Cruise 2001 Louis S. St. Laurent

PASSAGE

Pathway to the Arctic
Seismic Survey and Geoscientific Experiment

Resolute (Nunavut) to Thule (Greenland)

H.R. Jackson and Shipboard Party

Open File 4282

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PASSAGE 2001

Seismic Survey and Geoscientific Experiment

Resolute (Nunavut) to Thule (Greenland)

Pathway to the Arctic

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Authors

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***Cover design**: Thomas Funck*

Objectives of the Nares Strait Project

Nares Strait, the international boundary between Canada and Greenland (Denmark), separates rocks of similar age and character but contrasting styles of deformation. The strait is a unique laboratory for studying continental deformation because the amount and timing of it is quantitatively constrained by plate reconstructions. Greenland had spreading ridges on both sides. The motion of these ridges is recorded in the framing magnetic anomalies that enable the displacement between Greenland and Ellesmere Island to be determined. The debate on the origin of Nares Strait, aggravated by lack of data offshore, revolves around three hypotheses: the strait is a major strike-slip fault; plate motion has been taken up in a broad band of deformation; and the strait is not a tectonic boundary and the geology can be correlated across it.

The boundaries separating the main geological provinces of Nares Strait are not only surface features but are also crustal in extent. Therefore to determine the nature of the deformation a multidisciplinary examination from surface to upper mantle has been designed. In order to assess the relative merits of the hypotheses the project will:

1. Correlate the onshore geology into the strait;
2. Determine if surface deformation has occurred along the strait and if so, identify the stratigraphic units that are involved and characterize associated fault planes and their depths of detachment;
3. Identify the type and amount of deformation in the crust and upper mantle using seismic reflection, refraction and potential field information;
4. Constrain the timing of deformation using apatite fission track and other absolute dating techniques on rock samples collected from eastern Ellesmere Island and adjacent Greenland, and correlate this with constraints from the magnetic lineations;

Finally, scientific papers, geological transects and appropriate offshore geology maps of the report area based on the integrated program will be produced.

CCGS Louis S. St-Laurent Crew on Board

(North) As of: 19-Aug-01

Position (Rank)	Surname	Given Name	Cabin Assignment
Commanding Officer	Klebert	Stewart	
Chief Officer	Strowbridge	Robert W	
First Officer	Cooper	Richard	202
Second Officer	Boone	Ross	208
Third Officer	Hartling	Kevin	203
Chief Engineer	Meating	Paul	
Senior Engineer	Hewens	Stephen	411
First Engineer	Sarty	William	410
Second Engineer	Marceau	Julien	409
Third Engineer	Stevens	Freeman	408
Electrical Officer	Seaboyer	Phillip	407
Logistics Officer	Johnston	Rod	316
Electrician	Walsh	Edward	417
Bosun	Taylor	Robert	420
Leading Seaman	Robinson	Gerard	520
Carpenter	Mackenzie	Garth	542
Leading Seaman	Sutts	Gary	539
Leading Seaman	Hiltz	Dale	540
Seaman	Jollymore	Neil	518

Seaman	Fitzgerald	Jack	541
Seaman	Bogorode	Constantin	519
Seaman	Joncas	Judith	538
Seaman	Publicover	Colin	521
Engine Room Technician	Gale	James	550
Engine Room Technician	Smith	Burt	548
Engine Room Technician	Crews	Paul	552
Oiler	Barras	Trevor	512
Oiler	Langille	Winston	517
Oiler	Trahan	Paul	549
Oiler	Myers	Alexander	510
Oiler	Broas	Ariel	516
Oiler	Butt	Stephanie	514
Chief Cook	Connors	Walter	419
Storekeeper	Demerchant	Andrew	544
Storekeeper	Hann	Thomas	546
Assistant Cook	Anderson	Joan	543
Assistant Cook	Mcmahon	Thomas	545
Assistant Cook	Anderson	Phillip	522
Steward	Metcalfe	John	532
Steward	Higgins	Leo	530
Steward	Swain	Lester	528
Steward	Burhoe	Moira	524
Steward	Briffett	Peter	525
Helicopter Pilot	Godin	Adrien	423
Helicopter Pilot	Macrae	Harrison	421
Helicopter Engineer	Peachy	Peter	425
Helicopter Engineer	Autran	Pierre	423
Electronics Technician	Brown	J.G. Robert	422
Medical Officer	Snider	Karen	317
Ice Observer	Stock	Colin	315
Officer Cadet	Robitaille	Nicole	515
Scientific staff	Chapman	Borden	416
Scientific staff	Moller	Heinz	547
Scientific staff	van der Vliet	Rutger	612
Scientific staff	Helfferich	Vincent	611
Scientific staff	Anderson	Jason	609
Scientific staff	Halls	Henry	553
Scientific staff	Dehler	Sonya	311
Scientific staff	Tessensohn	Franz	301
Scientific staff	Woodbridge	John	610
Scientific staff	Damaske	Detlef	405
Scientific staff	Zentilli	Marcos	404
Scientific staff	Jackson	Ruth	310
Scientific staff	Nixon	Cory	513
Scientific staff	Jodrey	Fred	511
Scientific staff	Atagootak	Brian	605
Scientific staff	Nungaq	Jimmy	605
Scientific staff	Mudie	Peta	304
Scientific staff	Brent	Thomas	303
Scientific staff	Neben	Sonke	302
Scientific staff	Harrison	Christopher	303
Scientific staff	Oakey	Gordon	507

Scientific staff	Funck	Thomas	309
Scientific staff	Johnston	Larry	506
Scientific staff	Eert	Jane	509
Scientific staff	Morris	Robert	406
Scientific staff	Hall	Patricia	529
Scientific staff	Jensen	Anna	528
Scientific staff	Sapey	Justin	418
Scientific staff	Bailey	James	607
Scientific staff	Reid	Ian	308
Hydrographer	Welmers	Arnold	551
Scientific staff	Nielsen	Lasse	617
Scientific staff	Miller	Iain	608
Scientific staff	Grist	Alexander	508

Diary

August 2, 2001 Day 214 Thursday Halifax-Iqaluit-Halifax.

All the scientific staff arrived by 6:00 am (local time) at the airport in Halifax for the 7:00 am chartered flight to Thule, Greenland. About half of the Canadian Coast Guard crew were late due to the fact that the transfer bus did not show up at the base. We left in bright sunny conditions and arrived at Iqaluit to see the run way lined with bright purple flowers (broad leafed Willowherb), a most unexpected and enjoyable sight. Especially after the bleak and wind swept frigid picture that greeted me in late April during my stop over on the way to Grise Fiord, the nearest community to the Nares Strait project (Passages).

Initially we were told not to get off the aircraft for a quick fueling would be done. Almost immediately we were asked to deplane. After a multi-hour wait the aircraft flew back to Halifax. The airport in Thule we eventually learned had been closed due to unusually heavy rains causing flooding and interrupting fuel and water supplies. A disappointed group flew back to Halifax and the crew already on the Louis S. St Laurent did not get their scheduled flight home. The flight was rescheduled for Sunday. Since many people did not leave in Halifax this meant much scrambling for places to stay.

As we flew away from Nares Strait it reminded me of the difficulties the early explorers had in reaching and transiting this passage. It is hoped that the CCGS Louis S. St-Laurent voyage in 2001 will emulate the voyage of Admiral Sir George S. Nares of the Royal Navy. He made the first successful navigation of the strait to and from the Arctic Ocean in 1875-1876 and his name was given to this waterway between Greenland and Ellesmere Island.

Fig. 1. *The flooding conditions at Thule Air Base that prevented the chartered flight from Halifax to Thule from landing. Note the nearly-washed-out bridge.*

August 5, 2001 Day 217 Sunday Halifax to Iqaluit.

The same drill at the airport with an early morning start. All the staff and ship's personnel were ready for the flight. Meanwhile the ship had traveled through heavy ice from Thule along the Northwest Passage to get to Resolute Bay.

The aircraft left Halifax as scheduled and touched down in Iqaluit. We were told there would be a delay. Fog in Resolute Bay, a visible lowering of spirits spread through the group. After an extended wait the flight was canceled and we had to find accommodations in Iqaluit. The scientific staff found cheap accommodations at $65 a person in the Mariner Lodge and were glad of it. This second delay took us by surprise although considering the first experience it should have been expected.

August 6, 2001 Day 217 Monday Iqaluit-Resolute Bay-CCG S Louis S. ST-Laurent (LSL).

We woke up to heavy fog in Iqaluit. We dutifully loaded up our luggage and proceeded to the airport to wait for our flight. Flight after flight was cancelled. The weather in Resolute Bay was clear. Not long after the planned departure time of 9:30 am the 748 aircraft lifted into the air. There were sighs of relief from all.

In Resolute Bay the departing scientific staff met us at the airport. The replacement helicopter crews were flown to the ship and transfer of crew and staff began by helicopter thereafter. By 17:00 the ship was underway. There was frantic activity finding and unpacking scientific equipment.

Fig. 2. *A view of Iqaluit and Frobisher Bay from the hill behind the town.*

First a meeting with the ship's heads of departments and the senior staff was held to determine basic operating methods. This was followed by an assembly of the scientific staff to familiarize and present plans for the next few days. The set up of the computer laboratory was begun. Due to a recent virus Bob Brown the computer specialist had to scan all computers before connecting to the ship's network.

August 7, 2001 Day 218 Tuesday

Steaming along Lancaster Sound. The ice conditions are light and good progress was made during the night. The cliffs of Devon Island were a welcomed sight.

The parties flying on the helicopters had a video on operating procedures as part of the familiarization prior to flying on the helicopters. Three parties left on the helicopters: the fission track group, bedrock geologists and dyke mapping group. On board ship the technical support began preparing the compressors, airguns and electronics for the seismic reflection system. Fred Jodrey was working diligently to get the winch ready for coring. He was having trouble with the planned repairs and support from the engine room was required to get heat to it to increase the parts.

In addition, as part of the scientific staff's initiation we had an overview of the ship's safety features and fire and boat drill. By that time I realized that the seismic system would not be ready by tomorrow morning and reported the problem to Franz Tessensohn the chief scientist. This necessitated a change in plans and a meeting to update the scientific staff on the changes.

The geological field parties returned from southern Devon having spotted three polar bears, seals, walrus and muskox on Philpotts Island. Scientific discussions followed.

The navigation system was not as I expected. The hydrographer Arnie Welmers had loaded his preferred system HYPAC on the GSC computer and GPS connection planned or the Regulus navigation program. His system worked well for his needs but he was unaware of our requirements. His software was not satisfactory due to the need for using the system for firing the airgun array and the possibility he would take the system off the ship and into the launch leaving us with no capability of logging the navigation. Bob Brown the network specialist could deliver the navigation stream to several locations but not the bathymetry. We settled on returning the Regulus system to the GSC computer and giving another GSC computer to Arnie to run his system so he could log the digital navigation. It is further frustrating because we have no clock to deliver a pulse to the sounder to put regular time marks on it so we have to do this manually. Sonya Dehler is working diligently to establish a protocol for watch keeping.

We had fire and boat drills today which were necessary but time consuming. Fred and Larry were struggling with the coring winch most of the day. After supper they reported it operational for the core that is now scheduled for 5:30 l tomorrow. Meanwhile the 3/4 inch shackles Borden had ordered and were labeled as such were discovered to be 7/8 inch and had to be modified by the machine shop. The continuous water needed by the compressors was a problem for the ship and the pump and valve assigned to the task were giving problems that are as yet unsolved.

Fig. 3. *Brian Atagootak watching Jimmy Nungaq from Grise Fiord putting on a survival suit in a life boat drill. The helicopter pilot assisting them is Adrian Godin*

Peta Mudie was planning the core sight to be at 75°33N 78°49W based on the information she had from Andre Rochon's box coring activities on the previous leg. Jane Eert would also do a twenty bottle cast and a CTD at the same site. The timing of the sampling kept getting later as the fog increased and the ship slowed due to it.

Vincent and Rutger are working on taking and organizing pictures of scientific staff and crew. They have taken 33 of 85 persons onboard. This task demands diligence and a high degree of diplomacy.

August 8, 2001 Day 220 Wednesday Coburg Island to Cape Alexander Greenland

Foggy, steaming slowly, by noon clearing and sunny. Overnight a conductivity, temperature and depth (CTD) measurement and water rosette sampling were accomplished and an 11 m (37.5 ft) piston core. The coring operation did not go smoothly. One core head is missing a ring that causes it to twist on launch. This may have been the problem on the previous leg that caused the coring attempt to fail. Once it was replaced the operation went well There were also start up problems with the CTD winch that meant the sampling operation took over 4 hours in shallow water. This is exacerbated by the slow speed of the Hawbolts winch.

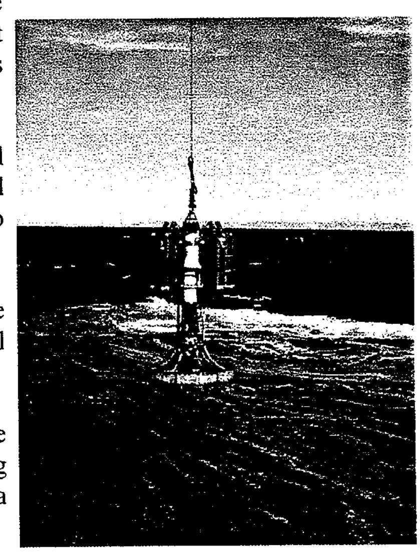

Fig. 4. *CTD Rosette just before being lowered into the water.*

Vincent attempted to turn on the computer that holds the software for the digital camera and the on/off button failed. He used duct tape and a coin to hold it on and the computer is up and running until the technical support staff can find time to fix the problem in a less jury rigged fashion.

The seismic team have the GI airguns attached to the beams and have to make the fittings from the British group match the hoses etc from the GSC. The water still has to be supplied from the ship to the compressors for cooling.

Until repairs are completed on the radars Bob Brown is not available to move the computers in the Geophysics lab so that Regulus can be set up. Sonya after being up during the night participating in the coring and CTD cast is designing a manual for the watch keepers.

The students from Grise Fiord, Jimmy Nungaq and Brian Atagootak, assisted Pat Hall with the marine mammal watch. Within one minute Brian sighted a seal. He is obviously an asset to this program. The students requested assistance with a phone call home. The ship's electronics technician assisted Brian and Jimmy with a call but it was busy at home. They tried about an hour later and were successful.

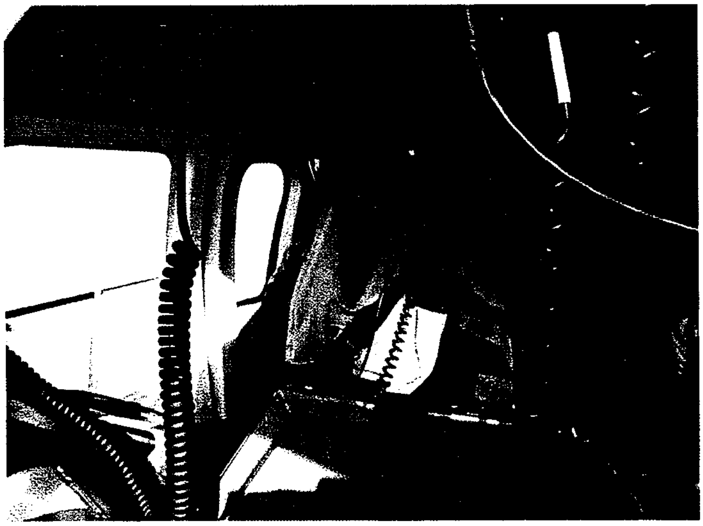

Fig. 5. *Jimmy Nungaq plans to be a helicopter pilot.*

We were off Clarence Head where there were many icebergs, perhaps they were aground in the shoals shown on the bathymetry map. The bright sun brought many of the scientific staff to the bow to watch the scenery and photograph it. Just before 15:00 l we crossed the border with Denmark and Anna Jensen raised the Danish flag.

The ship moved slowly during the morning due to fog and repairs to the radar; we picked up speed in the afternoon. Therefore we ran through several scenarios of possible activities. The configuration of the ice constrains us to south of Northumberland Island to shoot the first refraction line. In order for the Geodetic group to reach Cape Isabella and the magnetic group to set up the station magnetics we must be as far north as possible. This configuration means tomorrow will be dedicated to flying with the possibility of a n IKU dredge station. The hydrographer Arnie Welmars will also collect new bathymetric data north of Northumberland Island. Due to this he will be off the ship tomorrow and need sleep the night before therefore several watch keepers were trained to mark the bathymetric chart.

Chris Harrison remarked that when he was on Philpotts Island yesterday the large mylonite shear zones showed both dip/ slip and translation in a direction similar to that mapped on our seismic data base. This was of particular interest because the tying of onshore and offshore geological and geophysical data is one of the themes of our expedition.

With effort above and beyond the call of duty Bob Brown got the navigation system HYPAC installed on one of our computers for the hydrographer and Regulus was running on the computer we intended in a convenient spot in the GP lab.

The fog rolled in after supper and then left again. The water was flat calm with large icebergs both tabular and weathered, and the cliffs of Clarence Head to provide spectacular opportunities for photography. Without any wind the stern provided a fine viewing platform.

Vincent Helfferich and Rutger van der Vliet, students from the Vrjie University, stood an over night watch for the first time in support of the hydrographic program being run between Greenland and Northumberland Island.

August 9, 2001 Day 221 Thursday

Bright and sunny morning with the winds picking up from the north.

The Captain came to the Chief and senior scientists and made a proposal to extend the cruise until September 10, a four day extension. Due to the complicated contract arrangements we are carefully considering our options. A recommendation will be made from the representatives of BGR and GSC to their respective managements and their response will be awaited with interest.

During the day there was a lot of activity preparing the airgun array for firing. Heavy winds delayed deployment until 20:00 l. The tests went well. All air hoses and compressors and hydraulics working, one GI gun only firing on one of the two cylinders. Shot break phones signal is now recording electronically. It was disappointing that the sound of the GI guns is not readily heard above the noise. Pat Hall consistently monitored for marine mammals from 17:00 1 to the end of the seismic tests and saw nothing,

The preparations for seismic reflection profiling had consequences for the cabin assignments. It was not realized that there were no telephones below the fourth deck. Therefore we had to exchange rooms so that Borden Chapman and Justin Sapey had cabins with telephones in case of emergencies. This meant moving Henry Halls and Jason Anderson while they were at a base camp on Greenland.

The geodetic field parties had a successful day. They set up two base stations at Cape Alexander; the one closest to the shore also had a tide gauge installed. The third station was at Cape Isabella. These points received their names from the ships John Ross used in his exploration of the area in 1818. This group had joined the ship in Thule having flown in from Greenland and had to wait while the ship steamed to Resolute to pick up the rest of the staff and they were anxious to start their program The station magnetometer was also deployed near Cape Alexander.

Due to the fact that the scientific staff did not bring a network specialist many people have not yet been connected to the ship's network. This is restricting printing and file moving capabilities that are inhibiting scientific operations such as producing a cruise report. I also discovered that when the ship is moving rapidly at 12 knots or greater I cannot use the a: drive due to vibrations.

August 10,2001 Day 122 Friday

Sunny calm, ice free seas with spectacular icebergs near Northumberland Island.

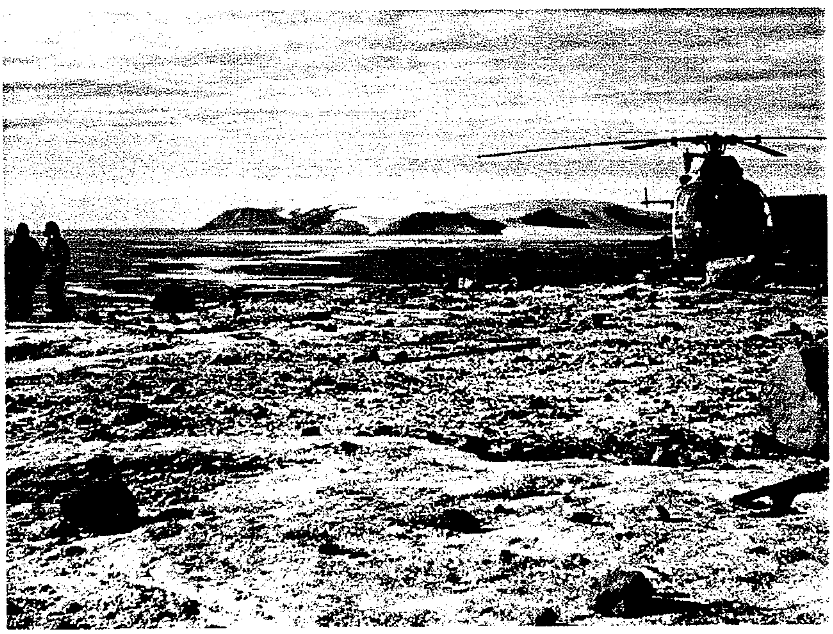

Fig. 6. *Cape Isabella, Ellesmere Island looking across at Cape Alexander, Greenland*

High quality images of the ice from both Radarsat and visual were received yesterday. The center portion of Kane Basin has ice conditions of 2-4 tenths and so does most of Kennedy Channel. No dramatic change as yet; ice conditions are still heavier than will allow for seismic reflection or refraction profiling. It is worth noting that Kane Basin was named after the American explorer Dr. Elisha K. Kane. He led an expedition in search of John Franklin in 1853-55 that contributed to the geological knowledge of the region.

The port airgun array was deployed after breakfast. The GI gun firing only one of its two cylinders was removed and replaced with a spare. The solenoids were working so this was deemed the most expedient repair.

The officials at BGR replied that they would accept the cruise extension offered out of good will by the Canadian Coast Guard. They of course were concerned there would be no additional charges and this was varied by email and that the ship would return to Thule so that the expensive rental of the hydrophone array could be terminated by shipping it south by the military.

At about noon the fog rolled in and prevented any field parties flying to the Carey Islands. This was unfortunate because it would have been useful to get fission track information on the age of uplift. It is of interest to note that the Carey Islands, Wolstenholme Island, and Smith Sound were discovered and named by William Baffin and Robert Bylot in 1616. The hydrographer Arnie Welmer noticed a distinct offset on the sounding record with steep sides coupled by another offset forming a small "graben" feature. The bathymetry map showed many steep faults.

The shooting of the first multichannel seismic profile began after supper. The one gun that was firing only partially was due to a fault in the electrical cables, not the solenoid or the gun itself as initially thought. The streamer was deployed without major problems. It had to be partially brought back in to readjust a bird that was not operating properly to keep the hydrophone array at a constant depth.

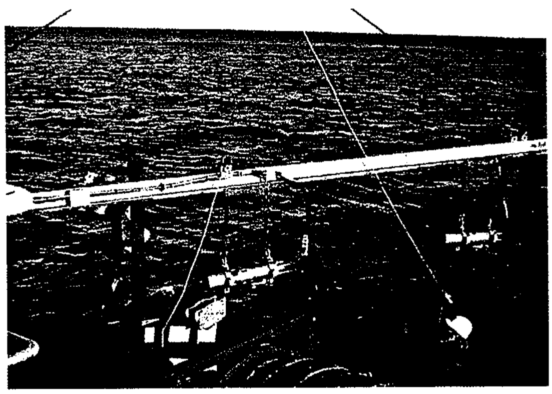

Fig. 7. *Deployment of the GI guns. The double ports inject the air bubble of the first into the second significantly reducing the bubble pulse.*

August 11, 2001 Saturday Day 11

Bright and sunny, flat calm.

Up at 2:00 am to bright sun and I put my sun glasses on. The horizon on the bridge consisted of the mountains near Clarence Head, many icebergs and a few small pieces of pack ice, all capable of damaging the streamer trailing 1370m behind the ship. The first few hours of watch were stressful as we threaded a way between the bergs as close as 1 cable from the ship and tried to predict the direction of the drift into the trailing gear. The officers and crew on the bridge and the seismic group contracted to run the system were all helpful. At near 6:00 am the line was terminated due to lack of soundings on the bathymetry charts.

The slow turn began under Soenke's guidance. We realized that the airgun beams could not be towed closer to the ship or they would turn side ways. The turn was too quick because it caused the airgun array and the streamer to cross. No damage was done. Meanwhile the first seismic line Nares_01 was played out, all 68.129 km. The data quality was high and revealed a series of interesting features.

The next line was started when Borden announced he would need to shut down the airguns for half an hour to repair a cooling hose for the compressor. We were back in operation in less than an hour. The line length was 102 km and the structures were complex and intriguing, and triggered lots of conversation and gesticulating.

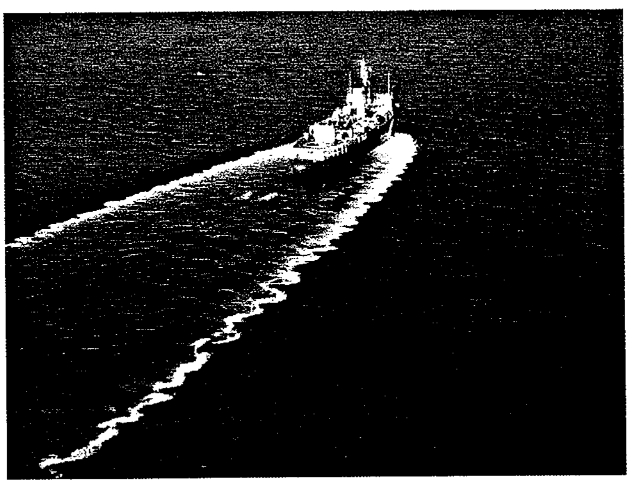

Fig. 8. *Louis S Saint Laurent towing the GI airgun array in nearly ice free waters*

August 12, 2001 Sunday Day 224

Bright sunny morning.

Seismic reflection ran all night. Line 03 finished at about 8:00 l followed immediately by the start of line 4 on a new course as we zigzag our way northward to Smith Sound. Mid morning problems with the recording of the seismics were pursued by the loss of two air guns. The starboard array with the two non-functioning airguns could not be brought in without hauling in the streamer. Therefore, we steamed towards Cape Alexander with just four guns. The icebergs and bergy bits in the water require the mates on the bridge to closely watch the ice as it comes up to the ship and follow it carefully as it drifts across the stern. It was necessary on several occasions to use the birds on the streamer to dive from 7 to 15 meters to protect it.

In order to better understand the seismic profiles we have collected and to allow the students from the Vrije University to participate in the science program, Chris Harrison and Tom Brent are organizing the interpretation, plotting and displaying of the seismic profiles. The onshore geology, in particular faults, will be added to this compilation to assist in onshore-offshore correlations. This is required for planning future lines in this program.

Franz has noted that due to ice on the Canadian margin, lack of soundings in regions off Greenland and not planning long enough lines on the Greenland margin we could be open for criticism that we have missed significant strike-slip features. We will correct this when we return to the area on the way south. Due to the still heavy ice conditions in Kane Basin we are considering a variety of plans in the more ice free areas to meet our scientific objectives. An ideal deep seismic refraction would be from Makinson Inlet to Hvalsund. These thoughts are back up plans in case the ice does not move out of Nares Strait in the next three weeks.

The watch keeping has stabilized with six reliable watch keepers and Sonya checking the navigation logging daily. Peta reports that her 33 meter core is everything she had hoped for and more. It has the slow sedimentation rates needed for high resolution, the formanifera and the shells for age dating and isotopic controls. The students Brian, Rutger and Vincent are all participating in cutting and photographing the core. Peta and Pat are both taking special interest in Brian to insure that he has a good understanding of both their disciplines. I hope this helps the time pass for him while Jimmy is on a field party on the land and he is here on the ship.

The clear visibility allowed for the helicopters to fly to Northumberland Island to pick up the field party of five that consisted of the groups studying dykes, dating uplift of rocks and their guide. They returned to the ship pleased to get a shower and a more varied diet. The melting permafrost, the steep scree slopes and the great distances made the work challenging. The CCG helicopter pilots exhibited skill in getting the geologists to high ledges to do their sampling. Brian Atagootak was pleased to see his buddy Jimmy Ningaq again.

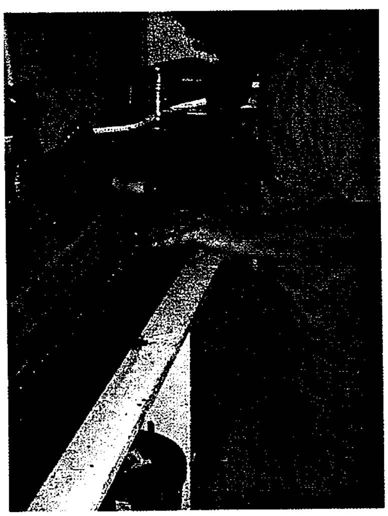

Fig. 9. *Fred Jodrey splitting the core from the region between Devon and Coburg Islands*

The day's activities also included the geodetic crews of Anna Jensen, Lasse and Bob Morris flying out to retrieve their stations and set up new ones as well. Detlef Damaske went out to check on the station magnetometer.

The waters for the planned line 05 are infested with sea ice. Modifications to the array such as shortening and using the ship's bubbler system to protect the array are being considered. Up until mid afternoon we had collected about 300 km of seismic data.

Sunday supper for eight was held in the Captain's dining room. This was a formal affair with ship's personnel dressed in their number one uniforms. But not so formal that they wore their jackets. Wine was served with the meals. Henry Halls was the star conversationalist.

The bubbler system was turned on as the density of the sea ice increased to several tenths. The system operated well for several hours. Then a current from the south perhaps generated by tides caused the bubbler's wake to no longer make a symmetrical path behind the ship. At about 23:00 l the tail buoy snagged on a piece of ice and broke off. The ship was slowed and the array was shortened to half its length, 600ft.

The bubbler certainly protects the airgun array and would probably be useful for retrieving the OBS. The ship and bubbler could open up an area and then the instrument could be recalled.

August 13, 2001 Monday Day 225

Foggy, multi tenth's of ice.

We moved slowly through Smith Sound into Kane Basin. We are moving to a position in central Kane Basin in which it will be possible to act as a base for helicopters flying a regional magnetic survey. Last night a total of two floats were lost on the tail of the streamer, one after it was shortened to half its length. The wind was across the beam and the ice cut across the wake. The bubbler would be more effective in conditions without cross winds. The Regulus navigation system was accidentally stopped last night hopefully after the end of the seismic line. The data logging was restored after 45 minutes.

We planned a Huntec survey for the central less ice congested zone of Kane Basin. The shape was constrained by ice conditions, the need to remain near a central region for the helicopter operation base and information from the seismic lines discovered by Tom Brent. Water and sediment samples were also planned and co-ordinated.

During the day the fog and the flow size (large to medium) meant for slow progress. The ship had to occasionally back and ram. The ice around the ship at one location contained great piles of rounded rocks perhaps acquired when the ice was shore fast during the spring run off. There were also a number of icebergs within the large flows. We were trying to reach the centre of Kane Basin so that the position of the ship would be most convenient for flying field geological parties to specified sites and accomplishing the aeromagnetic grid.

The conditions in the central ice area was 4 tenths ice with medium to large flows. The flow size is critical for the towing of equipment behind the ship. If there are several tenths of ice and the flow size is ice cakes of several meters and the ship's bubbler system is run, then there is an ice free zone behind the ship that would enable safe towing. Careful monitoring of the ice conditions at the stern of the ship took place most of the day. At supper time when we had reached the starting point it was obvious the Huntec would be torn from its towing point in a matter of minutes. The water sampling program went ahead. The ice observer also pointed out that interpretations of Radarsat ice images can never include ice floes less than medium to large size because any less is less than the resolution ability of the image.

The fog lifted late in the afternoon and the geodetic program flew to a site in Inglefieldland. The pilot Harrison McCrae returned with the information that the weather conditions were suitable for flying in the region as a whole and Henry was taken to a location on Inglefieldland next. The second helicopter was prepared for the beginning of the magnetic survey.

The marine mammal watches are still being carried out from the bridge but supported by observations from the personnel in the helicopters. On a large flow near the ship a seal was resting on the ice for some time until a helicopter flying overhead caused it to dive.

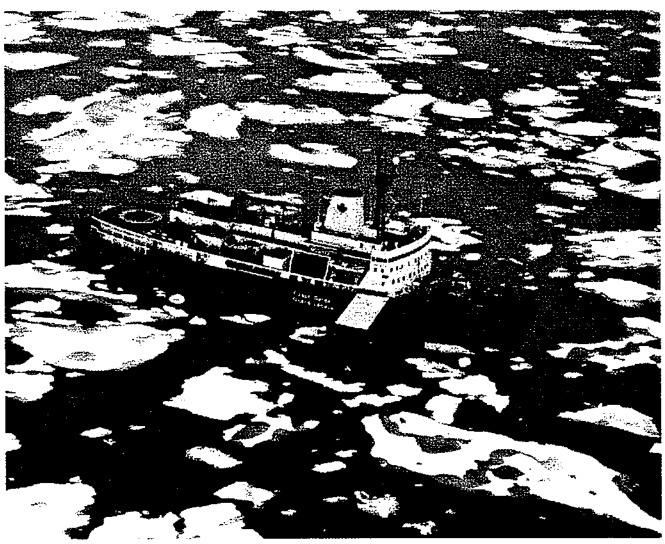

Fig. 10. *The ship taken from helicopter in central Kane Basin in four tenths ice during the aeromagnetic survey.*

Navigation was not logged for approximately 9 hours overnight. This gap will later be filled with data from the Hypack navigation system used by the hydrographer.

August 14, 2001 Tuesday Day 226

Foggy in the morning, no flying and the ship is motionless in the water. The aeromagnetic survey was terminated last night due to technical problems. Henry Halls returned from his dyke sampling localities with the most number of samples so far this trip and was pleased with his day's accomplishments. The ship drifted in a circle perhaps due to tides just like the ice flows that Colin the ice observer showed me on IceVue Program last night. As the weather improved the Geodetic group went out by helicopter to set up another station and the fission track group had two localities on Inglefieldland to sample, one near shore and the other inland.

Networking problems continue to plague the scientific staff, in spite of Bob's valiant efforts. After a week significant progress came instantaneously with the LINUX machine problems solved with Jane's help, and access to printers and the network gained on several machines.

The technical support for airguns and compressors are busy making minor repairs. One of the new Dalhousie airguns was found to have a defective O-ring even though it had no wear. Borden has sent an email to Dave Mosher to get information on the program that is firing the shots on distance and the NMEA string required has been identified and meanwhile the original programmer is looking to see if there is a problem with calculations at high latitudes. Borden will also move the GPS leads so that the Regulus navigation system will be able to have a course and speed input as well as bathymetry. Ian is working on a program to merge the digital bathymetric data with the navigation.

A science update meeting was held for all the staff to describe what had been accomplished and the constraints on balancing a diverse program and the plans for the next week. Two science talks were presented: one on marine mammals by Pat Hall and the other on dyke swarms by Henry Halls. Pat's information on the variety of marine mammals, the observation techniques used to study them, the changing ranges of mammals in the Arctic and the endangered but perhaps growing stock of bow head whales was of broad interest to scientific staff and crew alike. Henry Halls' description of his dyke swarm project with its three components (paleomagnetics, geochemistry and Ur-Pb age dating) was an informative and popular lecture. The four samples of cored dyke he passed around to see if the audience could distinguish Greenland material from Canadian was an effective way to bring home the similarities of rocks on either side of the strait.

August 15, 2001 Wednesday Day 227

Clear and calm; the ship is stationary in multi-tenths of ice in Kane Basin. The mountains of Ellesmere Islands are visible as the ship moves in a circle with the tides.

The aeromagnetic group successfully flew a grid last night. Eight lines were run at 600 m elevation plus or minus 5m. The data is remarkable clean with smooth curves. Their tired faces showed their satisfaction with a job well done.

The geodetic group and the fission track group will be flying during the day. Meanwhile the refraction group with input from the geologists put together a plan for a survey in Kennedy Channel if ice conditions allowed, taking into consideration the probable regions of lightest ice infestation. Our plan would take a minimum time of 5 days to run and 2.5 to prepare for the line. Soenke Neben and Justin Sapey spent the time doing preliminary processing on the seismic reflection profiles.

Fig. 11. *MO105 helicopter on flight deck of the Louis S. St Laurent used to support the onshore and the aeromagnetic programs*

Henry Halls and Jason Anderson said their good bye's as they prepared to fly by helicopter to Quaanaq, Greenland. The fog conditions there prevented the helicopter from flying. If conditions do not improve by tomorrow morning they will have no choice but to stay on the ship until we return to Thule on September 10.

Borden received a reply from Dave Mosher about the program that was to fire the airguns on distance that was not acting properly. A new program more stable at high latitudes and the providing of a NMEA string with more information should make for more reliable shooting.

August 16, 2001 Thursday Day 228

Rain.

At 8:00 1 the ship began moving north to Hall Basin after three days of being stationary to look for opportunities to run seismic studies in more ice free waters. The basin is named after Charles Francis Hall, an American that reached the Arctic Ocean via Nares Strait in 1871. He was buried at Hall's Rest near Thank God Harbour. The Radarsat image suggests that around the tip of the Judge Daly Promontory it may be possible to run a reflection profile. As the ice is in constant motion it is not until we reach the site that we will know for sure. The ship has sent a helicopter ahead of the ship on an ice reconnaissance mission with the ice observer to pick the route with the lightest ice. The marine biologist Pat is also flying with them to observe any wild life.

Sonya has the watch keepers back on schedule. The navigation files that we are missing can now be merged with the data we have using the program Ian just wrote. The hydrographer's files must be transferred to us over the network and he must be connected to do that. This is next on our agenda.

The aeromagnetic survey went well last night and they were able to run eight parallel lines and two cross lines. The pilots, officers in charge of flight control, and the staff were all tired. The total line km of magnetic data collected so far is 1575. The range of the helicopters necessitates the ship being near the center of the flight paths or a large percentage of survey time is lost in the refueling. This further limits the activities of the ship while an aeromagnetic survey is underway.

After breakfast I found Borden, Larry and Cory assembled around the winches where the high pressure hoses and cables are spooled. The firing lines' electrical circuits were interrupted. The combination of new stiffer high pressure hoses and cold must be breaking the electrical lines. This was thought to be a two day job to replace them and it's wet and cold on the deck. By lunch it was obvious it would take less time. Fred was assisting and help had been offered by other technical support -- Justin, James, John and Ian. Although much appreciated it was deemed unnecessary.

Plans were modified several times in the early afternoon. The helicopter pilot Harrison attempted to fly Henry and Jason to Thule. After supper they were back after an unsuccessful attempt. Meanwhile the ship was waiting for them unable to work or reach our new destination, John Richardson Bay. By 18:30 l we were in motion again with the mountains of Greenland gliding past us on the starboard side.

The news arrived by email that Jimmy Nungaq and Brian Atgootak would require fire arms certificates (FAC). I broke the news to them hoping they would not be too disappointed. I explained they would still be flying on helicopter flights that were scheduled to land. They took the information well and I offered that they could get off the ship on August 22. To my surprise and delight they asked if they could stay on. The Captain agreed they could stay on as long as they liked. At supper I told them this. They are now carefully weighing their options: to stay on and make more money or go home for the boating seasons. They would also like to arrive back in Grise Fiord on the ship. They can think about their preference until the August 22 flight.

As we approached John Richardson Bay the ice became thicker. The decision was made to halt at the mouth of the fiord and resume activities again in the morning. The ship crossed 80 ^{0} N around 22:00 l.

August 17,2001 Friday Day 229

Foggy, no flying.

The fog lifted slightly to reveal a dirty iceberg covered in sediment and large angular boulders. Last night the ship had hit a glancing blow off of it and startled the officers on the deck. The scientific staff encouraged by the Captain set out to sample it. Using the bubblers the ship was positioned beside the berg and Chris and Marcos were lowered in a basket to its surface. They immediately set about examining and collecting the rocks and boulders. For about an hour they were watched and photographed by the ship's personnel as they scoured their floating island examining its glacial debris. On return to the ship they sorted the rocks by type. The rocks were mostly lower Paleozoics and it was difficult to determine if the rocks were from Greenland or Canada. An IKU grab was taken to see if similar rocks were observed on the seafloor.

