WISSARD McMurdo Ice Shelf Test Field Report
Prepared for NSF-OPP

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The WISSARD Science Team
1. Introductory Remarks

Scientific equipment and deployment procedures were field tested on the McMurdo Ice Shelf at 77°53’25”S/167°0’30”E prior to deployment at Subglacial Lake Whillans (SLW). Science testing operations were from December 18 -22, after site was prepared and drill system, operating deck (LARS) and science vans were set-up, and following successful hot-water drilling to make the access hole. The site was selected because of: (1) proximity to McMurdo Station, via the Pegasus Air Field road, (2) a significant thickness of ice shelf (56m), and (3) water depth (917 meters below sea level (mbsl)) in excess to that of SLW (ca. 810 m below ice surface).

This report outlines operation of scientific instrumentation during the test. It does not provide documentation, assessment or analysis of logistic or hot-water drilling operations. However, logistics are briefly mentioned, as to how they impacted science operations. Lastly, this document explains what data were collected during the test.

2. Summary and Operational Notes

2.1 Niskin/Go-Flow

Niskin bottles were deployed on 22 December 2012. Conductivity and pH were measured on site, and samples for dissolved oxygen and dissolved inorganic carbon were preserved on site in the WISSARD chemical lab. Thirty-five liters of water were obtained from 86 and 906mbsl) and transported back to Crary Lab for further processing. The status of all analyses and experiments conducted on sub-Ross Ice Shelf water is summarized in Appendix Table 4.1.

2.2 In Situ Filtration Sampler

The in situ filtration sampler was tested on 29 December 2012. The unit was deployed in tandem with the CTD to a depth of approximately 850 meters below the ice-water interface (Figure 1). Once at depth, the sampler was allowed to pump for 4 hours before it was returned to the surface (total test time: 5h 37minutes). The in situ filtration unit was transported to the chemical lab where the filter housing was disassembled and the filters cut into quarters and preserved for nucleic acid extraction.

\[Figure 1\]. Schematic of instruments during MIS test
portion of the 10 µm filter was reserved for Reed’s diatom analysis. Deployment data indicated the in situ filtration unit had pumped water at a rate of approximately 2.5 L min⁻¹ for the entire 4 hours of deployment. The manual flow meter on the unit showed that a total of 295 liters was pumped within the deployment time.

2.3 Ekman Sediment Dredge
The Ekman Dredge was deployed twice. Both deployments were unsuccessful in retrieving sediments. The dredge did not collect sediments due to the strong currents below the ice shelf.

2.4 CTD
The Seabird 19PlusV2 was first deployed immediately following the POP on 19 December 2012. The purpose of this deployment was to obtain comparable data to the POP Seabird SMP 37 CTD. Firstly, the 19PlusV2 was deployed by itself and, secondly, on subsequent days, in tandem with other sampling equipment (Niskin bottles and the McLane in situ water filtration unit). Both profiling and moored mode were tested. The CTD performed well in profiling mode and provided reliable data when compared with published results for the Windless Blight area (Robinson et al. 2010). The 19PlusV2 will be deployed in tandem with other instruments while at SLW.

2.5 Multicorer.
The Uwitech multicorer was deployed once at the test site using the light winch. Three core tubes were deployed; with one core tube pre-drilled for Rhizon porewater samplers. On retrieval, all three coring units had appropriately triggered, and core-catcher balls were in place at the base of the core tubes. The tubes were water-filled, with no sediment recovered. On examination, Tube 2 had a small indentation at the base, providing evidence the core tube hit a rock and failed to penetrate the sediment. The bottom camera on POP had already confirmed the presence of a rocky bottom.

2.6 Instrument Package for Sub-Ice Exploration (IPSIE)
The NIU Instrument Package for Sub-Ice Exploration (IPSIE) is designed to collect real-time oceanographic/limnological measurements, video images, and in situ samples. The Physical Oceanographic Package (POP) configuration was fully tested at the MIS test site and successfully recovered real-time data through the borehole and water column through 917m below sea level (mbsl) to the seafloor. Both down- and side-looking video cameras recorded images of the firn, ice shelf, water level in borehole, ice shelf base, water column and seafloor. Instrumental data collected by the POP are: altitude relative to bottom (once within 200m), conductivity, temperature, depth (CTD), two separate values of current velocity, relative particulate concentrations (both transmissivity and reflectance), absolute suspended particle concentration and size, dissolved oxygen, and semi-quantitative chlorophyll (fluorometry). With the exception of the dissolved oxygen sensor, all sensors within POP worked appropriately and reported conductivity, temperature and depth values consistent with the independent Seabird 19PlusV2 CTD, as well as the previously published results from the Windless Bight area (Robinson et al. 2010).

