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G.D.M. Cameron

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Canada

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Introduction

Gordon Cameron, a marine geoscientist with the Geological Survey of Canada-Atlantic, participated in leg 1302 of the USCGC Healy's *Arctic West Summer 2013* cruise program, in collaboration with Woods Hole Oceanographic Institution and Scripps Institution of Oceanography, to study Arctic marine geoscience and paleoceanography. The cruise took place between August 15th and September 7th, 2013. The expedition began in Barrow, Alaska and travelled east, visiting sites along the U.S. and Canadian continental slopes of the Beaufort Sea in 400 to 1600 m water depth, Figure 1. Sites were also occupied on the continental shelf in the Mackenzie and Amundsen Gulf regions of the Canadian Beaufort Sea and around Barrow Canyon, offshore Alaska. Appendix I provides a daily operations log.

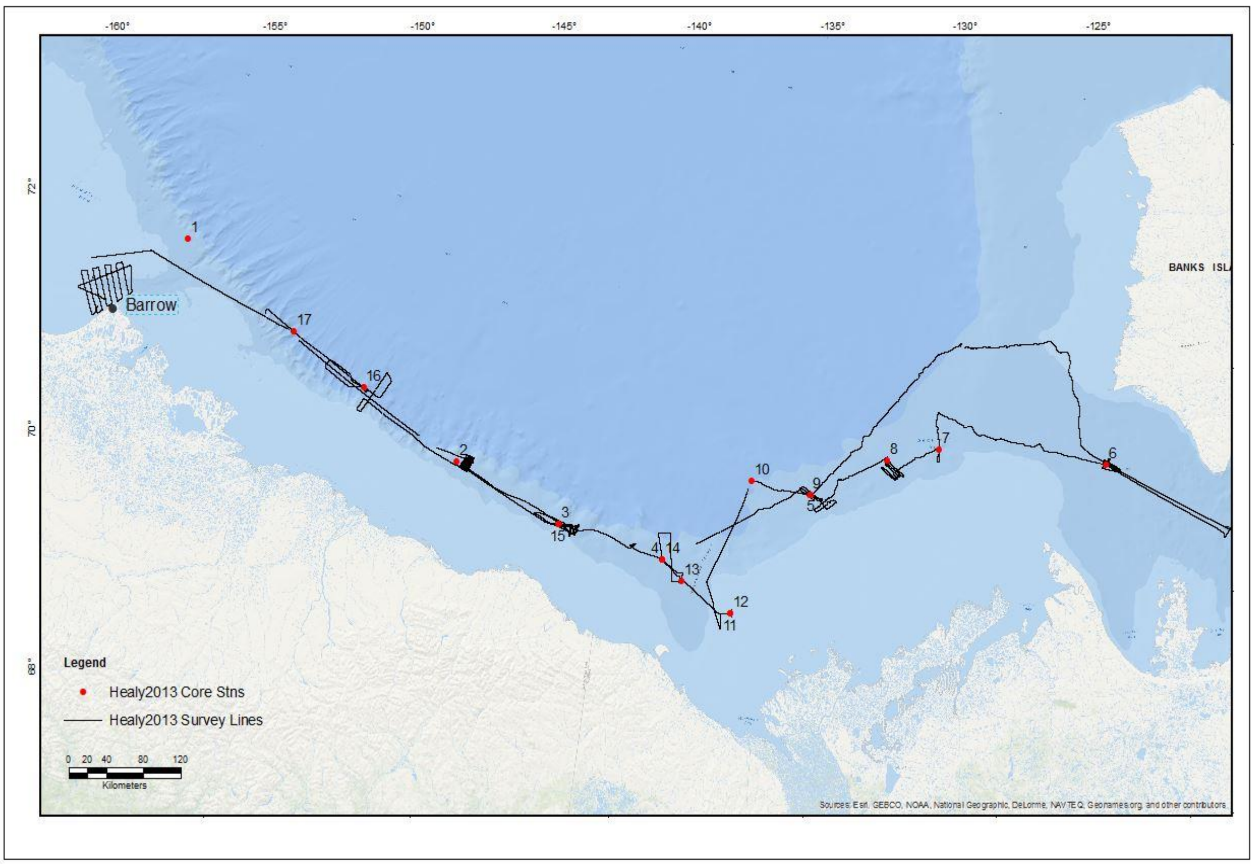

Figure 1. Map of seismic survey lines (multibeam, Knudsen 3.5 kHz and limited CHIRP) and core stations for Healy 1302 expedition.

