

Technical aspects of deep drilling, sampling, and analyses of extraterrestrial ice formations.

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The search for extraterrestrial life in the Solar System relies upon *in-situ* robotic exploration. Mars's polar ice cap is 2-3 km thick [1], while Europa's ice shell can be 100 km [2] and may contain a global subglacial ocean with extant organisms. To search for life embedded in the ice, it is fundamental to have in-depth access to and extraction of ice samples.

The concept of an autonomous, nonrecoverable drill-sonde equipped with sensors was proposed and used in Greenland in 1970-th [3]. The drill-sonde or IceMole (IM) probe sinks into the ice by melting. Another concept of a large diameter (0.4-0.8 m) IM is powered by an embedded heat and electricity source [4].

Our concept is a small diameter, low power thermal sonde - DaS (Drilling and Sampling) that melts ice and delivers meltwater and solid samples to the surface for analysis. DaS operates in an empty borehole. The winch on the surface moves DaS incrementally up and down. On the surface, samples are removed and analyzed. The operation is powered with KiloPowe [4] and set of solar panels; the expected total electric power of DaS is 2 kW. The specific design DaS feature is the ability to penetrate and sample ice heavily loaded with solid particles. We prove the ability of a thermal drill to penetrate an 80 mm thick layer of sand/ice (70/30 vol %), Figure 1 [5].

[1] Plaut, J.J., et al., Subsurface Radar Sounding of the South Polar Layered Deposits of Mars. *Science*, 2007. 316(5821): 92-95.

[2] Howell, S.M., The Likely Thickness of Europa's Ice Shell. *The Planetary Science Journal*, 2021. 2(24): 129.

[3] Philberth, K., The Thermal Probe Deep-Drilling Method by EGIG in 1968 at Station Jarl-Joset, Central Greenland. *Ice-Core drilling*. University of Nebraska Press, Lincoln, NE, 1974: 117-131.

[4] McClure Patrick R., et al., (2020) KiloPowe Project: The KRISTY Fission Power Experiment and Potential Missions, *Nuclear Technology*, 206:sup1:S1S12.

[5] Zagorodnov V., et al. Drilling of glacier boreholes with a hydrophilic liqueid. *NIPR*, 49: 153-164.

Caption Figure 1. An ice core was obtained with the thermal-electric drill; the ice core diameter in 78 mm.