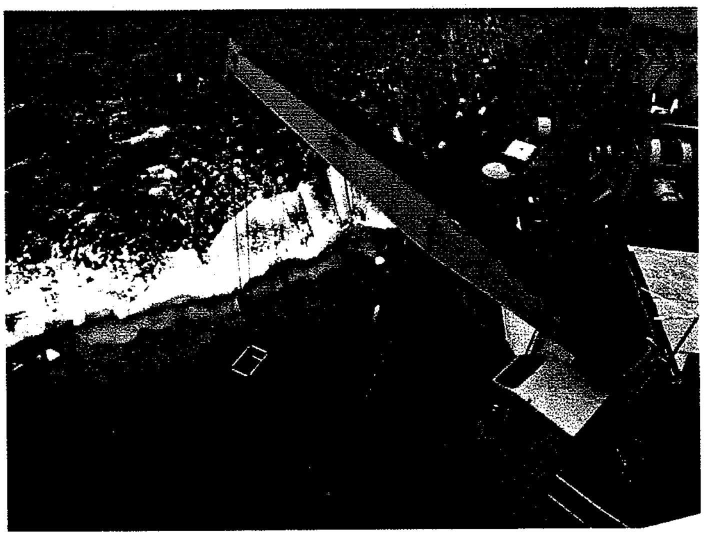

Fig. 12. *Marcos Zentilli and Chris Harrison sampling dirty iceberg. The basket used by the ship to lower them to the iceberg is shown*

We steamed slowly up John Richardson Bay. Five walrus were sighted on floes as we slowly moved up the fiord and into the northernmost arm where it diverged. We wanted to determine if the ice conditions were light enough for towing the Huntec,.a high resolution seismic system (boomer). This was deemed the seismic system most likely to survive an encounter with ice. The Huntec tows near the stern but off to the starboard side. It can rapidly be brought out of the water and does not require wide turns. The Huntec towed body or fish was put in the water within 4 nm of the glacier at the end of the fiord and the ship's bubbler system turned on. The Captain did a great job maneuvering through the ice. The technical support had advised against towing the equipment but based on the small size of the ice flows and the lack of wind I considered that given the time and money spent reaching this destination it was necessary to try and acquire data. Furthermore we had been doing little scientifically for several days and the towing of the streamer had ended on a low note with the loss of two floats. I needed to demonstrate that we could tow gear in ice-covered waters to restore confidence. After running for an hour Borden was pleased with the quality of the seismic profiles but wished it had not taken so long to set up and requested that we turn around and start again so we did. By 22:45 1 just outside the mouth of the fiord the fog rolled in, the technical support and the Captain were tired so we stopped this profile for the night. Peta picked a box core site for tomorrow. The Huntec profile was secured in blue data box in the Orion lab. For the rest of the day the ship will run hydrographic profiles and be at Peta's site for breakfast.

Anna Jensen gave a concise lecture on the goals and accuracy of the geodetic and tide gauge program. They are able to determine positions to 1 cm accuracy and height 1.5 cm. In addition, tide calibration to establish mean tides so that elevations can be determined more precisely is being done at a number of sites. There were a number of questions from the audience on the accuracy of GPS sets readily available at many consumer outlets and how to improve the height measurement.

August 18,2001 Saturday Day 230

Light fog with still waters in the morning, bright sun in the afternoon and evening.

After breakfast a box core was taken for Peta based the Huntec data. The core recovered a sticky grey mud and a two pipe piston (20 foot) core was rigged. Archiving of the paper records and tapes was initiated this morning which brought to light the need for better log keeping.

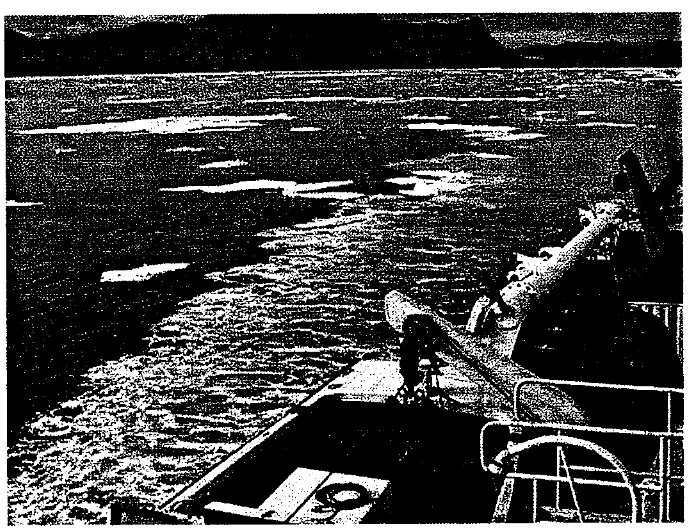

Fig. 13. *The ship's bubbler operating during a Huntec survey preventing the ice from drifting near the starboard side of the stern where the towing is being done*

For about an hour and a half the Huntec profile was extended from John Richardson Bay into Kennedy Channel in the hope of getting sufficient penetration to identify an offshore Tertiary basin identified on old seismic profiles. There was insufficient penetration so line 2 was terminated and the ship traveled north along Kennedy Channel as far as Carl Ritter Bay. The ice was at least eight tenths making any thought of seismic profiling impossible. The scenery was stunning, the faulted and thrusted cliffs of Ellesmere Island contrasting with the more distance flat lying beds of Greenland. The geodetics and the fission track groups set out stations or collected samples as we moved up the channel.

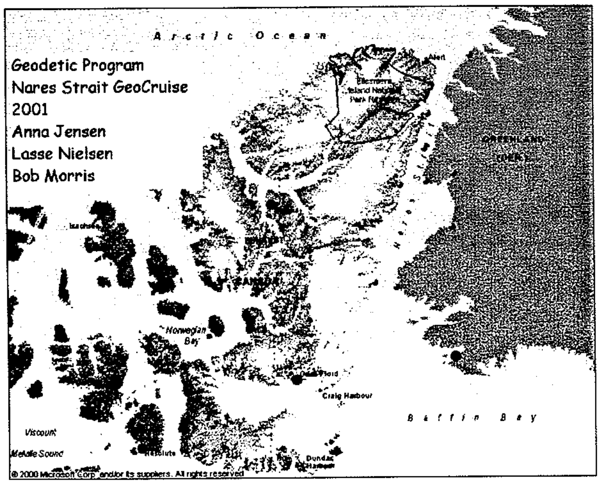

Fig. 14. *Location of the planned sites for the Geodetic stations and tide gauges*

August 19, 2001 Sunday Day 231

Bright and sunny patches, four-tenths to eight-tenths heavy ice off of Hans Island, Kennedy Channel. Mirages are forming on the cliffs and islands. The flat-lying beds and rounded topography of Hans Island contrast with the disturbed beds and jagged topography of Judge Daly Promontory.

The aeromagnetics group flew all night and managed a total of 12 lines, 10 parallel to each other and two cross lines over the Judge Daly Promontory. The geodetics crew is establishing another station, Chris Harrison is setting out a fly camp and the fission track group are flying today. One group could not fly because there were not enough individuals with fire arm certificates.

The marine mammals watches are still running. The technical support group have all the airgun firing hoses ready for shooting seismics again. Borden worked with Justin to fix a computer problem with the equipment used to control the recording of the multichannel system.

After a reconnaissance flight by the Captain, Colin Stock the ice observer and Soenke Neben, a route across the channel was found and we began preparations to run a reflection profile across Kennedy Channel near Hans Island. It took several hours to deploy the single airgun array and 200 m of the streamer. This means that we did not start close to the shore line and we may be missing important faults. The Huntec was also streamed at the same time. Both systems are having difficulties penetrating the hard bottom. There is some possibility that a few weak reflectors are showing beneath the ringing bottom. The Huntec on the multichannel (6 channels) seismic reflection profile number 6 reveals an interesting bottom topography: gently sloping from Greenland to Hans Island then two steep sided valleys. The Captain was needed on the Bridge the entire time to avoid the ice flows therefore the shooting was shut down at 01:30 to be continued the next day. The seismic group and Franz are relieved to be collecting data in this area. There was a worry that we had traveled this far north to no avail.

August 20, 2001 Monday, Day 232

Bright and sunny with winds to 30 knots.

A flight to put the fission track team on to the land and to observe the ice to determine the direction to run the reflection profiles started the day. With the high winds the position of the ice is highly dynamic. Over night the aeromagnetic flights had continued. After breakfast discussions with Thomas, Sonya and Ian, we requested helicopter time to deploy the Orions for a short but hopefully useful line across Kennedy Channel. Once we had the go ahead the operation commenced with programming the instruments, choosing sampling rates of 200 sps for recording, the firing rate for the guns 15 sec, planning site locations and getting Soenke's GPS clock in operation. Meanwhile we were preparing for another a reflection profile getting the compressors running and deploying the streamers and airgun arrays.

Then smoke was detected in the compressor container and antifreeze was observed running across the deck. The diesel compressor was stopped and the electric left running. Luckily an error in getting the cooling water to the compressor resulted in no permanent damage just a lot of clean up and several falls on the deck. Fortunately there were no injuries from this.

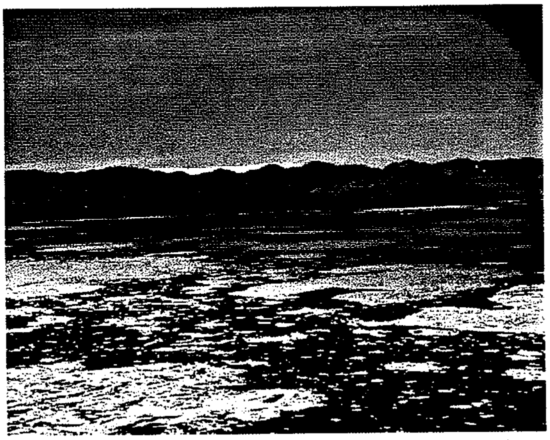

Fig. 15. *Ice conditions in Kennedy Channel the mountains are on Ellesmere Island*

It took far longer to deploy the single array than expected again. There was confusion about who was giving instructions on the stern to the crane operator. Due to the noise of the cranes and winches on the stern it is often difficult to determine what the problems encountered actually are. This one seemed to be related to communications. A casual remark to the Captain brought about dramatic changes in the organizational structure. The next deployment was faster than any of the previous ones. One beam with three airguns and the streamer were put in the water, the ship came back on to line after circling and we began steaming across the channel collecting data. The helicopter deploying the Orions left immediately after the beginning of the seismic line. The seismic program was temporarily under control.

A seismic reflection profile was completed across Kennedy Channel at an oblique angle. The ice moved during the line due to thirty knot winds from the north preventing us from getting as close to Ellesmere Island as we would have liked. The high winds also made putting out the Orion on Hans Island less than pleasant. The sites at Fossil Bugt and Carl Ritter Bay were more sheltered from the wind and not quite so onerous. The deployment crew (Sonya, Thomas and Rutger) returned tired and cold.

At the completion of the reflection profile the streamer was retrieved and the port array brought in because one of the airguns froze after being shut down. The repairs took about an hour. When the ship got underway on the refraction profile the ice prevented crossing the Channel along the line of the Orions. A new path was planned to maximize the usefulness of the arrivals. The winds had dropped and the sea state should allow good signal to noise ratio for this refraction line. However large old ice floes had drifted near the ship and the Captain spent considerable effort to find a safe route through the ice to prevent damage to the airgun array. Whenever we are towing gear in difficult ice conditions he is on the bridge.

The combination of onboard programs and flight operation requiring support from the officers and crew day and night is necessitating that they reorganize their watch structures so they can get sleep in longer periods than 3 or 4 hours. I am also concerned about the long hours Borden, Larry and Cory have to put in running compressors and electronic support for both the reflection and refraction programs.

Marcos Zentilli gave a well attended, informative talk to an interested and responsive audience on the fission track program. The speaker did an excellent job of giving the basics so that non specialists from the crew and staff could follow it and sufficient detail for a lively scientific discussion that continued in the geophysics lab later.

August 21, 2001 Tuesday Day 233

Calm seas, sunny near the ship, strips of fog along the Greenland coast.

The lack of winds made it difficult for the pilots flying the helicopter for the aeromagnetic survey. In particular it took several tries to get enough lift for taking off. Once again the aeromagnetic group managed to collect twelve new lines of data. They all look exhausted by breakfast. The refraction profile was terminated near Hans Island due to heavy ice conditions.

In the morning Sonya and Jason along with Anna went to retrieve seismometers and Geodetic stations. Marcos and Sandy were going out to get more samples. Marcos gave Jimmy a project to interview the people onboard ship and to tape them so he could have a record of his visit and be able to share it with his community. Ice observation and the picking up of the fly camp with Chris, Tom and Brian was done.

Sonya successfully recovered three Orions with data on them. Jason assisted with the heavy batteries and scoured the beach at Fossil Bugt for specimens. After the ice reconnaissance the ship steamed north to Cape Ulrich to find a region with low enough concentrations of ice to tow the seismic reflection system.

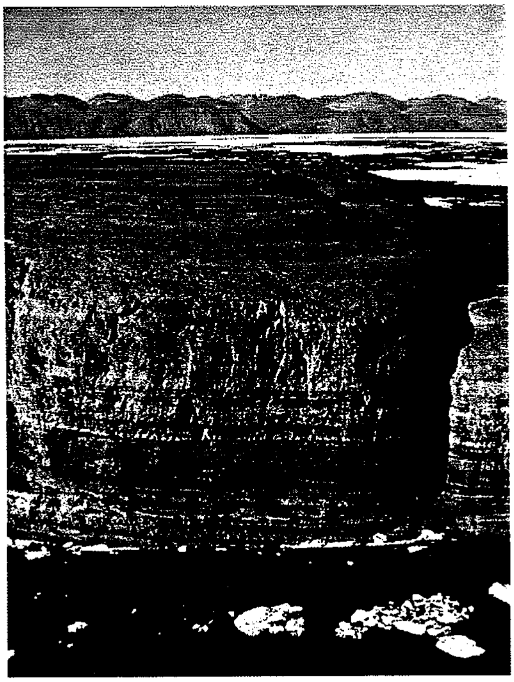

Fig. 16. *Hans Island in Kennedy Channel where one of the Orion seismometers was deployed*

Both the seismic reflection and aeromagnetic operations were curtailed by winds of 40-45 mph with gusts to fifty knots.

August 22, 2001 Wednesday Day 234

High winds gusting to 100 knots overnight prevented flying and seismic programs from running.

The winds dropped and conditions improved over the day. Operations were further interrupted waiting for the Twin Otter to arrive at Carl Ritter Bay. The time for the Twin Otter changed numerous times during the day and it made it difficult to schedule any shipboard operations. The purpose of the flight was to pick up the Geodetic group and the marine mammal observer, marking the close of their portion of the experiment. The Geodetic group completed 80% of the work they had planned and were pleased, especially taking into account the week delay in starting their program due to the aircraft not being able to fly into Thule. Pat Hall reported she had enjoyed the experience and was sorry to be leaving the ship. She had seen few marine mammals but had learned a lot about using a ship as a platform for observations. Both Pat and Anna promised to send me their cruise report after they had returned to their respective offices.

While we were preparing for the arrival of the Twin Otter, Peta had chosen a site north of Hans Island for a core. Unfortunately the ice prevented return to that sight so another had to be chosen on the basis of water depth alone. Two attempts were made. On the first nothing was recovered so the pinger was put on the wire to ensure that the bottom was actually reached. The second did hit the bottom as the core barrel was bent and contained about 50 cm of gravel.

Finally the decision was made to run a seismic line from the middle of Kennedy Channel towards Greenland. The ice as usual prevented the ship from getting near the coast of Ellesmere Island. The line began after supper and ran all night. The small orange float that Borden found in his container was an improvement over the large float that was readily caught on the ice and the small white float that was invisible from the bridge. The mates can do a much better job negotiating a path through the ice floes if they can readily track the end of the streamer at all times.

Meanwhile Franz, Soenke and I discussed the overall plans for the rest of the cruise. The ice is constantly interfering with reaching our prime seismic targets. We cannot stream more than 100 active m of the array, and we are unsure when we will be able to move south where better seismic reflection data can be acquired. This must be balanced with the needs of the geologists,

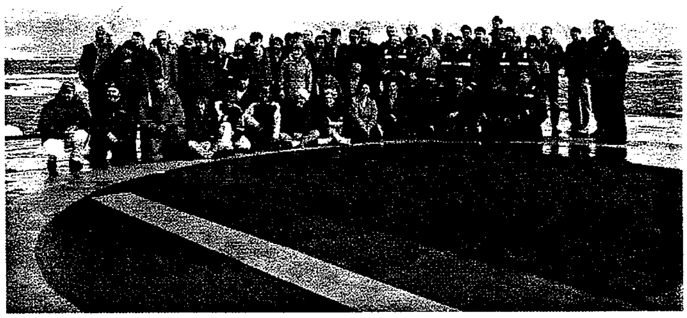

Fig. 17. *Picture of ship and scientific staff taken on the flight deck before the departure of the Geodetic group and the marine mammal observer*

fission track group and aeromagnetic survey. Finally we agreed that on Sunday we would start south after the Fort Conger expedition.

The winds were gusting to 35 knots and the multichannel seismic system was running as we travelled towards Hall Basin.

August 23, 2001 Thursday, Day 235

Flat calm early in the morning and bright sun.

We are now half way through the cruise. The multichannel reflection system ran all night with one beam of three guns deployed, although one of the guns was not firing. It was deemed not critical enough to call the crew out when they were sleeping. The bosun in particular is busy with flight operations 24 hours a day because the aeromagnetic survey has minimum magnetic noise during normal sleeping hours and the geologists need to fly during the brightest and warmest part of the day. In addition we are deploying and retrieving the airgun array at all hours of the day.

The aeromagnetic survey had another successful night flying in the region of Judge Daly Promontory. The flights of geologists to the onshore continue and we are all awaiting a summary of their activities to be presented Friday evening.

First thing in the morning when the crew was up, the three gun beam was lifted out of the water and the non-operating airgun repaired. A new seismic line number 14 was started in Petermann Fiord off of Hall Basin. Just as Borden began routine maintenance on the diesel compressor one of the valves of the electric compressor jammed and there was a half hour down time when the airgun could not be fired while repairs were made.

A Huntec line was desirable in the fiord but it took several hours to start the line between landing helicopters and other activities that the ship's crew were involved in. Thereafter it took another hour or two to adjust the Huntec record to match the bottom conditions -- a transparent upper layer in contrast with the hard bottoms we had imaged to this point. Due to the problems with the print head on the EPC recorder not working well on one half of the paper and the limited delays available so that the transmit and receive overlapped, a solution was found to maximize the good portion of the recorder by printing both the internal hydrophone and the external hydrophone array. This had the effect of centering the display.

I returned to my cabin to find Moira frantically bailing water in my bathroom. A stream of water a half inch in diameter was spurting out the top of a pipe behind the toilet. The chief engineer arrived and had to wade through water above his ankles to reach the pipe. The repairs were made and the only sign of the flood is a wet carpet in my bedroom.

Franz had news that there will be a thirtieth anniversary of the Canadian-German Co-operation in Hannover on October 22. He asked if I could give a talk on the project. I would be thrilled.

Marcus is working with Brian and Jimmy on their reports on their experiences on the ship, helicopter and field parties. They are suppose to interview the staff and write about their activities in their own words. Brain was particularly helpful to Chris' field party in repairing a Coleman stove that no one else could get to work.

August 24, 2001 Friday Day 236

Calm and still, mountains in full view on all sides.

Just after midnight the airguns were brought in to repair a gun that was not firing and to shorten the cable in the floats to bring the airguns closer to the surface to raise the frequency content. The servicing of the airguns took nearly four hours. Detlef was pleased that we moved little during this four hour period because he was planning a long northern flight for the magnetic program and the position of the ship would enable four lines on his flight plan rather than 2.5.

The gun problems were probably due to freezing up in the cold waters. Finally antifreeze was put in the air lines and the guns fired reliably. The region of Hall Basin near Greenland is less than one tenths ice and the multichannel reflection (curtailed to one beam with three airguns and a short array active section of 100m) are being run simultaneously with the Huntec. The region of Hall Basin north and west of Judge Daly Promontory has nine-tenths ice and cannot be surveyed wih seismic equipment.

After the guns were repaired the seismic system ran without incident. Finally the seismic technicians have a few hours of peace to recover from the constant demands of the program. We have about 600 km of reflection profiles now, 300 north of Kane Basin. During the day Peta reviewed the seismic reflection profiles, bathymetry and Huntec to choose core and IKU grab samples. Franz, Marcus and Sandy took the helicopter to Greenland.

Ian, Vincent and Chris are busily working on a map with seismic shot locations and onshore geology to plot the features on the now 18 profiles run in the region. Reliable printing for the scientific staff is still a problem. The ship provided a color printer and we have tried it in a few locations but no truly satisfactory solution has been arrived at. Sonya is preparing all of the Orions for deployment at a moment's notice.

Chris Harrison gave a presentation on highlights of geology along the route of our voyage It was accompanied by geological cross-section, maps and rocks. It even had a show and tell element with an inspired emptying of his back pack showing all the needs of a geologist making a transect in the Arctic. It finished was a lively discussion of the geological and geophysical contradictions of Nares Strait.

The seismic program finished late in the evening and the sampling program followed, running into early morning of the next day. A 26 foot core was recovered but the IKU dredge was dropped into mud so was unsuccessful as a sample site. However it does provide information to calibrate the interpretation of the seismic profiles.

August 25, 2001 Day237 Saturday

Overcast, heavy ice in Hall Basin.

Today anyone on the ship LSL who wanted to take a helicopter flight to Fort Conger on Discovery Harbor was provided with an opportunity to see the historic sight of the Greely and Peary expeditions. The site was a pleasant sheltered valley with a stream. The earth had ground hugging vegetation of willow, saxifrage, mushrooms, and grasses, such as Arctic cotton. There were also fine views of the mountains and a herd of muskox to observe. The site had three tiny wooden buildings with low ceilings and doors. Impossible to image spending the entire long winter in them. Their tiny interiors were dominated by stoves not surprisingly. Scattered bones, weathered cans, bedsteds and nails -- the detritus of human activity was obvious but did not detract from the tranquility and serenity of the location. The noisy helicopter ride back to the ship quickly returned me to the twenty-first century.

The planned barbeque on the helicopter deck was moved to the crew's mess due to the helicopter still ferrying people from Fort Conger to the ship. The buffet for all in the crew's mess was a lively feast with wine and beer. The noise of the ice as it crashed by the hull only seemed to add to the festive atmosphere. Supper was followed by a live music session in the crew's bar. Meanwhile the shipped steamed south.

Fig. 18. *Our chief scientist Franz Tessensohn having lunch at Fort Conger on Ellesmere Island*

August 26, 2001 Sunday Day 238

During the day it improved to sunny and flat calm.

The ship's progress south was limited due to the heavy ice conditions. This also means sleeping was disturbed by the vibrations of the ship. The aeromagnetic base station at the north end of Kane Basin was retrieved and it had recorded data. The one near Fort Conger had recorded data until the time when probably a fox had chewed the wires. This will enable the data to be corrected for diurnal variations.

After breakfast the ice was lighter and a search for a region with ice conditions light enough to run a reflection profile from near the Ellesmere Island coast was initiated. An ice reconnaissance flight determined that the region off of Cape Lawrence might be possible. The ice was thicker than we had pulled the multichannel seismic system through but the Captain thought he could break out an area to allow a start of line near the coast. This was started and both Soenke and I were slightly concerned for the safety of the gear. It was difficult getting the single airgun array and 200 m of hydrophone cable in the water without interference from the ice and several turns were required. The line was started and for the first time we saw clear slightly dipping reflectors that we were able to trace until they terminated towards the centre of Kennedy Channel. This line had to be restarted because the hydrophone array got tangled in the airgun array. Huntec was towed along the restarted line. During the day three large 1000 cu in airguns were mounted on the port beam and the preparations for the deployment of the OBS were begun. Borden's back was giving him considerable discomfort so it was dedication to a high standard of performance that kept it working.

The scenery at Cape Lawrence was splendid with the jagged colored mountain: bright red Cambrian quartzites, black sands and orange coarse-grained Tertiary cliffs. The seas were calm and the sun bright.

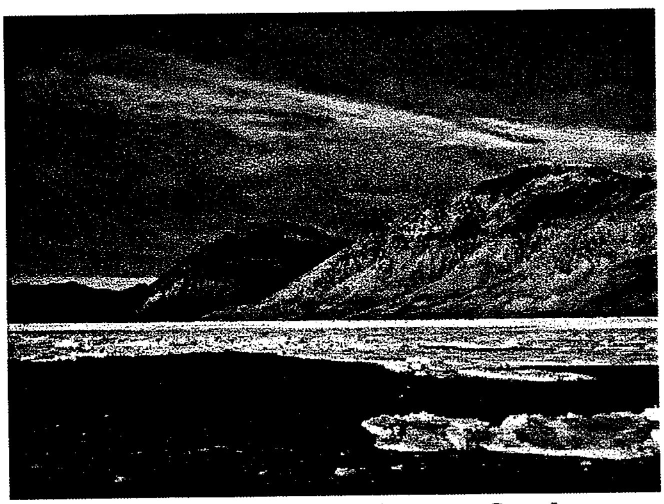

Fig. 19. *The spectacular red sandstones at Cape Lawrence*

The formal Sunday dinner with 8 at the Captain's dining room was a talkative and cheerful event. Since the ship's tour to Fort Conger we had lots of conversation about the conditions and motivations of nineteenth century explorers. It is important for the ship's personnel that Sunday is different from the other days of the week. One custom that helps us to distinguish the days of the week is the officers were wearing their number one uniforms with white shirts.

The seismic systems were retrieved about 20:00 l due to the ice not allowing progress further east, only south. One of the GI airguns that had been leaking air for some hours had a 3 inch collar of ice. The GI airguns were removed from the beam in preparation for installing the larger airguns for refraction.

August 27, 2001 Monday Day 239

Foggy in the morning occasionally clearing, contact ice forming around the sea ice.

The ice conditions were light enough last night that significant ice breaking did not take place so sleeping was easier and we reached the middle of Kane Basin. The fog was making it difficult to refurbish an aeromagnetic base station on Bache Peninsula and set out fuel cashes for the aeromagnetc survey planned in Kane Basin from Smith Sound region.

The refraction group met and discussed their plans with the Adrian the helicopter pilot. He stated that from the mouth of Makinson Inlet he can flight the Orions to the most remote stations without refueling. Due to concerns with not disturbing the marine life in Inglefield Breding two of the Orions were moved to a fiord to the south. In addition the position of Orions along Makinson Inlet was shifted slightly. This means Thomas will recalculate positions.

There was a fair amount of interest in who would be deploying which instruments. Sonya is making a carefully prepared roster so every one gets a fair chance to go ashore. The discussions were further complicated by the striking union on board ship and what the implications would be. In the end we planned as if this was not going to happen as bit was likely to cause delays but not stop the program.

Larry and Cory were preparing the second beam with three additional large guns for the refraction experiment. Borden finished refurbishing the OBS with batteries and checking out the electronic package. He also prepared beacons and Thomas checked that the Bridges VHF direction finder would be able to detect their signals. Sonya has the Orions prepared to go.

Ian continues to refine his plotting program so that he can indicate the location and shot numbers of the reflection profiles. In addition he has a log of all the ships station. At this point I have also asked the geological field parties to submit digital positions to him so that we will have a complete list of the accomplishments of the cruise.

August 28, 2001 Tuesday Day 240

Bright and sunny, still water with small floes.

The aeromagnetic program went well last night. The ship stopped in the optimum place to run their lines and the flights went exceptionally well. Jimmy and Brian were steering the ship this morning under the careful tutelage of the Quarter Master Dale and the watchful eye of the Captain. They were all smiles and are now hoping to steer for 10 hours to get a certificate.

There was significant grumbling over breakfast about the lack of information for planning. Franz agreed to have a planning meeting at 10:30 l so that everyone would have all the information they needed. He presented the priorities of seismic reflection and refraction over the next few weeks. He showed how the on land segments would be integrated. Henry Hall and Marcus Zentilli are getting ready to sample on Greenland and Ellesmere Island respectively on either side on Smith Sound. Jane Eert will be taking a five station water casts across the strait. This was Peter Jones highest priority.

CTD stations for Jane Eert began during the day and ran into the evening. Henry Halls went to the Cape Alexander region for the purpose of collecting dyke material. Aeromagnetics survey was successful again. Clean data with short wavelength anomalies to trace that will be useful in constraining the plate reconstructions.

August 29,2001 Wednesday Day 241

Fog on and off during the day making it difficult to plan the arrival at the first OBS deployment. Sometimes we are traveling 4 knots then 16 knots. Chris Harrison and Henry Hall went ashore on Ellesmere when the fog lifted for a short time. Then the fog closed in around the ship and the helicopter had to wait onshore near Boger Point until the ship was close enough to attempt a flight. This took several hours as we moved through heavier ice. The extent of the ice was hard to estimate due to the thick fog. Based on the Radarsat images the position of the refraction, profile was moved south to circumvent the drifting ice.

The helicopter flew back to the ship and it was agreed that conditions on Ellesmere Island were suitable for further helicopter operations. The ship reached the mouth of Makinson Inlet about 21:00 l where the helicopters range would allow the long flight necessary to place the land seismometrs. The mountains formed a spectacular rugged bowl around us. The low angle light highlighted or flattened their faces as it slowly shifted. The helicopter flew towards Stenkul Fiord to deploy six Orions over night. The OBS could not be launched due to the need for the deck crew to rest until after breakfast.

August 30,2001 Thursday Day 242

Bright, sunny and gale force winds

The ice had drifted further south over night. The modifications of the refraction line to accommodate this were insufficient. The geometry of the fiords prevents additional changes. It was not possible to deploy the OBS at the first location due to ice of tenths. We then traversed a region with up to nine tenths ice. This will make a gap in the line that may be partially compensate by the Orion on the eastward point of Ellesmere Island to the south of our line.

The winds picked up causing the ship to begin to take noticeable rolls. Equipment and personal belongings had to be secured. The launching of the OBS began in the rough seas. The preparation of the OBS went relatively smoothly except for a problem with the computer program that controls the OBS set up. If you input the time of the secondary release before the primary then any changes to primary time are not recorded. In addition the OBS and GPS clocks would not communicate. Two OBS and two clocks were tried. The manual suggested repeated trying to connect them until it worked. It did eventually and probably caused only an hours delay.

This delay is not serious because the sea state is too high to deploy the airgun arrays and unlikely to reduce significantly until tomorrow. Both the Captain and Bosun mentioned their concerns. The signal to noise on the Orions will also be degraded by the winds. The high winds have also prevented the flying of the helicopters and the setting out of field parties on the Carey Islands.

August 31, 2001 Friday Day 243

Calm seas near Thule harbour, windy in northern Baffin Bay

The Orion on Saunders Island was placed on the island immediately after break fast.

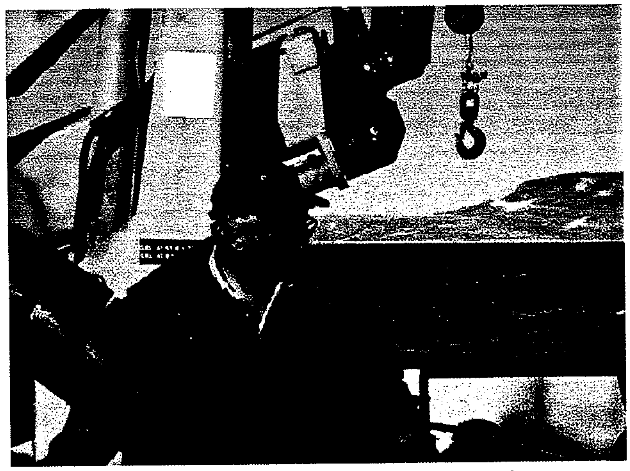

Fig. 20. *Larry Johnson with the wrapped air hoses during the deployment of the airgun array*

At 10:30 l the airgun array was ready to be deployed. The operation was stopped because Borden could not detect the minute pulse on our GPS clock. The launching of the airgun array was halted while the problem was addressed. It was determined the problem was the oscilloscope had a channel that was not operating. The deploying of the airgun array was put off until after lunch because of the return of the flight to assess wind conditions. Colin reported a low broad swell to the Carey Islands; thereafter, a wave height of 2 -2.5 m a with a 5-6 s period. This would allow us a 10 hour or 50 nm traverse along the planned refraction profile before conditions prohibited further work and there is always the hope that the sea state will abate before then. At noon the helicopter taking Marcus to a number of geological sampling sites took off and the launching of the 6000 cu in airgun array began thereafter. It took only 37 minutes to put in the water. The guns fired the first time. The port array was towing erratically diving towards the starboard array. Adjustments of the tugger winch cured this problem. Then the guns stopped firing. The GPS clock had lost lock. The ship was slowed and the system tinkered with. The lock was reacquired, the guns were firing and the ship brought back up to speed. This array is significantly louder than the other smaller volume higher frequency sound source used for the reflection profiling and the shallow water makes for a resounding crack every minute.

Fig. 21. *Deploying the 1000 cu in airguns*

After supper the Captain and Colin went over the recent weather and ice observations and forecasts with me. Winds to 25 knots. Hopefully it will be no more. If so the plan is to continuing running until the ice edge is reached. The shot clock has lost lock on one occasion and Larry just reset it and it immediately reacquired.

September 1, 2001 Saturday Day 244

Winds 45-50 Gusting to 100 knots

The conditions deteriorated for towing seismic gear. There were gale force winds and large waves with the tops being blown off. Borden called me before breakfast we now have only five guns firing and the winds had gone from 25 to 40 knots. After consultation with the Captain on options seeking shelter behind the Carey Islands or steaming northeast into the lee of Greenland, it was decided to continue along the planned course. The array cannot be retrieved due to the rolling of the ship. The decks are slippery and the people doing the compressor watches (Larry, Cory and Borden) must be careful not to slip and fall or worse.

Five guns continued to fire in spite of the high seas. Winds steady at 40 knots with gusts to 96 knots. About 1500 l we entered a zone with calmer conditions as we approached the ice edge. As strips of ice went by the airgun array we were not able to use the bubbler much because it caused the echo sounder to be unreliable and there were no soundings in the region. There was a strong motion of the ice to the south across our track. At about 16:00 l the array hit a piece of ice the size of a Volkswagen beetle and the line was terminated. It was luck and good work by the airgun team that enabled the system to withstand the beating it took for as long as it did. After the array was brought in, repairs were necessary to fix it that included firing lines that are severed and stretched. Meanwhile we are making our way through eight-tenths ice to the mouth of the fiord and then the ship will steam to the head of the fiord for OBS deployment in the morning

September 2, 2001, Sunday, Day 245

Blue skies no wind in the fiord. Really there were no winds. The wind direction indicator was displaying directions in the full range of the compass before the ship started to move

The airgun array was launched promptly after breakfast because Borden, Larry and Cory worked until after midnight to repair firing line. We steamed in flat calm waters up the ice free fiord. Beyond the mouth of the fiord the ice was heavy and the end of the line will have to occur there. The shooting of the seismic refraction profile continued until about 17:00 l with 5 of the six guns firing. The system was shut down. The beams with the large airguns were brought onboard and the stripping of the large guns in preparation for mounting of the smaller seismic reflection GI guns was begun. After the seismic line a box core was taken at the mouth of Makinson Inlet for Peta.

A meeting was held to discuss the closing of the geology program and incidentally the possibility of moving to the north to do aeromagnetics before recovering the OBS. This will put the OBS at risk of loss if the weather is dominated by high winds until the end of the cruise which is a possibility in September. I spent time with Colin going over the weather prognosis for early next week and Tuesday looks good for OBS pick up. I have discussed the option with Soenke of running the reflection profile along the refraction line first. The discussion of detailed plans with Franz will have to wait for his return from a field trip and the Captain to finish Sunday inspection rounds.

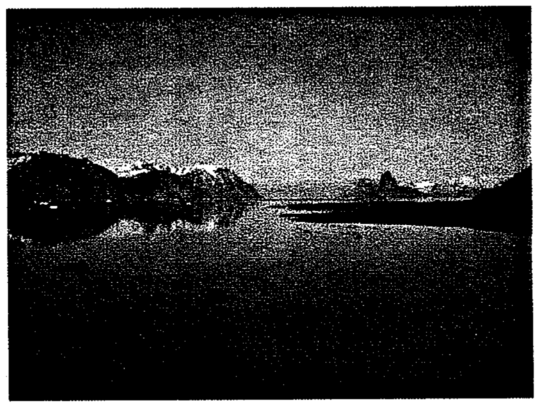
Fig. 22. *Makinson Inlet with the spire of Bowman Island in right hand back ground*

I had the task of inviting three individuals for dinner with the Captain tonight. The response from individuals either accepting or declining the invitation is variable and often surprising a real insight into their character.

Meanwhile geological parties were out sampling for rocks that could be used for fission track dating. I had the opportunity to fly with them for the afternoon. We saw from the helicopter the Precambrian to Lower Paleozoic (granites unconformable overlain by flysh and carbonates) spectacular exposures along Makinson Inlet. This was accompanied by informed geological commentary by Chris as we flew by. He also discussed the fault pattern, ages and types. Due to the retrieval of the airguns we had to stop in the granite spired island in Makinson Inlet. There was a lone hare that managed to survive on the sparse vegetation. Unfortunately there was a misunderstanding and helicopter was back an hour after it was convenient to begin picking up the Orions. Actually the pick up of the 6 Orions went quickly less than 2.5 hours of helicopter time and the shipped steamed first through the ice and then across northern Baffin Bay.

September 3,2001 Monday Day 246

The winds picked up early morning.

After breakfast near Thule Air Base, the helicopter was launched to pickup the Orion on Saunders Island. Meanwhile the first OBS was released and came to the surface. Because the ship's working decks are high above the water and it does not have bow thrusters we were unsure if we could retrieve the OBS using a grapple. To everyone's relief the pick up the OBS was accomplished on the first try. This means it will not be necessary to put a zodiac over the side to recover the instruments. The second OBS was released and it came promptly to the surface. The pick up on the ship was more difficult with a dropping of the instrument from the grapple hook and having to start over. The OBS actually bounced along the ship. The ship went to the third OBS site but increasing wave height and winds prevented its recovery.

The ship steamed back to the beginning of the refraction line where it was sheltered from the wind and began deploying the gear for a seismic reflection profile. Late in the evening Borden told me that the crank in the diesel compressor had broken and it would not be operational for the rest of the cruise. This will also be an expensive repair in port.

Thomas and Borden were working on the computer configuration and the cabling to be able to down load the refraction data. The GSC instrument co-operated first and data plots were made. Eventually the problems with the Dalhousie instrument down load was corrected and the first two OBS have good quality data. At first glance there is a major offset on the East side of the Carey Islands and the crust is probably thin about 15 km thick. Sedimentary, crustal and mantle reflections and refractions are visible.

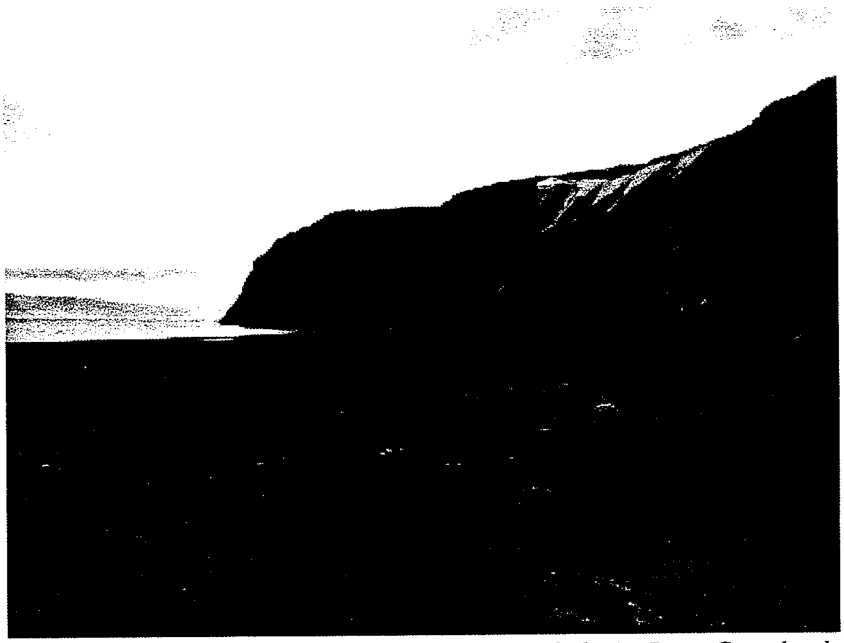

Fig. 23. *The Orion site at Saunders Island Near Thule Air Base, Greenland*

September 4, 2001 Tuesday Day 247

Overcast, light winds no swell near coast

The seismic reflection system had to have its sound source reduced by half when the crank on the diesel compressor broke. Luckily the records still have penetration above the multiple. In fact the seismic profiles show a well developed syncline of possibly Thule Group adjacent to a region with poor penetration interpreted to be Precambrian basement. This can be compared with the structures on the geological map of Greenland

Brain and Jimmy completed 10 hours steering the ship and their certificates have been prepared by the ship. The printing was done with beautiful penmanship of Kevin the third mate. The certificates will be laminated and presented to them.