Multibeam and 3.5 kHz sonar data were collected at every coring station and alone route between stations. Chirp seismic profile data was collected at only 4 stations (1, 2, 3 and 4); sea ice restricted the use of the towfish at most of the remaining sites. More than 3000 line kilometers of seismic data were collected. The coring operations occupied 17 stations with a total of 12 multi cores, 14 jumbo piston cores and 15 giant gravity cores collected, see Appendix II for details. Piston core were put through the multisensor track on the Healy. Multicores were extruded and subsampled for microfossil on the Healy.

Dr. Lloyd Keigwin, senior scientist at the Geology and Geophysics Department of Woods Hole Oceanographic Institution and Dr. Neil Driscoll, a geophysicist with Scripps Institution of Oceanography at UCSD, provided scientific leadership during this GSC-linked collaborative work on Healy leg 1302 expedition. Commanding Officer (CO) of USCGC Healy was Captain John Reeves and Executive Officer (XO) was Commander Gregory Stanclik. The United States coast Guard cruise report, covering all operations for all legs, is available at http://icefloe.net/archived-cruise-reports.

Navigation, multibeam and 3.5 kHz data is downloadable from http://icefloe.net/ once posted; http://www.rvdata.us/catalog/HLY1302. The Knudsen (3.5 kHz) seismic, multibeam and navigation data were delivered directly to GSC-A by Neal Driscoll, Scripps. These data were archived at the GSC-A. Also, all metadata, including sample and ship track lines are archived in GSC-A's online Expedition Database http://ed.gdr.nrcan.gc.ca/index_e.php. All the cores are archived at Woods Hole Oceanographic Institution but some post-cruise analysis will be conducted at the GSC-A core facility these cores will be archived at GSC-A. Core numbers and positions were collected during the expedition and are found in Table 1.

Proposed Goals: A younger Dryas Meltwater Outlet?

The overarching goal of cruise USCGB Healy was to survey, sediment core, and conduct shore-based studies to investigate the origin of the Younger Dryas (YD) climate cooling that began about 13,000 years ago (13 ka) and lasted more than 1000 years. This return to glacial-like conditions occurred after the Bolling-Allerod warming (~14.5 to 13.0 ka) and is one of the enduring enigmas in late Pleistocene climate. As the climate system was in an orbitally-induced warming, what caused the warming trend to reverse? Early researchers (1960s) first suggested that warm Atlantic waters penetrated the Arctic Ocean during Allerod time and destabilized extensive floating and grounded ice sheets. They reasoned that as disintegrating ice left the Arctic Ocean for the North Atlantic, it would have been sufficient to cool northern Europe climate, but in the 1960s apparently no one was thinking about the possible role of fresh water discharge from glacially dammed lakes in modulating the ocean's meridional overturning circulation (MOC) on millennial time scales. Although the existence of glacial Lake Agassiz around the southern margin of the Laurentide ice sheet has been known for more than a century, it was during the 1970s that the oxygen isotopic signature of deglacial meltwater during the Allerod was first discovered in the Gulf of Mexico. By the 1980s accelerator mass spectrometry (AMS) radiocarbon dating became common on small samples of foraminifera, and Broecker et al. (1989) made the connection between the end of the low ∂18-O interval in the Gulf of Mexico at the Allerod/Younger Dryas boundary and the YD cooling. They proposed that the opening of an eastern route for Lake Agassiz meltwater through the St. Lawrence River system as the Laurentide Ice Sheet retreated caused reduction of the Atlantic MOC that in turn reduced North Atlantic heat flux and (presumably) caused the Younger Dryas cooling. Thus was born the meltwater diversion hypothesis.

Although the hypothesis is elegant in its simplicity and grand in its scope, there are more than a few problems. First is the issue of timing. The age of the YD flood is determined by the dated shorelines of Lake Agassiz, especially the "Moorehead Phase" when Lake Agassiz level dropped, but these are controversial. The position of the ice margin with respect to both the eastern and the northern outlets is also controversial (Teller et al., 2005), although argue for both a large ice dome in northern Canada as well as an open northern route for Lake Agassiz flow. Observations have also documented the lack of geomorphological evidence for an eastern flood (Teller et al. 2005).

Despite years of searching, no one has ever reported stable isotope evidence for lowered surface ocean salinity in the western North Atlantic during the YD. Broecker et al. (2010) have now backed away from a meltwater cause of the YD. These authors suggest that the YD is part of the natural sequence of climate changes known as Dansgard-Oeschger oscillations and Heinrich Events; however their paper was accepted for publication before the appearance of Murton et al. (2010). A major reason for Broecker's abandonment of the meltwater diversion hypothesis was the lack of geomorphological evidence for a YD flood, and that is exactly the evidence marshaled by Murton et al. (2010) for the Mackenzie delta region.

