oxidants, providing insight into the habitability potential of icy soils.

Over the past few years there has been growing interest in life detection missions. This interest has been primarily driven by mission concepts to the ocean worlds of the outer Solar System – especially Enceladus. For the next Discovery call the Icebreaker payload will benefit from the technologies and approaches developed by the ocean worlds missions.

The Icebreaker payload fits on the same spacecraft/ lander used by Phoenix. The mission can be accomplished for modest cost, searching for a record of modern life on Mars while meeting planetary protection requirements.

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