During the test deployment, significant time was spent amongst the DOER engineers, the ASC marine techs and NIU scientists working out safe and efficient deck procedures for the assembly and deployment of POP. The POP went through a successful mock cleaning prior to deployment: the instrument was sprayed for decontamination, bagged for clean handling, then un-bagged as it was deployed down-borehole.

The Water nutrient chemistry Instrument Package for Sub-Ice Exploration (WIPSIE) configuration was not tested during the field test because of insufficient time. Some of these instruments utilize in situ wet chemical analyses (Envirotech NH₄, NO₃, Si, and PO₄ analyzers) and are all fully contained and
sealed. Although the likelihood of leakage is very low, due to our concerns of maintaining environmental integrity in the lake, we resolved not to deploy them in SLW. The Contros CO₂ and CH₄ sensors, which do not perform wet chemical analyses, may be used in the POP configuration in lieu of the Envirotech water sampler, depending on how operations are going at SLW. This configuration will allow us to deploy more instruments in less time at SLW.

2.7 Percussion Corer
The Percussion Corer hydraulics and hammer sections were tested on the surface several times and the hydraulic system was tuned to maximize the hammering rate. The MIS test provided an opportunity for us to establish efficient deck procedure during assembly and transfer to the moon pool.

2.8 Geothermal Probe
The Geothermal Probe was successfully deployed during the MIS test. This was an operational test. No thermometers were attached to the lance and no geothermal data were collected. The GP stayed in the sediments for 14 minutes and then was retrieved to the surface. Sediments on the lance showed full lance penetration of 1.4m. Sediments were recovered by Reed. The GP was disassembled in reverse order of assembly, cleaned, and stored for traverse.

2.9 “Smart” Winch
The winch used for NIU IPSIE and Percussion corer, as well as the UCSC Geothermal Probe uses a fiber-optic cable strengthened by steel mesh wires to provide a 10,000lb pull-out and the ability to command the probes and instruments from the surface while simultaneously receiving real-time telemetry from the instruments in the lake. All data transfer to and communications from the surface performed excellently and software engineers refined algorithms for processing the data in real-time.

2.10 Micro Subglacial Lake Exploration Device (MSLED)
The Mothership was deployed with the test MSLED B vehicle in the deployment mechanism on 23 December 2012. High quality video data were successfully delivered from the Mothership to the NIU command and control container at a steady rate and recorded. The onboard CTD was not tested at MIS.

3. Issues and Solutions

3.1 Ekman Sediment Dredge
Currents were the main problem with this light tool. The dredge is too light to contact the sea floor and stay in place while the messenger is traveling down the cable. At Subglacial Lake Whillans, currents should not pose a problem, which would alleviate the issue of determining when the dredge is actually on the bottom. Accurate bottom depth measurements will also help show the dredge has contacted lake sediments.

3.2 CTD
Care needs to be taken to ensure the CTD is kept warm prior to all deployments. Crane assisted deployment of the CTD in tandem with a Niskin bottle or in situ filtration unit will alleviate the freezing problems associated with long, out-of-water deployment times.

3.3 Multcorer
Crane assistance during deployment of the multicorer will alleviate problems encountered during initial deployment.

3.4 Instrument Package for Sub-Ice Exploration (IPSIE)

1. During deployment of POP power to the probe was cut off twice because guest observers accidently pushed an emergency stop switch. Upon recovery of POP, we discovered the WWater Distribution System (WADS) did not automatically turn on when power was restored. POP data appear to show that water was still being moved through the tubing and provided in situ data despite the power fluctuations. However, there was a lag-time between measurements and depth that introduced some errors. Now that we are aware of the issue of accidental cutting of power to the POP and WADS stopping, we will provide a protective shield to the emergency power knob, but if it does happen again we will know to restart WADS manually after each power cycling. We have planned a software patch to correct the issue for next season.