Our proposed expedition will survey and core high deposition rate locations along the north slope of Alaska and Canada, and the margin of the Canadian Archipelago. Model results and theory show that, with lowered sea level and with the northwest passage channels filled with ice, a YD meltwater flood from the Mackenzie River would turn right because of Coriolis force and follow the outer continental shelf/upper slope along the Canadian Archipelago to northern Greenland and enter the Nordic Seas through Fram Strait. We argue here that sediments in the eastern Beaufort Sea should accumulate at high enough rates to resolve the YD, that sufficient foraminifera should be present for stable isotope studies and AMS 14C dating, and that if there was indeed a flood of water from glacial Lake Agassiz, we should detect it. Our proposed modeling of this event will be guided by our geochemical and sedimentological results and will put the YD discharge into the broader context of the climate system. If successful, we will have solved one of the great puzzles in late Pleistocene climate

Navigation and Positioning

HEALY is outfitted with Sperry Marine's Voyage Management System (VMS). This system utilizes multiple heading, position, environmental, and navigation inputs to steer the ship along a desired course. Currently, Healy has the following GPS receivers: GPS, DGPS, P-Code GPS, and 3-D GPS. Heading inputs include two gyrocompasses and the 3-D GPS heading information.

The ship is also outfitted with an electronic magnetic compass. A Dynamic Positioning System (DPS) is available for station keeping and slow speed transits (towing, dredging). It was designed and built by ALSTOM and integrates the use of propellers, rudders, and the bow thruster to accomplish ship movement. DPS Limitations: At best heading in open water, in a 20 kt wind, seas with a significant wave height of 4.0 feet and a 1 knot currents, Healy is capable of maintaining a position of +/- 150 feet or 3% of water depth (whichever is greater) from a point or trackline and maintain a heading of +/- 5 degrees. The seas and wind shall be from the same direction, with the current from less the 45 degrees off the wind.

Coring Systems

The Healy is equipped with a JPC (Jumbo Piston Core) system for taking deep sediment cores up to 25 meters. The JPC core is deployed from the Starboard A-Frame using 9/16 wire. The pivoting core bucket is bolted to the deck under the A-Frame.