The hydrographic launch was lowered into the water after breakfast with a coxswain, Arnie, Vincent and Rutger to collect bathymetric soundings north of Northumberland Island in preparation for running a seismic profile in the region. We then headed back to the OBS we did not retrieve due to high winds and sea yesterday. In the quiet seas the ship was able to pick up the instruments easily. The last six instruments came aboard readily with the grappling hook and the careful coning of the ship by the Captain. The burn times for the instruments was close to 7 minutes for all but the second to the last instrument. It had a fifteen minute burn, an eternity for the refraction group.

I tried calling Mike Gorveatt three times today to talk to him about the cargo to be shipped from Thule to Trenton. I left a message but no response as yet. After lunch the picking up pf the OBS began. It was much easier than yesterday with light winds and calm seas.

September 5, 2001 Wednesday Day 248

Overcast, calm seas

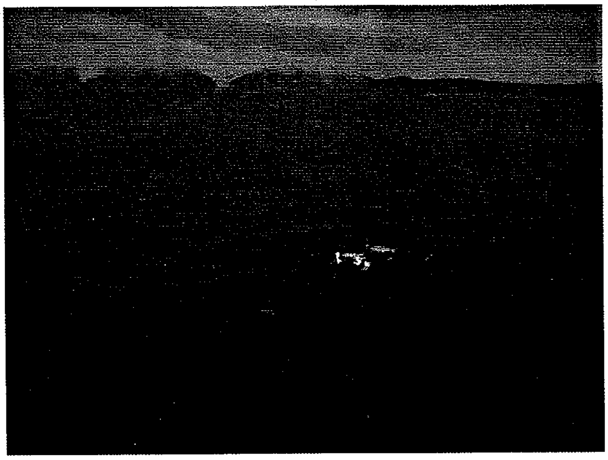
Fig. 24. *The return of the hydrographic launch*

The hydrographic launch with Arnie, Vincent, Rutger and a crew member were picked up about midnight after spending the day charting waters between Greenland and Northumberland and Hebert islands. The differences in his readings and the charts were significant and they were shallower. This is surprising but hopefully only occurs in these remote high Arctic regions.

The seismic reflection equipment was streamed after the retrieval of the launch and watches continued for the night. The seismic reflection profiles are showing interesting features including layered sedimentary rocks, synclines, folds and possible thrusts.

In the morning at 9:00 1 the Captain was concerned about arrangements for the cargo from Thule to Trenton and called a meeting with Franz and I. Finally I called George Stewart the contact in Ottawa and learned that any flight would probably not take place until December. Shipping by sea would be quicker. Franz is looking for alternatives. Perhaps the hours of Twin Otter time assigned to the project by PCSP can be used to alleviate the problem.

A meeting of the scientific staff to discuss obligations for cruise reports and publications was held, Notes were taken and will be distributed to help everyone remember their commitments.

September 6, 2001 Thursday Day 249

Overcast, calm seas

The ship was operating in the shallow water north of Northumberland and Herbert islands and the coast of Greenland. The multichannel seismic reflection system was running in a routine fashion with the full length of the hydrophone array out.

Based on last nights planning meeting I was working on a press release with Franz. It took most of the day to write and modify the page and a half document. The Acting Director at GSCA Dick Pickrill was notified of our plans and the pages sent to him for vetting. There was a rush to do this because of the strike action occurring at GSC that meant the building would be closed and there would be no opportunity to arrange the meeting with the press. Meanwhile, the Captain meet with us to discuss the possibility of shipping equipment south on a Danish cargo vessel that was to tie up in Thule at the same time as the LSL This will solve the shipping problems in getting large equipment south quickly and cheaply.

After lunch there was an announcement of an iceberg near the ship. We have seen hundreds of icebergs and this seemed an unusual statement. Next I heard the streamer had been severed from the ship. The float could be seen 100 m or so from the iceberg. The airgun array and the Huntec were brought in so the ship could turn to retrieve the streamer. The ship got close and then the fast rescue craft was put over the side. The tail buoy was brought on board the small craft and an attempt to tow the array was made. There was a fear that the "birds" (the devices used to deter the depth the streamer is towed at) were snagged on the iceberg. Fortunately this was not the case and the small boat was able to bring one end of the streamer to the stern of the ship where it was put on its reel and winched in. The "birds" had sampled the bottom in 70 m water depth and were covered mud and had rocks imbedded in them. All of the streamer was recovered and the damage was limited. Repairs were begun immediately.

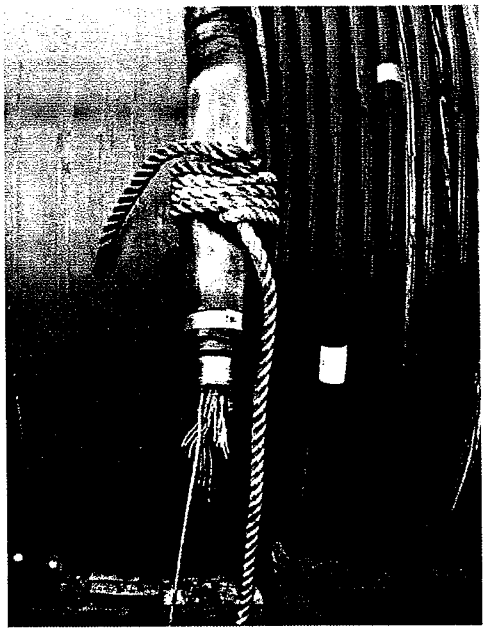

Fig. 25. *The hydrophone array is severed by an iceberg*

Meanwhile we steamed north for a position convenient for the helicopters to fly north to recover the station magnetometers and several fuel drums. At this locality a CTD was done followed by a piston core.

September 7, 2001 Day 250 Friday

Gray day, calm seas

A 3-4 m piston core was taken last night and a CTD station. Peta was pleased with the core because she believed it had reached an important Pleistocene boundary. By about 0600 l the multichannel seismic reflection system was in operation and we were headed south. Along this line the seismic section shows a series of dipping reflects that diverge. Chirs and Tom interpret the profile as thrusts in the Thule Group. The direction of thrusting is consistent with direction of Tertiary structures. The Huntec was put in the water as well. Borden spent an hour during the day trying to adjust it but is generally unhappy with the quality of printing on the graphic recorder. In addition we have little penetration but this may be due to hard bottom and glacial till.

The airgun beam that is not in use on the starboard side was striped and prepared for putting away so that when the ship ties up on the starboard side there will be a little working space. Boxes and packing material were obtained today and rough plans of when the computers would be packed to although time for work on their cruise reports.

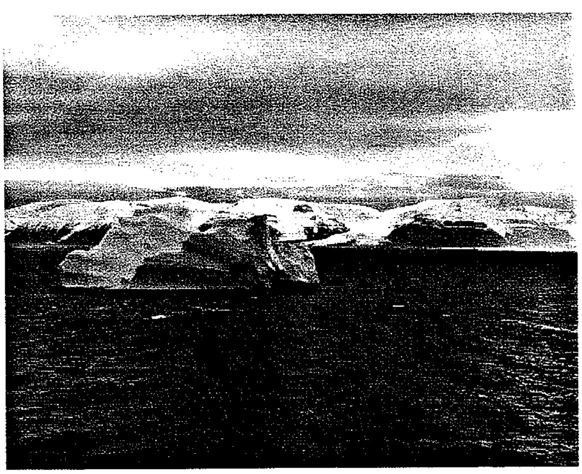

Fig. 26. *The ship's fast rescue craft heading towards the orange tail buoy to retrieve the streamer*

Posters of the LSL are being circulated and signed to give to Jimmy and Brian. Other pictures are being signed to give to the ship as a thank you. A queue at the laundry room is indicative of the mind set in the staffs mind as we shoot the final reflection profile on the leg to Thule harbour.

September 8,2001 Saturday Day 251

Clear day, flat calm seas

At 2:00 l the last multichannel reflection profile line 30 from the Carey Islands towards Thule was completed for a total of 1201.049 km of data. The Huntec was also brought on board. Borden who brought the gear in stayed up until breakfast putting away the gear on the stern to facilitate the tying up of the ship at the dock in Thule Harbour.

At 8:00 l there was a flurry of activity as the day watch keepers finished breakfast and began to pack up equipment for putting on the freighter Irene Arctic that is tied up at the wharf.

Jimmy and Brian gave me their cruise report to read. With guidance from Marcus they have produced a document that they will have for life. It will be included in this as part of the general cruise report as well.

At 10:30 l we were tying up at the dock and the log book for the cruise had its final entry.

The Wide Angle Reflection/Refraction program

Sonya Dehler, Thomas Funck, Ruth Jackson, Ian Reid ,
Borden Chapman, Larry Johnston and Cory Nixon

Field Report

An onshore/offshore refraction program was planned to determine the lateral and vertical distribution of the velocities of sedimentary and crustal rocks as deep as the Moho. The aim of the program was to provide a cross section of the crust from the Greenland plate to Ellesmere Island on the North American plate. This would provide insight into the style of deformation across the proposed Nares Strait transform. Does the depth of Moho change across the strait? Are the velocities in the crust similar or different across the strait? Is the thickness of the sedimentary layers variable across the Strait?

The highest priority line was planned across the Eurekan Orogen from Greenland to Ellesmere Island in the vicinity of Kane Basin. The ice conditions in Nares Strait did not make the original plan feasible so we modified it to be consistent with the crossing the orogen to the south (plan B) where ice conditions made the experiment logistically possible. Furthermore, the need for the various programs to be run in Hall Basin near the northern extremity of the strait, meant that the refraction experiment was run late in the cruise. Unfortunately the quiet seas encountered during the month of August were replaced by windy conditions. The sea state made it difficult to complete the profile in the minimum time of four days. During the deployment of the OBS old ice of up to nine-tenths coverage had drifted to within 50 km of the coast of Ellesmere Island making it risky to deploy OBS. To compensate 6 of seven the Orion instruments were used at the mouth of and along Makinson Inlet. This ice free and sheltered inlet from the gale force winds was a convenient spot to continue the line through the observed Precambrian and lower Paleozoic section that also included Tertiary in fault controlled basins.

For the marine component of the experiment the ocean bottom seismometers (OBS) were used as receivers. For the onshore component of the experiment the land seismometers (Orions) of the GSC and the University of Western Ontario were employed. The sound source for the actual line that crossed northern Baffin Bay from Thule Air base into Makinson Inlet on Ellesmere Island experiment was six 1000 cu in (16.4 liter) airguns towed on two beams 100 ft. behind the ship at 20 ft. depth. The shots were repeated every minute. On two shorter lines across Kennedy channel the GI gun array of 1200 cu in was the sound source fired at a 100 m distance.

Before the shooting of the line from Thule toward Baffin Bay we delayed for the night to give a tired crew a chance to rest and hope for lighter winds. For the initial third of the line the coast of Greenland provided shelter but the winds were at steady 40 knots for the central portion of northern Baffin Bay. Thereafter, high winds continued to the ice edge. Then a piece of ice hit the airgun array and the guns were brought on deck. The ship broke ice until we were within the sheltered of the Inlet. We steamed to the mouth of the southern limb of the fiord and then fired the airguns towards the sea in quiet conditions.

The airguns were brought in due to ice conditions that would damage them. This produced a gap in both the shooting and recording of the line near Ellesmere. The ship steamed overnight towards Thule. The wind speed increased to gale force again. However for the two OBS closest to Thule it was possible to retrieve them from the ship using a grapple. This was good news because before we sailed discussion had taken place about launching a small boat to recover the instruments due to the height about water of the ships deck and the lack of bow thruster. The combination of engine power and bubblers made the recovery possible in relatively calm seas. This would have been time consuming and dangerous in the high wind. The third OBS retrieval was canceled due to high winds. We waited 24 hours while a seismic reflection survey took place near the coast to begin the pick up of the instruments. With light winds this went smoothly recovering the last six instruments in an efficient fashion.

Refraction seismic data processing on board CCGS Louis S. St. Laurent

(August/September 2001)

This document was written by
Thomas Funck (Danish Lithosphere Centre)
on September 6, 2001

Below is a description of the data handling of the refraction seismic experiment during the Geo Nares Strait Cruise 2001. This includes a description of the:

- experiment
- data download
- preparation of navigation files
- creation of SEG-Y files
- data archival

The refraction seismic experiment

The refraction seismic group collected data along two segments of the Nares Strait. The first segment was in Kennedy Channel, utilizing the location of Hans Ø (Hans Island) in the middle of the channel. Three land stations (ORION's) were deployed during the experiment. One station was located on Hans Ø, one at Carl Ritter Bay on Ellesmere Island and one at southern Fossilbugt (Fossil Bay) on the Greenland side of the channel. The difficult ice conditions worsened after deployment of the instruments so that the three stations could not be linked with a shot line. Instead, the line started south of Carl Ritter Bay, passed Hans Ø in the south and continued towards Fossilbugt (Line 1), where the ship turned to move back to Hans Ø (line 2). At the island the shooting had to be stopped due to heavy ice west of Hans Ø. The seismic source for the two lines was the full array of the six GI guns (both port and starboard beam with a 255, a 210 and a 150 cubic inch gun each) provided by the British reflection seismic group. The guns were towed at a depth of 3 m. The shot spacing was 15 seconds with the shot times (using GPS clock) logged to a file (refl-2.raw). The shot times were corrected for the gun delay (27 ms) and then were merged with the positions obtained from the GPS navigation system (Loui232a.01E and Loui233a.01E). In addition, the course over ground was computed from these navigation files. This "pseudo" heading was used to correct for the offset between the GPS antenna (located 207 ft from the stern) and and airguns (towed 100 ft behind the ship). This shot table is saved as file (line1-2.dat).

During deployment of the ORION's for refraction lines 1 and 3 there were MCS shots along reflection seismic line 8 passing Hans Ø at close distance. This data was partly recorded by the stations and could be potentially useful. Unfortunately, the MCS shots were fired on distance (25 m) and not on time, so that no exact shot times were logged. However, the log file (mcs08.log) of the MCS shots contains a time stamp of the PC clock, when the recorded data was written to file. If it turns out, that this time stamp has a constant delay for all shots, one would be able to create a refraction seismic record section for which only a static time shift has to be determined. A preliminary shot table (line8.xyt) was calculated to be able to extract the appropriate time windows from the land stations. The seismic source during the MCS line was only half of the array (255, 210, and 150 cubic inch gun).

The main refraction line during the Nares Strait 2001 cruise was line 3. This line runs from Stenkul Fiord (western Ellesmere Island) to Makinson Inlet (Ellesmere Island) across northern Baffin Bay towards Thule Air Base in Greenland. Seven ORION's were deployed along the line: one at Stenkul Fiord, four along Makinson Inlet, one at Cape Combermere, and one on Saunders Island off Greenland. In addition, eight ocean bottom seismometers (six from GSC and two from Dalhousie University) were deployed in northern Baffin Bay. The shot line was split in two segments. The first segment in Baffin Bay up to the dense pack ice (9/10 ice coverage) that was blocking the Ellesmere coast. The second segment was shot in Makinson Inlet. The shot gap due to the ice conditions has a length of 63 km. The seismic source was the GSC airgun array with six 1000-cubic inch guns towed on two beams behind the ship (100 ft) at a depth of 20 ft. The shot interval was one minute with the pulse given by a GPS clock. However, the GPS clock had to be reset several time due to problems with the reception of the GPS signal. This resulted in additional shot gaps with up to 15 missing shots.

The OBS were launched by means of a crane located on the afterdeck. The waterdepths recorded at the time of deployment are given in meters below keel of the ship. The ships depth is ca. 9 m. The assumed sound velocity for the measurements is 1465 m/s.

The following description deals with the data processing applied to the eight OBS deployed along line 3. Processing and operation of the ORION land stations is described elsewhere.

Data download

Before and after recovery of the OBS the offset of the OBS clock towards the GPS time signal was measured. The initial offset before deployment was used as static time correction. The clock drift, which is assumed to be linear, was determined from the difference of the two clock calibrations.

The data were downloaded in the afterdeck storage room, using a PC with a DAQ card from National Instruments. For the download a DOS window was opened on the computer and *mirror.exe* was started to establish the communication between the computer and the OBS on a serial line with a Baud rate of 9600. Using the serial link, the hard disk was turned on (command dr +) and the program *run* was run. Then *mirror* was quitted by pressing the *F2* key. The data download with the program *pc7up.exe* was done in the same DOS window used for *mirror*.

pc7up downloads only one datafile. To download several files in one operation, the program *doall.exe* can be used in a batch file. Appropriate batch files were created (obs<line#><station#>.bat). The syntax is

doall batchfile first-datafile last-datafile (e.g. doall obs315 0 161). This will download all datafiles from datafile.000 to datafile.161

The batch file is the name of a batch that actually calls the program pc7up. The batchfile (e.g. *obs315.bat*) contains the following two lines

```
pc7up -b 9600 -i 0x0210 datafile.%1
move datafile.%1 c:\data\dat315\datafile.%1
```

The first line downloads the data with the according setting for the baud rate (-b option) and the port (-i option). The second line moves the downloaded datafile into a subdirectory of the working directory, in the example to the directory *dat315*. This directory was created before the download process.

Navigation files

One essential input file for the creation of SGY files from the raw data is the table with the times and positions of the shots. These tables were calculated from shipboard navigation data provided by Sonja Dehler. The data in these files (filename *int<Julian Day#><a/b>.dat*) were given for 10 second intervals. The shot times during refraction line 3 were logged and the according positions were extracted from these navigation files. A "pseudo" heading was calculated from the navigation files, which was used to determine the airgun position 307 ft behind the GPS antenna. The resulting shot table is named *line3.nav*. The shot delay could not be determined during the experiment and was therefore not incorporated in the shot table. During the Scotian Margin (SMART) project in June/July 2001, the shot delay for the GSC array was 60 ms on the last two lines and 150 ms on the first line (with a slightly different instrumental setup than on the two other lines) . A similar delay is to be expected for this experiment.

Creation of SEG-Y files

1. Creating preliminary shot tables for individual OBS with the program *maketab.for* using the input file *s[line#][station#].inp* and the navigation file line3.nav . Output files *s[line#][station#].sht*

The .inp files contain the following 11 lines

line3.nav	←	Navigation file
0	←	Offset between gun and GPS (set to ZERO, because already corrected)
s315.sht	←	input shot table
76.70289,-70.61467,-61.0	←	OBS position (latitude,longitude) and central meridian
242,20,59,0	←	clock start (day,hour,minute,second)
246,12,36,0	←	clock check (day,hour,minute,second)
0.0	←	clock drift in ms (use ZERO, will be corrected in next step)
0	←	gun delay (set to ZERO, is already corrected for in shot table)
0	←	offset between GPS/OBS clock (set to ZERO, will be corrected in next step)
243,16,10,0	←	start time to extract shots (day,hour,minute,second)
245,20,11,0	←	end time to extract shots (day,hour,minute,second)

2. The program *maketab.for* has difficulties with determining the correct sign for the ranges. The output shot tables were checked manually to determine shot numbers with negative offsets. The program *offset.for* then corrects the signs of the ranges. The program prompts for input and output files and for the minimum and maximum shot point number with negative offsets. After this step, the input shot tables were deleted and the output shot tables were renamed to the name of the input shot table.

The shot tables were then corrected for the clock drift and any static time corrections. This is done by the program *drift.for* . The input files are the shot tables and files with the name *mcs[line#][station#]tc.inp* and *s[line#][station#]tc.inp* (tc stands for time correction). These .inp files contain six lines of the following format

s315.sht	←	input shot table
s315tc.sht	←	output shot table
2.867	←	static clock correction (msec)
242,20,59,0	←	clock start (day,hour,minute,second)
246,12,36,0	←	clock check (day,hour,minute,second)
-18.867	←	clock drift (msec)

The output shot tables show the actual OBS clock time of individual shots. The names are *s[line#][station#]tc.sht*

3. Now the SEGY files were compiled using the program *Dobs2Sgy2000.exe.* Click on the program icon, click okay and browse to the directory with the raw datafiles. Click on the first datafile, move to the last datafile, hold the *SHIFT* key and click on the last datafile. Press *OK.* In the next field browse to the appropriate time corrected shot table *s[line#][station#]tc.sht*, and specify the output filename in the lowermost browse window. Record length is 60 seconds and choose *0* for all channels. The channel number will be added automatically to the SEGY file name.

Filenames: s[line#][station#]ch[channel#].sgy

With	ch1	the hydrophone component
	ch2	the vertical geophone
	ch3/4	the horizontal geophone components

The SEGY files are NOT standard IBM format but with ASCII encoded header and short integer formatted data.

Data Archival

After downloading the data from the OBS, the raw data files were written on a CD for each individual station. The SEGY files created were also saved on a CD and finally, backup copies of all CDs were made. Navigation data, shot tables, programs, raw plots, location maps and other documentation are saved as *Metafiles* on another CD. One set of the CD's was given to Ruth Jackson (for GSC archival), the other one is with Thomas Funck.

Comments

For one instrument (GSC-3 on position 3) the clock drift could not be determined because the OBS clock jumped by 27 sec. This occurred probably due to rough handling (fall of the cylinder on deck) of the instrument.

Two instruments have recorded recorded a second pulse on the hydrophone channel (OBS 10 and 13, that is instruments GSC-3 and GSC-4, respectively.

ORION Seismograph Stations, Nares Strait 2001 refraction program

(Sonya Dehler, GSC)

Airgun signals were recorded on Ellesmere Island and Greenland using an array of 24 bit portable Orion seismographs, manufactured by Nanometrics Inc. and owned by the University of Western Ontario and the University of British Columbia. Three component Mark Products L4 seismometers were deployed to record vertical and horizontal motions. Power in the field was provided by 12V sealed gel cell batteries, and a GPS receiver provided station position and time. Deployment time at each site was approximately 30 minutes.

Data were recorded on 1 gigabyte SCSI Orion disks at 200 samples per second. On retrieval, the SCSI disk was removed from the Orion and connected to a PC for data download. Scripts provided by GSC Ottawa for the Linux operating system were used to run Nanometrics Inc. data retrieval and playback programs on a laptop computer. Data retrieval consisted of trimming the ringbuffer files on the SCSI Orion disk, copying the trimmed ringbuffer files to a 1 gigabyte JAZ disk, and then compressing and moving the data to a backup directory on the Orion disk. Once the data were backed up, the ringbuffer files were converted to SAC and SEED seismic data formats. Later processing and merging with shot tables will produce SEG-Y files to be used in further processing and interpretation.

77.0486 N	75.9385 W	242/1426	348	OBS deploy 08
77.0070 N	75.1590 W	242/1539	524	OBS deploy 09
76.9642 N	74.3874 W	242/1704	545	OBS deploy 10
76.9177 N	73.6313 W	242/1802	217	OBS deploy 11
76.8664 N	72.8600 W	242/1856	157	OBS deploy 12
76.8104 N	71.9377 W	242/2033	805	OBS deploy 13
76.7608 N	71.3438 W	242/2116	33	OBS deploy 14
76.7033 N	70.6079 W	242/2210	194	OBS deploy 15
76.7003 N	70.6041 W	246/1157	83	OBS recover 15
76.7593 N	71.3430 W	246/1342		OBS recover 14
76.8052 N	71.9235 W	247/1530		OBS recover 13
76.8509 N	72.7532 W	247/1630	148	OBS recover 12
76.9164 N	73.6285 W	247/1805	209	OBS recover 11
76.9597 N	74.3788 W	247/1920		OBS recover 10
77.0018 N	75.1544 W	247/2049	522	OBS recover 09
77.0430 N	75.9222 W	247/2205	375	OBS recover 08
80.7419 N	67.7838 W	233/0148	120 2	Refraction start R_1
80.7431 N	65.8305 W	233/0713	151	Refraction end R_1
80.7578 N	65.7930 W	233/0726	158	Refraction start R_2
80.8403 N	66.3246 W	233/0854	316	Refraction end R_2
76.6203 N	69.3261 W	243/1621	111	Refraction start 3
77.0615 N	77.0814 W	244/1911	227	Refraction end 3
77.2603 N	81.6044 W	245/1235	164	Refraction start 3
77.2376 N	79.4948 W	245/2010	306	Refraction end 3

ORION Seismograph Deployment: Refraction Lines 1 and 2 across Kennedy Channel

STATION	LATITUDE	LONGITUDE	ELEVATION	ORION #	DISK #
1 Carl Ritter Bay	80.9327° N	67.6532° W	100 m	105	182
2 Hans Island	80.8240° N	66.4439° W	138 m	137	151
3 Fossil Bay	80.7401° N	65.3822° W	184 m	185	153

ORION Seismograph Deployment: Refraction Line 3 from Makinson Inlet to Thule

STATION	LATITUDE	LONGITUDE	ELEVATION	ORION #	DISK #
1 Stenkul Fiord	77.4011° N	83.4353° W	200 m (est.)	185	153
2 Swinnerton P.	77.2376° N	81.9078° W	111 m	105	182
3 Makinson Inlet	77.2861° N	81.0780° W	68 m	137	151
4 Makinson Inlet	77.2032° N	80.0776° W	28 m	191	181
5 Cape Stokes	77.1317° N	79.0999° W	50 m (est.)	188	156
6 CCombermere	77.0186° N	78.1224° W	12 m	158	161
7 Saunders Isl.	76.5934° N	69.7287° W	33 m	183	245

Seismic Equipment and Operational Report

(S. Neben)

Construction and Function of a GI-Gun

Because during this cruise GI-Guns were used by BGR for the first time the peculiarities of these seismic sources are described in more detail. Construction and working of a GI-Gun differs in some peculiar ways from a conventional air gun. A GI-Gun is made of two independent air guns within the same body. The first air gun is called "GENERATOR" and produces the primary pulse. The second air gun or "INJECTOR" controls the oscillation of the bubble produced by the GENERATOR.

A hydrophone provides the time-break signal and the shape of the near-field signal for permanent signature controlling. The function of an GI-Gun is shown in **Fig. 27.**

Phase 1:
The GENERATOR is fired. The blast of compressed air produces the primary pulse and the bubble starts to expand.

Phase 2:
When the bubble approaches its maximum size, it encompasses the INJECTOR ports, and its internal pressure is far below the outside hydrostatic pressure.
At this time, the INJECTOR is fired, injecting air directly inside the bubble.
Due to the quasi static state of the bubble, the timing of the INJECTOR is not critical.

Phase 3:
The volume of air released by the INJECTOR increases the internal pressure of the bubble, and prevents its violent collapse.
The oscillations of the bubble and the resulting secondary pressure pulses are reduced and re-shaped.

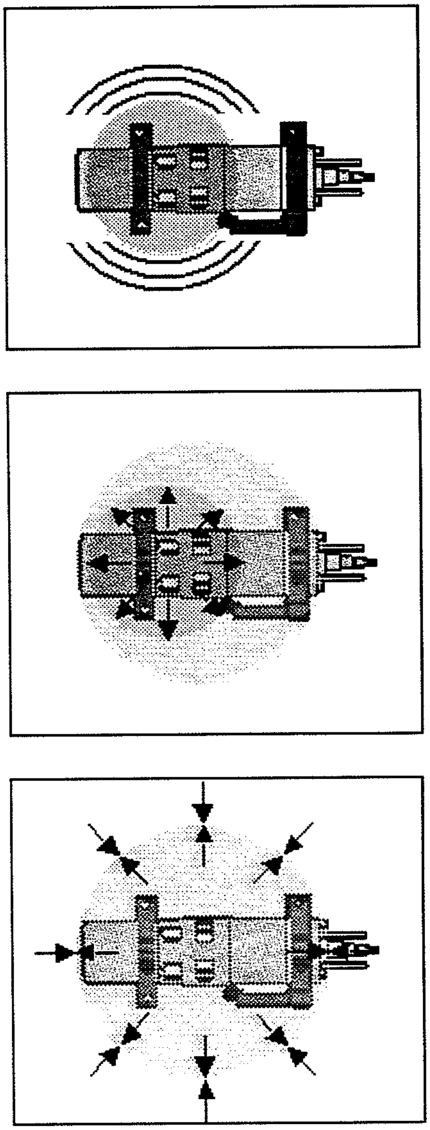

Fig. 27. *Three phase function of a GI-gun*

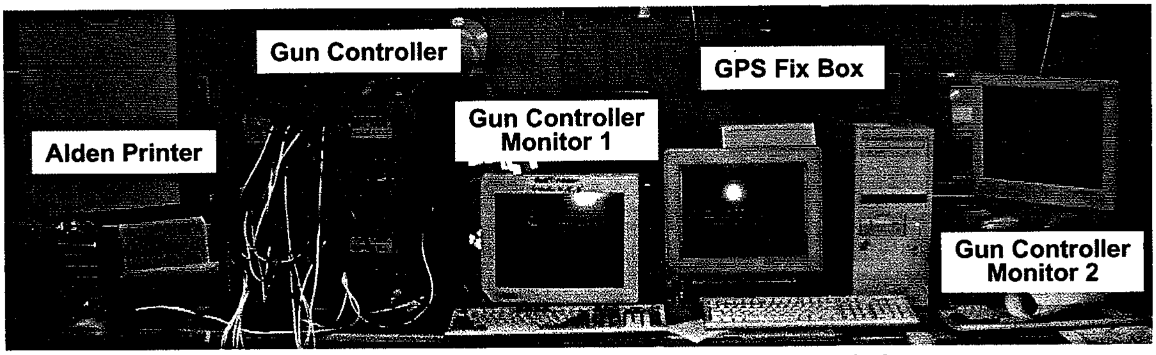

Fig. 30. *Photo of Alden printer, the gun controller and screens and the GPS fix box*

Geometrics StrataVisor™ NX

The GEOMETRICS STRATAVISOR™ (**Fig. 31.**) sits as the main hub of the reflection seismic package, where by the acquired data is inputted to be processed, sampled, and stored to tape in SEG D format for safe keeping. The STRATAVISOR™ recording cycle is started from a single opto output from one of the TGS-8 units upon the predicted gun fire point.

No user filtering has been applied to the data, so as to maximise the content. The recording parameters during the cruise were: Format: SEGD 8058 rev. 1, 32-bit IEEE demultiplexed, record length: 10240 ms resp. 6114 ms, sample rate: 4 ms / 2 ms resp. 2 ms.

In an extended header the co-ordinates (Latitude & Longitude) of each FFID (shot) were recorded.

Quality Control

The quality control was maintained during the recording in seven different ways. Each signal generated by the individual GI-Guns were observed via the MACHA control screens (**Fig. 30.**). Each shotgather plus auxiliary channel were displayed on the StrataVisor monitor. In addition, a PRINTREX 8.5" printer, connected to the STRATAVISOR™ parallel port was used to produce individual shot plots (0 – 2 s TWT) at an interval of every 40 shots. Plot parameters were: 7 tpi, 5"ps.

The streamer depth controllers (birds, see below) were observed via a modem and a PC. This system allows the control of the birds to operate at any desired depth. Depth readings from the Birds are displayed on the PC and recorded every 40 shots.

A READ WHILE WRITE V.14 (RWW14) system was used to produce an single trace gather on screen and parallel on an ALDEN 9315CTP 10.6" thermal plotter. This system captures the SCSI data as its feed to the tape drives, acting as an end of line terminator. The data was then displayed as constantly updating screen shots and single trace gather on the computer screen. In this instance a hardcopy gather was created for each line, with the relevant file also saved to hard disk, for later playbacks using different plot parameters (e.g. 40 tpi, 2 cmps, 3 cmps, 6 cmps, respectively) and filters.

Seismic Streamer

The seismic streamer sections consisted of two types; channels 1 to 24 were TELEDYNE sections and channels 25 to 48 were LITTON PROGRAMMABLE sections. The group length was 25 m with 20 hydrophones per group for the TELEDYNE sections and 24 hydrophones per group for the LITTON PROGRAMMABLE sections, respectively. The TELEDYNE hydrophones sensitivity was 5µV/µbar and LITTON PROGRAMMABLE hydrophones sensitivity was 4µV/µbar.

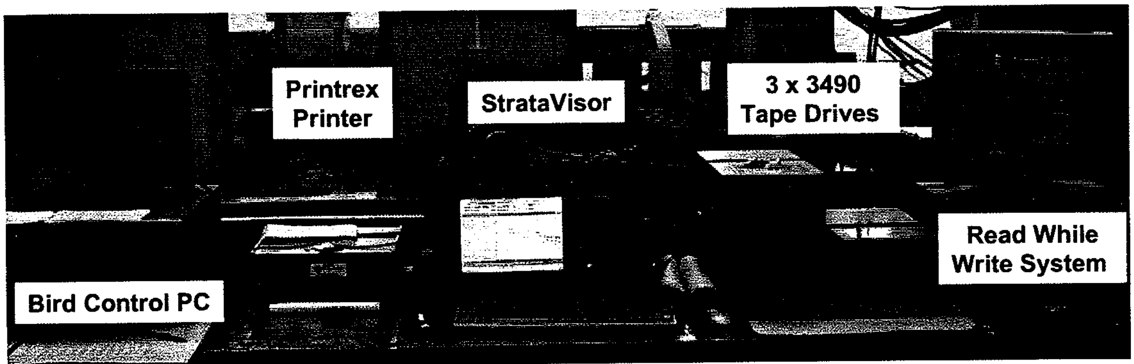

Fig. 31. *Photo of the bird control PC, Printrex printer, STRATAVISOR™, tape drives and the READ WHILE WRITE system during acquisition.*

The streamer consisted of twelve individual sections. Each section consisted of four groups (channels) and had a length of 100 m. Thus, the total active streamer length was 1,200 m.

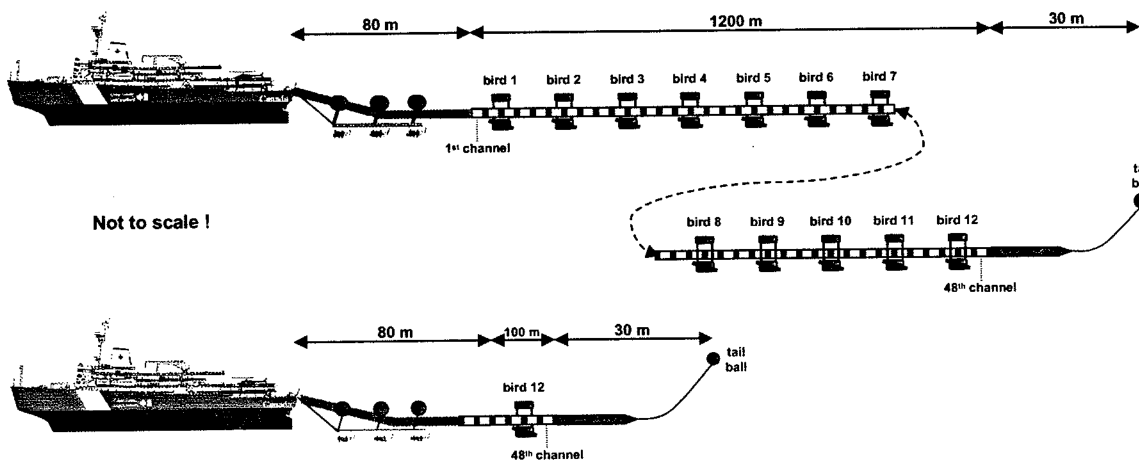

Fig. 32. *Streamer lay-outs during the NARES01 cruise.*

The channel assignment order was channel 1 closest to the vessel and 48 at the tail end. In the centre part of each section is coil for communications with a DIGICOURSE bird (see below), which can be attached at that point.

The tow depth has varied during this cruise according to the ice condition; the seismic field logs show depths for each line.

A lead-in of 80m has been used on all the profiles as the distance from aft deck to centre of first processed channel. The streamer lay-outs used during the cruise are shown in **Fig. 32.**

Depth Controllers

The tow depth of the streamer was controlled by up to twelve DIGICOURSE 5010 series cable levellers. These units can only operate when mounted close to a coil within the streamer.

During the use of the whole streamer length (in mostly ice-free open waters) floatation tubes were used with the birds to guarantee as close as possible neutral buoyancy of the streamer. One bird per active group was used. The position of the birds are shown in **Fig. 32.**

Storage Drives

For the storage of the seismic field data two 3490 tape drives connected to the STRATAVISOR™ were used. The capacity of the individual cartridges was 810 / 850 Mbyte. A third 3490 tape drive was connected (**Fig. 31.**) to another computer for playback through a basic seismic QC program (see 1.6).

