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Mars Exploration – Science, Instruments and Technologies (3B)

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DRILLING AUTOMATION FOR MARS SAMPLE ACQUISITION

Abstract

The proposed "Icebreaker" mission would be a return to the Mars polar latitudes first visited by Phoenix in 2007-08. Given the hard icy layers and perchlorates found there, Icebreaker is based on the Phoenix/InSight spacecraft bus but would carry an automated 1m rotary-percussive drill, a sample transfer arm, and non-pyrolytic instruments capable of detecting organics in the presence of perchlorates. Looking for organics, biomarkers and signs of past or extant life in the Mars arctic will require sample acquisition there below the desiccated and irradiated surface, and through the hard ice layers that stymied Phoenix. A decade of evolutionary development by NASA of integrated automated drilling and sample handling, at analog sites and in test chambers, has made it possible to go deeper through hard rocks and ice layers. The latest Icebreaker-3 drill was been tested with a Phoenix mockup and at the Haughton Crater Mars-analog site in the Arctic (with sample transfer arm) and in a Mars chamber, with successful sample acquisition under automated control.

Unlike terrestrial drills, Mars exploration drills must work dry (without drilling muds or lubricants), blind (no prior local or regional seismic or other surveys), and light (very low downward force or weight on bit, and perhaps 100W available from solar power). Given the lightspeed transmission delays to Mars, an exploratory planetary drill cannot be controlled directly from Earth. Drills that penetrate deeper than a few cm are likely to get stuck if operated open-loop (the MSL drill only goes 5cm, and the MER RATs 5mm by comparison), so some form of drill automation is required.

The Icebreaker-3 (IB-3) drill, completed in June 2014, was 3-5x less massive than earlier Mars drill prototypes. Power consumption is under 100W average during 5-10 min drilling sequences. IB-3 was tested in August 2014 at the Haughton Crater analog site in the Canadian Arctic, as have a series of past drill prototypes, running automated drilling sequences. IB-3 drilled ¿5m, in six boreholes, and with sufficient power (torque) and shaft stiffness to break and penetrate hard rock and ice-consolidated material. IB-3 drilled ¿2m in ice or ice-consolidated material. Unlike prior prototypes, IB-3 drilled rapidly

and experienced almost no fault conditions. Interoperability testing at Honeybee Robotics in June 2014 demonstrated that the IB-3's sample (cuttings) was handed-off from the drill to a sample transfer arm and thence to instrument inlets ("dirt-to-data").