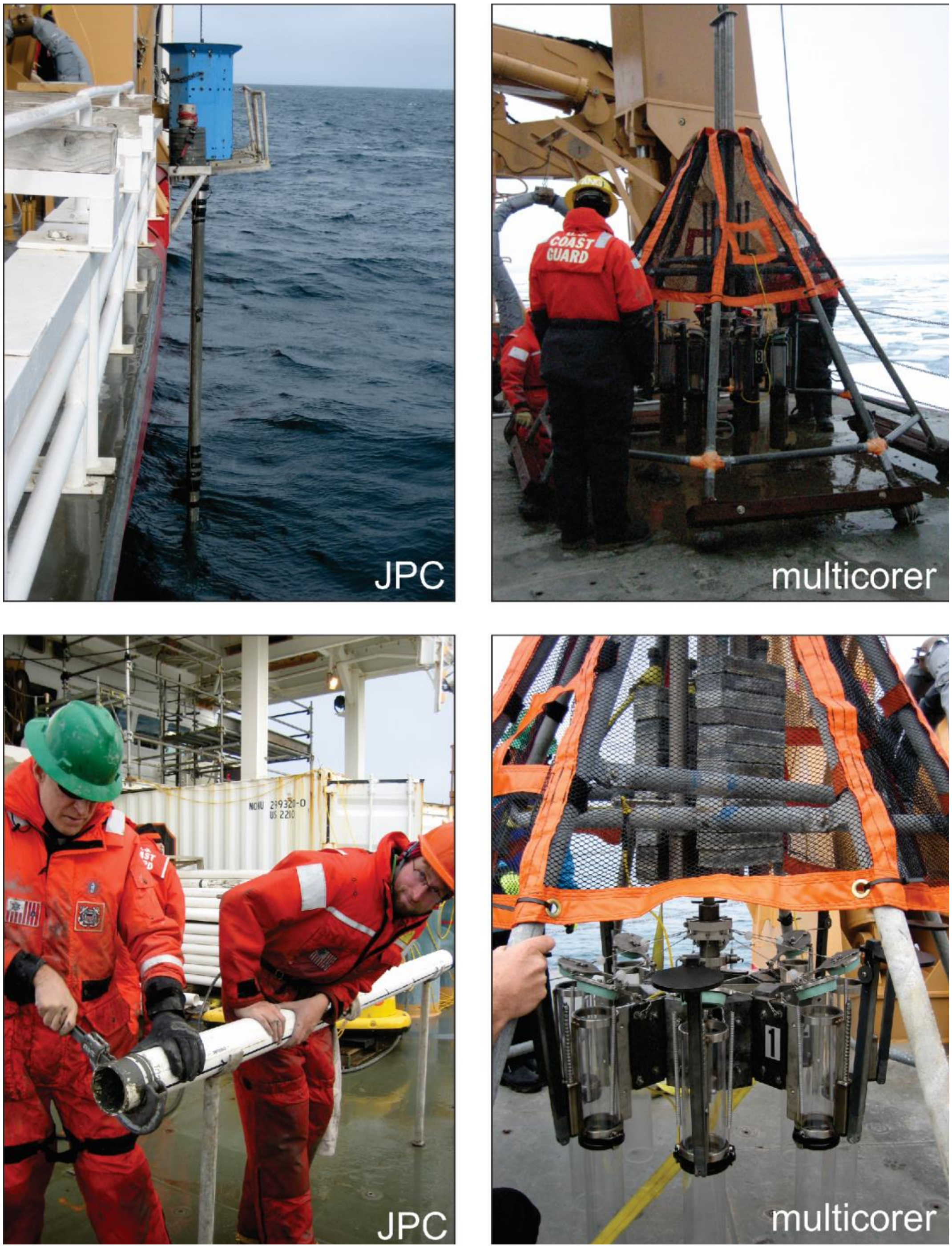

Figure 2. The Jumbo piston corer is (in the two left photographs) capable of collecting up to25 m cores. The Multicorer, featured in the right hand photographs, can collect 8 short cores simultaneously.

CTD operations can be carried out when the core bucket is installed, however the CTD must be lifted over the core bucket. Healy provides 4 core barrels and science users provide core liner. Healy typically has at least one 4,000 lb core head and one 5,000 lb core head in inventory. Healy also maintains a Gravity core system on board and other coring operations including a multicorer, Fig 2.

Kongsberg EM122 multibeam

Multibeam data was collected throughout the cruise using the EM 122 12 kHz multibeam echo sounder which is designed to perform seabed mapping bathymetry and seabed imagery to full ocean depth with high resolution coverage and accuracy. The system has up to 288 beams/432 soundings per swath with pointing angles automatically adjusted according to achievable coverage or operator defined limits. In multi-ping mode, 2 swaths are generated per ping cycle, with up to 864 soundings. The beam spacing is equidistant or equiangular. In high density mode more than one sounding can be produced per beam, such that the horizontal resolution is increased and is almost constant over the whole swath.

Figure 3. Multibean, 3.5 profiler and positional data is collected in the geophysical lab.

Knudsen 320B/R

Subbottom profile data was collected throughout the cruise using the Knudsen 320B/R which has two transceivers and is capable of operating as a subbottom profiler (CW at 3.5 KHz or frequency modulated chirp from 2 kHz to 6 kHz) and a conventional single beam echo sounder at 12 KHz. It is possible to run both modes simultaneously. Heave correction from the POS/MV is applied. Position data comes directly from a GPS receiver.

During normal operation on the Healy, the 12 KHz mode is not used as it interferes with operation of the multibeam system. The subbottom transducer array consists of sixteen Ocean Data Equipment Corp. TR-109 elements configured in a four by four array wired in a series-parallel arrangement and mounted in a transducer.

Like the multibeam array, the transducer is protected from the sea ice by a thick polyurethane ("SeaBeam Orange") window. The 12 kHz transducer may also be used for interrogating acoustic transponders and releases with an appropriate user-supplied deck unit.

Knudsen data is corrected for sound velocity using a uniform sound speed of 1,500 meters per second. Data files are routinely logged in KEA, KEB and SEG-Y formats. See Fig. 3 for layout of geophysical lab.

All sub-bottom data from the Canadian sector were converted from SEG-Y to JPEG 2000 format and can be used within a GSC-developed seismic interpretation program.

Chirp Sonar

The EG&G chirp sonar used during the Healy cruise is a wideband frequency modulated (FM) sub-bottom profiler utilizing full spectrum CHIRP technology. It generates high-resolution images of the sub-bottom stratigraphy in penetrating up to 200m.

Along with a towfish, a topside processor runs acquisition & processing software, as well as a customer-specified length of tow cable. It can be used in water depths of 3000 m. This profiling system was used at selected sites in Alaska and Canada when sea ice was not present.