Data Flow

The flow of the data during the multichannel seismic reflection data acquisition during cruise NARES01 is shown in **Fig. 33.**

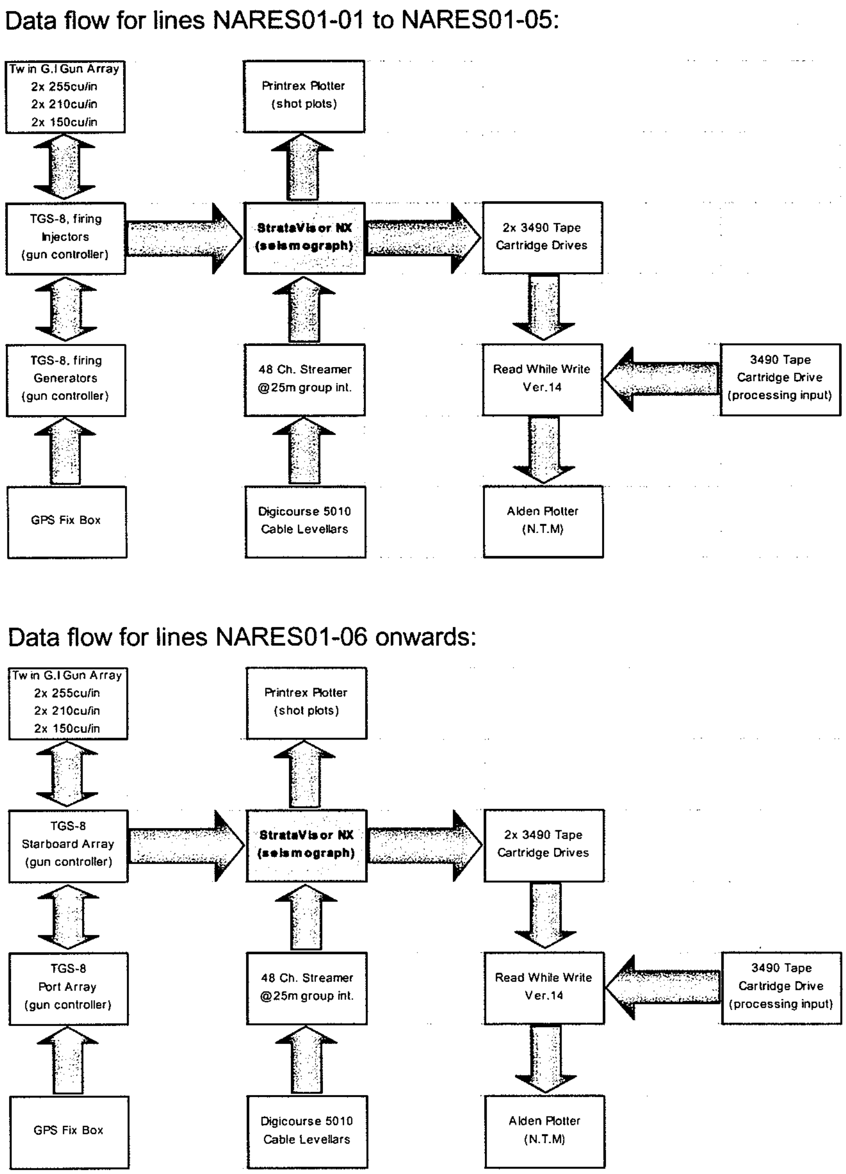

Fig. 33. *Data flow of the seismic data acquisition during cruise NARES01.*

Profile List

Profile	Start	End	Channels / Length [m]	Guns / Volume [l]	Number of shot points	ΔSP_{ave} [m]	Length [km]
NARES01-01	76°52.81' N 74°11.96' W	76°50.36' N 76°52.92' W	48 / 1200	6 / 20.16	1358	50.17	68.131
NARES01-02	76°50.34' N 76°45.58' W	76°53.73' N 76°31.79' W	48 / 1200	6 / 20.16	144	59.7	8.597
NARES01-02A	76°56.20' N 76°22.59' W	77°36.72' N 73°36.58' W	48 / 1200	6 / 20.16	2384	43.1	102.76
NARES01-03	77°32.88' N 73°51.19' W	77°39.62' N 75°40.27' W	48 / 1200	6 / 20.16	871	52.27	45.525
NARES01-04	77°38.05' N 75°32.63' W	78°17.77' N 72°58.98' W	48 / 1200	6 / 20.16	1860	51.6	95.975
NARES01-05	78°18.12' N 73°04.02' W	78°18.79' N 73°29.80' W	48 / 1200	6 / 20.16	210	46.69	9.805
NARES01-06	80°57.05' N 65°59.78' W	80°57.48' N 66°39.68' W	6 / 150	3 / 10.08	220	53	11.706
NARES01-07	80°57.65' N 66°37.81' W	80°49.94' N 65°50.34' W	6 / 150	3 / 10.08	435	34	19.963
NARES01-08	80°55.38' N 65°11.26' W	80°47.47' N 67°29.57' W	6 / 150	3 / 10.08	1751	25.3	44.3
NARES01-09	80°43.99' N 67°27.00' W	80°42.24' N 66°15.30' W	6 / 150	3 / 10.08	900	24.14	21.733
NARES01-10	80°42.37' N 66°14.61' W	80°47.92' N 66°31.95' W	6 / 150	3 / 10.08	663	17.45	11.569
NARES01-11	80°50.32' N 66°37.65' W	80°57.81' N 65°20.99' W	6 / 150	3 / 10.08	1101	22.84	26.651
NARES01-12	80°57.86' N 65°20.29 W	81°03.90' N 64°37.52' W	6 / 150	3 / 10.08	741	22.69	16.811
NARES01-13	81°18.44' N 63°10.53' W	81°15.66' N 62°45.23' W	6 / 150	3 / 9.34	403	21.84	8.798
NARES01-14	81°12.74' N 62°43.57' W	81°42.36' N 62°02.33' W	6 / 150	3 / 9.34	2149	26.23	56.36
NARES01-15	81°37.82' N 62°02.29' W	81°34.43' N 62°35.69' W	6 / 150	3 / 9.34	429	25.71	11.03
NARES01-16	81°34.05' N 62°38.58' W	81°31.76' N 61°44.26' W	6 / 150	3 / 9.34	693	22.26	15.425
NARES01-17	81°31.41' N 61°41.86' W	81°25.91' N 63°09.56' W	6 / 150	3 / 9.34	1053	24.83	26.146
NARES01-18	81°24.94' N 63°07.37' W	81°21.72' N 62°14.07' W	6 / 150	3 / 9.34	740	21.59	15.973
NARES01-19	81°21.53' N 62°13.46' W	81°18.56' N 63°15.63' W	6 / 150	3 / 9.34	870	20.97	18.242
NARES01-20	81°18.51' N 63°24.03' W	81°34.27' N 62°09.34' W	6 / 150	3 / 9.34	1600	22.55	36.077
NARES01-21	80°19.70' N 69°26.64' W	80°14.93' N 69°11.30' W	6 / 150	3 / 9.34	378	26.69	10.089
NARES01-21A	80°15.23' N 69°16.17' W	80°00.15' N 69°07.81' W	6 / 150	3 / 9.34	1161	24.28	28.187

Profile	Start	End	Channels / Length [m]	Guns / Volume [l]	Number of shot points	ΔSP_{ave} [m]	Length [km]
NARES01-22	76°38.16' N 69°34.27' W	76°44.29' N 71°17.06' W	48 / 1200	3 / 10.08	904	50.5	45.652
NARES01-23	76°45.25' N 71°19.18' W	77°12.89' N 72°07.36' W	48 / 1200	3 / 10.08	1155	47.95	55.377
NARES01-24	77°13.47' N 71°33.10' W	77°12.25' N 74°39.81' W	48 / 1200	3 / 10.08	1555	49.24	76.855
NARES01-25	77°12.47' N 74°41.37' W	77°34.10' N 74°34.45' W	48 / 1200	3 / 10.08	820	49.2	40.347
NARES01-26	77°34.51' N 74°32.91' W	77°56.64' N 73°02.62' W	48 / 1200	3 / 10.08	1089	50.31	54.793
NARES01-27	77°55.08' N 73°03.17' W	77°38.93' N 73°03.07' W	48 / 1200	3 / 10.08	647	47.15	30.05
NARES01-28	77°39.14' N 73°05.95' W	77°34.95' N 71°55.03' W	48 / 1200	3 / 10.08	1089	50.56	29.276
NARES01-29	77°34.08' N 73°40.19' W	76°53.53' N 74°24.08' W	48 / 1200	3 / 10.08	1555	?.?	?
NARES01-30	76°53.53' N 74°24.08' W	?°?.?' N ?°?.?' W	48 / 1200	3 / 10.08	?	?.?	?

Operational Report

Date	Ship's time (UTC + 3 h)	
06.08.01		Planning: First line should run from Coburg Island to Northumberland Island. R_x-Technicians of EE (Exploration Electronics) and GSCA (Geological Survey of Canada, Atlantic) have to work for approx. ca. 36h to fit GI-Gun arrays to the GSCA beams
07.08.01		Delay of work on the beams => revision of profile planning: start with R_x-seismics on 3 lines in Northern Baffin Bay
08.08.01		Continuing work on R_x-System
09.08.01	17:00	Work on guns and beams finished. Seastate 5-6, wind 25 Kn
	20:15	Deployment SB-Beam (personnel: 3 GSCA, 4 EE & 4 Crew), SB-Beam has limited manoeuvring space due to HUNTEC-System
	21:15	SB-Beam deployed. Start deploy P-Beam, air hose breaks, fixing time: 25 Min.
	22:00	P-Beam deployed. Start testing
	22:50	Testing finished: 5 Guns ok, 1 Gun problems with solonoid. Both beams brought to the close to the stern of the ship, out of the water
	23:32	Beams at the railing
10.08.01	07:30	Deployment P-Beam
	09:00	P-Beam deployed, work on SB-Beam starts
	10:27	Work finished, Deployment SB-Beam
	10:48	SB-Beam deployed, testing, SB2 doesn't work
	12:30	Start heaving SB-Beam
	13:05	SB-Beam on deck
	13:08	SB2 changed
	13:32	Testing shows that failure is not gun but broken trigger line in umbilical bundle, new line on bundle installed

Date	Ship's time (UTC + 3 h)	
	15:00	Repair finished
	15:05	Deployment SB-Beam
	15:25	SB-Beam deployed
	15:35	Streamer Deployment
	18:05	Streamer deployed, levelling starts, Bird 5 not working
	19:05	Bird change and lead applied to lead-in
	21:45	Start profile NARES01-01, 1200 m streamer, 6 guns
11.08.01	05:37	End profile NARES01-01
	05:40	Full turn with 6°/min, turn too fast => Streamer in P-Beam, P-Beam heaved to the ship, Streamer corrected
	07:12	Start profile NARES01-02
	08:10	Problems with Compressor, end of Profile NARES01-02
	09:00	Compressor repair finished
	09:15	Start profile NARES01-02A
	14:00	Shooting distance too short, triggering from trigger-programme incorrect => Shot intervals are controlled every 15 Min. by seismic watchkeepers
	22:04	End profile NARES01-01
	22:10	Start turn with 3 Kn
12.08.01	01:30	End of turn
	01:50	Start profile NARES01-03
	07:10	End profile NARES01-03
	07:30	Start turn
	09:09	Start profile NARES01-04
	11:06	Guns P2 & P3 not working (possibly due to icing), continuing with 4 Guns
	18:27	6 Guns again
	21:30	End profile NARES01-04. Start turn
	21:52	End of turn
	21:54	Start profile NARES01-05
	23:00	Tail ball teared off from iceflow (3/10-4/10 ice)
	23:08	End profile NARES01-05
	23:15	Start streamer retrieving
13.08.01	00:19	Streamer on deck, decision: stop profile NARES01-05, go to start of line NARES01-06, streamerlength: 600 m. During approach 6/10-7/10 ice
	04:00	During deployment of streamer tail ball was teared off again 450 m behind the ship, although bubbler system on. Southerly wind drifts ice into streamer already 200 m behind ship => stop shooting, retrieve gear, steam to central Kane Basin
13.08.-18.08		Raw processing on lines 01 and 02A
19.08.		Helicopter ice reconnaissance for R_x measurements
	20:35	Start profile NARES01-06, 150 m streamer, 3 guns
	22:08	End profile NARES01-06. Start turn
	22:17	Start profile NARES01-07
20.08.	01:15	End profile NARES01-07, streamer on deck, P-Beam heaved to railing
	09:30-11:20	Helicopter ice reconnaissance for R_x measurements
	12:00	Deployment of gear
	12:40	SB-compressor cooling problems, air hose explodes, anti-freeze runs out, continuing with P-compressor

Using permanent GPS stations as reference stations is advantageous since the positions of the stations are known very well after a few months of operation. Further errors arising from set up and centering of the GPS antenna are minimised.

Station locations and planned activities

KMS Station Number	Location	Station Marker	Planned activity
1007	Joe Island	Tablet, CHS	GPS observations Tide (if not on Hans Ø) New bolt
1707	Nyboe Land	Tablet, KMS	GPS observations Tide New bolt
1709	Cape Baird	Tablet, KMS	GPS observations New bolt
2025	Kap Alexander	Tablet, TSC	GPS observations Tide in Etah just North of Kap Alexander New bolt
2026	Cape Isabella	Tablet, KMS	GPS observations New bolt
2050	Kap Agassiz	Tablet, CHS	GPS observations Tide New bolt
2055	Kap Madison	Tablet, CHS	GPS observations New bolt
2060	Hans Ø	Tablet, TSC	GPS observations Tide - if possible New bolt
2071	Cape Wilkes	Tablet, TSC	GPS observations New bolt
2704	Cass Fjord	Tablet, KMS	GPS New bolt

CHS = Canadian Hydrographic Survey
TSC = Topographical Survey of Canada
KMS = National Survey and Cadastre, Denmark

Field Operations

The field work was carried out using MBB-105 helicopters operating from the CCGS Louis St. Laurent. The sequence of the stations visited was fully dependent on the location of the Louis, since no fuel caching was carried out. Further, the helicopters were closely shared between several groups working onshore, which also influenced the geodetic survey activities.

List of major events
July 28.
Bob boarded the Louis St. Laurent in Grise Fiord.

August 1.
The Louis arrives at Thule Air Base. Lasse and Anna board.

August 9.
GPS equipment set out on Kap Alexander and Cape Isabella. Water level logger and GPS in new bolt set out just south of Etah and levelling carried out between the two.

August 12.
Levelling and pick up of water level and GPS equipment in Etah. GPS equipment picked up at Kap Alexander and Cape Isabella.

August 13.
GPS equipment set out at Kap Agassiz. New bolt established and 2 hours of data collected continuously between the new and old markers. Water level logger and GPS equipment in new bolt set out at sea level just beneath the Cape. Levelling carried out between the new bolt and the water level logger.

August 14.
GPS equipment set out at Kap Madison and Cape Wilkes. New bolt established at Kap Madison, 20 minutes of data was collected continuously between the new and old markers.

August 15.
GPS equipment and water level logger picked up at Kap Agassiz. Control levelling carried out between the water level logger and the new GPS bolt.

August 18.
GPS equipment picked up at Kap Madison and Cape Wilkes. GPS equipment set up on Hans Island. New bolt established on Hans Island and 30 minutes of data was collected continuously between the new and old markers.

August 19.
GPS equipment set out on Joe Island and Cape Baird. New bolts established in both locations. 30 minutes of data was collected continuously between the new and old markers on Joe Island. GPS equipment left in both markers on Cape Baird.

August 21.
GPS equipment picked up at Hans Ø, Joe Island and Cape Baird.

August 22.
Bob, Lasse and Anna leave the Louis with PCSP Twin Otter from Carl Ritter Bay.

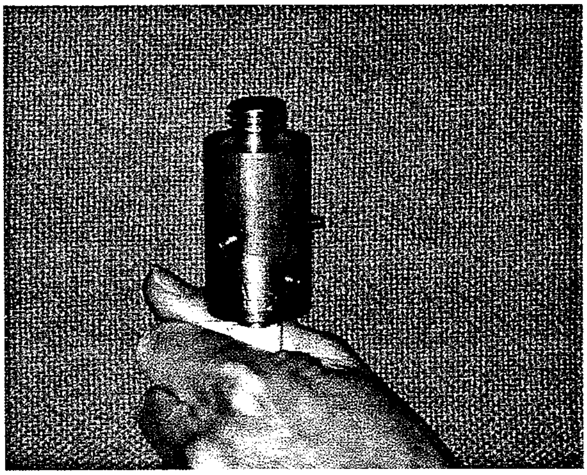
Fig. 35. *GPS bolt*

Field Survey Routine

In most locations new GPS markers were established. The markers are bolts with a 5/8" thread making it possible to mount a GPS antenna directly onto the bolt. The bolts are drilled and epoxied directly into the rock.

When new bolts were established, approximately 30 minutes of GPS data was collected continuously by the GPS equipment left over the new and the old markers. The GPS equipment in the new marker was then left for approximately 3 days. At the sites where new bolts were not established, the GPS equipment was left on the old marker for approximately 3 days.

In the locations where water level observations were carried out, a GPS bolt was established in a location suitable for GPS

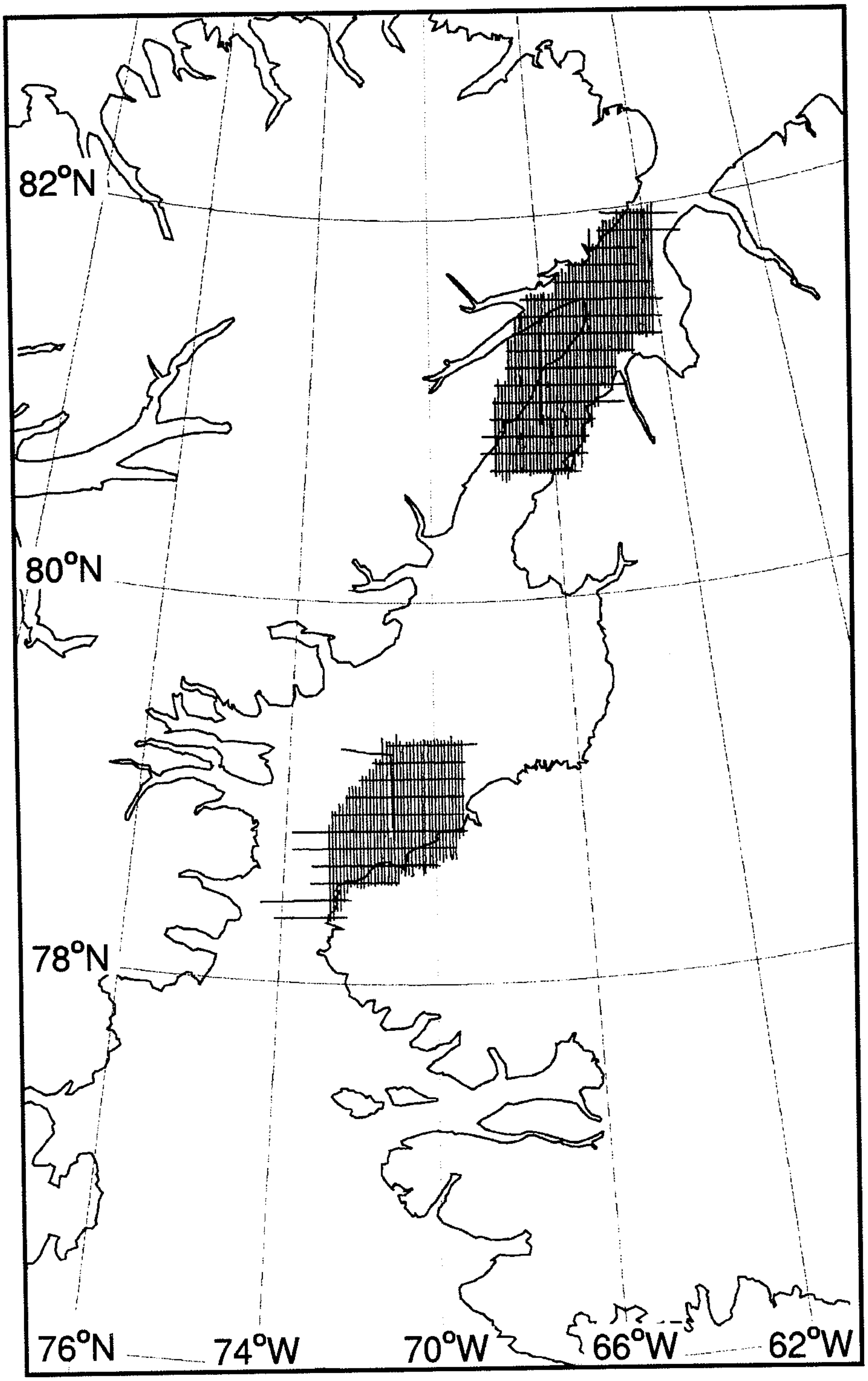

Fig. 37. *Nares Strait - 2001 Aeromagnetic Program*

KBA : Hall Basin				
LINE	DAY	FLIGHT	BINARY FILE	COMMENT
L419A	233	17	S1082102.B07	
L421A	233	17	S1082101.B47	
L423A	231	12	S1081907.B05	
L425A	231	12	S1081906.B45	
L427A	231	12	S1081906.B17	10sec time errors after 24010sec
L429A	231	12	S1081905.B47	
L429B	235	21	S1082302.B55	
L431A	231	11	S1081904.B28	
L431B	235	21	S1082302.B50	
L433A	231	11	S1081903.B35	
L433B	235	21	S1082302.B42	
L435A	231	11	S1081904.B03	
L435B	235	21	S1082302.B34	
L437A	231	11	S1081903.B07	
L437B	235	21	S1082302.B22	
L439A	232	14	S1082000.B48	
L439B	235	20	S1082301.B31	
L441A	232	14	S1082001.B43	
L441B	235	20	S1082301.B21	
L443A	232	14	S1082001.B19	
L443B	235	20	S1082301.B09	
L445A	232	14	S1082000.B13	
L445B	235	20	S1082300.B58	
L447A	232	15	S1082003.B31	
L447B	235	20	S1082300.B46	
L449A	232	15	S1082004.B04	
L449B	235	20	S1082300.B35	
L451A	232	15	S1082004.B27	
L451B	235	20	S1082300.B23	
L453A	232	15	S1082004.B56	
L453B	235	20	S1082300.B07	
L455A	232	16	S1082006.B16	
L455B	233	19	S1082107.B09	
L457A	232	16	S1082006.B55	
L457B	233	19	S1082107.B54	
L459A	232	16	S1082007.B18	
L459B	233	19	S1082107.B41	
L461A	232	16	S1082007.B51	

KBA: Hall Basin - Survey Line Summary				
Total Distance : 5583026 m **Total Time :** 106849 sec (29h 12m)				
Line	Day	Flight	Dist (m)	Time (sec)
L437A	231	11	74825	1405
L433A	231	11	82815	1598
L435A	231	11	80806	1456
L431A	231	11	81435	1535
L429A	231	12	68023	1307
L427A	231	12	82166	1574
L425A	231	12	59074	1149
L423A	231	12	55959	1045
T117A	231	13	36331	782
L471A	231	13	106805	1950
L473A	231	13	94697	1904
T116A	231	13	61015	1125
L445A	232	14	73862	1548
L443A	232	14	79976	1399
L441A	232	14	82372	1716
L439A	232	14	85191	1431
L447A	232	15	75995	1703
L449A	232	15	76554	1273
L451A	232	15	76538	1655
L453A	232	15	79780	1282
L455A	232	16	77513	1750
L457A	232	16	80688	1318
L459A	232	16	83721	1898
L461A	232	16	87268	1395
T115A	233	17	75655	1530
T114A	233	17	75215	1374
L421A	233	17	55537	978
L419A	233	17	46102	952
L467B	233	18	63556	1225
T112A	233	18	55657	1042
T113A	233	18	64014	1231
T117B	233	19	35974	712
T118A	233	19	61765	1217
L461B	233	19	39053	689
L459B	233	19	36211	733
L457B	233	19	47807	859
L455B	233	19	46151	950

KBA: Hall Basin - Survey line summary				
Line	Day	Flight	Dist (m)	Time (sec)
L453B	235	20	33608	628
L451B	235	20	33430	650
L449B	235	20	32662	614
L447B	235	20	33787	644
L445B	235	20	32920	617
L443B	235	20	33746	639
L441B	235	20	27864	524
L439B	235	20	29446	548
L437B	235	21	22229	416
L435B	235	21	22393	433
L433B	235	21	23189	429
L431B	235	21	12353	240
L429B	235	21	13165	244
T119A	235	21	52346	1031
L469A	235	21	70984	1372
L475A	235	21	46912	836
L463A	235	22	112805	2284
L465A	235	22	121832	2083
L463J	235	22	12564	246
L477A	235	23	95337	2099
T106A	235	23	29053	613
T107A	235	23	40441	702
L479A	235	23	94305	1623
L475B	236	24	44198	850
L481A	236	24	43308	817
L483A	236	24	47348	874
L485A	236	24	47382	879
L487A	236	24	47931	892
L489A	236	25	38837	711
L491A	236	25	43240	863
L493A	236	25	41529	740
L495A	236	25	44009	880
L497A	236	25	42654	759
L499A	236	25	44106	864
L501A	236	26	44761	921
T104A	236	26	21857	456
T105A	236	26	47600	842
T104B	236	26	28254	580
L507A	236	26	43932	809
L505A	236	26	44351	840

KBA : Hall Basin - Survey line summary				
Line	Day	Flight	Dist (m)	Time (sec)
L503A	236	26	44102	795
T108A	236	27	55347	1006
L467C	236	27	52850	983
L469B	236	27	52797	1077
T109A	236	27	81986	1618
L483B	237	28	53780	1152
L481B	237	28	23333	431
L485B	237	28	24573	529
L487B	237	28	53552	904
L485C	237	28	33248	697
L489B	237	28	55016	937
L503B	237	29	32271	684
L505B	237	29	32338	533
L507B	237	29	33907	767
L509A	237	29	74689	1172
L511A	237	29	77560	1888
T110A	237	30	37781	729
L475C	237	30	34503	832
L481C	237	30	34228	540
T110B	237	30	52591	1037
T111A	237	30	86253	1630
L501B	237	31	32191	544
L499B	237	31	44092	943
T112B	237	31	20864	398
L491B	237	31	43357	698
L493B	237	31	42324	938
L495B	237	31	42522	709
L497B	237	31	42192	896

KBB : Kane Basin				
LINE	DAY	FLIGHT	BINARY FILE	COMMENT
L319A	241	37	S1082903.B27	
L321A	241	36	S1082901.B27	
L323A	241	36	S1082901.B09	
L325A	241	36	S1082900.B47	
L327A	241	36	S1082900.B12	
L329A	241	38	S1082907.B09	
L331A	241	38	S1082906.B50	
L333A	241	38	S1082906.B30	
L335A	241	38	S1082905.B56	
L337A	240	33	S1082805.B03	Processed with s1082804.t46
L337B	241	37	S1082903.B15	
L339A	240	33	S1082803.B32	Processed with s1082803.t29
L339B	241	37	S1082903.B01	
L341A	240	35	S1082809.B57	
L341B	241	37	S1082902.B43	
L343A	240	35	S1082809.B43	
L343B	241	39	S1082909.B29	
L345A	240	35	S1082809.B29	
L345B	241	39	S1082909.B17	
L347A	240	35	S1082809.B13	
L347B	241	39	S1082909.B05	
L349A	240	35	S1082808.B59	
L349B	241	39	S1082908.B55	
L351A	240	35	S1082808.B35	Recorded as L359A renamed in AQN
				10sec error after 3280 sec
L351B	241	39	S1082908.B43	
L353A	240	34	S1082807.B17	
L353B	241	39	S1082908.B15	
L355A	228	07	S1081605.B00	
L355B	240	34	S1082806.B05	Recorded as L355A renamed in AQN
L357A	240	34	S1082806.B57	
L359A	240	34	S1082806.B05	
L361A	227	02	S1081505.B24	
L363A	227	02	S1081504.B48	
L365A	227	04	S1081508.B22	
L367A	227	04	S1081508.B53	
L369A	227	04	S1081509.B18	10sec error after 34845 sec
L371A	227	04	S1081509.B42	
L373A	228	06	S1081602.B12	

KBB : Kane Basin				
LINE	DAY	FLIGHT	BINARY FILE	COMMENT
L375A	228	06	S1081601.B39	
L377A	227	03	S1081507.B18	
L379A	227	03	S1081506.B45	
L381A	228	07	S1081603.B43	
L383A	228	08	S1081606.B24	
L385A	228	08	S1081606.B57	
L387A	228	09	S1081608.B03	
L389A	228	09	S1081608.B37	
L391A	228	05	S1081600.B06	
L393A	228	05	S1081600.B43	
L395A	228	10	S1081609.B53	
L397A	228	10	S1081610.B26	
T135A	228	10	S1081610.B44	
T135J	228	10	S1081610.B44	Copied from T135A after 40460 sec
T136A	240	32	S1082800.B05	
T137A	240	32	S1082800.B33	
T138A	240	32	S1082800.B57	
T139A	240	32	S1082801.B25	
T140A	240	33	S1082803.B48	Processed with s1082804.t29
T140B	240	33	S1082804.B46	Processed with s1082804.t46
T141A	240	33	S1082804.B13	Processed with s1082804.t13
T142A	228	07	S1081604.B16	
T143A	228	07	S1081604.B40	
T144A	241	37	S1082903.B53	Recorded as T114A renamed in AQN 10sec error after 15388 sec time set to 14397 at FID 5158 to fix processing error
T145A	241	37	S1082902.B29	

KBB: Kane Basin - Survey Line Summary				
Total Distance : 3587807 m **Total Time** : 67832 sec (18h 32m)				
Line	Day	Flight	Dist(m)	Time(sec)
L363A	227	02	76753	1493
L361A	227	02	77342	1405
L379A	227	03	74468	1395
L377A	227	03	74245	1336
L365A	227	04	77547	1516
L367A	227	04	78609	1427
L369A	227	04	74777	1412
L371A	227	04	73613	1324
L391A	228	05	71730	1335
L393A	228	05	68307	1325
L375A	228	06	77958	1442
L373A	228	06	78428	1534
L381A	228	07	74700	1430
T142A	228	07	74720	1348
T143A	228	07	50675	968
L355A	228	07	83884	1561
L383A	228	08	70494	1339
L385A	228	08	70630	1315
L387A	228	09	68902	1316
L389A	228	09	69280	1292
L395A	228	10	57356	1103
L397A	228	10	55265	1014
T135A	228	10	51219	983
T135J	228	10	29537	552
T136A	240	32	54098	1040
T137A	240	32	61647	1226
T138A	240	32	68946	1378
T139A	240	32	75552	1453
L339A	240	33	34128	618
T140A	240	33	65253	1266
T141A	240	33	95043	1715
T140B	240	33	42265	826
L337A	240	33	29356	574
L359A	240	34	87415	1732
L355B	240	34	27592	507
L357A	240	34	57196	1045
L353A	240	34	53617	1020
L351A	240	35	55180	1005

KBB: Kane Basin - Survey Line Summary				
Line	Day	Flight	Dist(m)	Time(sec)
L349A	240	35	41918	764
L347A	240	35	43847	826
L345A	240	35	38168	720
L343A	240	35	38584	719
L341A	240	35	33747	655
L327A	241	36	57290	1103
L325A	241	36	62491	1225
L323A	241	36	58350	1074
L321A	241	36	63707	1222
T145A	241	37	41374	764
L341B	241	37	33574	607
L339B	241	37	34678	692
L337B	241	37	35012	631
L319A	241	37	55961	1122
T144A	241	37	52416	1044
L335A	241	38	58714	1076
L333A	241	38	57948	1126
L331A	241	38	58323	1051
L329A	241	38	57093	1095
L353B	241	39	32611	632
L351B	241	39	32012	611
L349B	241	39	32729	612
L347B	241	39	33206	635
L345B	241	39	33445	624
L343B	241	39	32610	632

Nares Strait 2001 Aeromagnetic Program Survey Flight Times					
Total Flying Time : 68h 08m **Hall Basin :** 39h 58m **Kane Basin :** 26h 28m					
Flight	Date	JDay	Takeoff	Landing	Flight Time
SF01	8/13	226	21:01	22:43	1h 42m
SF02	8/14-15	227	01:55	03:00	1h 05m
SF03	8/14-15	227	03:47	04:48	1h 01m
SF04	8/14-15	227	05:23	07:10	1h 47m
SF05	8/15-16	228	21:07	22:19	1h 12m
SF06	8/15-16	228	22:39	23:48	1h 09m
SF07	8/15-16	228	00:41	02:33	1h 52m
SF08	8/15-16	228	03:24	04:31	1h 07m
SF09	8/15-16	228	05:04	06:13	1h 09m
SF10	8/15-16	228	06:54	08:28	1h 32m
SF11	8/18-19	231	00:07	02:05	1h 58m
SF12	8/18-19	231	02:48	04:37	1h 49m
SF13	8/18-19	231	05:21	07:24	2h 03m
SF14	8/19-20	232	21:49	23:45	1h 56m
SF15	8/19-20	232	00:31	02:25	1h 54m
SF16	8/19-20	232	03:16	05:26	2h 10m
SF17	8/20-21	233	21:42	23:38	1h 56m
SF18	8/20-21	233	00:32	02:38	2h 06m
SF19	8/20-21	233	03:39	05:43	2h 04m
SF20	8/22-23	235	21:07	22:51	1h 44m
SF21	8/22-23	235	23:22	01:16	1h 54m
SF22	8/22-23	235	02:05	03:41	1h 36m
SF23	8/22-23	235	04:29	06:27	1h 58m
SF24	8/23-24	236	21:03	22:47	1h 44m
SF25	8/23-24	236	23:20	01:17	1h 57m
SF26	8/23-24	236	02:10	04:06	1h 56m
SF27	8/23-24	236	04:37	06:28	1h 51m
SF28	8/24-25	237	21:06	22:52	1h 46m
SF29	8/24-25	237	23:31	01:19	1h 48m
SF30	8/24-25	237	02:05	03:57	1h 52m
SF31	8/24-25	237	04:21	06:17	1h 56m
SF32	8/27-28	240	21:07	23:00	1h 53m
SF33	8/27-28	240	00:30	02:21	1h 51m
SF34	8/27-28	240	03:03	04:48	1h 45m

Survey Flight Times					
Flight	Date	JDay	Takeoff	Landing	Flight Time
SF35	8/27-28	240	05:26	07:14	1h 48m
SF36	8/28-29	241	21:14	23:02	1h 48m
SF37	8/28-29	241	23:26	01:23	1h 57m
SF38	8/28-29	241	02:53	03:42	1h 49m
SF39	8/28-29	241	05:13	06:56	1h 43m

Onshore bedrock geology mapping program
Part of the Nares Strait Project, 2001

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Table of contents

Summary description of planned onshore field projects, northeast Ellesmere Island

Cambrian-Precambrian boundary

Regional scale bedrock mapping southwest of Carl Ritter Bay near Kennedy Channel on coastal northeast Ellesmere Island in 2000 indicated that a critical Lower Cambrian trilobite locality, previously thought to occur in the lower part of the Kennedy Channel Formation (Long, 1989), is more likely to be in a fault slice of Kane Basin Formation (U. Mayr and K.Dewing, pers. comm., 2001). This evidence, combined with lithological correlation of sequences to the Mackenzie Mountains region of the Northwest Territories, suggests that the Kennedy Channel and Ella Bay formations may be upper Neoproterozoic (K. Dewing, pers. comm, 2001). Correlative strata may also be Neoproterozoic , including the Aurland Fiord Formation and Nesmith beds of northernmost Ellesmere Island, and the Skagen, Portefjeld and Paradisfjeld groups of North Greenland. To test this hypothesis, proposed field work in August 2001 will include 1) detailed mapping, 2) measurement of stratigraphic sections, and 3) prospecting for trace fossils, small shelly fauna and soft-bodied Ediacaran assemblages in the vicinity of the Cambrian-Precambrian boundary potentially located in the lower part of the Archer Fiord Formation. A maximum of six field localities have been pre-selected on Judge Daly Promontory with work to be conducted from fly camps and on day-trips from the research coastguard vessel, onshore access to be facilitated by MBB105 helicopter.

Basement shear zones

Regional bedrock geological maps of Johan, Knud and Bache peninsulas, and adjacent areas of southeast Ellesmere Island indicate that steep faults in Cambrian and younger strata are rooted in Paleoproterozoic basement gneisses (Frisch, 1988). Onshore field work planned for these areas will attempt to 1) locate and describe these basement faults, 2) provide appropriate kinematic analyses, 3) obtain samples potentially suitable for absolute dating purposes, and 4) define the role, if any, of antecedent shear zones in the later (Phanerozoic) brittle deformation. Field work will be conducted during day-trips from the research vessel with access facilitated by MBB105 helicopter.

Expanded ice sheets

Ground traverses by this writer on northern Judge Daly Promontory in 2000 revealed that banks and small sheets of perennial ice are common in selected low elevation areas near Kennedy Channel. Some of these are readily identifiable on the available set of 1:60,000 scale air photographs (1962 vintage) and on high resolution satellite images acquired since 1999. Comparison of ground observations with the 1962 air photo set indicates that during the last four decades some of these ice banks have grown in all directions and, in several cases, have coalesced into cirque-filled ice sheets up to several kilometers in long dimension. Expansion of ice masses between 1962 and 1999/2000 is also confirmed by comparison of the two vintages of imagery. Field work planned for 2001 will be to ground check other potentially expanded ice bodies identified and mapped out on aerial imagery of Judge Daly Promontory and on coastal northeastern Ellesmere Island south of Alert. Field work will be conducted during day-trips from the research vessel with access facilitated by MBB105 helicopter.

Overview of work accomplished

To meet the principal objectives of the project, eighteen sites on northeastern Ellesmere Island were preselected and priority-rated for field work. This included one first priority site related to the Cambrian-Precambrian boundary problem (visited Aug.19-21), five second priority sites including three to address mapping problems in the Phanerozoic (one site visited at Cape Back on August 22; the other two not visited due to distance from the ship and poor weather) and two to study potential basement shear zones on southern Bache Peninsula and on Pim Island (neither site visited due to weather problems and heavy sea ice conditions in the region). Eleven third priority sites were identified; mostly bedrock mapping problems to be resolved in the Phanerozoic. Four of these were occupied. The remaining seven sites, not reached during the cruise, were all located south and west of Rawlings Bay. Access to this large region was precluded by distance from the ship and related heavy ice conditions throughout western Kane Basin.

Onshore work, related to the stated objectives, took place over nine days between August 8th and September 3rd, 2001. Investigation of potential Cambrian-Precambrian boundary strata and related bedrock mapping objectives occurred on northern Judge Daly Promontory between the Carl Ritter Bay area and the northern extremity of the peninsula at Cape Baird. This work occurred August 19-21 in the vicinity of a temporary onshore camp and, with the support of the ship's MBB 105 helicopter, at scattered locations on August 22 and 23. Mapping confirmed the stratigraphic and structural position of ollenellid trilobites in the upper part of the Kane Basin Formation. The implication of this work is that the Kennedy Channel, Ella Bay and Archer Fiord formations, including the correlative strata of North Greenland, are unlikely to be younger than the pre-trilobitic Lower Cambrian (Tommotian). Samples of the lower Archer Fiord Formation have been collected for shelly microfossils.

Discovery and examination of Precambrian shear zones and related brittle deformation features was accomplished in cooperation with the sampling objectives of Zentilli and Halls. On each occasion the opportunity for field work was limited to not more than 2 to 4 hours. This included brief visits to Precambrian outcrops on Philpots Island on the east coast of Devon Island (4 hours on August 8th), Orne Island and Cape Faraday on the southeast Ellesmere coast (4 hours total on August 29th), Nordvesto in the Carey Oer (2.5 hours on August 31), and a sampling stop on the shore of Makinson Inlet (1 hour on September 3, 2001). General results of these site visits was the discovery of a wide-range of ductile, semi-ductile, and brittle deformation fabrics including flattening and stretching fabrics in cross-cutting shear zones on Orne Island, mylonites and pseudotachylites on Philpots Island and in Makinson Inlet, and hematized brittle fractures on Nordvesto. Many of these late stage features are parallel to regional scale structures associated with the development of the Labrador Sea and Baffin Bay oceanic spreading system and its' rifted margins (Jackson et al., 1992; Whittaker, et al., 1997). Samples have been collected for absolute age determination.

The recently-expanded cirque-related ice bodies of northern Judge Daly Promontory, identified in 2000, were observed briefly from the air on August 23, 2001. It became immediately apparent that these ice masses were much smaller than in the previous year, and that new work on the ground would yield information of no significant value.

An unanticipated but informative site visit on September 3 was to an outcrop section of Paleocene sandstones and volcanics near Split Lake, north of the head of Makinson Inlet. This locality, previously investigated by this writer in 1989 (Harrison et al., 1999; Thorsteinsson et al., 1991), has experienced extensive stream incision as a consequence of accelerated erosion rates during the last decade. Recently exposed outcrop provides valuable new insight into the geology and Cenozoic structural history of the region. Samples were collected for petrography, thermal maturity and fission track analysis.

Also included in these notes is a report and description of rock samples collected from a sediment-covered iceberg during a brief visit from the ship on August 17th. The iceberg on this date was floating off the east Ellesmere coast near Cape Hayes in southern Kennedy Channel. Preliminary analysis of these samples indicates calving of the iceberg from Petermann Glacier, which drains the Greenland Icecap, and derivation of the related sediment load from adjacent outcrops of either northern Washington Land or western Hall Land.

Ground traverse on coastal northern Philpots Island: August 8, 2001

Air photo: not available
Reference: Frisch, 1988
Personnel: T.A. Brent, J. C. Harrison

Purpose of traverse: to locate Cambrian and or Ordovician outcrop mapped on western Philpots Island by Frisch (1984). To describe and, if appropriate, measured a stratigraphic section through some part of the aforementioned Paleozoic beginning as close as possible to the basal unconformity above the Precambrian.

General observations: streams flowing northwest across the mapped Paleozoic were preselected as most likely to yield suitable outcrop. The island was approached from the south by MBB105 at about 150 m (500') elevation. Good outcrop of basement gneisses were identified all along the coast between Beatrice Point and Queen Harbour. The remaining southwest-facing coast of Bethune Inlet presented a continuous belt of sand beach backed to the northeast on Philpots Island by a sand, gravel and erratic covered plain with numerous very shallow lakes and ponds; all not more than one or two metres above sea level. The eastern margin of this plain, close to the first outcrops of Precambrian, features a number of small irregular gravel ridges, perhaps 5 to 10 metres high. Inland on Philpots Island, the western limit of the Precambrian forms a sinuous, ill-defined escarpment: low lying lakes and gravel plain to the west; hills to the east, with common Precambrian outcrop that rise to one hundred metres elevation in the southeast and to approximately 240 m in the northeast. The river system, preselected for a ground traverse was found to be entirely devoid of obvious Paleozoic outcrop or associated felsenmeer as was the coastal zone on the northwest side of the island facing Hyde Inlet. The north end of Bethune Inlet features a narrow isthmus of sand and lakes that, even at high tide, probably forms a permanent land connection of Philpots "island" to the eastern mainland of Devon Island. The easternmost limit of Devon Ice Cap empties into Hyde Inlet but is separated from the shore of Bethune Inlet by a strip of what appears to be end moraine that locally reaches a height of 60 metres above sea level. As there did not appear to be any likelihood of encountering Paleozoic outcrop along the preselected traverse route, an alternative route was chosen that would begin on the Precambrian near the north coast and would follow, first a segment of the inland escarpment edge of the shield and afterward, a portion of the plain along the coast.

