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Introduction: In this paper we present first results from Year 1 of a new PSTAR program investigating the potential for habitable niches and microbial life to become established at the seafoor of ice covered oceans, the mechanisms by which biosignatures arising from such systems might become emplaced in the overlying ice and future technologies that might be used to explore the interior of ocean worlds, semi-autonomously.

In earlier work (NASA-ASTEP grant, 2009-2014) our team demonstrated novel exploration strategies that revealed an unexpected abundance and diversity of styles of seafloor venting on the Mid-Cayman Rise, an extremely deep and slow-spreading section of Earth's Mid Ocean Ridge system. Results from that work included demonstration that H_2 rich hydrothermal systems could be established in more ways than previously known [1-3], identified novel pathways for abiotic organic synthesis to occur [4] and showed how metabolisms employed by microbial ecosystems might respond to variations in fluid geochemistry [5].

New Work: Encouraged by those past successes, we embarked our new prototype robotic vehicle Nereid Under Ice (NUI) aboard the German ice-breaker FS Polarstern in Sept-Oct. 2016. Using the vehicle in both fully autonomous (AUV) and then remotely operated (ROV) modes we conducted our robotic-based exploration at the Karasik Seamount, immediately adjacent to the ultra-slow spreading Gakkel Ridge axis, near 87°N in the Arctic Ocean. Karasik was of particular interest because, as a shallow massif, rising from >5000m to <600m depth immediately adjacent to the ridge axis, it offered a geologic setting directly reminiscent of that hosting the Lost City hydrothermal field on the Mid Atlantic Ridge. In parallel with our NUI program, we also conducted ice-core studies of the ice overlying the massif and water column analyses from both directly above the Karasik massif and at an adjacent site along the deep ridge axis that revealed evidence for high temperature, hydrogen-rich/ultramafic influenced seafloor venting. Although no direct observations of active fluid flow were made at either location, abundant life was observed across the summit of the Karasik seamount which we were able to sample using the NUI vehicle in ROV mode. In parallel, multiple lines of evidence indicate that we approached to within <200m of the deep seafloor source of high-temperature venting. Biogeochemical ± microbiological analyses of the samples collected from close above that vent source and in the resultant plume, dispersing through the water column, will be discussed.

Future Research: All samples from the research program have now been transferred back to the relevant home laboratories in the USA and Germany where continuing biogeochemical and microbiological analyses are underway. From these, we will be able to predict both the precise nature of the end-member vent-fluid source at the seafloor (hence, the likely water-rock interactions that occur) and the fate of any diagnostic signatures arising from that vent-source as they are dispersed into the surrounding ocean ± overlying ice.

In parallel, our technological research has already captured important field data on the importance of "human in the loop" interventions in the process of robotics-based exploration of these extreme ice-covered ocean unknown environments. An important focus of our continuing research will be to develop and assess new semi-autonomous methods to explore for life and life-related chemistry that recognize the benefits of such interactions while developing levels of autonomy that allow missions to continue effectively in the presence of limited communications.

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