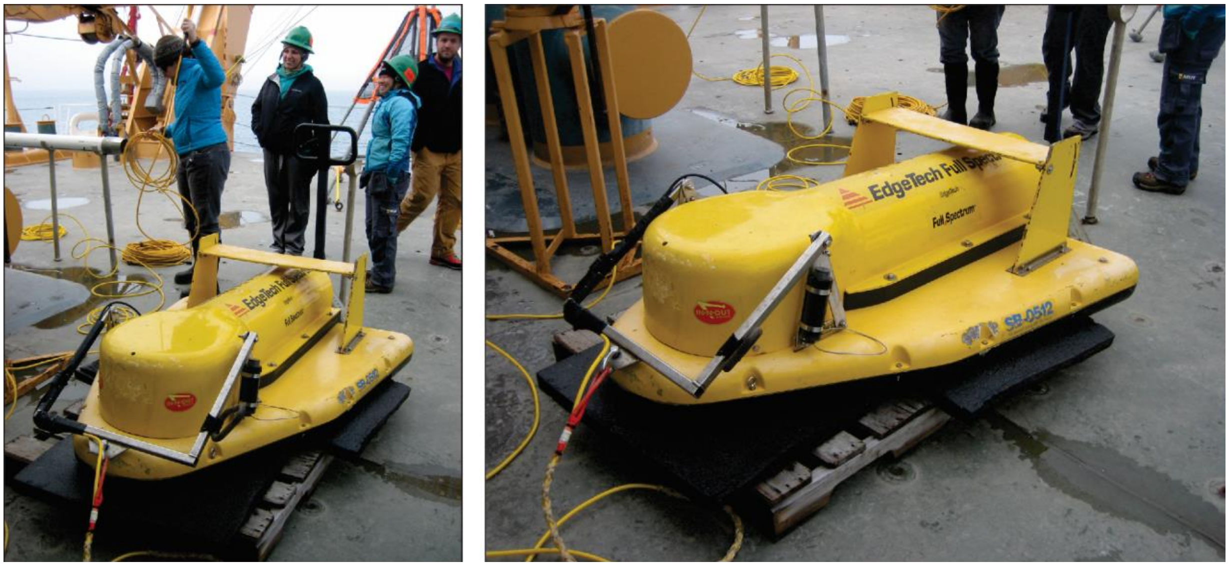

Figure 4. Chirp acoustic profiling system towed vehicle on the back deck of the icebreaker Healy.

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USCGC Healy Commander and Select Crew, 2013, Arctic West Summer 2013 USCGC Healy (WAGB 20) 11 Jul 2013- 05 Nov 2013 Cruise Report.

Appendix I: Daily Log

Wednesday 14th

I flew out of Halifax at noon to Anchorage through Chicago on United Airlines. It was a 3 hour 10 min flight to Chicago which was uneventful. The 6.5 hour flight from Chicago to Anchorage went well…we flew over the prairies and then the Rockies and the numerous ice fields and glaciers along the coast of Alaska to Anchorage.

Thursday August 15th

I woke at 4 am to catch a 6:10 flight to Barrow through Fairbanks and Prudhoe Bay (Dead Horse). We arrived in Barrow around 10:30 to heavy overcast skies with light drizzle. The terrain is flat, barren-land tundra which is poorly drained and very wet. Barrow is a native community which still continues to practice traditional activities like whale hunting by harpoon. We were shuttled to the ship between 1-3 pm by helicopter. We were assigned rooms and email accounts and I settled into my spacious cabin after supper, for a well-deserved rest.

Friday August 16th

I rose before 7 am…and had a breakfast of mostly fruit…need to get as much of this as possible while it is still available. We are preparing the labs and fantail deck for coring in the morning and will receive several more science crew members this afternoon. We will continue to rig the ship tomorrow and likely sail late in the day tomorrow. Our first core location will be in Barrow Canyon.

Saturday August 17th

Core locations were planned today with Lloyd and Neil in the morning and early afternoon. We decided that the first two stations will be in Barrow Canyon. I have convinced the co-chief scientists that the three stations in the western Canadian Beaufort are good targets to try to get sediment section older than 14 ka. We continue to prepare for survey work before leaving Barrow. The chirp is being re-rigged with a new cable. We should leave Barrow between 16:00 and 18:00 hours and survey with the chirp over the sites through the night and select targets for coring in the morning.

Sunday August 18th

We surveyed overnight in two core locations in the Barrow Canyon area. One at the Barc 5 core site and the other was at the Barrow 19 site. In both cases we ran chirp profile lines down slope from the site locations looking for good target locations. It was decided that the Barc5 location will be sampled on our return to Barrow at the end of the cruise because it is close to Barrow. We spent the day sampling at the second location (Barrow 19 site about 5-6 hours from Barrow), this is sample site 1. The multi-corer was used first and 4 of the eight cores were successful. Then we buried a 13 meter corer over the weight…a very successful core. We also collected a gravity core at this site. This site is named West Flank Barrow Canyon Station 1 with cores MC 0, MC1, JPC2 and GGC3.