Date: 08/08/801 Station: HBB-01-001 Location: 75° 00.070'N 079° 59.600'W
Field notebook: 1/1A,B
Description: coastal outcrop of garnet sillimanite paragneiss, rock types, structure, measured foliation

Date: 08/08/01 Station: HBB-01-002 Location: 75° 00.150'N 080° 00.280'W
Field notebook: 1/1B-2A
Description: 20 metres wide zone featuring 19 thin mylonitic and brittle fractures in otherwise uniformly strained garnet sillimanite gneiss and pegmatite; 10 measured mylonitic fractures; average N43W/83SE, generally right lateral and eastside up
Photos: R1-1 to 12
Sample: HBB-01-2: representative suite of mylonite and host rock

Date: 08/08/01 Station: HBB-01-003 Location: 75^0 00.050'N 080^0 00.590'W
Field notebook 1/2A
Description: diabase dyke exposed in recessive felsemeer; paced 45-50 m wide. Outcrop in open valley seen several hundred metres inland. Trend of valley and dyke: N70W
Sample: HBB-01-3: north chill margin, collected from felsenmeer.

Due to lack of time the intended traverse was not completed beyond this location.

General results of the day's activities. Aerial examination of western Philpots Island failed to identify any Paleozoic outcrop. Small erratics of pale coloured dolostone and sandstone were encountered during the ground traverse. However, these could be far-travelled and, like the gravel ridges and erratics on the west end of the island, could have been derived from a bedrock source beneath eastern or central Devon Island and carried to their present location by glacial and glaciofluvial processes. While no actual ground traversing was accomplished in the earea, aerial reconnaissance indicates that the western surface of Philpots Island is probably a glaciofluvial outwash plain. While the bedrock beneath this plain could include Paleozoic strata, there is equal or greater likelihood of bedrock being no different than that of the surrounding Precambrian. The sinuous nature of the eastern edge of the plain indicates that the two distinct physiographic regions of the island are probably not separated by faults. As such any Paleozoic outcrop in the area would be more likely exposed as high-standing escarpment-bound erosional remnants above irregular but lower exposures of shield, as is the case at the edge of Paleozoic cover on northern Inglefield Land or on Bache Peninsula, in central Manitoba, in southern Ontario and elsewhere in Canada. A literature search is required to complete the present reassessment of bedrock under western Philpots Island.

Sediment covered iceberg near Cape Hayes, northeast Ellesmere Island: August 17, 2001

Date: 17/08/01 Station: HBB-01-004 Location: 80^0 07.705'N 069^0 53.908'W
Personnel/Authors this section): M. Zentilli, J. C. Harrison

The iceberg was relatively flat, covered with dark rocks and with almost no ice visible, which made it difficult to spot in the fog; it looked much like the dark water between ice floes. It was missed by less than a ship's width (see photos). Its dimensions are estimated at 70 m long by 50 m wide. It had two higher spots about 15-20 m elevation, but otherwise was flat with an average elevation of about 5 m. Rock cover, as an irregular layer, was between 0.1 and 75 cm

The majority of the fragments were angular, but there were some rounded pebbles. The largest erratic was a fossiliferous limestone block about 2 x 2 x 3 m. There were other in the 1 m range, but the majority were less than 50 cm. There was sand and clay in the puddles. On first inspection 90% or more of the clasts were limestone. Sampling was not systematic, but rather to collect a wide variety of lithologies with the intention of ascertaining a possible source of the erratic covered iceberg. A bituminous sample and well-preserved fossils called our attention and may be over represented.

Sample descriptions

031-1 Mixed unconsolidated sand and mud collected from iceberg surface

031-2 Sample has angular surfaces. Laminated and wavy laminated lime mudstone, medium light grey weathering, and dolomitic mudstone, pale yellowish grey weathering. Slightly wavy laminations. Bituminous smell when struck with the hammer. Incidence on iceberg: common. Provenance: Upper Ordovician or Lower Silurian; i.e. lower Allen Bay Formation of Arctic Islands or Aleqatisiaq Fjord Formation(?) of NW Greenland. Possible oil source rock

031-3 Collected piece is ellipsoidal subrounded with small angular surfaces. Weakly cemented lime grainstone containing angular centimetre-scale fragments of lime mudstone; pale greyish orange weathering. Individual limestone grains are rounded and vary from vitreous white to greyish yellow to (rarely) black. Possible, minor, vitreous white quartz grains, well rounded. Rock effervesces vigorously in 10% Hcl. Incidence: anomalous. Provenance: unknown

031-4 Subangular fragment of chain coral. Incidence: anomalous. Provenance: Upper Ordovician Arctic-Red River or Bighornia-Therodontia assemblages

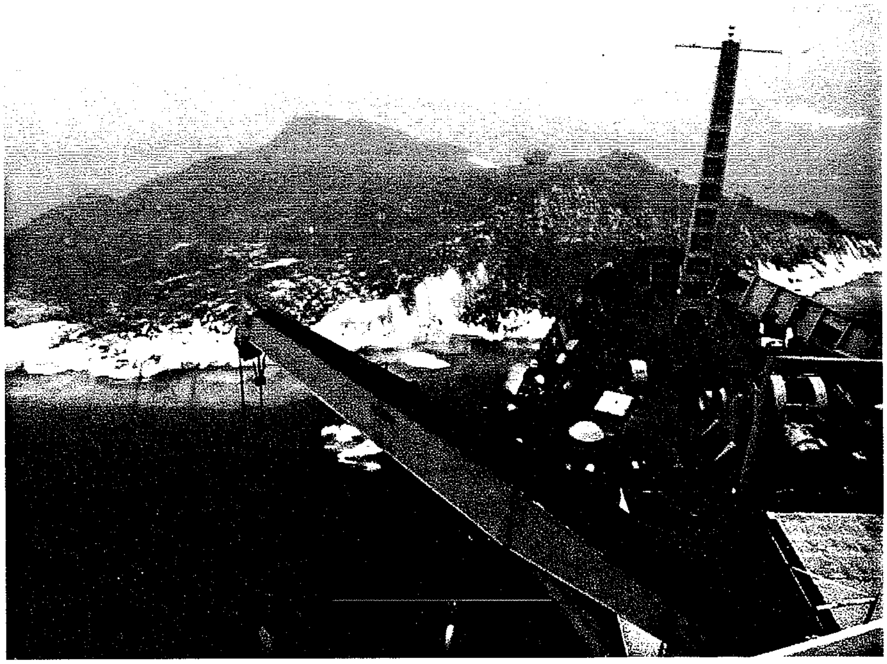

Fig. 38. *View of the iceberg. Chris and Marcos are in central area. (photo R.Morris)*

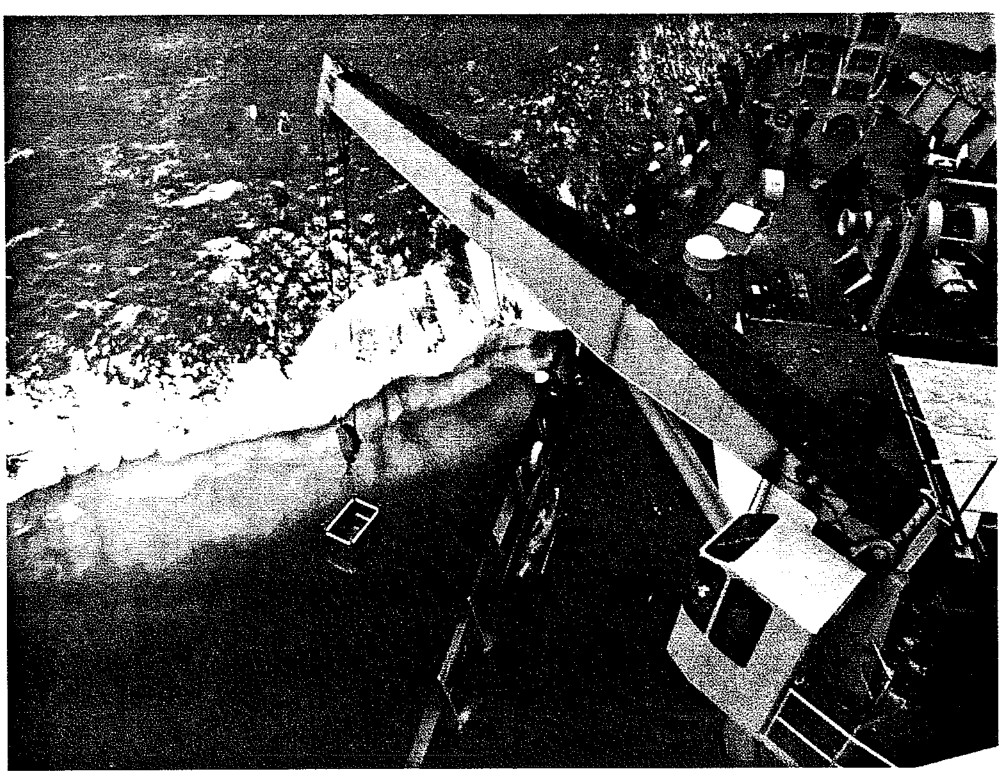

Fig. 39. *Approach. Note elevation and rock cover. People for scale. (photo R.Morris)*

Fig. 40. *The iceberg just after first contact. Note elevation about 17 m. (photo R. Morris).*

031-5 Subrounded hemispheroidal fragment: "cabbage head" bryozoan. Incidence: anomalous. Provenence: Upper Ordovician Arctic-Red River or Bighornia-Therodontia assemblages

031-6 Subangular sample. White weathering orthoquartzite, compositionally very mature, probably silica cemented. Incidence: anomalous. Provenance: Lower Cambrian Dallas Bugt Formation, or mid-Proterozoic Thule Group

031-7 Angular fragment. Mottled pale yellowish grey weathering dolomitic mudstone with discontinuous laminae and thin beds of light grey weathering lime mudstone. Moderately burrow mottled. Not bituminous. Incidence: common and representative. Provenance: Middle Ordovician Bay Fiord Formation (Cape Webster Formation of North Greenland); possibly Cape Storm Formation (mid-Silurian, Ludlow) or Goose Fiord Formation (mid-Silurian to Lower Devonian; Ludlow to Lochkovian)

031-8 Angular fragment, 10 to 12 cm. Laminated. Light to medium brownish grey weathering, finely crystalline dolostone, distinctly bituminous, parting surfaces parallel to compositional laminae. Incidence: common and representative. Provenance:Upper Ordovician or Lower Silurian; i.e. lower Allen Bay Formation of Arctic Islands or Aleqatisiaq Fjord Formation(?) of NW Greenland. Possible oil source rock (see also 031-2)

031-9 Subrounded and angular weathered surfaces, 15 cm. Light and very light brownish grey weathering, finely crystalline dolostone. Indistinct compositional banding. Strongly bituminous. Incidence: common and representative. Provenance:Upper Ordovician or Lower Silurian; i.e. lower Allen Bay Formation of Arctic Islands or Aleqatisiaq Fjord Formation(?) of NW Greenland. Possible oil source rock (see also 031-2,031-8).

031-10 Subrounded weathered surfaces with angular fracture planes exposing fresh material. Yellowish grey and light olive grey weathering dolomitic mudrock. Weak parallel parting but no obvious compositional layering. Provenance: Middle Ordovician Bay Fiord Formation (Cape Webster Formation of North Greenland); possibly Cape Storm Formation (mid-Silurian, Ludlow) or Goose Fiord Formation (mid-Silurian to Lower Devonian; Ludlow to Lochkovian). See also 031-7

031-11 Subrounded cobble, 6 cm. Pink weathering gneissic granite with potash feldspars to 2 mm, 15 to 20% vitreous white quartz, 10% biotite and greenish amphibole. Incidence: anomalous. Provenance: fluvial gravel ultimately derived from Precambrian shield

031-12 Well rounded large pebble, 4 cm. Coarsely crystalline red weathering granite. Potash feldspars to 1 cm. Quartz aggregates to 6-8 mm. Minor biotite and black amphibole. Incidence: anomalous. Provenance: fluvial gravel ultimately derived from Precambrian shield.

031-13 Small angular pebble. Pale reddish orange lime grainstone. Incidence: uncommon, not anomalous. Provenance: unknown

031-14 Well rounded pebble, 2 cm. Mottled grey weathering and greyish orange weathering lime mudstone. Incidence: uncommon, not anomalaous. Provenance: Lower Paleozoic

031-15 Flat pebble, rounded and weathered, 1.5 cm, with an angular fresh surface. Pale reddish orange weathering lime mudstone with moderate grey mottles. Incidence: uncommon, not anomalaous. Provenance: Lower Paleozoic

031-16 Subangular pebble, 3 cm. Red weathering gneissic granite, medium crystalline. Pink and red potash feldspars to 3 mm, 15-20% vitreous white quartz, 10-12%, biotite and greenish amphibole. Incidence: anomalous. Provenance: Precambrian shield, no obvious fluvial cycle

031-17 Rounded pebble, 1 cm. Mottled pale grey weathering dolomitic mudrock and pale greyish orange weathering dolomitic mudrock. Incidence; moderately common. Provenance: Middle Ordovician Bay Fiord Formation (Cape Webster Formation of North Greenland); possibly Cape Storm Formation (mid-Silurian, Ludlow) or Goose Fiord Formation (mid-Silurian to Lower Devonian; Ludlow to Lochkovian). See also 031-7, 031-10

031-18 not examined

031-19 Well rounded cobble, 10 cm. Biotite cordierite(?) orthogneiss. Incidence: anomalous. Provenance: fluvial gravel ultimately derived from Precambrian shield.

031-20 Angular fragment, 10 cm, hammered from larger angular block. Pale yellowish brown and brownish grey weathering mottled limestone with chalky white chert nodules. Incidence: burrow-mottled limestone is very common, chert nodules are anomalous. Provenance: upper part of Thumb Mountain Formation (or Troedssen Cliff Fm of North Greenland), Upper Ordovician

031-21 Angular fragment hammered from larger block. Burrow-mottled limestone, pale yellowish brown and brownish grey mottles. Incidenece: very common. Provenance: Upper Ordovician Thumb Mountain Formation (or Troedssen Cliff Fm of North Greenland) or Lower Silurian Allen bay Formation (Aleqatisiaq Fjord Fm of NW Greenland).

031-22 Subrounded pebble, 4 cm. Nodular limestone: brownish grey weathering skeletal lime mudstone nodules in a sparse recessive matrix of pale yellowish brown weathering lime mudstone. Nodular fabric is produced by in-sediment burrowing. Recognizable brachiopod valves and trilobite fragments. Cross-cutting and bifurcating calcispar vein (8 mm wide). Incidence: common. Provenance: Irene Bay Formation (Cape Calhoun Formation of N Greenland), Upper Ordovician

031-23, 24 two pieces hammered from common original angular block. Voarsely crysalline very pale yellowish orange weathering lime grainstone with cavernous lenticular voids containing boxworks of yellowish orange weathered earthy calcite(?). Incidenece: anomalous. Provenance: unknown, lithological similarity to 031-3

031-25 Subangular, 15 cm. Intensely burrow-mottled medium light grey and medium dark grey lime mudstone. Distinctly bituminous. 3-5% white calcispar as replacement of brachiopod valves and unidentifiable skeletal fragments. Vertically coiled gastropod (one). Incidence: common. Provenance: lower Allen Bay Formation (Aleqatsiaq Fjord Fm of Greenland), Upper Ordovician

031-26 Subangular fragment hammered from large piece. Medium dark grey weathering lime mudstone, possible calcispar replacement of skeletal fragments (10%). Modestly bituminous smell when struck. Incidence: common. Provenance: lower Allen Bay Formation (Aleqatsiaq Fjord Fm of Greenland), Upper Ordovician

031-27 Small angular piece hammered from larger block. Intensely burrow-mottled light grey skeletal wackestone and nodular medium grey weathering lime mudstone. Tiny trilobite fragments Incidence: common. Provenance: Irene Bay Formation (Cape Calhoun Formation of N Greenland), Upper Ordovician (see also 031-22).

031-28 Irregular angular fragment hammered from larger piece. Fine and indistinctly flat laminated, very pale yellowish brown dolostone. Notable sets of wavy subparallel grooved surfaces (styolites?) arranged perpendicular to compositional layering. Bedding-parallel parting surfaces, bounded by styolites, feature smooth dish-shaped concave lenses of residual pyrobitumen(?); (one of these dish-shaped features is interpreted as the cast of an unornamented armoured placoderm carapace fragment - Jason Anderson, UofT). Incidence: rock type common, features anomalous. Provenance: Restricted marine carbonates, Lower Ordovician to Lower Devonian

031-29 Subangular fragment. Pale yellowish grey weathering, finely crystalline dolostone. Indistinctly flat laminated. Styolitic grooved fractures perpendicular to layering. Good flat-coiled macluritids on one surface. Disc-shaped impression of possible placoderm carapace, including dimpled ornamentation. Incidence: rock type common, features anomalous. Provenance: Maclurites sp is common in the upper Thumb Mountain Formation (Troedsson Cliff Fm of Greenland) Upper Ordovician.

031-30 Subangular piece. Pale grey and very pale grey weathering, wavy and discontinuously laminated microcrystalline dolostone with very pale grey rip-up clast layers and stratified breccia layers. Incidence: uncommon, not anomalous. Provenance: Lower Paleozoic

031-31 Clast-supported lime mudstone breccia. Medium pale grey lime mudstone angular clasts in a medium dark grey lime mudstone matrix. Incidence: uncommon, not anomalous. Provenance: Lower Paleozoic, as for 031-30

031-32 Subrounded piece, 10cm, hammered from larger cobble. Very pale rey weathering dolostone with discontinuous partings of dark yellowish brown weathering pyrobitumen. Light grey dolostone without bitumen also occurs in "clasts" forming laminated pseudobreccia layers. Incidence: uncommon, not anomalous. Provenance: Lower Paleozoic, as for 031-30, 031-31

031-33 Subangular fragment, 10 cm, hammered from larger piece. Pale grey weathering lime mudstone containing angular breccia clasts of very pale yellowish brown weathering dolostone. Not bituminous. Incidence: uncommon, not anomalous. Provenance: Lower Paleozoic, as for 031-30, 031-31, 031-32

031-34, 031-35 Two fragments broken from common large piece. Moderate yellowish brown and brownish grey weathering finely crystalline dolostone, indistinctly laminated and profoundly bituminous. Incidence: relatively common, not usually this dark. Provenance: Upper Ordovician or Lower Silurian; i.e. lower Allen Bay Formation of Arctic Islands or Aleqatisiaq Fjord Formation(?) of NW Greenland. Possible oil source rock (see also 031-2)

031-36 Pale reddish orange weathering lime grainstone. Tiny cavities on weathering surfaces; also several centimetre-scale cavernous voids. Incidence: anomalous. Provenance: Unknown, possibly same as for 031-13?

031-37, 031-38 Angular (031-37) and subrounded (031-38) pieces. 031-37 was likely hammered from a larger block. Moderate yellowish brown weathering skeletal wackestone with fissile discontinuous partings of pale greenish grey weathering skeletal lime wackestone. Skeletal material includes crinoid ossicles and trilobite fragments. Incidence: very common. Provenance:

Irene Bay Formation (Cape Calhoun Formation of N Greenland), Upper Ordovician (see also 031-22, 27).

031-39 Angular fragment hammered from a larger block. Pale yellowish brown weathering skeletal lime grainstone. Brachiopod valves to 2 cm replaced by white calcispar. Negative zinc test on honey brown calcispar. Distinctly petroliferous odour when struck with the hammer. Incidence: fossils rarely observed; rock type is common. Provenance: Upper Ordovician or Lower Silurian; i.e. lower Allen Bay Formation of Arctic Islands or Aleqatisiaq Fjord Formation(?) of NW Greenland.

031-40 Intensely burrow mottled moderate yellowish orange lime grainstone with nodules of moderate brownish grey limestone. Collected for Maclurites sp. Common crinoid ossicles Incidence: very common rock type Provenance: Maclurites sp is common in the upper Thumb Mountain Formation (Troedsson Cliff Fm of Greenland) Upper Ordovician.

031-41 Moderate yellowish brown weathering skeletal lime grainstone. Good brachiopods, some identifiable. Incidence: common rock type, fossils are unusual. Provenance: probably Silurian platform carbonate formation

031-42 Large angular block, 25 cm. Moderate yellowish brown weathering skeletal wackestone with fissile discontinuous partings of pale greenish grey weathering skeletal lime wackestone. Skeletal material includes crinoid ossicles and trilobite fragments. Incidence: very common. Provenance: Irene Bay Formation (Cape Calhoun Formation of N Greenland), Upper Ordovician (see also 031-22, 27, 37, 38).

031-43 Large angular block, 25 cm. Tabular cross-stratified calcispar-cemented quartz arenite in 10 cm-thick bed with downlap of stratification onto a bed of orthoquartzite. Overlain by very pale yellowish orange weathering dolomitic mudstone (2+ cm thick). Incidence: anomalous. Provenance: Thule Group (mid-proterozoic), Lower Cabrian Dallas Bugt Formation, or possibly Cape Storm Formation or equivalent mid-Silurian (Ludlow) shelf carbonate of NW Greenland

Associated rocks with similar provenance (arranged from most common to least common):

031-20,21,27,40 Burrow-mottled limestone. 031-28,29 Styolitic dolostone with Macluritids: Thumb Mountain Formation (Troedsson Cliff Fm of Greenland) Upper Ordovician, one with Maclurites sp. Incidence: most common

031-2,8,9, 25,26,34,35 Variably bituminous shelf carbonate. Upper Ordovician or Lower Silurian; i.e. lower Allen Bay Formation of Arctic Islands or Aleqatisiaq Fjord Formation(?) of NW Greenland; Incidence: very common

031-22, 27, 37, 38, 42 Nodular burrow mottled skeletal limestone. Irene Bay Formation (Cape Calhoun Formation of N Greenland), Upper Ordovician. Incidence: very common

031-7,10,17 Wavy laminated carbonate mudstone. Provenance: Middle Ordovician Bay Fiord Formation (Cape Webster Formation of North Greenland); possibly Cape Storm Formation (mid-Silurian, Ludlow) or Goose Fiord Formation (mid-Silurian to Lower Devonian; Ludlow to Lochkovian). Incidence: common

031-30 to 33 Carbonate intraclast breccia. Provenance unknown. Incidence: uncommon, not anomalous

031-13 to 15, 031-18,36 Reddish orange weathering lime grainstone. 031-3,23,24 Yellowish orange lime grainstone, weakly cemented. Provenance unknown. Incidence: anomalous

031-6,43 Orthoquartzite interbedded with dolomitic mudrock. Mid-Proterozoic Thule Group, Lower Cambrian Dallas Bugt Formation or Cape Storm Formation and equivalent mid-Silurian of Greenland. Anomalous

031-11,12,16,19: Precambrian shield samples(Lower Proterozoic or Archean), some showing evidence of fluvial or glaciofluvial rounding. Incidence: all highly anomalous

Conclusions

The nearest candidate outlet glaciers capable of discharging sediment covered icebergs include the immense Petermann and Humboldt glaciers on the NW Greenland coast. By comparison outlet glaciers on the Ellesmere coast are tiny. These include ice tongues that reach tidewater on Dobbin Bay, Richardson Bay and Rawlings Bay.

The north arm glacier of Richardson Bay and the glacier at the head of Rawlings Bay are unlikely sources as these are apt to yield mostly Cambrian sandstone debris (unpublished bedrock geology maps and field observations of U.Mayr and C. Harrison, 1998-2000). Likewise the Humboldt Glacier is an unlikely source because associated rocks of southern Washington Land and northeasternmost Inglefield Land are either Precambrian shield or Lower and Middle Cambrian clastics and dolostones, respectively (Dawes et al., 2000; Jepsen et al., 1983). All these compositions are exceedingly rare on the iceberg.

The general composition of the iceberg materials and the collected clasts is consistent with derivation from glaciers emptying into Dobbin Bay and the south arm of Richardson Bay (unpublished bedrock geology maps and field observations of U.Mayr and C. Harrison, 1998-2000). However, all the rocks on the Canadian side display a penetrative slaty cleavage, a feature identified in no samples from the iceberg. Similarly the eastern Ellesmere outlet glaciers cannot have been a source for the anomalous Precambrian granitoid rocks and gneisses.

The mostly likely source for the iceberg and its sediment load is Petermann Glacier and the adjacent valley outcrop which includes Lower to Upper Cambrian strata in the southeast, and Lower Ordovician through Upper Silurian carbonates in the northwest, close to the Hall Basin outlet (Dawes et al., 2000; Jepsen et al., 1983). While shield rocks do not occur at surface on Petermann Glacier, it is likely that the shield is present under the inland ice to the southeast (Dawes et al., 2000; Henriksen, 1989). Wisconsinan till carrying shield material could also have been deposited in northern Washington Land and then been reworked and redeposited by recent incision of Petermann Glacier. Location and examination of lateral moraine on the Petermann Glacier could narrow the provenance of the sampled iceberg to either a northeastern Washington Land source or an adjacent source on the western edge of Hall Land.

Three-day fly camp west of Carl Ritter Bay, August 19-21, 2001

Three bedrock geological mapping and sampling traverses were carried out in a small area from a fly camp located (at 80°52'N, 068°35'W) approximately 16 km WSW of Carl Ritter Bay. The purpose of these traverses was to clarify the structural and stratigraphic setting of an important trilobite locality in the area, and to collect suitable biostratigraphic material for dating of the lower Archer Fiord, Ella Bay and Kennedy Channel formations (earliest Cambrian or latest Proterozoic). Samples were also to be collected for fission track dating
Personnel: B. Atagootak, T.A. Brent, J. C. Harrison

Ground traverse to fly camp 16 km westsouthwest of Carl Ritter Bay, Judge Daly Promontory: August 19, 2001
Air photo: A16609-134, 133

Date: 19/08/01 Station: HBB-01-005 Location: 80^0 53.434'N 068^0 37.651'W
Field notebook 1/10B
Drop off location. Geological annotation of air photograph

Date: 19/08/01 Station: HBB-01-006 Location: 80^0 53.850'N 068^0 35.328'W
Field notebook 1/10B
Description: lower Archer Fiord Formation; So attitude collected
Sample: HBB-01-06 silty lime mudstone and oncoidal limestone: for calcareous microfossils

Date: 19/08/01 Station: HBB-01-007 Location: 80^0 53.820'N 068^0 35.110'W
Field notebook 1/11A
Description: lower Archer Fiord Formation
Sample: HBB-01-07 silty lime mudstone and lime mudstone: for calcareous microfossils

Date: 19/08/01 Station: HBB-01-008 Location: 80^0 53.770'N 068^0 34.874'W
Field notebook 1/11A
Description: lower Archer Fiord Formation
Sample: HBB-01-07 lime mudstone: for calcareous microfossils

Date: 19/08/01 Station: HBB-01-009 Location: 80^0 53.760'N 068^0 34.374'W
Field notebook 1/11B
Description: upper Ella Bay Formation

Date: 19/08/01 Station: HBB-01-010 Location: 80^0 53.751'N 068^0 33.873'W
Field notebook 1/11B
Description: lower Cass Fjord Formation; fault contact with Ella Bay in talus; So attitude collected

Date: 19/08/01 Station: HBB-01-011 Location: 80^0 53.474'N 068^0 33.697'W
Field notebook 1/11B
Description: Rawlings Bay Formation; fault contact with Scoresby Bay Formation in talus; So attitude collected

Date: 19/08/01 Station: HBB-01-012 Location: 80^0 53.413'N 068^0 32.501'W
Field notebook 1/11B,12A
Description: Rawlings Bay Formation; potential Ritter Bay Formation in fold hinge; So attitudes collected

Date: 19/08/01 Station: HBB-01-013 Location: 80^0 53.324'N 068^0 29.305'W
Field notebook 1/12A
Description: Rawlings Bay Formation circa 60 m above contact with Ritter Bay Formation

Date: 19/08/01 Station: HBB-01-014 Location: 80^0 52.869'N 068^0 29.504'W
Field notebook 1/12A
Description: slate marker in Rawlings Bay Formation; good horizontal traces noted

Ground traverse from fly camp 16 km westsouthwest of Carl Ritter Bay, Judge Daly Promontory: August 20, 2001

Date: 20/08/01 Station: HBB-01-015 Location: 80^0 51.874'N 068^0 35.446'W
Field notebook 1/12B, 13A
Description: right lateral strike slip fault mapped in outcrop separating Ritter Bay and Rawlings Bay formations; 200-250 m of offset; fault measured, So and S1 planes measured on either side of fault
Field photos: R4-19 to 23
Sample: HBB-01-15, elevation: 440 m; Rawlings Bay Fm sandstone for AFTA

Date: 20/08/01 Station: HBB-01-016 Location: 80^0 51.890'N 068^0 35.985'W
Field notebook 1/13A
Description: Rawlings Bay Formation; So planes measured

Date: 20/08/01 Station: HBB-01-017 Location: 80^0 51.976'N 068^0 36.857'W
Field notebook 1/13B
Description: upper part of Rawlings Bay Fm grading up into Kane Basin Fm; So plane measured

Date: 20/08/01 Station: HBB-01-018 Location: 80^0 51.977'W 068^0 37.748'W
Field notebook 1/13B
Description: slate beds in Rawlings Bay Fm or upper Ritter Bay; So plane measured

Date: 20/08/01 Station: HBB-01-019 Location: 80^0 51.932'N 068^0 39.431'W
Field notebook 1/13B, 14A
Description: Rawlings Bay Fm; So plane measured

Date: 20/08/01 Station: HBB-01-020 Location: 80^0 51.963'N 068^0 40.126'W
Field notebook 1/14A
Description: Rawlings Bay Fm; good vertical worm burrows; So plane measured

Date: 20/08/01 Station: HBB-01-021 Location: 80^0 51.994'N 068^0 40.814'W
Field notebook 1/14A
Description: upper part of Rawlings Bay Fm; last outcrop below Kane Basin Fm (contact covered); So planes measured

Date: 20/08/01 Station: HBB-01-022 Location: 80^0 52.007'N 068^0 42.700'W
Field notebook 1/14B
Description: upper part of Kane Basin Fm; famous Ollenelus locality previously and mistakenly placed in the oldest part of the Kennedy Channel Fm; So planes measured
Sample: HBB-01-22 skeletal trilobite packestone; for shelly microfossils

Date: 20/08/01 Station: HBB-01-023 Location: 80^0 51.067'N 068^0 42.940'W
Field notebook 1/14B, 15A
Description: 100 m along strike to SW of previous locality; upper part of Kane Basin Fm
Sample: HBB-01-23A skeletal trilobite grainstone, 30-35 m below base of Scoresby Bay Fm; for shelly microfossils
Sample: HBB-01-23B skeltal bivalve packestone, 25-30 m below base of Scoresby Bay Fm; for shelly microfossils

Date: 20/08/01 Station: HBB-01-024 Location: 80^0 52.170'N 068^0 44.023'W
Field notebook 1/15A, 15B
Description: slate and pyritic quartz sandstone; lowest outcrops of Kennedy Channel Fm above covered faulted base and above faulted top of Scoresby Bay Fm; So planes measured

Date: 20/08/01 Station: HBB-01-025 Location: 80^0 51.370'N 068^0 43.299'W
Field notebook 1/15B
Description: lower Archer Fiord Fm. No limestone beds in this section of the Archer Fiord Fm

Ground traverse from fly camp located 16 km westsouthwest of Carl Ritter Bay, Judge Daly Promontory: August 21, 2001

Date: 21/08/01 Station: HBB-01-026 Location: 80^0 51.370'N 068^0 43.299'W
Field notebook 1/15B
Description: Rawlings Bay Fm
Sample: HBB-01-26 laminated orthoquartzite and micaceous sandstone for AFTA; elevation 1160 m

General results of fly camp work, August 19-21, 2001

Kennedy Channel Formation appears to be in fault contact to the southeast with Scoresby Bay Fm. Farther to the northeast along strike, the Kennedy Channel Fm is cut out in the upthrown block. Ella Bay Fm in this direction is in fault contact with Scoresby Bay and Rawlings Bay fms. The downthrown panel of Cambrian strata is deformed by both northeastward trending tight folds, fold-oblique strike slip faults and a high angle set of right-lateral strike slip faults one of which is exposed at station HBB-01-15.

The known ollenellid trilobite located, originally indicated in published literature of D. Long (1989) to be located in the stratigraphically lowest beds of the Kennedy Channel Formation, was in fact found to be in the slate and lime mudrock-dominated upper part of the Kane Basin Formation less than 15 to 20 m below a faulted sliver of Scoresby Bay Fm. In addition, the location of this key outcrop was found to be 1200 m upstream from the site indicated on an air photograph of the region as provided by GSC Calgary staff before the present field work. These observations have significant implications for the detailed structural interpretation of the region. More important are the implications for the age of the lower Archer Fiord, Ella Bay and Kennedy Channel formations (and equivalent strata of North Greenland) which are unlikely to be younger than the pre-trilobitic Lower Cambrian (Tommotian).

Traverses at Cape Back and on northern Judge Daly Promontory: August 22, 2001

Helicopter-supported mapping and short ground traverses were conducted on this day (August 22) on northern Judge Daly Promontory, first in the morning near Cape de Fosse with Zentilli and Grist; later in the afternoon with Grist at Cape Back and inland near the Daly River.

Date: 22/08/01 Station: HBB-01-027 Location: 81^0 14.167'N 065^0 42.287'W
Personnel: M. Zentilli, S. Grist, J.C. Harrison
Notebook 1/16A
Description: lower part of Danish River Formation near Cape de Fosse sampled at 3 m above sea level by Zentilli and Grist for AFTA; lithic sandstones interbedded with slate and carbonate debris flows; So plane measured
Field photo: R5-14 to 21

Date: 22/08/01 Station: HBB-01-028 Location: 81^0 14.623'N 065^0 37.743'W
Personnel: M. Zentilli, S. Grist, J.C. Harrison
Notebook 1/16A
Description: Eids Formation sampled by Zentilli and Grist, estimated 30 m above base of upper member near Cape de Fosse, 542 m above sea level; cyclically interbedded fine grained lithic sandstone and grey silty shale; So plane measured

The following two localities were visited in order to establish the local stratigraphic relationship between the Cape Back Formation (Paleocene quartz sandstone and lacustrine mudrocks) and the Cape Lawrence Formation (Paleocene conglomerate) exposed along strike immediately to the south (Miall, 1982; 1986). Samples were collected for petrographic study by C.C.Lee (University of Reading).
Personnel: S. Grist, J.C. Harrison

Date: 22/08/01 Station: HBB-01-029 Location: 80^0 59.444'N 066^0 59.843'W
Notebook 1/16B
Description: Granule sandstone bed in lower part of Cape Back Formation, estimated 80 m above base of formation. Granules are composed of variegated limestone grains to 2 mm, also grains of quartz and calcispar; elevation 312 m
Sample: HBB-01-29: representative sample

Date: 22/08/01 Station: HBB-01-030 Location: 80^0 59.431'N 066^0 59.270'W
Notebook 1/16B
Description: Carbonate pebble conglomerate bed in Cape Back Formation. Outcrop is 9m long by 2 m wide and surrounded by overburden. It is interpreted to be fluvial incised valley fill in a lower alluvial fan sequence. Clasts are subrounded to subangular and consist of various limestones, sandstones and vein quartz. Shades of carbonate clasts vary from black to grey to pale yellowish orange. Maximum clast size is about 5 cm. Outcrop elevation: 276 m.
Sample: HBB-01-30: representative suite, 3 bags
Field photos: yes (R5)

Date: 22/08/01 Station: HBB-01-031 Location: 81^0 12.343'N 066^0 53.681'W
Personnel: S. Grist, J.C. Harrison
Air photo: A16609-167
Notebook 1/16B, 17A
Description: Ground checking of faulted outcrops located during reconnaissance mapping near the Daly River, 19 km west of Cape De Fosse. Kane Basin Formation at this locality is faulted against Scoresby Bay Formation. So plane measured
Samples: collected by Grist

Date: 22/08/01 Station: HBB-01-032 Location: 81^0 12.352'N 066^0 54.988'W
Personnel: S. Grist, J.C. Harrison
Air photo: A16609-167
Notebook 1/17A

Description: Ground checking of faulted outcrops located during reconnaissance mapping near the Daly River, 19 km west of Cape De Fosse. Kane Basin Formation slate outcrops

Date: 22/08/01 Station: HBB-01-033 Location: 81° 15.881'N 066° 37.625'W
Personnel: S. Grist, J.C. Harrison
Air photo: A16609-169
Notebook 1/17A, 17B
Description: View stop for regional bedrock mapping purposes, looking east along the Daly River 18 km west of Cape de Fosse. A subsequent brief stop in the valley east of this stop showed that the Rawlings Bay Formation (Lower Cambrian) is here in probable thrust or transpressive fault contact with footwall Eleanor River Formation (Lower Ordovician)
Field photos: R6-0 to 3

Ground and aerial traverse northeast of Cape de Fosse, Judge Daly Promontory: August 23, 2001

Purpose of the field work on this day was to complete the bedrock mapping of coastal outcrops between Cape de Fosse and Cape Baird. This was accomplished by helicopter flights along the shoreline, by brief stops at three locations onshore and, subsequently, by examination of the coastal exposures using binoculars from the bridge of the ship.
Personnel: S. Grist, R. Helfferich, J.C. Harrison

Date: 23/08/01 Station: HBB-01-034 Location: 81° 23.774'N 064° 44.767'W
Air photo: A16680-107
Notebook: 1/17B, 18A
Description: Lower (dark coloured) member of the Eids Formation, mixed lime mudstone, skeletal wackestone, lithic sandstone, grey shale; So planes measured

Date: 23/08/01 Station: HBB-01-035 Location: 81° 23.248'N 064° 48.208'W
Air photo: A16680-107
Notebook 1/17B, 18A
Description: Cape Phillips Formation: 40 m of petroliferous and graptolitic lime mudstone with thin chert beds, overlain by greenish weathering Danish River Fm, overlies burrow mottled limestone of Allen Bay Formation; So plane measured

Date: 23/08/01 Station: HBB-01-036 Location: 81° 28.244'N 065° 17.689'W
Air Photo: A16680-87
Field photos: yes
Notebook 1/17B
Description: Pavy Formation. Stream bank section of Paleocene volcanic sandstones and mudrocks located 14 km SW or Cape Baird; also noted were thin coal seams, silicified logs and wood, and one bed of magnetite-rich sandstone (paleoplacer bed?); So planes measured
Sample: HBB-01-36 representative suite for C.C.Lee; see also Grist sample for AFTA

General results: Mapping, supported by air photo interpretation, was accomplished in fold hinges and small fault blocks throughout the area southeast of a major sinistral strike slip fault of Cenozoic age that lies onshore and extends from the delta west of Cape de Fosse, in the south, to Cape Baird area at the north end of Judge Daly Promontory. This fault has also been defined in the aeromagnetic surveys of Damaske, Möller and Oakie (this report). The mapped Paleozoic(?) features in this area include a Triangle zone structure, fold-thrust stack and basal decollement, all turned on their side so that these features are now seen in map view as if one were examining a structural cross-section. The surface trace of the tilted "basal decollement" is the aforementioned sinistral strike slip fault. The Ordovician to Lower Devonian stratigraphic stack that lies above the Triangle zone structure is located at Cape de Fosse. To the northeast and downsection is a hinterland vergent fold-thrust stack that lies above a roof thrust in the Bay Fiord (Middle Ordovician evaporite) Formation. Still farther to the northeast and in the footwall of the roof thrust is a foreland-vergent fold-thrust stack that locally places Lower Cambrian strata over Silurian flysch. The roof of the Paleozoic Triangle zone may be continuous with the monoclinal foreland limit of Paleozoic deformation on northernmost Hall Land and northernmost Nyboe Land (Henriksen, 1989). In the opposite direction the foreland limit of Paleozoic deformation, west of the major strike slip faults of Judge Daly Promontory, is in the vicinity of Scoresby Bay (unpublished bedrock geology maps and field observations of U. Mayr, C. Harrison and others, 1998-2000). This point provides an estimate of the maximum sinistral displacement on the Judge Daly fault (circa 200 km).

