**THE ICEBREAKER LIFE MISSION TO MARS: A SEARCH FOR BIOMOLECULAR EVIDENCE FOR LIFE.**

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**Introduction:** The search for evidence of life on Mars is the ultimate motivation for the scientific exploration of that planet. The results from previous missions, and the Phoenix mission in particular, indicate that the ice-rich regolith at low elevations is likely to be the most recently habitable place on Mars. The near-surface ice likely provided adequate water activity during periods of high obliquity, 5 to 10 Myr ago [1]. Carbon dioxide and nitrogen are present in the atmosphere, and nitrates may be present in the soil. Together with iron in basaltic rocks and perchlorate in the soil they provide carbon and energy sources, and oxidative power to drive metabolism. 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. The Mars Icebreaker Life mission focuses on the following science goals: (1) Understand the habitability of ground ice through composition and chemistry. (2) Search for evidence of life. (3) Reconstruct the recent climate history of Mars (4) Assess the ground ice as a resource for human exploration.

The Icebreaker Life payload of a 1-m drill (Fig. 1) [1-5], an organic detection instrument (Laser Desportion Mass Spectrometer [6]), a life detection instrument (SOLID [7]) and a wet chemistry cell [8] has been designed around the Phoenix spacecraft and is targeted to a site near the Phoenix landing site (Fig. 2). The Icebreaker payload could also be supported on other Mars landing systems. Preliminary studies of the SpaceX Dragon lander show that it could support the Icebreaker payload for a landing either at the Phoenix site or at midlatitudes [5]. Duplicate samples could be cached as a target for possible return by a Mars Sample Return mission. If the samples were shown to contain organic biomarkers, interest in returning them to Earth would be high.

**Habitable Conditions at the Phoenix Landing Site on Mars:** The Phoenix landing site on Mars is arguably the most likely site to support life during recent periods of high obliquity, 5 to 10 Myr ago:

1. Pressure above the triple point of water (610 Pa)
2. Ice near the surface as a source of liquid water.
3. High summer insolation at orbital tilts >35º (present 25º), equivalent to levels of summer sunlight in Earth's polar regions at the present time.

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. 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 [e.g. 9]. Smilar biomolecular evidence of life could have accumulated in the ice-rich regolith on Mars.

Figure 1. The Icebreaker drill, build by Honeybee Robotics being testing in University Valley in the Dry Valleys of Antarctica – a location of ice-bearing permafrost overlain by "dry permafrost". This area is the best analog on Earth for the ice-rich regolith at the Phoenix Landing Site on Mars [1-4].

Figure 2. Icebreaker concept with drill deployed.

**References:** [1] McKay et al. (2013) *Astrobiology, 13*, 334-353. [2] Davé et al. (2013) *Astrobiology, 13,* 354-369. [3] Zacny et al. (2013) *Astrobiology 13,* 1166–1198. [4] Glass et al. (2014) *Journal of Field Robotics, 31,* 192-205. [5] Heldmann, et al. (2014) *Astrobiology, 14,* 102–118. [6] LDMS [7] SOLID. [8] WCL. [9] Gilichinsky et al. (1992) *Adv. Space Res. 12,* 255-263.