Station 1 West Flank Barrow Canyon

MC0 72 08.661 155 22.049 415 m

MC1 72 08.650 155 22.020 401 m

JPC2 72 08.665 155 22.109 401 m

GGC3 72 08.641 155 22.080 400 m

Monday August 19th

We are transiting to the next site, P189AR-P45 in 405 meters of water. Once there we will survey all night and select a core site during the night. We will take a multicore, gravity core and a piston core at this location.

Tuesday August 20th

A change in plans has allowed us to survey a proposed IODP site overnight instead of the P-45 site. We multi-beamed this site and collected a grid of 3.5 data. We then collected chirp data through the night over the proposed core location. We are taking multicore, piston and gravity cores here today.

The coring was a success and we were able to recover good multicore, piston, and gravity cores at this site. The sample site was North-Slope-1 station 2 with GGC 4, JPC6 and MC7 cores taken.

Station 2 North Slope-1

GGC 4 70 57.201 145 39.420 411 m

JPC6 70 57.186 145 39.409 373 m

MC7 70 57.174 145 39.292 416 m

Wednesday August 21st

We surveyed the P-45 site last night. We collected multibeam and 3.5 first and then chirp surveyed after. When we find a good site the location is logged and given to the bridge. The geophysical data is of good quality.

I gave Neil the three Canadian sites in the Mackenzie region and we assigned a survey priority. The plan is to survey the Mackenzie Trough location first and then move to the slope locations. We will collect multibeam and 3.5 first and then chirp. We will likely be at the survey site today by 8 pm.

We are now collecting cores at P-45 and will occupy the site all day. The site is North Slope-2 close to Mackenzie River at station #3.

Station 3 North Slope-2 close to Mackenzie River

GGC8 70 35.002 142 25.220 396 m

JPC9 70 34.953 142 25.020 394 m

MC10 70 34.973 142 24.499 396 m

Thursday August 22nd

We surveyed the first Canadian core site in Mackenzie Trough last night. We first collected multibeam and 3.5 over the site. When the best core site was identified, we collected three chirp lines through the core location. All the seismic data looks great!

Station 4 in Mackenzie Trough

Station 4 GGC11 Lat 70 24.094 Long -139 18.718 in 685.6 m water depth on barrel (10 feet).

Station 4 MC-17 Lat 70 24.149 Long -139 18.548 in 686.3 8 cores were recovered.

Station 4 JPC-13 Lat 70 24.127 Long -139 18.7159 in 686 m 49 feet recovered.

Friday August 23rd

Very heavy ice cover in the vicinity of core sites BP10-PC24 and BP10-PC2 on the upper Mackenzie slope. We were only able to collect multibeam and 3.5 kHz profiler data. The chirp was not deployed because of heavy ice. The seismic data collected was of good quality. We surveyed a three line grid between the two core sites and found a good core location close to BP10-PC2.

Station 5 Eastern Mackenzie Trough (Beaufort Slope)

GGC14 Lat 71 06.308 Long 135 08.613

JPC15 Lat 71 06.222 Long 135 08.129 depth 687.2 m 50 ft

MC16 Lat 71 05.357 Long 135 08.798

Saturday August 24th

Today we found our way into the ice to find a location for ice liberty. We went out on the ice and took group photos and generally had a fun time. The science team made supper for the crew…many different kinds of pizza and salad…and we cleaned-up after…great fun!

We are now heading for our next core location near Amundsen Gulf.

Sunday August 25th

We are sailing to waypoints in Amundsen Gulf. After visiting one site we have decided to return to an area that we sailed past earlier in the day.

Monday August 26th

We have found a great site near a recessional moraine in the Amundsen Trough with thick sediments built out in front of the moraine. We have surveyed this location with 3.5 and multibeam. This is a great spot for deglaciation reconstruction in Amundsen Gulf. We will take a piston core, gravity and multicore at this site.

Station 6 Amundsen Gulf

GGC17 71 17.361 126 16.79 439 m water 20 foot core barrel

MC18 71 17.362 126 16.830 448 m water 20 foot core barrel

JPC19 71 17.398 126 16.800 442 m water 60 foot core barrel 50 foot recovery

Tuesday August 27th

We surveyed in Amundsen Gulf through the "Dave Scott" site on the way out of the Gulf. We visited the farthest McLean site but it was not a good site. We surveyed along the trough axes and into deep water. The sediment succession was mostly stacked debris flows out of the Amundsen Trough into deep water. This was not attractive geology for us. The ice was extremely heavy and it became impossible for use to move further west. We decided to turn south to get out of the ice and find better geology. We found both and are occupying a selected site now.

