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IceMole – Prototype Development and Testing of a Subsurface Icecraft

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We present the novel concept of a combined drilling and melting probe for subsurface ice research. This "subsurface icecraft", named "IceMole", is currently developed, built, and tested at the FH Aachen University of Applied Sciences' Astronautical Laboratory. Here, we describe the IceMole's first prototype design and report the results of its first field tests on the Morteratsch glacier in Switzerland.
We have developed the combined drilling and melting concept to surpass the limited controllability and penetration capability of traditional melting probes, which have been used since the 1960s. The IceMole has the shape of a rectangular tube (15cm x 15cm cross section) with a ~3kW melting head and a rotating (hollow) ice screw at the tip. The required electric power is generated by a surface aggregate and transmitted via a cable that is uncoiled from the probe. Communications and data transfer to the surface is also via the power cable. The ice screw generates a driving force that presses the melting head against the ice, thus leading to a good conductive heat transfer. The IceMole can change direction by differential heating of the melting head (in the next prototype, also side heaters will be implemented), which generates a torque that forces the IceMole into a curve. The IceMole design philosophy is that of rapid prototyping. The first IceMole prototype was build in 2009/10 and was tested on the Swiss Morteratsch glacier in September 2010. Three penetration tests have been successfully performed: 1) melting 45° upwards for ~1.5m, against gravity; 2) melting horizontally for ~5m; 3) melting 45° downwards for ~3m, thereby penetrating three obstructing non-ice layers (mud and sand found on the glacier) and driving a curve with a radius of ~10m. The penetration velocity was ~0.3m/h (but will be increased for the next prototype). The test results show that the IceMole concept is a viable approach to deliver scientific instruments into deep ice and to recover them afterwards. An advantage with respect to drilling is that biological contamination can be minimized and the process can be made highly autonomous, so that there is no need for an operator on the surface.

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