2. The Envirotech water sampler had water ingress in its motor housing, which caused erratic operation during the test. The instrument has been repaired, but we do not have the means to pressure-test it in Antarctica. Due to this inability to test again under pressure, at SLW we may elect to substitute the sampler with the Contros CO₂ and CH₄ sensors from WISPIE.

3.5 Percussion Corer

During initial deployment while at the top of the water column, sensors indicated an electrical fault and we withdrew the corer immediately. Subsequent investigation by the DOER engineers showed that a torn O-ring allowed water to leak into the motor section, compromising a circuit. The unit was fully drained and the electronics repaired before the corer was reassembled. Unfortunately there was no time to redeploy during the testing period, but it is ready to go for the lake operation.

3.6 Geothermal Probe

The geothermal probe requires an accurate depth to sea floor measurement, which was difficult during the MIS test. The use of the MSLED mother ship on a calibrated line is a solution to this issue and will be used at SLW. Despite the fact that there were no thermometers attached to the lance of the geothermal probe, we do not see this as an issue during the SLW deployment.

3.7 “Smart” winch

The winch successfully deployed the NIU and UCSC instruments. However some issues limited its efficiency.

1. The level-wind was malfunctioning at the end of each run across the drum. Manual corrections helped this problem, but resulted in slow retrieval. DOER engineers made adjustments on-site during operations that alleviated the much of the problem, but a complete fix will require either a firmware patch or additional modification to the hardware. As the system still works reliably and safely, we have decided to proceed as is for this season, and work on a full correction for next season.

2. The “smart” winch algorithmically calculates the length paid out based on the number of drum rotations and the diameter of the umbilical. After multiple deployments, it became apparent that the error in this approach was not better than 1%, which was ideal limit for operations with the geothermal probe, which cannot use real-time data or a video camera to show its position relative to the sea floor. Though this is not a mission critical issue, DOER and HWD engineers will install a digital encoder directly on the block for real-time, meter-out measurements, which would speed up future deployments at the lake.

3. The tension read-out on the winch is faulty and DOER is exploring a fix to allow best operation of the percussion corer and geothermal probe in future seasons. There is a real-time tilt sensor in the
IPSIE control stage that is also used above the geothermal probe. This was used effectively to determine when tension was decreased on the cable as the geothermal probe rested on bottom. That allowed us to determine a precise position of seafloor depth required for the best deployment of the probe.

3.8 Micro Subglacial Lake Exploration Device (MSLED)

1. The deployment technique was cumbersome and contributed to a decrease in video feed quality. A solution to the problem involves the light winch and capstan device for smooth deployment. This deployment strategy has been tested to function properly. Furthermore, the larger borehole at SLW will further alleviate problems encountered at the MIS test.

2. The securement harness for MSLED when it is being deployed in the Mothership proved inefficient. MSLED B vehicle was lost during the retrieval of the instrument. Several fixes have been made to MSLED A (the SLW flight vehicle). Extra buoyancy and a more robust securement harness have been added and successfully tested for secure deployment. Also, redundant recording and connectors have been added to provide live feed of potential problems during deployment.

4. Summary of Outcomes and Deliverables from MIS Test

A successful testing of the hot-water drill and scientific instrumentation was achieved during the MIS site test. There were valuable lessons learned and almost all problems that arose have been fixed or effectively mitigated. We believe we are fully ready for successful entry into SLW in an environmentally clean manner to ensure viable sampling and environmental stewardship. Sampling should be effective and if allowed appropriate time by weather, sampling will be comprehensive given the range of sensors and samplers we have proven to work.

Although science was not the mission of the testing phase, samples and sensor data have provided new and interesting results that we believe are very relevant to science and should be published. Thus we have established the following milestone:

To publish a paper in a peer-reviewed journal, likely JGR: Biogeosciences or Biogeochemistry using data collected during the MIS test.

Tentative Title: Biogeochemical characteristics of sub-Ross Ice Shelf waters near McMurdo Sound

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