Station 7 SW corner of Amundsen Trough

GGC20 71 31.468 N 131 18.240 642 m 20 ft

MC21 71 31.427N 131 19.03 W 646 m

JPC22 71 31.66N 131 21.16W 668 m core separated

Wednesday August 28th

We are surveying an area south and west of last night's core site between Amundsen Trough mouth and Mackenzie area, on the slope between 400 and 700 meters. Ice cover is also bad in this area so the seismic data is degraded in ice. The weather is bright and sunny but cold at -4. We have cored this site…

Station 8 East Flank Mackenzie

GGC24 71 25.720 132 52.364 750m

JPC25 71 26.473 132 52.209 746m

MC22 71 27.36 132 51.82 740m

Thursday August 29th

We surveyed an area upslope from Station 5 in 400 to 200 meters of water. The idea is to sample sediment influenced by shallower water mass. We were able to recover only fair to good seismic data because of pack ice. Coring did not take place at this site; instead we went back to station 5 and took another piston core. We than went to find an ice island and after finding it placed a buoy/beacon on it for tracking purposes. We also took a CTD and launched a drifting buoy in the area. Now we are transiting to a Pingo field to survey in 30 to 50 meters of water. Ice continues to be heavy, but we are at the southern edge of it so still able to work.

Station 9 East Mackenzie Trough (Beaufort Slope)

JPC27 71 06.36 N 135 09.64 W 693 m

Station 10 Ice Island

Launch CTD and UpTemp0 drift buoy

71 11.724 N 136 54.655 W

Friday August 30th

Last night we surveyed a Pingo field on the eastern flank of Mackenzie Trough. We were very cautious in approaching these Pingos since they are in 40 to 50 meters of poorly chartered water. We ran the boat parallel to the trend of the features to first see them on the outer reaches of the multibeam…and it worked well. We found several excellent Pingos and great core locations; with great stratified sediments infilling low areas around the Pingos. The 3.5 data is excellent and we were able to image 50 or more meters below the seafloor. We have cored at one of the Pingo locations.

Station 11 Beaufort Shelf-Pingo

MC29 69 58.498 137 14.634 67.6 m

GGC30 69 58.481 137 14.551 60 m

JPC32 69 58.464 137 14.388 60 m

GGC33 69 58.608 137 14.768 66 m

GGC34 69 58.500 137 14.857 60 m

UpTempo buoy 70 14.000 138 41.538 m

Saturday August 31st

We surveyed more regional lines at station 5 in the Mackenzie Trough using 3.5 and multibeam sonar. These lines went further north over the self-break. Several cores were taken at station 5 (new station 12). A longer 60 foot core was attempted but failed to recover a deeper section.

Station 12 Beaufort Shelf

GGC33 69 58.608 137 14.768 66 m

GGC34 69 58.500 137 14.857 60 m

Station 13

upTempo drift buoy 70 14.005 138 41.538

Station 14 North Slope this station is a reoccupation of Station 4 a longer 60 foot core was attempted to try and recover a deeper section.

JPC36 70 24.134 139 18.585 665 m

Sunday September 1st

We surveyed using multibeam and 3.5 kHz sonar at Station 3 improving the seismic coverage. We have cored here again (Station 3) with a 70 foot piston core to sample deeper into the paleo record.

Station 15 (at Station 3)

JPC37 70 34.940 142 25.108 385 m

CTD38 plus buoy 70 35.156 142 24.619 393 m

Monday September 2nd

We surveyed a new area off the shelf in deep water, in a canyon area of the Alaskan slope. This part of the slope is a sediment by-pass area but we were able to find an over bank deposit on top of a canyon ridge that is an erosional remnant. The target area for the core is about 1.5 nm wide and we surveyed about 6 nm downslope using the multibeam and 3.5 kHz sonar. We recovered very successful cores from this spot.

Station 16 (new site) deep water site Lower Beaufort off Alaska

GGC39 71 24.117 148 51.737 1616 m

JPC41 71 24.216 -148 52.543 1623 m

MC42 71 24.266 148 51.991 1616 m

UpTemp Buoy 71 23.690 148 50.621

Tuesday September 3rd

We did not sample the site that we surveyed last night, which is site 17, because of weather. Coring activities are waiting out the weather. We have moved into Barrow canyon to survey.

Wednesday September 4th

We are now sampling at station 17 a deep water site with canyons. We started surveying a grid across Barrow Canyon.

Station 17

JPC44 71 41.407 151 21.128 1439 m

GGC45 71 41.425 151 21.039 1438 m

MC47 71 41.431 151 20.985 1437 m

Thursday September 5th

We have moved into Barrow Canyon and are taking 9-10 CTD casts. We have surveyed a grid across Barrow Canyon after the CTD work, using the multibeam and 3.5 kHz sonar, looking for bedform features on the western flank of the Canyon and possible shoreline benches on the eastern flank.