Orne Island and Cape Faraday, August 29, 2001

The following two areas of coastal southeast Ellesmere Island (Orne Island and Cape Faraday) were visited opportunistically with Henry Halls and Jason Anderson on August 29, 2001. The principal reason for the visit to this site was dyke sampling for paleomagnetics by Halls. An additional purpose was to assess the nature of deformation in the basement gneisses, to locate and measure any minor faults in the gneisses, and to collect representative samples of gneiss that have experienced brittle or semi-brittle deformation.
Personnel: J. Anderson, H. Halls, J.C. Harrison

Two hour ground traverse on Orne Island: August 29, 2001. An arcuate 60 m wide diabase dyke intrudes the Orne Island gneisses and transects the island from west to northeast (Frisch, 1988).
Air photo A16616-102
Field photos: yes

Date: 29/08/01 Station: HBB-01-037 Location: 7^0 53.083'N 076^0 18.831'W
Notebook 1/18B
Description: garnet biotite gneiss, locally retrograded; easterly-striking Si plane measured

Date: 29/08/01 Station: HBB-01-038 Location: 77^0 52.790'N 076^0 20.645'W
Notebook 1/18B, 19A
Description: garnet biotite gneiss, locally retrograded; easterly-striking Si plane measured; narrow shear zone associated with retrograde metamorphism was located striking NNE and dipping to east at 45°.

Date: 29/08/01 Station: HBB-01-039 Location: 77^0 52.762'N 076^0 19.843'W
Notebook 1/19A
Description: narrow shear zone associated with retrograde metamorphism was located, striking NNE and dipping to east at 45°; strong southwest plunging stretching lineation defined by stretched and flattened ellipsoidal amphibole-biotite aggregates (retrograded garnet porphroblasts).
Sample: HBB-01-39: stretched and flattened ellipsoidal amphibole-biotite aggregates from shear zone in strained retrograde garnet gneiss

Two hour visit to dyke sample site on Cape Faraday: August 29, 2001
Air photo: A16612-6
Field photos: yes

Date: 29/08/01 Station: HBB-01-040 Location: 77^0 53.863'N 076^0 38.837'W
Notebook 1/19B
Description: Orthopyroxene garnet biotite gneiss intruded by a northeasterly-striking diabase dyke. The dyke is noticeably more recessive weathering than the surrounding gneisses. Measured dyke width: 120 m at northern exposed limit; 100 m wide at a distance of 200 m along strike to the south. S1 plane measured in gneiss (N10E/90). No shear zones or brittle fractures found in the gneisses in this area.

Nordvesto in the Carey Oer, August 31, 2001.

The following site on the north coast of Nordvesto in the Carey Oer was visited with Henry Halls and Jason Anderson on August 31, 2001. The principal reason for the visit to this site was dyke sampling for paleomagnetics by Halls.
Reference: Dawes, (1991).
Personnel: J. Anderson, H. Halls, J.C. Harrison

Date: 31/08/01 Station: HBB-01-041 Location: 76^0 44.335'N 073^0 13.521'W

Notebook: 1/19B, 20A, 20B
Field photos: yes (R9)
Description: Shallow northerly-dipping and westerly striking sill intrudes pale grey tonalitic gneiss. Si planes in the gneiss strike to the north. The gneiss locally contains "exploded" boudins of amphibole biotite amphibolite (agmatite) intruded by tonalite gneiss. There is a well developed fracture system in the gneisses with locally intense development of hematite-stained brittle fractures. Measured fracture planes strike northwest and dip at 54-57 degrees to the northeast. These small fractures are more-or-less parallel to the major faults within the Thule Basin in the Thule area.
Sample: HBB-01-41A: sample of pegmatitic dyke interior for AFTA
Sample: HBB-01-41B: sample of grey gneiss and amphibolite for AFTA

Split Lake area, north of Makinson Inlet, September 3, 2001

The following outcrops were first described by Riediger et al (1984). The section was visited, mapped and redescribed by the present author during the course of regional bedrock mapping of the Vendom Fiord map area (Thorsteinsson et al., 1989; Harrison et al., 1999). Measured sections are also available but have not yet been published. Large differences in the depth of erosion are noted since 1989. As much as 10 m of incision have taken place along the entire length of the creek exposing numerous outcrops not previously visible.
Air photo: not available
Field photos: yes
Personnel: J. Anderson, S. Grist, V. Helfferich, R. Jackson, J.C. Harrison

Date: 03/09/01 Station: HBB-01-042 Location: 77^0 51.299'N 081^0 36.984'W
Notebook 1/20B
Description: Volcanic sandstone outcrop in the Mt. Lawson Formation. Anomalous magnetic susceptibility noted by Zentilli. Good planar cross-stratification in the sandstone. Also noted in this section are thin coals, mudrocks, and a silicified log. Correlation of these beds with the Pavy volcanic sandstone of Cape Back and Pavy River is likely. Possible peat beds are noted eroding out of the river bank on the opposite side of the valley at the same elevation (400 m).
Sample: HBB-01-42. Representative suite of volcanic sandstones. Zentilli also collected at this site.

Date: 03/09/01 Station: HBB-01-043 Location: 77^0 51.274'N 081^0 39.768'W
Notebook 1/20B, 21A
Description: Interbedded lignite coal and sand in the upper part of the Mt. Moore Fm., 40-50 m below the exposed top of the formation.
Sample: HBB-01-43A. Coal samples from three separate beds for petrography and thermal maturity
Sample HBB-01-43B: fine grained sand for petrography and heavy minerals
Sample HBB-01-43C: weakly coalified wood
Zentilli also collected at this site.

Date: 03/09/01 Station: HBB-01-044 Location: 77^0 51.268'N 081^0 39.949'W
Notebook 1/21A
Description: conglomerate bed located in the uppermost part of the Mt. Moore Formation
Sample: HBB-01-44: representative suite. Zentilli also collected at this site.

Date: 03/09/01 Station: HBB-01-045 Location: 77^0 51.274'N 081^0 40.132'W
Notebook 1/21A
Description: arkosic conglomerate from ca.40 m above the unconformable base of the Split Lake beds. Thrust sense slickenside lineations noted (and photographed by Zentilli). Minor thrust fold noted in coal and sand interval immediately down stream from this locality. Standing stumps of coalified wood noted high in stream bank section.
Sample: HBB-01-45L representative conglomerate sample; Zentilli also collected at this site.

Makinson Inlet Granite and Gneiss locality, September 3, 2001

Reference: Frisch (1988)
Date: 03/09/01 Station: HBB-01-046 Location: 77^0 51.393'N 081^0 41.515'W Elevation: 546 m.

Notebook 1/21A
Sample: HBB-01-46A: cordierite garnet paragneiss
Sample: HBB-01-46B: granite
Sample: HBB-01-46C: mylonite collected from felsenmeer along sheared contact between granite and paragneiss
Grist also collected samples at this site including a recessive northerly-striking diabase dyke

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Appendix 1: Field station numbers, dates occupied, and station locations Nares Strait project, 2001

Key to fields:

Field 1: date of site occupation: day, month, year (two digits each)
Field 2: field officer code (3 letters), year (2 digits), station number (3 digits)
Field 3: latitude north (degrees, 2 digits)
Field 4: latitude north (minutes and decimal minutes)
Field 5: longitude west (degrees, 3 digits)
Field 6: longitude west (minutes and decimal minutes)

Ground traverse on coastal northern Philpots Island: August 8, 2001
080801 HBB01001 75 00.070 079 59.600
080801 HBB01002 75 00.150 080 00.280
080801 HBB01003 75 00.050 080 00.590

Sediment covered iceberg near Cape Hayes, northeast Ellesmere Island: August 17, 2001
170801 HBB01004 80 07.705 069 53.908

Ground traverse to fly camp 16 km westsouthwest of Carl Ritter Bay, Judge Daly Promontory: August 19, 2001
190801 HBB01005 80 53.434 068 37.651
190801 HBB01006 80 53.850 068 35.328
190801 HBB01007 80 53.820 068 35.110
190801 HBB01008 80 53.770 068 34.874
190801 HBB01009 80 53.760 068 34.374
190801 HBB01010 80 53.751 068 33.873
190801 HBB01011 80 53.474 068 33.697
190801 HBB01013 80 53.324 068 29.305
190801 HBB01014 80 52.869 068

Ground traverse from fly camp 16 km westsouthwest of Carl Ritter Bay, Judge Daly Promontory: August 20, 2001
200801 HBB01015 80 51.874 068 35.446
200801 HBB01016 80 51.890 068 35.985
200801 HBB01017 80 51.976 068 36.857
200801 HBB01018 80 51.977 068 37.748
200801 HBB01019 80 51.932 068 39.431
200801 HBB01020 80 51.963 068 40.126
200801 HBB01021 80 51.994 068 40.814
200801 HBB01022 80 52.007 068 42.700
200801 HBB01023 80 51.067 068 42.940
200801 HBB01024 80 52.170 068 44.023
200801 HBB01025 80 51.370 068 43.299

Ground traverse from fly camp located 16 km westsouthwest of Carl Ritter Bay, Judge Daly Promontory: August 21, 2001
210801 HBB01026 80 51.370 068 43.299

Helicopter-supported mapping and short ground traverses on northern Judge Daly Promontory; August 22, 2001
220801 HBB01027 81 14.167 065 42.287
220801 HBB01028 81 14.623 065 37.743
220801 HBB01029 80 59.444 066 59.843
220801 HBB01030 80 59.431 066 59.270

220801 HBB01031 81 12.343 066 53.681
220801 HBB01032 81 12.352 066 54.988
220801 HBB01033 81 15.881 066 37.625

Ground and aerial traverse northeast of Cape de Fosse, Judge Daly Promontory: August 22, 2001
230801 HBB01034 81 23.774 064 44.767
230801 HBB01035 81 23.248 064 48.208
230801 HBB01036 81 28.244 065 17.689

Two hour ground traverse on Orne Island: August 29, 2001
290801 HBB01037 77 53.083 076 18.831
290801 HBB01038 77 52.790 076 20.645
290801 HBB01039 77 52.762 076 19.843

Sample site on Cape Faraday: August 29, 2001
290801 HBB01040 77 53.863 076 38.837

Sample site on Nordvesto, Carey Oer: August 31, 2001
310801 HBB01041 76 44.335 073 13.521

Ground traverse north of Makinson Inlet and Split Lake: September 3, 2001
030901 HBB01042 77 51.299 081 36.984
030901 HBB01043 77 51.274 081 39.768
030901 HBB01044 77 51.268 081 39.949
030901 HBB01045 77 51.274 081 40.132
030901 HBB01046 77 51.393 081 41.515

Appendix 2: Table of magnetic declinations: northern Ellesmere Island, northwest Greenland and intervening waterways, July 2001 (L.W. Newitt, GSC Ottawa).

Description of tables:
Columns 1,5: Latitude (degrees north)
Columns 2,6: Longitude (degrees west)
Columns 3,7: Magnetic declination (degrees west)
Column 4: blank

76	-85	-62.44		76.5	-85	-64.66
76	-84	-62.72		76.5	-84	-64.8
76	-83	-62.88		76.5	-83	-64.85
76	-82	-62.95		76.5	-82	-64.81
76	-81	-62.94		76.5	-81	-64.69
76	-80	-62.85		76.5	-80	-64.52
76	-79	-62.69		76.5	-79	-64.28
76	-78	-62.47		76.5	-78	-63.99
76	-77	-62.2		76.5	-77	-63.66
76	-76	-61.88		76.5	-76	-63.3
76	-75	-61.53		76.5	-75	-62.89
76	-74	-61.14		76.5	-74	-62.46
76	-73	-60.72		76.5	-73	-62
76	-72	-60.27		76.5	-72	-61.52
76	-71	-59.8		76.5	-71	-61.02
76	-70	-59.31		76.5	-70	-60.51
76	-69	-58.8		76.5	-69	-59.98
76	-68	-58.28		76.5	-68	-59.44
76	-67	-57.76		76.5	-67	-58.88
76	-66	-57.22		76.5	-66	-58.33
76	-65	-56.67		76.5	-65	-57.76
76	-64	-56.12		76.5	-64	-57.19
76	-63	-55.56		76.5	-63	-56.61
76	-62	-55		76.5	-62	-56.02
76	-61	-54.43		76.5	-61	-55.43
76	-60	-53.86		76.5	-60	-54.83
76	-59	-53.28		76.5	-59	-54.22
76	-58	-52.69		76.5	-58	-53.61
76	-57	-52.1		76.5	-57	-52.99
76	-56	-51.5		76.5	-56	-52.36
76	-55	-50.89		76.5	-55	-51.71
77	-85	-66.93		77.5	-85	-69.26
77	-84	-66.95		77.5	-84	-69.15
77	-83	-66.88		77.5	-83	-68.97
77	-82	-66.74		77.5	-82	-68.74
77	-81	-66.53		77.5	-81	-68.44

77	-80	-66.27	77.5	-80	-68.11
77	-79	-65.96	77.5	-79	-67.73
77	-78	-65.61	77.5	-78	-67.31
77	-77	-65.22	77.5	-77	-66.87
77	-76	-64.8	77.5	-76	-66.39
77	-75	-64.35	77.5	-75	-65.9
77	-74	-63.88	77.5	-74	-65.38
77	-73	-63.38	77.5	-73	-64.84
77	-72	-62.87	77.5	-72	-64.29
77	-71	-62.33	77.5	-71	-63.72
77	-70	-61.79	77.5	-70	-63.14
77	-69	-61.23	77.5	-69	-62.55
77	-68	-60.66	77.5	-68	-61.95
77	-67	-60.09	77.5	-67	-61.34
77	-66	-59.5	77.5	-66	-60.72
77	-65	-58.91	77.5	-65	-60.1
77	-64	-58.31	77.5	-64	-59.46
77	-63	-57.7	77.5	-63	-58.82
77	-62	-57.08	77.5	-62	-58.17
77	-61	-56.46	77.5	-61	-57.51
77	-60	-55.83	77.5	-60	-56.85
77	-59	-55.19	77.5	-59	-56.17
77	-58	-54.54	77.5	-58	-55.48
77	-57	-53.89	77.5	-57	-54.79
77	-56	-53.22	77.5	-56	-54.08
77	-55	-52.54	77.5	-55	-53.36
78	-85	-71.62	78.5	-85	-73.97
78	-84	-71.4	78.5	-84	-73.64
78	-83	-71.12	78.5	-83	-73.26
78	-82	-70.78	78.5	-82	-72.84
78	-81	-70.41	78.5	-81	-72.39
78	-80	-70	78.5	-80	-71.9
78	-79	-69.55	78.5	-79	-71.39
78	-78	-69.07	78.5	-78	-70.85
78	-77	-68.57	78.5	-77	-70.29
78	-76	-68.04	78.5	-76	-69.71
78	-75	-67.5	78.5	-75	-69.12
78	-74	-66.93	78.5	-74	-68.51
78	-73	-66.35	78.5	-73	-67.88
78	-72	-65.76	78.5	-72	-67.25
78	-71	-65.15	78.5	-71	-66.6
78	-70	-64.54	78.5	-70	-65.94
78	-69	-63.91	78.5	-69	-65.27
78	-68	-63.27	78.5	-68	-64.59

78	-67	-62.62	78.5	-67	-63.91
78	-66	-61.97	78.5	-66	-63.21
78	-65	-61.31	78.5	-65	-62.51
78	-64	-60.63	78.5	-64	-61.79
78	-63	-59.95	78.5	-63	-61.07
78	-62	-59.26	78.5	-62	-60.34
78	-61	-58.57	78.5	-61	-59.6
78	-60	-57.86	78.5	-60	-58.85
78	-59	-57.14	78.5	-59	-58.1
78	-58	-56.42	78.5	-58	-57.33
78	-57	-55.68	78.5	-57	-56.55
78	-56	-54.93	78.5	-56	-55.77
78	-55	-54.18	78.5	-55	-54.97
79	-85	-76.27	79.5	-85	-78.49
79	-84	-75.84	79.5	-84	-77.96
79	-83	-75.37	79.5	-83	-77.4
79	-82	-74.87	79.5	-82	-76.82
79	-81	-74.34	79.5	-81	-76.22
79	-80	-73.79	79.5	-80	-75.6
79	-79	-73.21	79.5	-79	-74.96
79	-78	-72.61	79.5	-78	-74.31
79	-77	-72	79.5	-77	-73.64
79	-76	-71.36	79.5	-76	-72.95
79	-75	-70.72	79.5	-75	-72.26
79	-74	-70.06	79.5	-74	-71.55
79	-73	-69.39	79.5	-73	-70.84
79	-72	-68.71	79.5	-72	-70.11
79	-71	-68.02	79.5	-71	-69.37
79	-70	-67.31	79.5	-70	-68.63
79	-69	-66.6	79.5	-69	-67.87
79	-68	-65.88	79.5	-68	-67.11
79	-67	-65.15	79.5	-67	-66.34
79	-66	-64.42	79.5	-66	-65.56
79	-65	-63.67	79.5	-65	-64.78
79	-64	-62.91	79.5	-64	-63.98
79	-63	-62.15	79.5	-63	-63.18
79	-62	-61.38	79.5	-62	-62.37
79	-61	-60.6	79.5	-61	-61.55
79	-60	-59.81	79.5	-60	-60.73
79	-59	-59.02	79.5	-59	-59.9
79	-58	-58.21	79.5	-58	-59.06
79	-57	-57.4	79.5	-57	-58.21
79	-56	-56.58	79.5	-56	-57.36
79	-55	-55.75	79.5	-55	-56.5

80	-85	-80.58	80.5	-85	-82.54
80	-84	-79.96	80.5	-84	-81.84
80	-83	-79.33	80.5	-83	-81.13
80	-82	-78.68	80.5	-82	-80.41
80	-81	-78.01	80.5	-81	-79.67
80	-80	-77.32	80.5	-80	-78.93
80	-79	-76.62	80.5	-79	-78.17
80	-78	-75.91	80.5	-78	-77.41
80	-77	-75.19	80.5	-77	-76.63
80	-76	-74.45	80.5	-76	-75.85
80	-75	-73.71	80.5	-75	-75.06
80	-74	-72.96	80.5	-74	-74.27
80	-73	-72.2	80.5	-73	-73.46
80	-72	-71.43	80.5	-72	-72.65
80	-71	-70.65	80.5	-71	-71.83
80	-70	-69.86	80.5	-70	-71.01
80	-69	-69.07	80.5	-69	-70.17
80	-68	-68.26	80.5	-68	-69.34
80	-67	-67.46	80.5	-67	-68.49
80	-66	-66.64	80.5	-66	-67.64
80	-65	-65.81	80.5	-65	-66.78
80	-64	-64.98	80.5	-64	-65.92
80	-63	-64.15	80.5	-63	-65.05
80	-62	-63.3	80.5	-62	-64.18
80	-61	-62.45	80.5	-61	-63.3
80	-60	-61.59	80.5	-60	-62.41
80	-59	-60.73	80.5	-59	-61.53
80	-58	-59.86	80.5	-58	-60.63
80	-57	-58.99	80.5	-57	-59.74
80	-56	-58.11	80.5	-56	-58.84
80	-55	-57.22	80.5	-55	-57.93
81	-85	-84.38	81.5	-85	-86.13
81	-84	-83.61	81.5	-84	-85.28
81	-83	-82.82	81.5	-83	-84.43
81	-82	-82.03	81.5	-82	-83.58
81	-81	-81.24	81.5	-81	-82.72
81	-80	-80.43	81.5	-80	-81.86
81	-79	-79.62	81.5	-79	-81
81	-78	-78.81	81.5	-78	-80.13
81	-77	-77.99	81.5	-77	-79.27
81	-76	-77.16	81.5	-76	-78.39
81	-75	-76.32	81.5	-75	-77.52
81	-74	-75.49	81.5	-74	-76.64

81	-73	-74.64	81.5	-73	-75.76
81	-72	-73.79	81.5	-72	-74.87
81	-71	-72.93	81.5	-71	-73.98
81	-70	-72.07	81.5	-70	-73.09
81	-69	-71.21	81.5	-69	-72.19
81	-68	-70.34	81.5	-68	-71.29
81	-67	-69.46	81.5	-67	-70.39
81	-66	-68.58	81.5	-66	-69.48
81	-65	-67.69	81.5	-65	-68.57
81	-64	-66.8	81.5	-64	-67.66
81	-63	-65.91	81.5	-63	-66.74
81	-62	-65.01	81.5	-62	-65.82
81	-61	-64.11	81.5	-61	-64.9
81	-60	-63.2	81.5	-60	-63.98
81	-59	-62.29	81.5	-59	-63.05
81	-58	-61.38	81.5	-58	-62.13
81	-57	-60.47	81.5	-57	-61.2
81	-56	-59.55	81.5	-56	-60.27
81	-55	-58.63	81.5	-55	-59.34
82	-85	-87.83	82.5	-85	-89.53
82	-84	-86.91	82.5	-84	-88.54
82	-83	-86	82.5	-83	-87.56
82	-82	-85.08	82.5	-82	-86.59
82	-81	-84.17	82.5	-81	-85.62
82	-80	-83.25	82.5	-80	-84.65
82	-79	-82.34	82.5	-79	-83.69
82	-78	-81.43	82.5	-78	-82.73
82	-77	-80.51	82.5	-77	-81.77
82	-76	-79.6	82.5	-76	-80.82
82	-75	-78.68	82.5	-75	-79.86
82	-74	-77.77	82.5	-74	-78.91
82	-73	-76.85	82.5	-73	-77.96
82	-72	-75.93	82.5	-72	-77.01
82	-71	-75.01	82.5	-71	-76.06
82	-70	-74.09	82.5	-70	-75.1
82	-69	-73.16	82.5	-69	-74.15
82	-68	-72.23	82.5	-68	-73.2
82	-67	-71.31	82.5	-67	-72.25
82	-66	-70.38	82.5	-66	-71.3
82	-65	-69.44	82.5	-65	-70.35
82	-64	-68.51	82.5	-64	-69.4
82	-63	-67.58	82.5	-63	-68.44
82	-62	-66.64	82.5	-62	-67.49
82	-61	-65.7	82.5	-61	-66.54

82	-60	-64.76	82.5	-60	-65.59
82	-59	-63.83	82.5	-59	-64.64
82	-58	-62.89	82.5	-58	-63.69
82	-57	-61.95	82.5	-57	-62.74
82	-56	-61.01	82.5	-56	-61.79
82	-55	-60.07	82.5	-55	-60.85
83	-85	-91.26			
83	-84	-90.21			
83	-83	-89.17			
83	-82	-88.14			
83	-81	-87.12			
83	-80	-86.1			
83	-79	-85.09			
83	-78	-84.09			
83	-77	-83.09			
83	-76	-82.09			
83	-75	-81.1			
83	-74	-80.11			
83	-73	-79.12			
83	-72	-78.14			
83	-71	-77.16			
83	-70	-76.18			
83	-69	-75.2			
83	-68	-74.23			
83	-67	-73.25			
83	-66	-72.28			
83	-65	-71.31			
83	-64	-70.34			
83	-63	-69.37			
83	-62	-68.4			
83	-61	-67.44			
83	-60	-66.47			
83	-59	-65.51			
83	-58	-64.55			
83	-57	-63.59			
83	-56	-62.63			
83	-55	-61.68			

Fission Track Thermogeocronology Study

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Summary

The timing of uplift and exhumation of the lands bordering the Nares Strait are being studied using the apatite fission track (AFT) dating technique. Under certain conditions AFT allows one to date the last time rocks cooled through a temperature of ca. 100°C, equivalent to exhumation from a depth of ca. 3-4 km in the crust. The analysis of confined fission track lengths in the dated apatite crystals allows to model time-temperature histories between temperatures of 125 and 70°C for rocks now at the surface. The sampling strategy, in suitable rocks on both sides of Baffin Bay, Kane Basin and Nares Strait, was intended to allow us to address specific questions concerning the uplift/exhumation related to extension and rifting in Baffin Bay-Labrador Sea, compressional tectonics of the Eurekan Orogeny, and to better understand the tectonic and thermal history of Tertiary clastic sediments in the region. A total of 75 samples were collected using the helicopters, short traverses and a 3 day fly camp on Northumberland Island. A few samples were also collected for us opportunistically by researchers involved with various other onshore activities. Our sampling complements that undertaken for AFT studies underway by GEUS and GSC (1995-1999). We also report, for the record, on observations of pillow lavas in Rensselaer Bugt, volcanic erratics in Northumbarland Island, and a mineral occurrence in Northumberland Island, all Greenland.

Introduction

We were invited by Chris Harrison, GSC Calgary to participate in the Nares Strait Geocruise 2001, and we accepted because it would give us an opportunity to follow up AFT thermogeochronology work already completed in the Sverdrup Basin, in central and western Ellesmere Island (Arne et al., 1998, Arne et al., in press). It was later brought to our attention that Peter Dawes (Geological Survey of Greenland - GEUS) in collaboration with Tom Frisch (GSC, Ottawa) had also collected samples for fission track studies along a 200 km traverse across Smith Sound in 1995 and 1999, although these data remain unpublished (Dawes et al., 2000; pers. comm. 2001). Therefore we designed our sampling strategy to complement that effort, and offered to collaborate with Dr. Kirsten Hansen, Copenhagen, who is carrying out the analytical work.

This report explains what the apatite fission track represents, our sampling rationale, lists the samples taken and their locations, and briefly discusses expectations and possible implications. It also reports on some geological observations unrelated to the AFT study.

The Apatite Fission Track Technique

The AFT method is based on the measured density and length distribution of linear tracks of crystal damage produced during the spontaneous fission decay of trace amounts of ^{238}U in apatite (i.e. Wagner and Van den Haute, 1992). Track densities provide a measure of mineral age, and corresponding etchable confined track length distributions contain valuable information with respect to low-temperature thermal history. Track length reduction by annealing of the fission damage is a thermally activated process that is incremental and irreversible; complete erasure of apatite fission tracks occurs at temperatures of 100°-150°C over geologic time periods (i.e. 1-10 My; the precise value depending on apatite composition and heating rate). Track lengths are therefore indicative of thermal history below the closure temperature because the probability of any track intersecting the polished surface and contributing to the AFT age is proportional to its length. Also, within a single age population shorter tracks are older than longer tracks. The range of temperatures over which fission tracks are shortened but not totally annealed, resulting in a reduction of the fission track age is called the partial annealing zone (PAZ). Several apatite annealing models have been developed based on empirically determined laboratory fission track annealing behaviour extrapolated to geologic time (i.e. Laslett et al., 1987, Willett, 1997) and these will be used in this project to model thermal histories.

The AFT technique gives information on the last time the rocks sampled were at a temperature of ca. 100°C, equivalent to a depth of ca. 3 to 4 km in the crust. Another method applicable to apatite - the (U-Th)/He method - dates the last time the rocks were at ca. 70°C. During mineral separation we also concentrate other heavy minerals, such as zircon and titanite, whose fission-track closure temperatures are ca. 200°C and 300°C respectively. K-feldspar can also be dated by $^{40}Ar/^{39}Ar$ to complement time-temperature models. Although our focus will be AFT thermogeochronology, if funding is available we hope to be able to utilize one or more of the above techniques.

The analytical procedures in our lab have been described in Grist and Ravenhurst, 1992. Rock samples (from 1 to 10 kg) will be crushed/disaggregated using a sledgehammer, jaw crusher and a rotary disk mill equipped with ceramic plates to minimize heating. Apatite mineral concentrates will be obtained using a Wilfley® gravity shaker table, heavy liquid separation using the non-toxic heavy liquid sodium polytungstate in a centrifuge, magnetic separation using a Frantz® magnetic barrier separator, a second heavy liquid separation using di-iodomethane, followed by hand picking as necessary. The apatite grains will be mounted in epoxy, polished, and etched with nitric acid to reveal spontaneous (fossil) tracks. The ages of individual grains will be determined using the external detector method (Hurford and Green, 1982). For this method the grainmounts, with affixed mica external detectors, are irradiated in a nuclear reactor at Dalhousie University to induce fission in a portion of the isotope ^{235}U. Spontaneous and induced tracks for each grain are counted at high magnification. Translation between grains and induced track images is accomplished using a robotic 3-axis microscope stage. The lengths of horizontal confined fission tracks will also be measured using a microscope drawing tube and calibrated digitizing tablet. Compositional variations in terms of chlorine and fluorine of the apatite grains will be analyzed with the electron microprobe, because composition determines modelling protocols.

Sampling Strategy

Our sampling was planned with the intention of addressing the following interrelated questions:

1) Flank uplifts and normal faulting related to the Baffin Bay – Labrador Sea Rift
2) Timing and magnitude of uplift/exhumation related to Eurekan compression.
3) Thermal history of Cenozoic clastic units.

The location of samples is given in the table on page 103 and **Fig. 41.** Also, **Fig. 41.** shows the Dawes-Frisch (1995-1999) sampling transect (Dawes et al. 2000). Sampling was carried out from the icebreaker CCGS Louis S. St. Laurent by Sandy Grist and Marcos Zentilli in every possible opportunity depending on ship position with respect to the coast, weather and helicopter availability. One 3-night fly camp in Northumberland Island afforded some familiarization with Thule Group stratigraphy and its associated mafic sills and dykes. Some samples were collected for us by Henry Halls and Jason Anderson during drilling of mafic dykes for paleomagnetic studies, by Chris Harrison during his field mapping work, and by Anna Jensen during the setting up of geodetic ground stations.

(1) Flank Uplift due to Rifting

The Labrador Sea / Baffin Bay Rift System separated Greenland from the North American plate between anomaly 34 time (ca. 85 Ma; Late Cretaceous) and anomaly 13 time (ca. 35 Ma; Oligocene) (e.g. Srivastava, 1978; Tessensohn and Piepjohn, 2000).

The presence of elevated Precambrian crystalline terrains around Baffin Bay (e.g. Trettin, 1991) is most likely the result of thermal perturbations after rifting, yet little is known about the timing and magnitude of this elevation, nor why it is still elevated after modification by Tertiary drainage systems and Pleistocene glaciations. In terms of morphology (e.g. Summerfield 1991) did the Baffin Rift generate high escarpments or a subdued topography? Did it show a marked asymmetry (e.g. Lister et al., 1991) on its flanks?

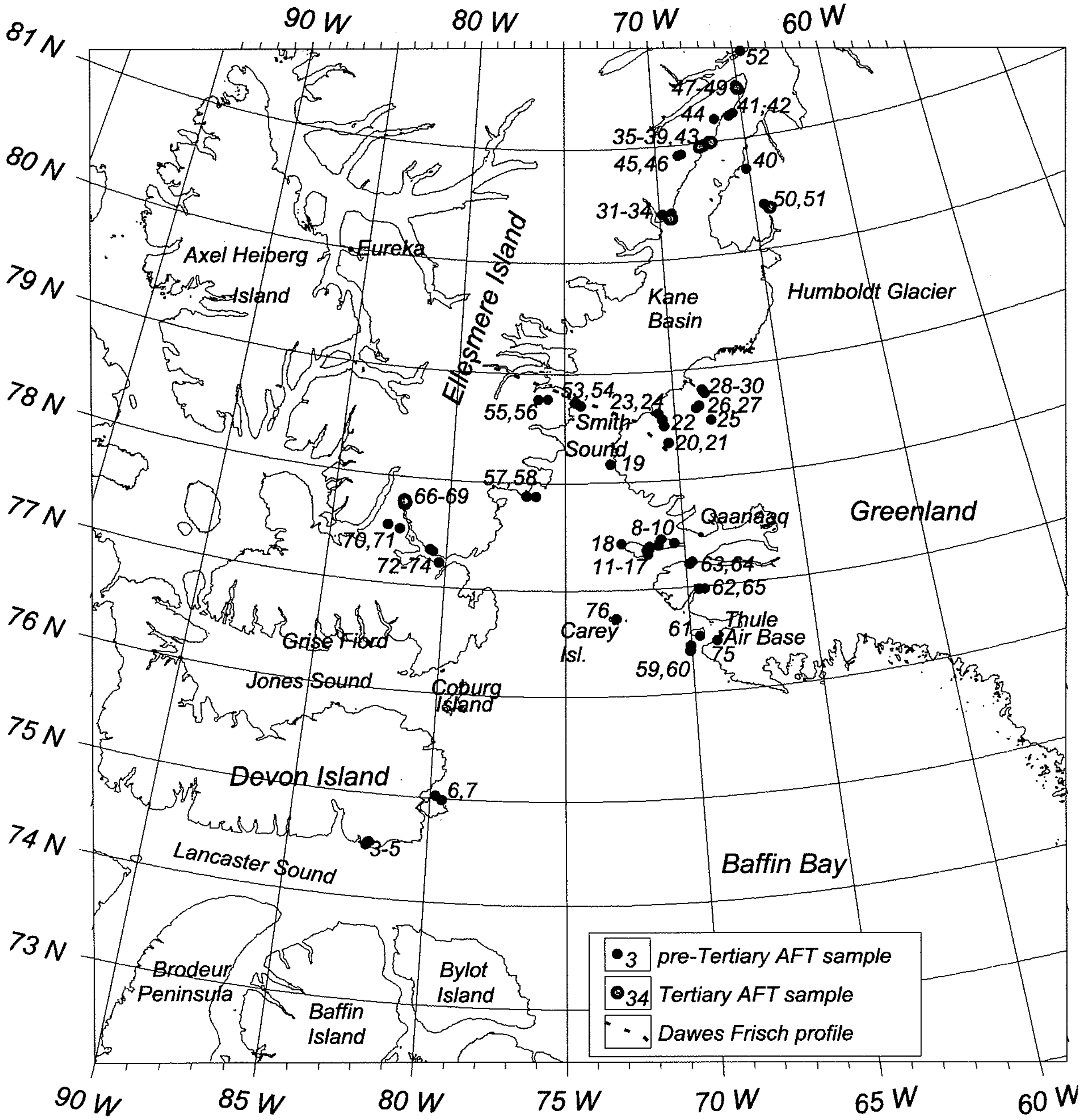

Fig. 41. *AFT Sample Sites*

The escarpments created by the Baffin Rift must have affected regional river drainage patterns (Trettin, 1991) and exerted a first order control on the stratigraphy of the adjacent basins, at least from 65 to 47 Ma before climate became a major controlling factor (Harrison et al., 1999). The rising topography must have affected climate, which in turn influenced rates of erosion and exhumation. The generation of topography at rifted continental margins results from the interplay between tectonics, erosion and isostatic rebound (e.g. Stephenson and Lambeck, 1985; Gilchrist and Summerfield, 1990, van der Beek, 1995). The exact mechanism of escarpment formation remains controversial; tectonic rift margin uplift may be related to decompression melting and sublithospheric underplating (e.g. Dam et al., 1998), but there are problems in explaining some long-lived elevated rift margins (e. g. Weissel and Karmer,1989). It is expected that AFT will pose constraints that will help assess the validity of various tectonic and landscape-evolution models in the Arctic.

In our sampling (**Fig. 41.**), we attempted to cover as much as the flanks as possible (Inglefield Uplift, Carey Islands, and the Thule region, and more or less perpendicular to the rift axis along Inglefield Land and Washington Land in Greenland.

In areas of known normal faults, we collected samples of crystalline rocks on both up- and down-faulted blocks, in order to ascertain any differences in thermal history that could help determine the age of faulting. The first area was in Inglefield Land, where we sampled on both sides of a prominent NW trending fault-lineament near Minturn Elv, which affects the basement gneisses (Dawes et al., 2000, Fig. 2). The second was in Steensby Land, at the head of Granville Fiord, where the Thule Group sediments are displaced by a large WNW fault whose down faulted block lies to the north (Geological Survey of Greenland Map 5).

(2) Eurekan Compression

Compressive deformation of the Eurekan Orogeny affected northeastern Ellesmere Island and north Greenland in Palaeocene to earliest Oligocene time. It was characterized by thrust faulting and associated folding and minor strike-slip faulting, with various trends at least in part controlled by pre-existing structures. The Eurekan compressive deformation is interpreted to be a response to counter-clockwise rotation of Greenland during spreading in the Labrador Sea/Baffin Bay rift system (e.g. Okulitch and Trettin, 1991). Trettin (1991) suggested that differential uplift in northeastern Ellesmere Island and north Greenland resulted from isostatic response to Eurekan crustal thickening combined with post-Eurekan erosion. A fundamental driving force for orogeny is considered to have been gravitational potential and spreading forces created by sublithospheric underplating and plume-induced regional uplift acting on the ancestral Greenland microplate (Harrison et al., 1999).

The fact that mountains still persist in this area despite active erosion must mean that the roots of the orogen have not yet been eliminated. Trettin (1991) suggests that isostatic uplift was probably intermittent and rapid, but little information is available on related relict erosion surfaces. These cycles of uplift and erosion presumably were of large amplitude (in order of km) and long duration (millions to tens of millions of years). The AFT method is particularly suited to date and determine approximate rates of exhumation cooling for these events. Apatite fission track data will not be able to resolve superimposed Quaternary oscillation of land surfaces caused by elastic response to glacial loading and unloading, which were of low amplitude and duration (< 150 m; Hodgson, 1991) and short duration (< 1 My; Trettin, 1991).

Our sampling strategy was guided by Chris Harrison and our limited experience in Vesle Fiord (Arne et al., 1998; 2001). Therefore we tried to sample the hanging wall and footwall of important thrust faults, such as in the region of Cape Lawrence, Judge Daly Promontory, and Makinson Inlet (**Fig. 41.**).

(3) Tertiary Conglomerates

The name Eureka Sound Group has been used to refer to the last pulse of clastic sedimentation of the Sverdrup Basin succession, and its rocks range in age from Maastrichtian to earliest Oligocene. Various formations show strong variations from place to place within the Arctic Islands, reflecting a complex paleogeography that was continuously evolving in response to contemporaneous movements of the Eurekan Orogeny (e.g. Miall, 1991). Harrison et al. (1999) have reorganized, using foraminifera, dinoflagellates, miospores, land mammals and other macrofauna, magnetostratigraphy and various radiometric methods, these diverse formations into 12 regionally correlative depositional sequences that range in age from Danian to Pleistocene.

Locations of samples of Tertiary clastic units are indicated using grey circles in **Fig. 41**. In northeastern Ellesmere Island, these sediments occur in the regions of Lake Hazen on Judge Daly Promontory, Cape Lawrence, Cape Back, and near Split Lake at Makinson Inlet. Of particular interest for this study is the fact that in some of these locations the Tertiary sediments, interpreted to have been deposited in the Tertiary Foreland Basin, are overridden by thrusts of Eurekan age, and involved in complex deformation (e.g. Piepjohn et al., 2000). Sampled lithologies include carbonate-clast conglomerates, volcanic sandstones, sandstones with interbedded lacustrine mudstones, and shaley sandstone/siltstone sequences with coal beds. In Greenland a distinct Tertiary conglomerate referred to as the Bjørnehiet Formation by Bennike (2000), occurs in Washington Land slightly north of the Humboldt Glacier.

It is expected that AFT data on these Cenozoic clastic units will provide constraints on the following issues: a) the age of major movement of the overriding structures (see 2 above); b) the maximum temperature (due to burial) experienced by these clastic units (to be compared with organic maturation data of enclosed coaly matter); c) age of unroofing of the source areas of the clastic units, and d) comparative thermal history of different units at the same locality.

Another unit of particular significance for our AFT study is the volcanic sandstone sampled in near Lake Hazen on Judge Daly Promontory, Cape Back and near Split Lake at Makinson Inlet. This dark gray sandstone has the highest magnetic susceptibility of any lithology measured in the Nares Strait region (see Table on page 105 and Table on page 106), indicating a fresh volcanic provenance. Its apatite would have essentially no pre-depositional thermal history and hence be the best indicator of the post-depositional thermal history of the units. In the course of our sampling we also discovered that this unit is the cause of a major NNE-SSW trending magnetic anomaly along the Ellesmere Island coast that was detected during the aeromagnetic survey.

