THE ICEBREAKER LIFE MISSION TO MARS: A SEARCH FOR BIOCHEMICAL EVIDENCE FOR LIFE.
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Summary: We propose a mission concept to drill into ice-cemented ground on Mars to search for biomarker evidence of life. This has relevance to science, as well as being an important precursor for human exploration. The proposed instruments have already been tested in relevant analogue environments, and a plausible and demonstrated landing platform is available.

Introduction: The search for evidence of life on Mars is the primary motivation for the exploration of that planet. The results from previous missions, and the Phoenix mission in particular, indicate that the ice-cemented ground in the north polar plains is likely to be the most recently habitable place on Mars [1]. The near-surface ice likely provided adequate water activity during periods of high obliquity, ~ 5 Myr ago. Carbon dioxide and nitrogen are present in the atmosphere, and nitrates may be present in the soil. Perchlorate in the soil together with iron in basaltic rock provide a possible energy source for life [1]. Furthermore, the presence of organics must once again be considered, as the results of the Viking GCMS are now suspect given the discovery of the thermally reactive perchlorate [2]. Ground-ice may provide a way to preserve organic molecules for extended periods of time.

Icebreaker: The Mars Icebreaker Life mission (Figure 1) focuses on the following science goals: 1. Search for biomolecules that would be conclusive evidence of life, 2. Search for organic material in the ground ice, 3. Determine the processes of ground ice formation and the role of liquid water, 4. Understand the mechanical properties of the Mars ice-cemented soil, 5. Assess the recent habitability of the environment with respect to required elements to support life, energy sources, and possible toxic elements, and 6. Compare the elemental composition of the northern plains with mid-latitude sites. Observations at the Phoenix site (Figure 2) indicated that the ice was a few to 10s of cm below the surface and that accessing a depth of 1 meter would be sufficient to sample deeply into the ice-cemented ground [3,4]. Icebreaker is based on a drill capable of reaching 1 meter depth coupled to a sampling system that can deliver drill cuttings to the instruments. The core instrument is the Signs of Life Detector instrument, that uses an immunoassay microchip to search for organics and biomolecules [5]. A derivative of the Phoenix Wet Chemistry Laboratory instrument determines the solution chemistry [6], and an Alpha Proton X-Ray Spectrometer identifies elemental composition. A camera system based on the Phoenix Surface Stereo Imager provides context images and is also used for monitoring drill and sample delivery operations, geologic mapping, multispectral analysis, and atmospheric observations. A laser desorption mass spectrometer provides a second method of organic detection. The planetary protection requirements for Icebreaker will be the same as for Phoenix. The main part of the spacecraft will need to satisfy Category IVa cleanliness. The drill and any portions of the spacecraft that could come in contact with the ice in the subsurface will need to satisfy Category IVc requirements. The core of the science for Icebreaker Life is biomarker detection. The robust detection of such biomarkers would constitute proof of life – sometime in the present or past on Mars. However, the lack of detection of biomarkers would also be important as this would signal a lack of Earth-like life, although not necessarily a complete lack of life, with implications for human exploration and contamination control on returned samples.

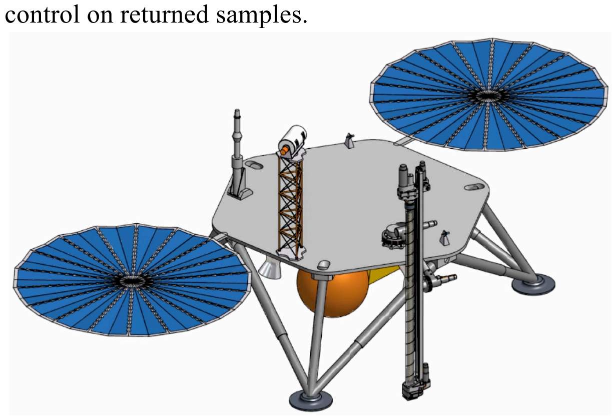

Figure 1. The Icebreaker drill on the Phoenix Lander.

Mission: We have developed a point design for Icebreaker for the 2018 opportunity. The nominal mission trajectory is a Type II with 9 months in cruise, launching December 2018. The Icebreaker spacecraft arrives over the northern plains of Mars in August 2019 (Ls=60), landing between 60ºN and 70ºN. Like Phoenix, the Icebreaker lander is solar powered and operates for 90 days only during the polar summer months. The Icebreaker Life payload has been designed around the Phoenix spacecraft and is targeted to a site near the Phoenix landing site. However, the Icebreaker payload could be supported on other Mars landing systems. Preliminary studies of the SpaceX Red Dragon Mars lander show that it could support the Icebreaker payload for a landing either at the Phoenix site or at mid-latitudes

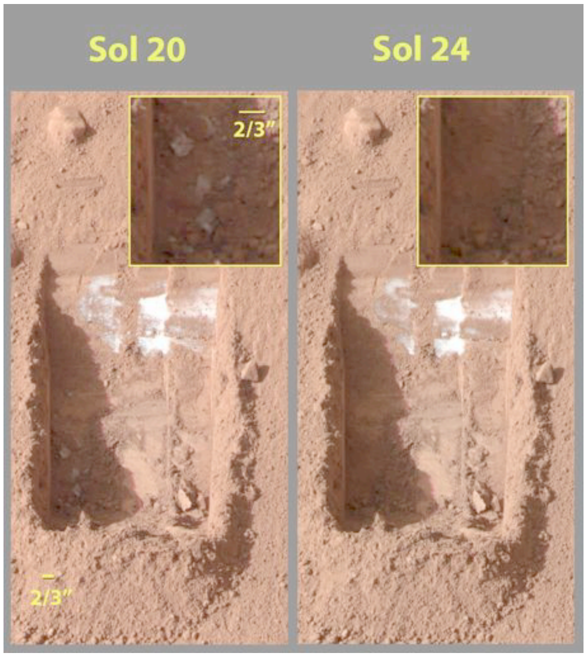

Figure 2. Subsurface ice and ice-cemented ground at the Phoenix landing site [3,4].

Human Exploration and Sample Return: The Icebreaker Life payload has been developed as a science-driven Discovery Class mission. The core of the science for Icebreaker Life is biomarker detection. The robust detection of such biomarkers would constitute proof of life – sometime in the present or past on Mars. However, the lack of detection of biomarkers would also be important as this would signal a lack of Earth-like life, although not necessarily a complete lack of life, with implications for human exploration and contamination control on returned samples.

The Icebreaker drill and science payload could also be applied to collection and characterization of samples for a Mars Sample Return program.

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