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Clean Sampling of an Englacial Conduit at Blood Falls, Antarctica – Some Experimental and Numerical Results

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There is significant interest in sampling subglacial environments for geochemical and microbiological studies, yet those environments are typically difficult to access. Existing ice-drilling technologies make it cumbersome to maintain microbiologically clean access for sample acquisition and environmental stewardship of potentially fragile subglacial aquatic ecosystems. With the “IceMole”, a minimally invasive, maneuverable subsurface ice probe, we have developed a clean glacial exploration technology for in-situ analysis and sampling of glacial ice and sub- and englacial materials.

Its design is based on combining melting and mechanical stabilization, using an ice screw at the tip of the melting head to maintain firm contact between the melting head and the ice. The IceMole can change its melting direction by differential heating of the melting head and optional side wall heaters. Downward, horizontal and upward melting, as well as curve driving and penetration of particulate-ladden layers has already been demonstrated in several field tests. This maneuverability of the IceMole also necessitates a sophisticated on-board navigation system, capable of autonomous operations. Therefore, between 2012 and 2014, a more advanced probe was developed as part of the “Enceladus Explorer” (EnEx) project. The EnEx-IceMole offers systems for accurate positioning, based on in-ice attitude determination, acoustic positioning, ultrasonic obstacle and target detection, which is all integrated through a high-level sensor fusion algorithm.

In December 2014, the EnEx-IceMole was used for clean access into a unique subglacial aquatic environment at Blood Falls, Antarctica, where an englacial brine sample was successfully obtained after about 17 meters of oblique melting. Particular attention was paid to clean protocols for sampling for geochemical and microbiological analysis.

In this contribution, we will describe the general technological approach of the IceMole and report on the results of its deployment at Blood Falls. In contrast to conventional melting-probe applications, which can only melt vertically, the IceMole realized an oblique melting path to penetrate the englacial conduit. Experimental and numerical results on melting at oblique angles are rare. Besides reporting on the IceMole technology and the field deployment itself, we will compare and discuss the observed melting behavior with re-analysis results in the context of a recently developed numerical model. Finally, we will present our first steps in utilizing the model to infer on the ambient cryo-environment.