Magnetic Susceptibility Measurements in Rocks

We routinely use a Kappa Meter (EDA K-2) Magnetic Susceptibility Meter to ascertain whether potential samples will have sufficient heavy minerals for dating, as we have found a reasonable qualitative correlation between magnetic mineral content and apatite content. During the course of this campaign we measured values of most sites in 10 points within an area of about 10 m^2 . In some instances there was no time (helicopter waiting with running rotors) and measurements are not representative of the sites, but merely of our geochronology samples. Table on page 105 gives the magnetic susceptibility of the surface rocks at the sampling localities, not necessarily of the actual sample collected. Where values are missing, measurements are not available or considered unreliable. These measurements will be completed, once in our lab, by carefully measuring magnetic susceptibility of collected samples, and made available at that time.

Table on page 105 shows that, in general, sedimentary rocks have the lowest magnetic susceptibility, often below detection limit (0.01; we are uncertain of the exact units of measurement for the K-2 instrument and for now prefer to use only relative numbers), whereas mafic dyke and sill rocks give the maximum magnetic susceptibility (in particular at their margins, 2.00 and locally more than 6.00), 200 to 600 times higher than sedimentary rocks. Metamorphic and granitoid rocks have values in between, and we noticed some minor effects of lowering of magnetic susceptibility due to weathering (oxidation).

It was therefore surprising to discover relatively high magnetic susceptibility (up to 5.00 and locally 50.00!) in Tertiary clastic units at Split Lake, Cape Back, and especially at Cape De Fosse. Accordingly, these sandstones produce prominent anomalies in the airborne magnetic survey (Damaske and Oakey, this volume).

Therefore we measured in some detail, using a 2 m measuring tape or pacing, profiles across the exposed sections (see table on page 106 and table on page 107). The average magnetic susceptibility of the volcanic sandstone unit at Cape Back is 200 times higher than surrounding Paleozoic sediments. Another profile of 300 m was measured on lithologically similar sandstones at Cape deFosse (see table page 107). Although the general values encountered are similar to those at Cape Back, one bed (our sample na 48B) yielded an average value of 37.00, with a maximum reading of 50.00, the highest encountered in this project. These sandstones contain a large proportion of fresh magnetite (Chris Harrison, personal communication, August 2001).

Possible Implications for Hydrocarbon Maturation

On the basis of the appearance of carbonaceous matter in many of the Tertiary units in Ellesmere Island, and reports of the presence of sub-bituminous and high-volatile bituminous coal in the Judge Daly and Bache Peninsula (Bustin and Miall, 1991), we expect to find that fission track data will indicate that some clastic units have been heated to temperatures within the oil window (Arne and Zentilli, 1994). The permeable Tertiary clastic units would make excellent reservoirs. Coaly and organic rich strata are potentially good source rocks for hydrocarbons. It is possible that significant hydrocarbons may have been accumulated within these Cenozoic units if they have been buried by thrust stacking, in particular because many of the thrust faults are rooted in impervious evaporites (Chris Harrison, personal communication). Depending on our expected results, we may recommend that future hydrocarbon exploration in northeastern Ellesmere Island should focus on sub-thrust plays to test potential structural traps at depth (e.g. Arne et al., in press).

During the project, petroliferous carbonates were encountered as glacial drift in sediment covering an iceberg, and in the field. These rocks are likely to come from Ordovician and Silurian strata which are known to have petroleum accumulations in Greenland, and also in Ellesmere Island (Chris Harrison, personal communication).

Unforeseen Observations in Greenland unrelated to Fission Track Studies

Pillow Lavas in Inglefield Land. During one traverse (14/08/01) ending at Rensselaer Bugt, we came across an outcrop of pillowed basalts, which are likely to be part of the lowermost Thule Group (Nares Fm.), which is known to contain mafic extrusive as well as intrusive (sills and dykes), but we were unaware of the presence of spectacularly preserved pillow lavas. The outcrop is located 60 m west of our sample locality na23 (Lat. 78° 34.545' N/Long. 70° 37.017' W, at 169 m.a.s.l.). The outcrop is at least 20 m thick, covered by scree from the overlying Thule Supergroup and Cambrian clastics and carbonates), and exposed 60-100 m along the valley. It is difficult to be sure of the age of these lavas, because the Plaeozoic unconformity is almost exactly at the level of the pre-Thule Supergroup unconformity, as noted by Dawes et al. (2000), yet we have no knowledge of the existence of Palaeozoic volcanics in this region. The pillows are in average in the order of 1 m across, 0.6 m high, but some are much larger and some seem fragmental. They have clear downward pointy terminations accommodating to underlying pillow topography. Pillow margins are (devitrified) glass about 2 cm (1 to 3 cm) thick all around the pillows. Pillow interiors are amygdaloidal, and the amygdules appear to be filled with chlorite. Serpentine-colored minerals also occur. Magnetic susceptibility is about 2.10 (0.95 to 2.40), hence very similar to the major mafic sills and dykes intruding the Thule Supergroup (see table page 105). However, the local basement gneiss is also relatively magnetic (average 3.00, but highly variable), hence the volcanic unit would not be distinguishable in the aeromagnetic maps. Unfortunately we picked only a fist-size petrographic sample of basalt, since it appeared too fine to yield useful apatite crystals for AFT, and we were already overloaded.

Mineral occurrence (Pb-Ba) in Northumberland Island, Greenland. During a traverse (10/08/01) from our fly-camp in Northumberland Island, we came across "vuggy" basalt, which after closer inspection turned out to be a cavity ridden upper part of a mafic sill (more unlikely a flow), with irregular cavities (1-20 cm) and irregular veins (0.5 to 10 cm) filled or partially filled with calcite, barite, and sulphides, mainly galena. The locality is at Lat. 77° 22.087' N/Long. 71° 30.568, at 265 m.a.s.l., on a northeasterly sloping, relatively flat surface in Kap Henson. The altered and sparsely mineralized rock outcrops within an area of 250 in an E-W direction, by 35 m NS, and is beyond that covered, or the rock is unaltered. Galena crystals are cubic, up to 2 cm, and occur in irregular masses associated with 2 types of carbonate (one weathering light brown, the other white), and tabular barite. There are partially weathered remnants of another sulphide or sulphosalt (tetrahedrite-tennantite?), and some altered zones have green efflorescence suggesting copper and arsenic. Alteration has corroded the rock and given it the vuggy appearance, and elsewhere the rock is intensely altered and can be dug out with a knife. It is suggested that the control is permeability provided by NS? Extensional fractures, and the upper contact of the sill (S_1) with grey shales of the Dundas Group (D) (Geological Map of Greenland, Sheet 5, Thule). We report this occurrence because we have seen no reference to mineralization in association with the mafic sills in this region. The association suggests the possibility of the galena being argentiferous. Hand samples are available.

Fresh volcanic clasts in recent glacial deposits in Northumberland Island. During the stay in the fly camp in Kap Henson, we observed remarkably well preserved conical kames near the camp, at the foot of a glacier. These are up to 20 m high, pointy, and are totally unconsolidated, and extremely unstable, suggesting that they are very new. In one of these, located at Lat. 77° 21.672' N/Long. 71° 34.181' W; 346 m.a.s.l., we found that among the blocks and pebbles, which consist of 89% quartz sandstone and 10% red conglomerate, there is less than 1 % volcanic erratics. These are angular mono-lithologic, fresh-looking, vesicular, scoriaceous basalt fragments, from 5 to 20 cm in size. In the vicinity of the kame we found one large (30-cm) "bomb-like", relatively-rounded, boulder. The basalt is fragmental, agglomeratic, of dark grey colour with purplish-gray zones. The scoriaceous parts have abundant white coatings (<1 mm), but a few of the vesicles are filled with calcite. In first inspection they remind one of *in situ* cinder cone material. We report these findings because we are aware of relatively fresh volcanic clasts having been found as erratics in Daugard-Jensen Land and Washington Land north of latitude 80° (Dawes et al., 2000b). However, the ones we describe are definitely more angular and fresher looking than those described in the latter publication. There are volcanics at Sonntag Bugt (Dawes et al., 2000b) and Rensselaer Bugt (1, above), and the Geological Map of Greenland, Sheet 5, Thule, indicates that there are outcrops of Nares Strait Group in western Northumberland Island, which the legend says include volcanic lavas and pyroclastics. The glacier transport agrees with this possible source in the northwest. Without having seen these latter outcrops, we cannot discount the possibility that these are the source of the volcanic erratics. Yet they look so fresh that they deserve a petrographic study. Two specimens are available.

Acknowledgements

We thank Chris Harrison for inviting us to participate in this expedition, for educating us, guiding us to the best outcrops and assisting with collection of samples. Thanks also to Franz Tessensohn, Chief Scientist, for generous allocation of helicopter hours and guidance in the field. Henry Halls, Jason Anderson and Anna Jensen, also collected samples for us in several sites. Brian Atagootak and Jimmy Nungaq, from Grise Fiord, and Bob Morris, protected us from bears and muskox and helped in the field. Helicopter pilots Harrison Macrae and Adrien Godin, expertly landed in nearly impossible sites. We are also grateful to the scientific staff and to Captain Klebert and the entire crew of CCGS Louis S. St. Laurent for making this cruise so worthwhile and memorable.

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Sample	Location and rock type	latitude (deg. min.)	longitude (deg. min.)	elevation (m)
na40	Fossil Bugt lmst	80 43.125	65 20.188	205
na41	Cape deFosse flysch sst	81 14.167	65 42.387	3
na42	Cape deFosse flysch sst	81 14.625	65 37.742	535
na43	Cape Back tan sst	80 59.445	66 59.845	314
na44	n of Daley River, Kane Basin(?) sst.	81 12.343	66 53.681	532
na45	Rawlings Bay Fm sst	80 51.37	68 43.299	1160
na46	Rawlings Bay Fm. Sst	80 51.874	68 35.446	440
na47	Cape deFosse Eids Fm. Sst	81 23.764	64 44.948	582
na48	Cape deFosse fwall Tert. volc. sst.	81 28.323	65 17.401	215
na49	Cape deFosse hwall Danish R. Fm.	81 30.697	65 7.582	482
na50	Bjorneheit Fm. sst in congl.	80 25.645	64 26.502	395
na51	north of Bjorneheit Fm. sltst	80 25.74	64 46.74	353
na52	north of Fort Conger sltst.	81 40.245	64 23.166	38
na53	Pim Island granite	78 41.14	74 17.581	441
na54	Pim Island granite	78 40.96	74 13.95	0
na55	Leffert Glacier gneiss	78 43.643	76 6.335	661
na56	Leffert Glacier dyke	78 43.608	75 41.021	460
na57	Cape Faraday dyke	77 53.863	76 38.837	3
na58	Orne Island dyke	77 52.853	76 19.122	10
na59	Westenholme Island sst.	76 26.004	69 54.82	351
na60	Westenholme Island sill	76 27.095	69 54.969	43
na61	Manson Island dyke	76 37.865	69 10.965	0
na62	Granville Fiord (dyke?)	76 58.93	68 42.272	655
na63	Kap Trautwine gneiss	77 12.686	69 45.253	665
na64	Kap Trautwine gneiss	77 14.188	69 53.074	0
na65	Granville Fiord gneiss	76 58.929	69 39.035	3
na66	Makinson Inlet/Split Lake (volc.) sst.	77 51.298	81 36.984	398
na67	Makinson Inlet/Split Lake sst.	77 51.274	81 39.768	171
na68	Makinson Inlet/Split Lake sst.	77 51.268	81 39.949	172
na69	Makinson Inlet/Split Lake congl.	77 51.294	81 40.132	143
na70	Makinson Inlet/Strathcona Fiord sst.	77 35.103	82 27.281	500
na71	Makinson Inlet/Strathcona Fiord sst.	77 34.082	81 54.586	457
na72	Makinson Inlet gneiss/granite/dyke	77 20.449	80 41.791	546
na73	Makinson Inlet granite	77 19.849	80 43.927	80
na74	Makinson Inlet/Bowman Isl. granite	77 14.859	80 14.028	60
na75	Thule dyke	76 27.562	69 14.474	3
na76	Carey Islands dyke/gneiss	76 44.335	73 13.521	15

Magnetic Susceptibility of Selected Rock Types in the Nares Strait Area Using EDA K-2 Magnetic Susceptibility Meter

Location and rock type	Avg.Mag. Suscept.	lat	min	long	min	a.s.l. m	Sample
Carl Ritter Bay flysch(?) sandstone	*0*	80	59.04	67	57.98	569	na39
Bjorneheit Fm. sandstone in conglomerate	*0*	80	25.65	64	26.5	395	na50
Makinson Inlet/Strathcona Fiord sandstone.	*0.005*	77	35.10	82	27.28	500	na70
Makinson Inlet/Strathcona Fiord sandstone.	*0.005*	77	34.08	81	54.59	457	na71
Carl Ritter Bay limestone	*0.01*	80	58.24	67	22.81	731	na38
Fossil Bugt limestone	*0.01*	80	43.13	65	20.19	205	na40
Cape deFosse flysch sandstone	*0.01*	81	14.17	65	42.39	3	na41
Cape deFosse flysch sandstone	*0.01*	81	14.63	65	37.74	535	na42
Makinson Inlet gneiss	*0.01*	77	20.45	80	41.79	546	na72A
Cape Back tan sandstone	*0.02*	80	59.39	67	1.12	173	na37
Makinson Inlet/Split Lake sandstone.	*0.02*	77	51.27	81	39.95	172	na68
Granville Fiord gneiss	*0.03*	76	58.93	69	39.04	3	na65
Makinson Inlet/Split Lake conglomerate	*0.1*	77	51.29	81	40.13	143	na69
Pim Island granite	*0.11*	78	41.14	74	17.58	441	na53
Makinson Inlet granite	*0.12*	77	20.45	80	41.79	546	na72B
Makinson Inlet/Split Lake (volc.) sandstone.	*0.46*	77	51.30	81	36.98	398	na66
Pim Island granite	*0.72*	78	40.96	74	13.95	0	na54
Kap Trautwine gneiss	*0.75*	77	14.19	69	53.07	0	na64
Kap Trautwine gneiss	*0.9*	77	12.69	69	45.25	665	na63
Granville Fiord (diabase dyke?)	*1.5*	76	58.93	68	42.27	655	na62
Cape Faraday diabase dyke	*1.6*	77	53.86	76	38.84	3	na57
Westenholme diabase Island sill	*1.7*	76	27.10	69	54.97	43	na60
Northumberland Island diabase dyke	*1.7*	77	20.84	71	31.19	410	na17
Cape deFosse fwall Tert. volc. sandstone.	*1.7*	81	28.32	65	17.40	215	na48
Herbert Island diabase dyke	*1.9*	77	25.21	70	25.29	769	na08
Northumberland Island diabase dyke	*2*	77	21.71	71	33.40	348	na11
Hakluyt Island diabase dyke	*2*	77	25.79	72	38.32	409	na18
Renssaeler Bugt pillow basalt	*2.1*	78	34.55	70	37.02	159	na23B
Cape Back mafic volc. sandstone.	*2.6*	80	59.48	67	0.43	279	na36
Cape Back mafic volc. sandstone.	*2.7*	80	59.79	66	58.76	411	na35
Manson Island diabase dyke	*2.9*	76	37.87	69	10.97	0	na61
Renssaeler Bugt (ortho?) gneiss	*3*	78	34.55	70	37.02	169	na23
Orne Island diabase dyke	*3*	77	52.85	76	19.12	10	na58
Cap Alexander sill	*3*	78	10.04	72	58.47	411	na19
Northumberland Island diabase dyke	*3*	77	22.66	71	28.97	110	na15
Leffert Glacier diabase dyke	*3*	78	43.61	75	41.02	460	na56
Leffert Glacier gneiss	*4.4*	78	43.64	76	6.34	661	na55
Cape deFosse fwall Tert. volc. sandstone.	*37*	81	28.32	65	17.4	215	na48B

Magnetic Susceptibility Profile at Cape Back, Ellesmere Island Volcanic Sandstones				
Locality: NA-35 Lat N 80° 59.791' / Long W 66° 58.759' Alt. 411 m Using EDA K-2 Magnetic Susceptibility Meter Marcos Zentilli Section is measured on vertical strata, up section n is always 10 mesurements within 1 m^2 area				
m	**Mean**	min	max	**comments**
>30 m				
44	**1.200**	0.80	1.50	shaly ss
42	**2.200**	1.80	2.90	FT sample na 35, ss
40	**0.62**	0.40	0.85	coarse ss with foreign clasts
38	**0.92**	0.80	1.20	oxidised ss, hard ridge, concretions
36	**0.820**	1.10	0.05	oxidised ss, concretions
34	**1.800**	1.40	2.40	ss
32	**3.100**	2.90	3.60	ss
30	**1.900**	1.40	2.60	ss
28	**1.300**	1.00	1.40	ss with sh blocks
26	**1.600**	1.40	5.50	ss & sh
24	**1.900**	1.40	2.40	ss w. pebbles
22	**2.000**	1.70	2.60	ss w. pebbles
20	**2.1**	1.00	2.90	ss w. pebbles (faults are lowest)
18	**1.9**	1.50	2.60	ss w. concretions
16	**1.500**	1.20	2.40	ss w. pebbles
14	**2.200**	1.80	2.50	fine ss w. trees
12	**3.400**	2.10	4.80	fine ss w. trees
10	**2.100**	1.10	2.80	ss w. trees
8				covered
6				covered, probably fine ss
4	**5.600**	4.70	5.80	ss
2	**2.500**	1.90	4.60	ss
0	**1.6**	1.20	2.90	ss
> 20 m	**2.012**	0.80	5.80	
Note: Tertiary sediments below volcanic unit have values 0.00-0.03, mean 0.005				

Magnetic Susceptibility Profile Cape de Fosse, Ellesmere Island

Volcanic Sandstones
Locality: NA-48 Lat N 81°^{28}.323' / Long W 65° 17.401' Alt. 215 m
Using EDA K-2 Magnetic Susceptibility Meter
Sandy Grist
Section is measured up section
n is mean of various measurements within 1 m^2 area

m	**Mean**	min	max	**Sample**
>30 m				
310	**1.558**	0.95	2.40	na 48
280	**2.000**	1.80	2.20	
250	**37.000**	29.00	50.00	na 48B
200	**2.150**	1.90	2.40	
150	**2.325**	1.10	0.05	
100	**1.250**	1.00	1.70	
0	**2.625**	1.70	3.80	
AVGE	**6.987**	0.95	50.00	

Paleomagnetism, U-Pb Geochronology and Geochemistry of Proterozoic Dykes in Greenland and Northeastern Canada: Relevance to the Nares Strait Problem

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Introduction

The Nares Strait controversy (Dawes and Kerr 1982a) concerns the extent of sinistral transcurrent motion along the Nares Strait between Canada and Greenland that is expected as a result of the opening of the Labrador Sea (Roest and Srivastava 1989). Plate tectonic reconstructions call for at least 150 km of sinistral motion, whereas different geological correlations (Dawes and Kerr 1982b) indicate minimal displacement. The analysis of marine magnetic anomalies suggests that initially from 69 to 56 Ma Greenland moved approximately northeast about 175 km relative to Canada, and that subsequently from 56 to 35 Ma as much as 175 km of convergence with Ellesmere Island occurred with Greenland moving in an approximately northerly direction.

The purpose of this research is to test whether or not Proterozoic dyke swarms can be used to demonstrate the sinistral offset and any relative rotation of Greenland with respect to Canada.

In the Thule area of Greenland a major set of vertical WNW-trending dykes, probably part of the 723 Ma Franklin swarm, is composed of fresh, generally olivine-free diabase (**Fig. 42.**). The dykes are up to 100 m wide, chemically variable and include both tholeiitic and alkaline varieties. K/Ar dating from both dykes and sills in the Thule group range from 729±22 to 645±26 Ma (Dawes and Rex 1986). The dyke swarm has a width of about 200 km and a length of at least 450 km.

The NW-trending Melville Bugt dyke swarm runs for about 1000 km along the west coast of Greenland and is at least 150 km wide (Nielsen 1990). Rb-Sr dated at 1645±35 Ma (Kalsbeek and Taylor 1986), the dykes are petrographically distinguishable from the younger Thule set by the presence of olivine. Geochemically they are unusually high in Ba (~1000 ppm). The number of dykes in the swarm is at least 30 but several are ~100 m wide and extend for several 100 km. The swarm is relatively attenuated in the Thule area and apart from one poor exposure which cannot be confirmed as a dyke (P. Dawes, personal communication, 2001) is not seen along the NW coastline of Ingerfield Land (circled 1 in **Fig. 42.**). In the region of Ingerfield Bay (circled 2 in **Fig. 42.**) the chilled margin of one NW-trending dyke gave a K-Ar age of 1538±46 Ma (Dawes and Rex 1986) and another NW-trending dyke on Josephine Peary Island (circled 3 in **Fig. 42.**) at the eastern end of the bay gave a K-Ar age of 1563±60 Ma (Dawes et al.1973).

In Canada, the only dyke swarm is on Devon Island and along the south shore of Ellesmere Island. Here vertical, olivine-bearing, tholeiitic dykes are W to NW-trending and vary in thickness from 1 to 30 m (Frisch 1988). Two of these dykes yield K-Ar ages of 726±6 and 625±8 Ma. The width of the swarm is about 200 km. Farther north on Ellesmere island dykes are relatively few with various trends. The southern half of Ellesmere appears to be relatively devoid of dykes but north of 78°N, two E-W dykes more than 20 km long occur (shown as dotted lines in **Fig. 42.**, on the north sides of Leffert and Cadogan Glaciers).

Two observations supporting offset are that the region most devoid of dykes on Ellesmere lies on strike with the densest part of the Thule swarm in Greenland and that the northern edge of the Thule dyke swarm is offset sinistrally by about 200 km from the northern edge of the Devon Island swarm, corresponding approximately to expectations based on marine magnetic anomalies.

On Coburg Island (circled 4 in. **Fig. 42.**), and along the east coast of Ellesmere island to the north, a swarm of N-trending dykes, about 100 km long, occurs. Dykes of this trend also occur rarely throughout Ellesmere where they outnumber W-trending dykes by about three to one. One of these dykes along the south coast of Devon yields a K-Ar age of 1336 ±15 Ma.

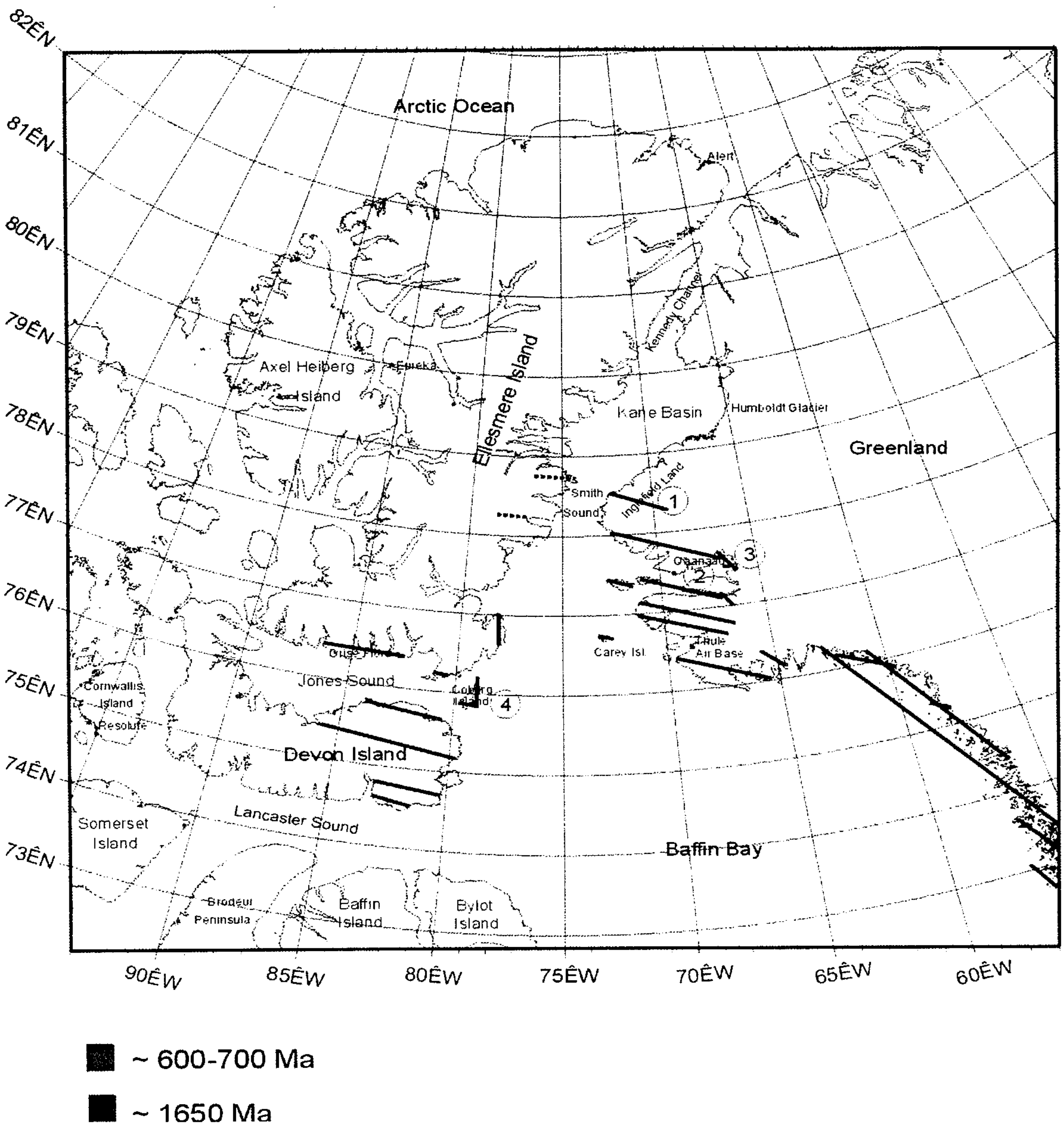

Fig. 42. *Map showing schematically in red the 600-700 Ma Thule-Devon Island dyke swarms, and in blue the 1650 Ma Melville Bugt dyke swarm and possible correlatives in Canada*

If Greenland and Canada are placed in their pre- separation position, the Thule swarm appears to form the eastward continuation of that in Devon island, although the intervening gap after the restoration is about 200 km. The correlation is supported by the high TiO_2 content (4-5 wt%) in both swarms (Frisch, 1988, Nielsen, 1987), but there appears to be a difference in their olivine contents. A second correlation is that the N-S trending swarm in Canada could represent the western margin of the Melville Bugt swarm of Greenland, although even after restoration the Melville Bugt swarm retains a more NNW trend compared to the Canadian dyke set.

The project proposes to carry out paleomagnetic, geochemical and U-Pb dating studies on the four dyke sets to see if there is any basis for their along strike correlation. If successful this will be the first time that a single dyke swarm has been matched between Canada and Greenland. The Euler pole which determines the amount of rotation of Greenland during its movement from Labrador to Ellesmere varies in different models between zero and 20 °(see Fig.2 of Grant, 1982). It may be possible to paleomagnetically detect any counterclockwise rotation of Greenland should it be more than ~10° by examining differences between the mean declination of remanent magnetization for the Thule and Devon Island swarms. This in turn could further constrain the Euler pole position and strengthen particular models over others.

Sampling strategy and methodology

A portable rock drill is used to obtain 2.5 cm diameter core samples from the centre to margin of each dyke with preference being given to the fine-grained chilled margins. Chilled margins are more likely to contain single domain magnetite which has a higher magnetic coercivity compared to larger multi-domain grains and is therefore more likely to retain its original magnetization. Coarser-grained interiors tend to carry multi-domain magnetite with low coercivity which is more easily replaced by viscous remanent magnetization in the present Earth's field. Only if the magnetite is Ti rich and displays ilmenite exsolution lamellae produced during deuteric alteration, can a primary high coercivity remanence be preserved in the small magnetite volumes between the lamellae. The high Ti content of the Thule dykes offers hope that coarser-grained interiors may yield stable remanence. Once a core is drilled, it is oriented by means of an aluminum platform attached to a tube that fits over the standing core, and both magnetic and sun compasses are used to orient it. Orientation by sun compass is essential whenever the rocks are observed to deflect the magnetic compass. About 10 to 15 sites should be collected from a swarm in order to average out the effects of secular variation, which is a general term given to changes in the magnetic field direction with periods of ten to a few thousand years caused by changes in the Earth's core. Once collected the cores are cut into 2.5 cm and their remanent magnetization direction and intensity measured on a spinner magnetometer.

Results

The initial target was to obtain paleomagnetic sites in approximately 15 dykes of the Thule swarm and about 5 sites in the Melville Bugt swarm but thick and persistent fog, especially in the vicinity of Ingerfield Bay, the main area of interest, limited sampling to only ten sites.

During the Nares Strait Geocruise 2001, a number of helicopter flights were made from the CCGV "Louis S. St. Laurent" between August 1 and September 10, 2001. Due to the large number of ongoing experiments, shoreline access was determined mostly by the ship's location at any one time. More than 70 oriented cores and 8 blocks were obtained from eight dykes and two sills. Nine of the sites were field drilled of which eight had both magnetic and sun orientations. Only at five sites (OR,CV, CA, KL and TB) were chilled margins preserved and sampled. A summary of each paleomagnetic site is given on page 112.

The sun measurements were essential because the intrusions are very magnetic. One site (a sill at NU3) was collected as block samples with orientations by magnetic compass only. Site PH1 was on Philpots Island at the eastern end of Devon Island, where a dyke about 30 m wide was sampled; two small bedrock holes within an otherwise rubble-covered surface provided the five cores. Sites NU1-3 were from three dykes on top of Northumberland Island. None had chilled margin outcrops, and only at NU2, where a river had cut through the dyke, was completely fresh material available. Site KL was taken from the Kap Leiper dyke previously described and sampled by Dawes et al.(1982). Here the western margin was exposed within half a metre, where the vertical dyke was observed to cut buff-coloured sandstones of the Thule Group dipping 20°S. The dyke is more than 50 m wide. Another vertical dyke, (site PK), forms a high E-W trending ridge. About 65 m wide, it cuts almost horizontal Thule strata, although the chilled contacts were not exposed. A geologically similar situation was found at site TB near Thule Air Base, but here the southern chilled margin was well-exposed on the beach. On Orne Island, off Ellesmere, a E-NE trending dyke, about 60 m wide is present, with excellent chilled margins exposed against retrograded garnet gneiss. From the air the dyke was seen to transect the entire island so that the two dykes shown on the geological map are the same dyke. This site (OR) was unusual because two samples were difficult to measure using the magnetic compass - changes of up to 30° occurred in a space of minutes. The interpretation of this behaviour is that the horizontal northerly component of the field generated by sunspot activity became comparable or exceeded that of the Earth's field at the site, and these variations persisted over perhaps 10 minutes before the site was completed. On Cape Faraday at site CV a 120m-wide, NNE trending dyke cuts retrograded garnet gneiss. The dyke shows excellent exposure of its western chilled margin.

The original plan was to depart the "Louis St. Laurent" on August 15th for Qaanaaq where a rendevouz was planned with a GEUS survey ship "Kissavik". However thick fog over Ingerfield Bay prevented helicopter delivery to Qaanaaq and persisted until the Louis St. Laurent was scheduled to move farther north to Kennedy channel, making Qaanaaq out of reach by ship's helicopter. No further sampling was possible until August 28th when the boat once more returned to the vicinity of the Thule area. Due to the small number of dykes sampled only a progress report can be issued, pending further sampling, planned for next year.

Acknowledgements

This research originated from a chance encounter with Chris Harrison at a Geological Association of Canada meeting in Sudbury in 1999, when we discussed the Nares Strait problem and the possibility that dykes could hold the key to demonstrating the sinistral offset between Greenland and Canada. The inclusion of this research in the Nares Strait Geocruise is a direct outcome of the his continued encouragement of the project over the last two years. The logistic help that he has provided through the Geological Survey of Canada is also gratefully acknowledged. I would also like to thank: Jason Anderson for his excellent field assistance and cheerful support throughout many weather-related delays and changes of plans during the cruise, Chief Scientist Franz Tessensohn for allocation of helicopter time, Jimmy Nungaq of Grise Fiord, Chris Harrison and Fred Jodrey for polar bear protection and help in the field, helicopter pilots Harrison Macrae and Adrien Godin for making difficult landings look so simple, and finally to Captain Klebert and crew for making the cruise such an enjoyable and rewarding experience.

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Summary of Paleomagnetic Sites

SITE	LATITUDE	LONG[W]	N	D/B	W(m)	TREND	DATE
PH	75° 00.88'	79° 37.07'	5	D	30	75	07/08/01
NU1	77°21.499'	71°33.733'	8	D	40	98	09/08/01
NU2	77°22.718'	71°29.038'	8	D	40	105	10/08/01
NU3	77°20.879'	71°31.461	4	B	~50	100	11/08/01
KL	78°41.0'	70°40'	12	D	54	100	13/08/01
PK	77° 56.30'	72° 12.511'	9	D,B	65	98	28/08/01
OR	77° 52.930'	76° 19.056'	10	D,B	60	80	29/08/01
CV	77° 53.863'	76° 38.837'	7	D,B	120	38	29/08/01
CA	76°44.382'	73° 13.477'	6	D	20	~90	30/08/01
TB	76°27.562'	69° 14.474'	9	D,B	30	116	02/09/01

N is the Number of oriented samples; D/B indicates whether samples were drilled (D) or taken as blocks (B); W, PHI are the width and trend of the dyke/sheet respectively. All locations are by GPS. All sites are from suspected Thule dykes except sites CA and NU3 (Thule sills) and site CV (NNE trending dyke).

NARES 2001: Paleoclimate Program

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GSCA, Marine Environmental Geology

Objectives

1. To obtain marine sediment cores that will allow reconstruction of climate change on an annual to decadal scale for the past 4,000 – 10,000 years

2. To obtain box cores for calibration of (A) microfossil assemblages and sea surface conditions; (B) Ice rafted detritus and sediment provenance

3. To obtain samples of bedrock outcrops for ground-truth on seismic records

Rationale

The impact of climate change on sea ice and temperature of the Arctic has become a topic of major concern to the scientific community and governments concerned with the welfare and resource protection of Canada's northern areas. There is now ample evidence that the average global temperature has risen by 0.6°C during the past 150 years, and that there has been a 4x greater increase in some Arctic regions. For example, the average annual temperature has increased by 1.5° C in the Mackenzie Basin during the past 30 years, and the pack-ice has decreased in thickness and area by 40% and 14%, respectively. Already, these changes are having a large impact on the northern communities e.g. erosion of shorelines by rising sea-level and melting permafrost; reduced hunting of mammals that depend on ice floe platforms for feeding, breeding or migration.

The recent global warming appears to be a response to the increase in CO_2 and other "greenhouse" gases during the Industrial Age. Computer-generated Global Climate Models (GCMs) forecast that the temperature will continue to rise to 2.5 – 3.5°C by 2021 and that the Arctic Ocean will be ice-free in summer by 2070. These forecasts also have drastic implications for Arctic transport through the Northwest Passage which is the fastest route from Europe to Northeast Asia.

However, the reliability of the GCMs depends on the correctness of the input data and knowledge of the amount of normal drift permissible during the running of a forecast model. To constrain the GCMs, data from recent oceanographic experiments and historical data are used, but these only cover a period of ~200 years or less, which is a very small part of the natural warm-cold cyclicity known from geological records and inferred from archeological evidence. For example, it is known that glacial-interglacial cycles over the past 1 MA record changes in SST of 4-8°C in Labrador Sea (Aksu et al., 1992), and cores from North Water Polynya show cyclical changes in SST of 2 – 4°C for the past 8,000 years (Levac et al., 2001). Likewise, ongoing archaeological work in Disko Bay shows that periods of Greenland paleo-Eskimo settlement correspond to major shifts in late Holocene climate during the past 4,000 (Kuipers and Troelstra, 2000).

Our marine geology program is therefore designed to provide a quantitative record of changes in sea ice and sea surface temperature (SST) in the Canadian Arctic Archipelago during the past 6,000 to 10,000 years of normal climate variation prior to the Industrial Age changes. To be useful for the GCMs, the time resolution must be on a scale of years to decades and the quantitative reconstructions must have the same order of precision as the modern oceanographic data. This quantitative precision is obtained by calibrating dinoflagellate assemblages from the tops of box-core samples against the corresponding oceanographic data for the core sites to develop multiple regression equations used in the transfer function method of paleoclimatic reconstruction. The present dinoflagellate database has 665 coretop samples for the circum-Arctic region, but is lacking data for critical areas of lower SST and surface salinity in northern Nares Strait which will be provided by the NARES 2001 cruise. Ice rafted detritus (IRD) is also used as a proxy for reconstruction of changes in ice cover and flow direction of the surface circulation. The IRD method will employ the 1000-sample Arctic coretop database of Darby and Bischof which allows precise backtracking of the IRD provenance. The new NARES 2001 data will provide the first samples for Nares Strait north of Smith Sound.

Methods

Coring. A large box corer (0.5 x 0.5 x 0.6 m) and Benthos Piston corer was lowered from the forward deck, using the coring winch which first had to have the motor repaired by Jodrey, Rochon and Larry Johnston. After the repairs and initial problems with one of the piston core heads, most coring attempts were successful but were slowed by the very low maximum speed of the winch that could only be operated in first gear. For example, in typical coring depths of 650 m, it took 1.5 hours to lower and raise the piston corer. The present winch set-up also requires changing the block and tackle for the winch cable when alternating between box/grab sampling and coring. This operation adds another 60 minutes to the sampling time, often in unclement weather in transit to the sampling site. It is a tribute to the skill and patience of Bosun Bob Taylor and his deck crew that almost all attempted samples were successfully recovered.

Shipboard sampling. Core sites were located using existing bathymetric charts and new Huntec or 12 kHz data obtained on the cruise. The locations of the cores are listed in the LSSL 2001 Sample Data table (see page 115) and shown on **Fig. 42.** After recovery, the Benthos TWC and piston cores were cut into ~1.5 m-long sections, capped, sealed in beeswax and stored upright in a refrigerator room at 4° C to allow settling. The cores were split one to two days later, using the portable splitter jointly owned by UQAM and GSCA which worked very well when mounted on the table in the fore-deck container. The working core halves were photographed using the GSCA camera system assembled on the bench of the largest oceanography lab off the midship main deck lab. After core description, all cores were sampled at 10 cm intervals for palynology (20 cc volume) and at 20 cm intervals for foraminifera and oxygen isotopes (40 cc volume). The split cores and samples were then stored at 4°C. The archive halves will be X-rayed for fine sediment structure on return to GSCA.

Geotechnical measurements. The piston cores were sampled for bulk density immediately after splitting the cores. Samples were taken at about 1-meter intervals and stored in pre-weighed bottles for drying and density measurement onshore. Core penetrometer measurements were made on the archive halves of the split TWC and piston cores. Initial results are shown in **Fig. 43.** Magnetic susceptibility measurements will be made on the Archive core halves on return to GSCA.

Results

Piston Coring

JonesSound/Coburg Polynya, Devon Island (LSSL2001-06). Rochon recovered a boxcore (LSSL2001-001B; see page 115) in 564 m water at the site of Core 83-02-52 of Brian MacLean (1983) where Upper Holocene hemipelagic mud with a high rate of deposition (~5 m in 6.5 ka), unconformably overlies early Holocene glaciomarine sediments with an age of >8 ka, and tills dated >20 ka. The boxcore returned full, with a surface layer of soupy brownish mud over ~55 cm of organic-rich olive gray mud with black streaks. Four push cores were taken for microfossil assemblage correlation with water column data from CTD profiles of Topham et al. (1983) and new data from CTD's of Jane Eert/Peter Jones (CTD #003).

Rochon attempted to obtain a piston core (LSSL2001-002) at the same site but ran into problems with a broken winch gear and strong northerly wind that resulted in drifting to shallower water (500 m) at the edge of the Coburg Polynya basin. Only 41 cm of sediment were recovered in the trigger weight core (TWC) and 142 cm in the piston core. The base of both cores recovered sandy gravelly mud indicating that core penetration was limited by the presence of the glacial till pinching out to near the surface at the edge of the basin.

