Toward Exploration of Subglacial Seas using Thermal Melt Probes. D.P. Winebrenner[1,2], W.T. Elam[2], and P. Kintner III[1], [1]Department of Earth and Space Sciences, University of Washington (dpw@uw.edu), [2]University of Washington Applied Physics Laboratory.

Introduction: Observations at numerous locations within subglacial seas are likely to be needed for understanding of geo-, or biogeochemistry within them. However, emplacement of the requisite instruments is severely constrained by logistical burdens. Electrically powered thermal melt probes are inherently logistically light and efficient, especially for reaching greater depths in colder ice [1]. They therefore offer an important means of addressing current measurement problems, but such probes have been limited historically by a lack of technology for reliable operation at the necessary voltages and powers. Here we report on field tests in Greenland of two new thermal melt probes developed by the University of Washington Applied Physics Laboratory.

Field Test Results: We conducted field tests during July 2013 and July 2014 in the ablation zone in SW Greenland, at 67.2N, 49.5W, at approximately 1000 m elevation. Ice temperature at 10 m depth at the site is approximately -15 C. Our probes are approximately 170 cm in length and 7 cm in diameter, are for brevity are termed Ice Divers. Figure 1 shows one probe prior to launch, as well as the complete launch set-up.

Figure 1. (left) An Ice Diver prior to launch, with a 3-person mountaineering tent for scale. (right0 An Ice Diver prepared to launch, together with all equipment required for operation.

We operated one probe at 2.2 kilowatts (kW) and 1050 volts (V) applied at the ice surface, achieving a depth of 400 m beneath the ice surface over approximately 120 hours running time, without electrical failure (the run was terminated deliberately at the end of our field season). Based on available literature, that depth appears to be the second greatest depth achieved thus far with a thermal melt probe in polar ice sheets, exceeded only by one run to 1005 m in Greenland of a probe built by Philberth and colleagues in 1968, which ended due to an electrical failure [2].

Our test run took place in two intervals separated by a year, with the probe frozen into the ice at 65 m depth during the interim, after which we easily re-established communications, unfroze the probe by applying power to distinct probe components in a particular sequence, and proceeded to the greater depth.

Our estimates of depth at the end of the first and second field tests are based on two independent measurements and model results consistent with those measurements. First, our probe relies on two wires that spool from the probe as it descends, one insulated, and one bare. The electrical resistance of bare wire increases as the probe descends, as less wire remains shorted on the bare-wire spool. After accounting for wire temperatures, we estimate depth vs. time as shown in Figure 2. Second, we conducted an

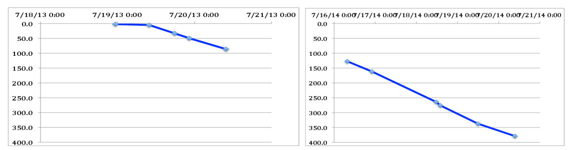

Figure 2. Probe depth inferred from wire-resistance measurements as a function of time, in field tests 1 (left) and 2 (right).

Improved time-domain reflection experiment at the end of field season 2, from which we obtained a depth-estimate consistent with the wire-resistance estimate. Finally, both estimates are consistent with modeled rates of descent given power supplied to the probe.

Moreover, we observed precise maintenance of vertical probe travel by means of pendulum steering throughout both tests, as well as nearly autonomous descent with essentially no intervention by operators on the surface after launch. The latter suggests potential for crews of 1-2 to operate several descending melt probes concurrently. During the second field test we also operated a higher probe, initially at 2.5 kW and 1500 V and progressing up to 4.5 kW and 2000 V. Initial data indicate that this latter probe achieved a descent rate near 6.5 m/hr at the end of the test, which may be the fastest rate yet achieved for such probes. This probe, however, suffered an electrical failure after 7 hours operation at 4.5 kW – we are revising heater designs to correct this.

Discussion: As we go on to demonstrate higher-power probes reaching greater depths, questions as to instrumentation come to the fore. We presently anticipate low-bit-rate measurements of dissolved gas and major ion concentrations. We hope with this presentation to foster discussion of additional measurements. st

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