Friday Sept 6th

We surveyed through part of the day and through the night and finished about 7 am Friday morning. We are now at anchor off Barrow and this phase of the Healy 1302 expedition is finished!

Appendix II: Stations Log

Station	CoreNo	Latitude	Longitude	Depth _m	Length_cm	Comments
1	MC0	72.14435	-155.36748	415		West flank Barrow Canyon
1	MC1	72.14417	-155.36701	401	60	West flank Barrow Canyon
1	JPC2	72.14442	-155.36848	401	1123	West flank Barrow Canyon
1	GGC3	72.14402	-155.36801	400	313	West flank Barrow Canyon
2	GGC4	70.95335	-145.65701	411	404	North Slope 1
2	JPC6	70.95311	-145.65682	373	1201	North Slope 1
2	MC7	70.95291	-145.65487	416	40	North Slope 1
3	GGC8	70.58337	-142.42033	396	465	North Slope 2 close to Mackenzie River
3	JPC9	70.58255	-142.41701	394	1341	North Slope 2 close to Mackenzie River
3	MC10	70.58288	-142.40832	396	47	North Slope 2 close to Mackenzie River
4	GGC11	70.40157	-139.31197	685.6	411	Mackenzie Trough, 10 foot barrel
4	MC12	70.40248	-139.30913	686.3	38	Mackenzie Trough, 8 cores were recovered
4	JPC13	70.402133	-139.311933	686	1413	Mackenzie Trough, 15 m recovered
5	GGC14	71.10513	-135.14355	0	329	Eastern Mackensie Trough (Beaufort slope)
5	JPC15	71.10371	-135.13548	687.2	1335	Eastern Mackensie Trough (Beaufort slope)
5	MC16	71.08928	-135.14663	0	39	Eastern Mackensie Trough (Beaufort slope)
6	GGC17	71.28935	-126.27983	439	398	6 m core barrel
6	MC18	71.28937	-126.2805	448	46	6 m core barrel
6	JPC19	71.28997	-126.28001	442	1288	18 meter core barrel
7	GGC20	71.52447	-131.30401	642	332	SW corner amundsen Trough, 6 m barrel
7	MC21	71.52378	-131.31717	646	39	SW corner amundsen Trough
7	JPC22	71.52767	-131.35267	668	1421	SW corner amundsen Trough, core separated
8	GGC24	71.42867	-132.87273	750	254	East Flank Mackenzie
8	JPC25	71.44121	-132.87015	746	1368	East Flank Mackenzie
8	MC26	71.45601	-132.86367	740	40	East Flank Mackenzie
9	JPC27	71.10601	-135.16067	693	1524	East Mackenzie Trough (Beaufort Slope)
10	CTD, buoy	71.1954	-136.91091	0		CTD and UpTemp0 buoy, Ice Island
11	MC29	69.97497	-137.2439	67.6	47	Beaufort Shelf Pingo
11	GGC30	69.97468	-137.24252	60	285	Beaufort Shelf Pingo
11	JPC32	69.7944	-137.2398	60	1410	Beaufort Shelf Pingo
12	GGC33	69.97681	-137.24613	66	162	Beaufort Shelf
12	GGC34	69.97501	-137.24762	60	319	Beaufort Shelf
13	buoy	70.23342	-138.69231	0		upTempo Buoy
14	JPC36	70.40223	-139.30975	665	1708	North Beaufort Slope
15	JPC37	70.58233	-142.41847	385	1366	revisit Station 3 for longer core
15	buoy CTD	70.58593	-142.41032	393		CTD38 plus buoy
16	GGC39	71.40195	-148.86228	1616	488	Lower Beaufort off Alaska
16	JPC41	71.40361	-148.87572	1623	1526	Lower Beaufort off Alaska
16	MC42	71.40443	-148.86652	1616	50	Lower Beaufort off Alaska
16	buoy CTD	71.39483	-148.84368	0		UpTemp Buoy Lower Beaufort off Alaska
17	JPC44	71.69012	-151.35213	1439	1607	Beaufort/Chukchi Slope
17	GGC45	71.69042	-151.35065	1438	472	Beaufort/Chukchi Slope
17	MC46	71.69051	-151.34975	1437	50	Beaufort/Chukchi Slope
18	DBO line					Barrow Canyon
18	MC47	71.4135	-157.503	124	29	Barrow Canyon

Cores collected at each station and their locations. The coring operations occupied 17 stations with a total of 12 multi cores, 14 jumbo piston cores and 15 giant gravity cores collected.

Appendix III: Science Party Participants List

Last name	***First Name***	***Email***	***Phone***	***Address***
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