LSSL 2001 Sample Data							
	Sample #	Sample type	JD/time	Lat. N	Long. N	"Water, m"	"Core, cms"
1	001B	Box core	209/12:32	75 35.3	78 41.99	564	54-59
2	002PC	Benthos Piston	209/19:21	75 32.93	78 48.91	500	142
	002TWC	TWC					41
	003SPM	Rosette bottles	220/03:00	75 35.19	78 41.58	561	NA
3	006PC	Benthos Piston	220/08:27	75 35.19	78 41.58	561	1137
4	006TWC	TWC					138
5	015IKU	IKU grab	221/18:34	77 46.9	73 29.13	200	half full
6	031IRD	sea ice sample	229/11:45	80 07.705	69 53.908	192	NA
7	032IKU	IKU grab	229/14:00	80 08.1695	70 13.505	98	3/4 full
8	038B	Box core	230/11:33	80 09.58	70 50.137	188	32-34
9	039PC	Benthos Piston	230/13:40	80 09.54	70 50.27	189	418
		TWC					128
10	056PC	Benthos Piston	234/17:15	80 48.107	67 10.574	410	0
11	057PC	Benthos Piston	234/17:30	80 48.97	67 06.562	410	68
		TWC					0
12	079PC	Benthos Piston	237/03:52	81 28.317	62 16.370	550.5	805
		TWC					148
13	080IKU	IKU grab	237/08:20	81 22.4062	62 19.1023	465	0
14	130B	Box core	245/21:45	77 15.9497	79 39.7522	245	52-54
15	163PC	Benthos Piston	250/00:35	77 42.1025	75 04.4449	657.5	441
		TWC					148

Mudie and Jodrey repeated the attempt to get a long core from the central, high sedimentation part of Coburg basin and successfully recovered 11.37 m of organic-rich olive gray laminated sediment in core LSSL2001-006 (**Fig. 45.**). The core contains abundant foraminifera and common small shells that will provide good age control from radiocarbon dating. It is likely that core base has an age of 6-8 ka and a sedimentation rate of up to 2 m/ka and will provide an unbroken sub-decadal scale proxy-climate record for most of the Holocene period.

John Richardson Bay, Kane Basin (LSSL2001-039)

Echosounder (12.5 kHz)_and the Huntec record (Line 2) were used to select a site for a long core from the outer basin of this fjord, away from the two glaciers at the head. The Benthos piston corer recovered 4.18 m of sediment (core LSSL2001-039), with about 2 m of dark gray clayey mud with common dropstones overlying ~2 m of laminated gray mud and with sandy/gravelly diamicton at the base. The burrowed surface unit is probably correlative with the expanded Holocene section from Coburg Polynya (**Fig. 45.**). The laminated mud is probably an early Holocene distal glaciomarine unit similar to that described from Hudson Strait cores by MacLean (2001). Foraminifera and shells from this basal unit are brobably sufficiently abundant to allow radiocarbon dating of the time of glacier retreat from this fiord – shells from raised deltas near Bache Peninsula suggest that this occurred about 8 Kyr BP (England et al., 2000).

Kennedy Channel (LSSL2001-057). Huntec records (Line 3) showed a hard bottom for most of this area, with a thin veneer of gravelly mud on the surface. The Benthos corer (core LSSL2001-057PC) recovered 68cm of gravelly/sandy calcareous brown mud (**Fig. 45.**), with pebbles and FeMn-stained slate at the base that probably prevented further penetration. The basal sand contains a calcareous foraminiferal assemblage similar to that found on the surface of cores from Axel Heiberg Shelf; these and small shells will allow dating of the Kennedy Channel diamicton. The core cutter sample contained large chalky forams that may be of Pliocene age, possibly dating the bedrock surface at this core site.

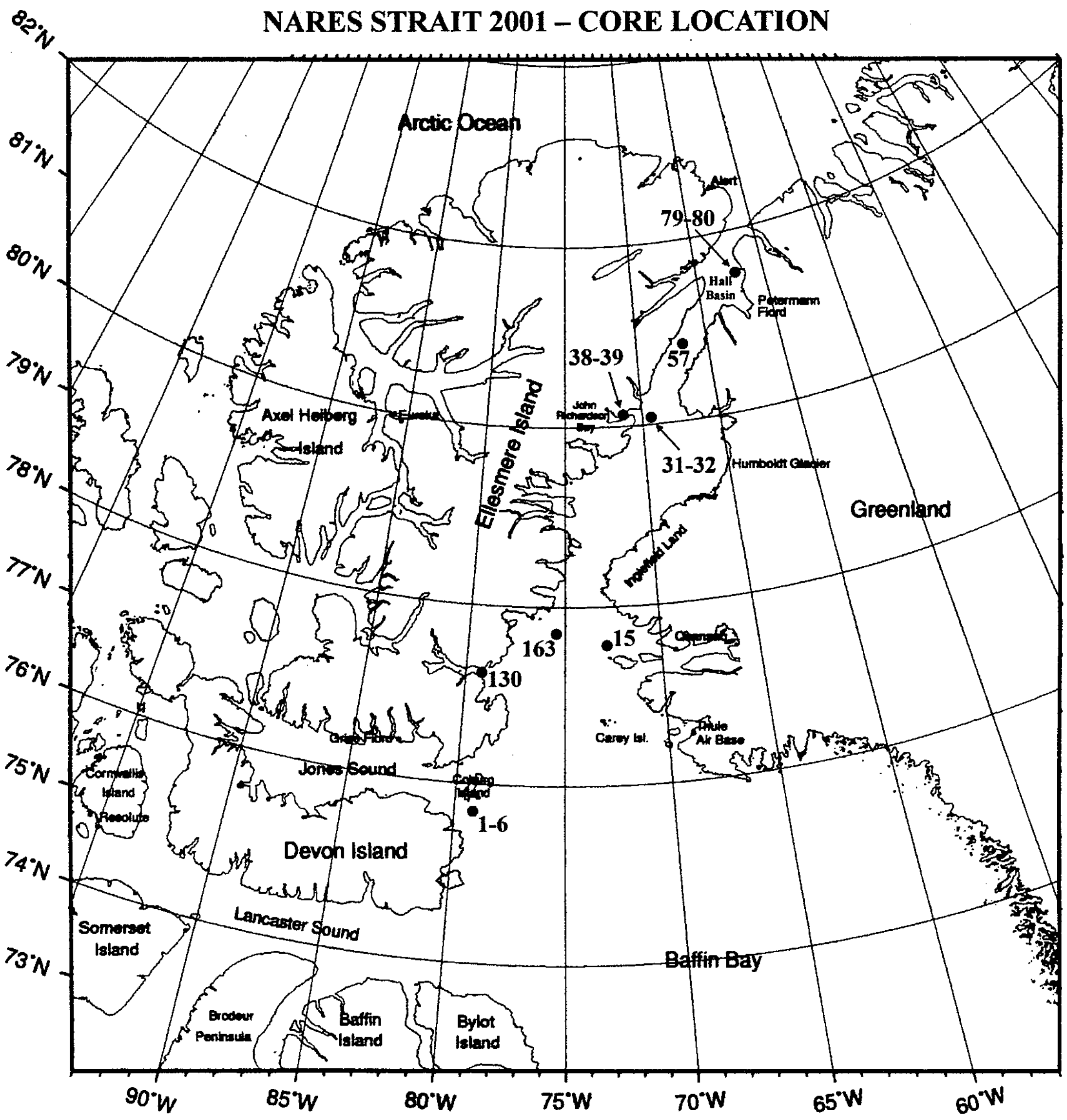

Fig. 43. *Map of the Nares Strait region, showing locations of the sample sites.*

Petermann Fiord, Hall Basin (LSSL2001-079). A core site was selected from Huntec Line 4 which showed about 10 m of mudoverlying a very thick (>40m) stratified unit (**Fig. 45.**). The piston corer recovered ~9m of clayey calcareous mud, including an upper (0-4 m) faintly laminated brown unit with sand, granules and rare dropstones , overlying 4 m of brown and gray banded mud (**Fig. 45.**). The surface unit has diverse benthic forams and planktic foraminifera or ostracodes and pteropods. The banded sediment has relatively low numbers of benthics (mostly the low salinity ice margin species *Elphidium clavatum)* and rare very small planktics). Alternating brown and gray laminae have more or less carbonate and quartz sand, respectively, but it is not clear if these represent seasonal changes or longer-term pulsating events (e.g. wetter-drier cycles). Molluscs are very rare: only fragments of the small, translucent Ice Island species were observed. However, it should be possible to get a radiocarbon age for the base of the core from bulk foraminifera. This is important to evaluate the age represented by the laminae and to confirm that the banded sediment represents deposition under a floating iceshelf and lack of grounded ice in Hall Basin during the last glaciation.

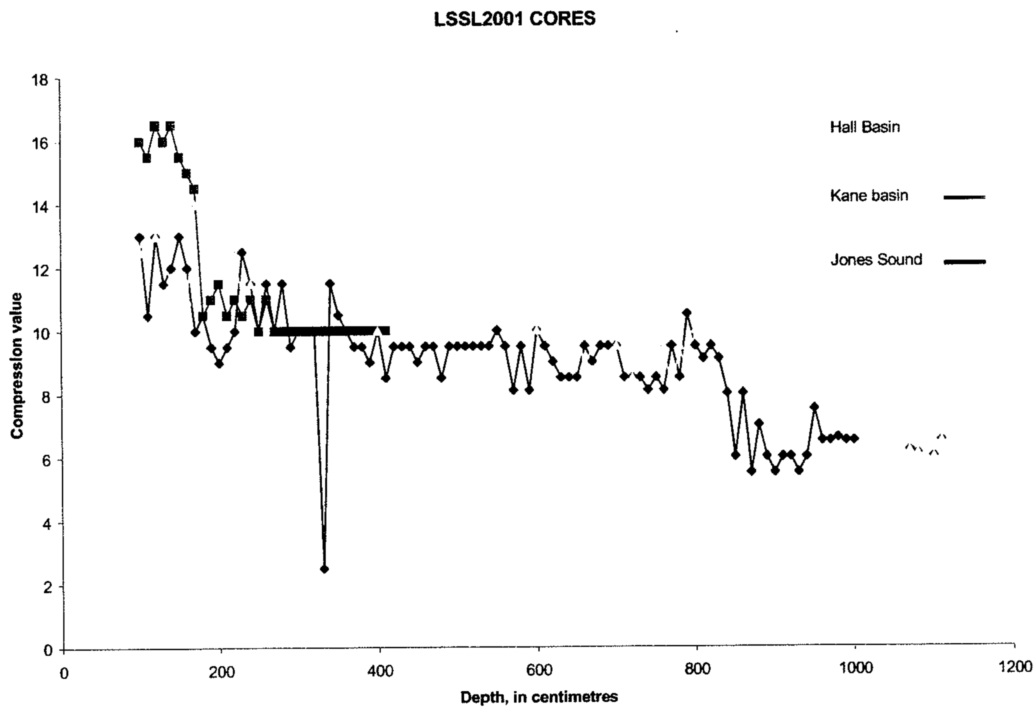

Fig. 44. *Comparison of variations in sediment compaction values as measured by cone penetrometer readings from cores –06 (Jones Sd.), -039 (Richardson Bay, Kane Basin) and –079 (Hall Basin).*

Southern Smith Sound (LSSL2001-163). A core site was selected in the deep channel south of Smith Sound in order to obtain a detailed Holocene record from the North Water region where oceanographic data show the strongest mixing of Arctic and Atlantic water. This site is on Seismic line #4 which hopefully can be tied to the site of Core 91-27-08, which is the paleoceanographic reference section for northern Baffin Bay (Levac et al. 2001). The piston corer penetrated and recovered 4.41m of sediment. A very stiff black ("hockey-puck") sandy mud prevented greater core penetration and made the core pull-out difficult. However, the upper 2m of olive-gray mud were undisturbed, and hopefully will provide a good continuous record for the period 0-4ka and fill the 2-0.5 ka gap in the reference section. Below the olive gray unit is ~ 1m of light brown clayey mud that looks like the sediment now being deposited at the glacier terminus in Hall Basin and probably indicates ice flowing southward from Kennedy Channel. The black basal unit contains large, heavy-walled mollusc shell fragments and diverse thick-walled and transluscent benthic foraminifera in addition to abundant FeMn particles, mica and multi-coloured sand. These features are not characteristic of tills and suggest that the base of the core is a Late Tertiary marine deposit, possibly correlative with the Kennedy Channel bedrock sample in Core LSSL2001-057.

Box cores and IKU grabs

Box cores from John Richardson Bay (LSSL2001-038, 35 cm) and Mackinson Inlet; 52 cm) returned soft mud with a few small dropstones, abundant small worm tubes (~0.5 - 1 cm long) , and rare large sea cucumbers. This is a much less diverse fauna than found on the shelf outside the Bay (LSSL2001-032) or on the Northumberland Island shelf, West Greenland (LSSL2001-015, IKU), and is more similar to the Ice Island benthos than the Baffin fiord benthos reported by Syvitski (~1989). The grab samples from the shelf contained mostly ice-rafted gravel and pebbles, with sea urchins and feather stars dominating the benthos. Off Greenland, Thule Super-Group yellow sandstone and Precambrian gneisses are the dominant lithologies and the benthos includes brittle stars, small starfish and common bivalves (*Macoma nasuta*?). The samples from the colder, less saline waters of the Ellesmere margin, fine black standstones and carbonates

Oceanography Programme

The major oceanographic objective for this cruise was to repeat a section taken in 1997 across Smith Sound. Analyses of nutrient data (N-P relations) and salinity give an indication of the whether water flowing through the Strait is mainly of Atlantic or Pacific origin and in the case of Atlantic water, whether it arrived via the Arctic Ocean or directly from the Atlantic.

Two sections of 5 CTD/Rosette casts each were obtained: the Smith Sound section and one across Kennedy Channel near Hans Island. As well, four isolated casts were taken in association with coring activity. At each fully sampled station, temperature, salinity and pressure were recorded during the cast and water samples were taken at standard depths. Water samples were analysed on-board for dissolved oxygen and salinity and will be returned to BIO for later analysis of nutrients and to IOS for oxygen isotopes. Expendable temperature profilers (XBT's) were deployed along both cross- and along-strait lines while in transit or during seismic survey work. Temperature information from XBT's was collected at 70 stations and will be used to support the fully sampled stations.

Both the ship's crew and the scientific staff were extremely helpful. Since the oceanography programme was involved on an opportunity basis, the co-operation of both the GSC and BGR scientists in making it possible to get both sections is much appreciated.

Marine Mammal and Seabird Observation Programme

P. Hall and B. Atagootak

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Programme Overview

The programme provides value-added marine work to passages of Canadian Coast Guard vessels through the Canadian Arctic. The Nares Strait GeoCruise, conducted aboard *CCGS Louis S. St-Laurent* in August 2001, is the third CCGS Arctic transit to include the marine mammal and seabird observation programme.

Programme participants document current marine mammal and seabird distributions, and opportunistically collect biological and oceanographic samples in support of research studies conducted by DFO and its co-management partners in Arctic Canada. Specific occurrences, especially in areas which are poorly sampled, along with related habitat information such as ice types adds to distributional knowledge. This information, when combined with Traditional Ecological Knowledge, can provide a benchmark for measuring changes in animal distribution, health and habitat parameters. Component sub-projects of the Marine Mammal and Seabird Observation Programme for 2001 included: Visual Survey (directed and opportunistic); Hydroacoustics data collection, Opportunistic necropsy; Habitat sampling; and, Angling/net fishing.

Sub-Project Descriptions and Accomplishments

Visual Survey (Directed and Opportunistic)

The geographic and temporal distributions of marine mammals in the Canadian Arctic are incompletely known. This is especially the case for areas that are not regularly traveled or are distant from northern communities, in seasons other than late summer. Global change may result in significant shifts in such distributions; thus establishing present distributions through opportunities presented by the Nares Strait GeoCruise was a high priority. The **objective** of this work was to record observations of marine mammals and seabirds (species, numbers, location, activity, environmental parameters) from a variety of platforms (e.g., ship's bridge, helicopter, land). **Accomplishments:** Observers systematically recorded marine mammal and seabird sightings from the ship's bridge during 05-20 August 2001, and opportunistically recorded sightings during the remainder of the cruise (**Fig. 46.**). Observers collected new information about Atlantic walrus (Odobenus rosmarus) distribution in Kane Basin. Other mammal sightings included ringed seals (Natsiq, *Phoca hispida*), bearded seals (Ugjuk, *Erignathus barbatus)*, harp seals (Qairulik, *Phoca groenlandica*), and narwhal (Tuugaalik, *Monodon monoceros)*. Marine and terrestrial bird sightings included Northern Fulmar (Qaqulluq, *Fulmarus glacialis)*, Ivory Gull (Naujavaaq, *Pagophila eburnea)*, Glaucous Gull (Naujaq, *Larus hyperboreus)*, Thayer's Gull *(Larus thayeri*), Black-legged Kittiwake (Nauluktuapik, *Rissa tridactyla*), Arctic Tern (Imiqqutailaq, *Sterna paradisaea*), Long-tailed Jaeger (Isunngarluk, *Stercorarius longicaudus)*, Thick-billed Murre (Akpa, *Uria lomvia*), Black Guillemot (Pitsiulaaq, *Cephus grylle*), Dovekie (Akpaliarjuk, *Alle alle)*, Gyrfalcon (Qinnuajuaq, *Falco rusticolus)* and *Raven* (Tulugaq, Corvus corax).

Hydroacoustic Data Collection:

Underwater audio recordings can provide information about the presence/absence of different marine mammals over a larger geographic area than can be surveyed visually. The **objective** of this project was to acoustically investigate marine mammal presence from locations remote from the CCGS *Louis S. St-Laurent*. **Accomplishments:** There were no opportunities to collect acoustic recordings during the Nares Strait GeoCruise.

Opportunistic Necropsy

Morphometric measurements and biological samples contribute information about stock identity, population genetics, contaminant loading, feeding ecology, reproductive status, general morphology, etc. The **objective** of this project was to collect body size measurements and biological samples from marine mammal carcasses encountered during the course of this transit. **Accomplishments:** Observers measured and sampled one seal carcass. These samples will be distributed to the relevant researchers in DFO Central and Arctic Region, in support of ongoing Arctic marine mammal investigations.

Habitat Sampling

Water and sediment samples contribute information about the marine environment. In addition to basic water chemistry, contaminant residues and stable isotope signatures can be matched to those occurring in fish and marine mammal tissues. The **objective** of this project was to collect water and sediment sample from nearshore areas, in support of stock discrimination studies for marine mammals and fish. **Accomplishments:** Researchers supervising concurrent DFO programs contributed water samples collected from CTD casts (J. Eert), and sediment samples collected from piston and box cores (P. Mudie). These samples will be distributed to the relevant researchers and will be analyzed for contaminants and stable isotope signatures.

Angling/Net Fishing:

Marine fish faunas are generally poorly known in the Canadian Arctic. The **objectives** of this project were to sample nearshore marine fish to document available marine mammal prey species, to update marine fish distribution records and contribute samples to marine fish population genetics and stock identification studies. Accomplishments: There were no opportunities to collect nearshore samples of marine or freshwater fish during the Nares Strait GeoCruise.

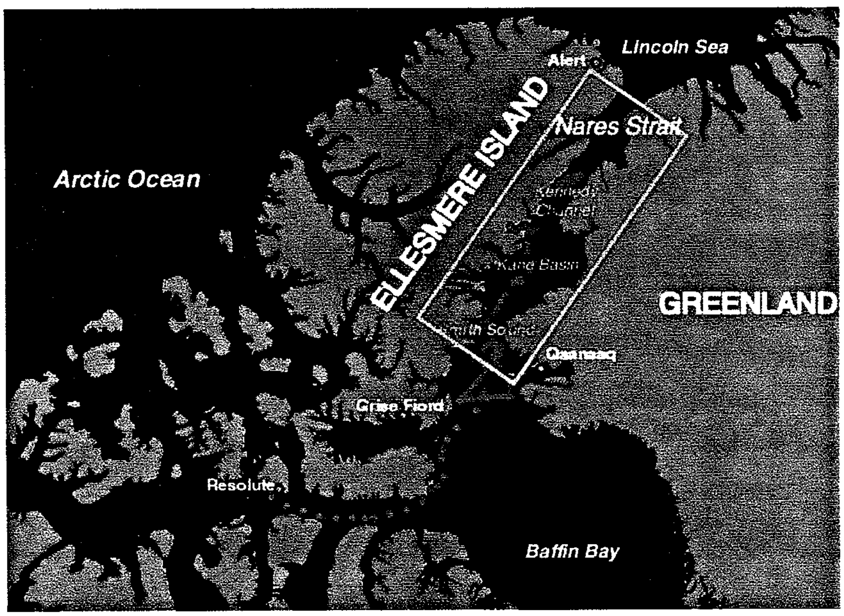

Fig. 46. *Track of CCGS Louis S. St-Laurent between 05 and 21 August 2001, along which observers conducted systematic visual surveys of marine mammals and seabirds.*

Report on our Summer Job in the CCGS Louis S. St. Laurent

Nares Strait Geo-cruise 2001

(August 6 to September 10, 2001)

Brian Atagootak and Jimmy Nungaq
Grise Fiord, Nunavut

Introduction

A scientist from the Geological Survey of Canada, Ruth Jackson, came to Grise Fiord in April 2001. She talked at our school and invited us to give her a resume for a job in August. The whole senior class sent them, and I guess we were lucky because we got it. Ruth said we won because we gave her our resume right away, so she could talk to us.

We were picked up by the ship's helicopter July 29th near Craig Harbour. The ship, the icebreaker Canadian Coast Guard Ship (CCGS) Louis S. St. Laurent went to Thule, Greenland to receive the scientists, but there was a rain storm and the river cut the fuel lines, and the airport was closed, so the plane could not land We had to travel to Resolute, and the new crew and all the scientists joined the ship August 6.

Our job has consisted of many different things, some which we explain below. Mainly, we will write about some work we did for the scientists and for the coastguard. Also, because we are interested in becoming helicopter pilots, we want to write about that. There were many interesting things that happened, we met many people, scientists from Canada and Europe, and the crew, and we have learned a lot of new things. We interviewed some scientists and members of the crew, but we only include here some of them, because we ran out of time.

We went as far north as Fort Conger, about 70 km from Alert, and worked in the fiords in Ellesmere island and in Greenland. We saw many icebergs and all kinds of animals. We worked helping with samples for the geologists. For instance we painted numbers on rocks they picked up from an iceberg.

Also, we were trained to steer the ship, and were given a quartermaster certificate from the Coast Guard. This was the best part of the things we did on the ship. What we liked the most was the work with the geologists on the land in Greenland and Ellesmere Island, although they walk too much and it was hard on your back. We will explain more about that later.

We were hired also because Inuit in Nunavut know about guns and the geologists needed protection from bears while on the land. They thought that it would be alright for us to take the guns from the ship. But after a few trips we were told that a new law says anyone carrying a gun must have a licence, and we didn't have one, ad it takes a long time to get it. From then on only the helicopter pilots and 3 scientists who have the licences carried guns, and most of our work was on the ship. This was a disappointing part of our summer. Some times it was hard to sleep, because the ships makes a lot of noise when it breaks ice. The worst part was getting seasick during a storm that lasted 2 days. We were really sick and barfed and slept because we couldn't handle it.

The Nares Strait Project

The Nares Strait Geocruise 2001 is a project of cooperation between Germany and Canada, to study the geology and oceanography of the Nares Strait. Scientists say they want to know if Ellesmere Island has moved about 250 km along a fault or break with respect to Greenland, because of plate tectonics. The scientists really want to know, and to answer this question may help to find oil, minerals, coal and other things in Nunavut. Also, they take samples from the ocean bottom in the fiords and can tell if the climate is warming up or has changed much over the last thousands of years. They tow some airguns from the ship, take water samples, and measure the depth of the sea in parts where the charts are not good. One group of geodesy used a very expensive GPS to find out if the land is going up with respect to the sea.

There were 35 scientists from Canada, Germany, Denmark, The Netherlands. Two were from Grise Fiord. Some were contractors from England who worked with the airguns for the geophysics study.

The project costs a lot of money. The Coast Guard icebreaker ship Louis S. St Laurent costs $30,000 a day, and helicopters $100,000 for 100 hours. The government of Germany paid almost $2,000,000, the Coastguard a good part and the rest comes from the Geological Survey of Canada, and the universities from where some of the scientists come. The scientists from the Geological Survey had their way paid, but those from universities had to pay for food and rooms. It took 2 years to prepare this expedition.

Why would Germany want to pay for this project in Canada? Because they have an agreement with the Canadian government, they have a tradition of mapping geophysics, and they want the Germans to know about and be known in other parts of the world.

The Chief Scientist of the project is Franz Tessensohn of Germany, a Geologist with the Geological Survey of Germany. He has worked before in Ellesmere Island, and many years in Antarctica. He decided what had to be done every day and where the helicopter could go with the geologists

The Marine Mammals Watch

This part was carried out by Pat Hall, a biologist of the department of Fisheries and Oceans in Winnipeg, Manitoba. The idea was to record all marine mammals and any animal life every day of the cruise. Pat asked us to help her because we were interested and we could see animals far away. If we saw and animal, we recorded the GPS coordinates of the location, and that information gathered may help biologists learn about what is happening to the wildlife in the Arctic. In this trip we saw:

Bearded seal
Harp seal
Ring seal
Walrus
Narwhal
Arctic cod
Hares (many in Makinson Fiord)
Muskox
Caribou
Bear tracks; bears were seen by other members of the party one night when the ship was stuck in ice outside Resolute. The bear came really close to the ship and they took many pictures of it.
Fox
Weasel
Ptarmigans
Many birds, especially white ones, but we don't know their names in English.

Ruth Jackson

We interviewed Ruth Jackson. She works for the Geological Survey of Canada in Dartmouth, Nova Scotia. Her job is to map the seafloor in the Nares Strait. I asked her how long she has been working on this and she said 28 years, and that if you have this job you have to like traveling in ships like this one. To do seismics you have to have a university degree after completing high school. After that you need a graduate degree called a doctor of philosophy (Ph.D.) which takes about 4 years after the first degree in university. That is 20 years of school, and then you can teach at a university or be a scientist like Ruth. A scientist with a lot of experience will make about $80,000 a year. They seem to like their work a lot.

Ruth is the Chief Scientist for the seismic studies, and her group has about 11 people. The ship tows behind the airguns. The airguns have lots of air in them at high pressure (1600 psi) and go off every 20 seconds. It makes a loud noise, and the sound waves go down and bounce back at the bottom, and go into the mud and sand and bounce back when they hit the hard bedrock, and even go deeper and bounce back if there is a any change in the rock, or if there are breaks in them they call faults. These returned waves are recorded in some microphones (geophones) that are both on the ship, some in the ocean floor (Ocean Bottom Sensors, OBS) and on the land. The OBS are set in the ocean floor and when their work was finished they floated to the surface and the ship's crew had to fish them up. The results are put into computers and Ruth gets a picture of what is down there as deep as 10 km, like an ultrasound picture of the ground.

We asked why she chose Grise Fiord to look for students. She said because it is closest to the Nares Strait.

Gordon Oakey

Gordie is a geophysical technologist with the Geological Survey of Canada, in Dartmouth, Nova Scotia. He does magnetics and gave us very long explanations, too long to write here. Gordie designs flight plans and takes notes when they are flying. We understood that they use a magnetometer in a bird that hangs from the helicopter, something like a very sensitive compass that senses if the rocks are magnetic (they act like magnets because they have a mineral called magnetite, an iron oxide, Marcos says). They fly at 2000 feet above the ground with the helicopter and the instrument records all magnetic rocks in the ground. They fly at night because during the day the sun's magnetic forces interfere and the data are no good. Gordie puts the data on computers and plots maps that show how magnetic the rocks are. To do his job one needs a university degree in science. He has a Bachelor and a Master of Science degree in Geology from Dalhousie University, in Halifax, Nova Scotia.

Geology Work on the Land

Marcos Zentilli teaches Geology at Dalhousie University in Halifax, Nova Scotia. He takes samples from rocks with Sandy Grist (also from Halifax) and they will find out how old they are in millions if years. We asked him why he is here, and he said he loves the Arctic; he has worked in the north and his daughter taught school at Pond Inlet for 4 years. His work will tell when the mountains went up, and may help find some oil or gas.

Brian went with Marcos and Sandy for day trips with the helicopter. Brian carried the gun and safety gear. The helicopter would leave us in one place and we would walk up to 12 km where the helicopter would pick us up later. In one place in Greenland Marcos found some dark rocks that he says are pillow lavas. When a volcano is under water the lava forms like bubbles and they are called pillows. They mean that this part of the land had volcanoes under the sea many millions of years ago. Brian taught Marcos how to make fire with arctic heather, to warm up while waiting for the helicopter to pick us up.

Brian also went on a fly camp with another geologist, Chris Harrison. Chris works for the Geological Survey of Canada in Calgary, Alberta, and knows Ellesmere Island very well. He walks a lot and very fast, it was hard to keep up with him. We walked 25 km in 2 days. We camped with dome tents and cooked with a Coleman stove. Chris makes geological maps. These are maps that show the coast and the rivers and the different rocks they find are painted with different colors. The companies then use these maps to find minerals like at Nanisivik, and oil.

Jimmy went to the land in Northumberland Island, Greenland. There were 2 helicopters with Marcos, Sandy, Henry Halls, Jason Anderson and Jimmy in the camp. They used a big tent and small dome tents for each. Jimmy halped carrying a drill, and the gun in case they found bears. Also Jimmy had to bring water from a river for the drill. Henry is a geologist who studies some rocks called dykes. He drills little holes with a drill made from a chainsaw, only it has no chain but a tube that spins around fast. He tube has diamonds and they cut a circle in the rock, and then cuts into it about 5 inches. They use water that one pumps to keep the drill from heating up. He needed to sun to record the exact orientation of the hole. With a chisel he broke out the rock inside the cut, and it came out like a carrot, which he called a core. He later will study them in the lab at the University of Toronto, where he is a professor, like Marcos. He will find out if there has been a lot or little displacement along the Nares Strait, which some people say is a big fault, but others disagree. This is the reason for the Nares Strait Geo-Cruise 2001.

If the dykes match on both Ellesmere and Greenland, then there was no movement, but if they don't match, there could have been a big displacement. The method is called paleomagnetism, because rocks that come from volcanoes or deep in the earth record the direction of the magnetic field of the earth when they formed. Something like that. Henry worked with Jason, who helped him as well. We saw many hares, heard a fox, and saw many birds. We walked about 10 km one day. The fog moved in, it was cold, and the helicopter came one day late, and they were running out of food.

Jack Fitzgerald

Jackie is a deckhand in the Coast Guard ship Louis St. Laurent. He works on the deck, for example when the helicopter is refuelling he is ready with emergency gear. He does all kinds of jobs on deck, as needed. They work about 12 hours in a day, so he makes overtime. Before he worked in a factory making tires. He would prefer to work there because one makes more money, but he likes the sea and going places. When a launch (the Penguin) was sent to do bathymetry (they measure how deep the ocean is at every place) near Thule, the captain asked Jackie to be the pilot. Jackie lives in Cape North, Cape Breton Island, Nova Scotia. It is a small place (250 people) a bit bigger than Grise Fiord, but there are good roads to get there. Jackie has 33 years of experience.

Nicole Robitaille

Nicole is a student at the Coast Guard College, studying to become an Engineer. She is working as a student apprentice on the LSL for 5 months, without going home. She is a strong woman, doing a man's job, it must be hard. The course takes 4 years, and after that she can work as an Engineer in a Coast Guard ship. There are only 13 students in a class and it costs nothing, not even room and board, and the students get paid $300/month, but you are expected to work for the Coast Guard at the end. Students have to wear Coast Guard uniforms from Monday to Friday. While employed with the Coast Guard as a student you are paid a bonus $1,200/month.
There is only one Coast Guard College in Canada, located in Sydney Nova Scotia.

Harrison Macrae

Harrison Macrae has been a helicopter pilot for 24 and a half years, and only the last 2 years in the Canadian Coast Guard. He finished high school in new Brunswick. He said that one should take Maths, Physics and English (lots of writing) if one wants to be a helicopter pilot. One has to learn aerodynamics (how airplanes fly) and meteorology (the weather), mechanics. We asked him how long it takes to train as a helicopter pilot. He said it depends on how smart you are. For him it took 2 and a half months, in a course offered by Canadian Helicopter Corporation, in Montreal. There are more schools in Toronto (the best, he thinks), Brockville and Vancouver. The course costs $50,000 to $70,000. To rent a helicopter it costs about $1,500 per hour.

We asked him how much a helicopter pilot makes. He said when just starting you earn $20,000/year, 5 years later $40,000/year and after 10 years $55,000/year. If one is a helicopter pilot, no drinking is allowed.

If you want more information on becoming a helicopter pilot, he said to call 1-416-555-1212 (directory assistance) for information; ask for Canadian Helicopter Corporation at the Buttonville Airport.

The helicopters we used in this trip are made in Germany and are over 30 years old. They are BO 105 helicopters, and the Coast Guard has 16 of them, and 13 of another kind. The BO 105 can carry up to 4 people and the pilot. They can fly at 115 km/hour for about 2 and ahalf hours, about 250 miles distance, then they have to refuel. They can carry about 2000 lbs of cargo. The pilots were Harrison Macrae and Adrien Godin.

Conclusion

This has been a very good experience. We had never been on a ship before, and we learned about all kinds of things that we didn't know even existed. It was easy to meet people, good people. We were treated really good. We felt that we were treated with respect, like we are part of the group, like friends. We would like to do this again, but only if we had a real job to do. We would like to do quartermaster work, steering the ship, checking for ice in the course. We would like to go in the land, but not if we had to walk too much, because we are not used to it; at home we always go places with a machine. It is hard to be away from home. We did communicate by e-mail and also by phone, but it costs money.

We have to get licences to carry guns if we want to work in the land from a Coast Guard ship. Otherwise they won't let you take the guns out of the ship.

Thanks

We wish to thank Ruth Jackson for hiring us and taking so good care of us. The scientists, in particular Pat, Henry, Jason, Marcos, Sandy and Chris for their encouragement and Franz Tessensohn for letting us work on the land. Captain Stewart Klebert and the crew, for their consideration, especially Dale Hiltz, leading Seaman, for teaching us and helping us get the Quartermaster certificate (and for the nice pen). Thanks to all who agreed to be interviewed, and those who shared their pictures (Pat, Bob, Jane, Marcos, etc.). We thank Marcos Zentilli for helping us put this report together.

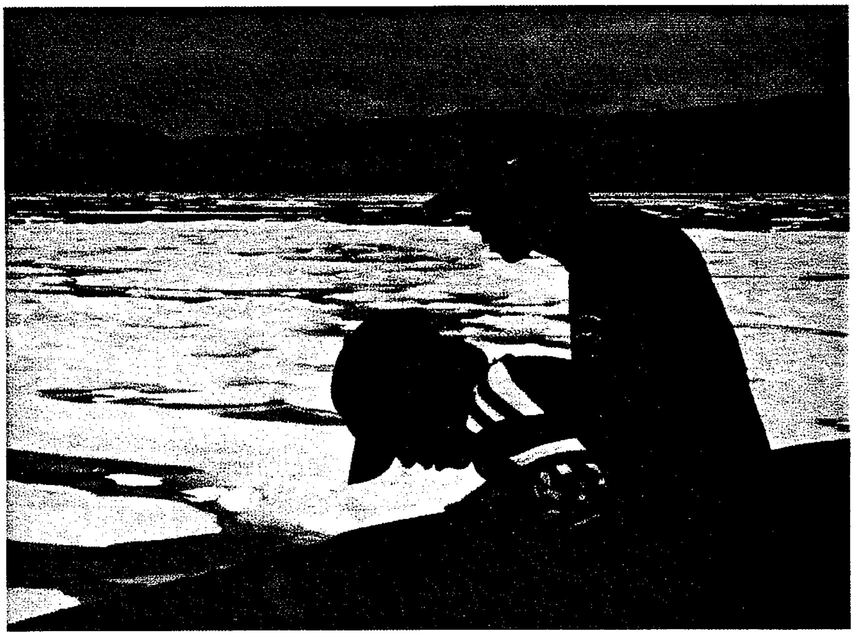

Fig. 48. *Here we are watching how the icebreaker cuts thin ice by climbing over it and crushing it with its weight*

Fig. 49. *Here we are at Fort Conger, the farthest north we went on the land*

Fig. 50. *From the helicopter, returning to the ship after working on the land.*

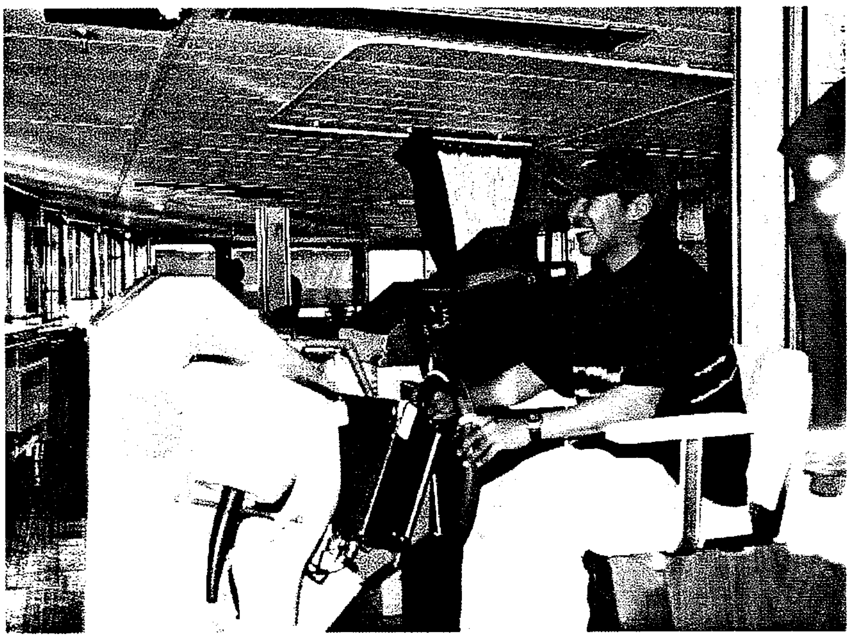

Fig. 51. *Brian learning to steer the ship in the bridge of CCGS Louis S. St. Laurent.*

Fig. 52. *Brian in Rensselaer Bugt in Greenland, doing geological work with Marcos and Sandy*

Fig. 53. *Jimmy steering the icebreaker; we both got Quartermaster certificates after 10 hours of instruction. One has to watch the compass and for ice. It was cool.*

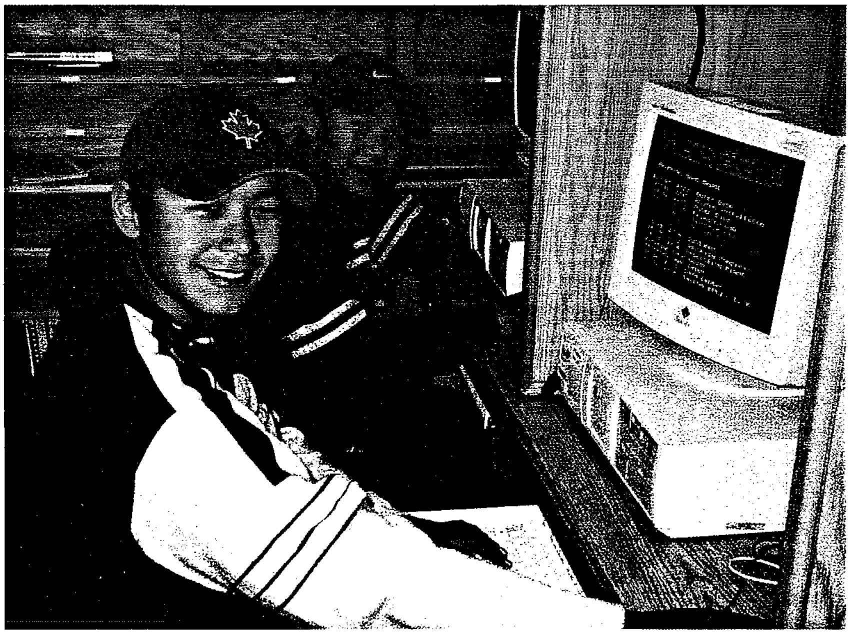

Fig. 54. *Checking the e-mail from home*

Fig. 55. *Brian pointing to the rim of a pillow in submarine lavas in Greenland. They form when lava from a volcano erupts under water. These lavas in Rensselaer Bay are about 1000 million years old.*

Fig. 56. *Muskoxen near the icecap in Greenland. We also saw caribou in the same trip.*

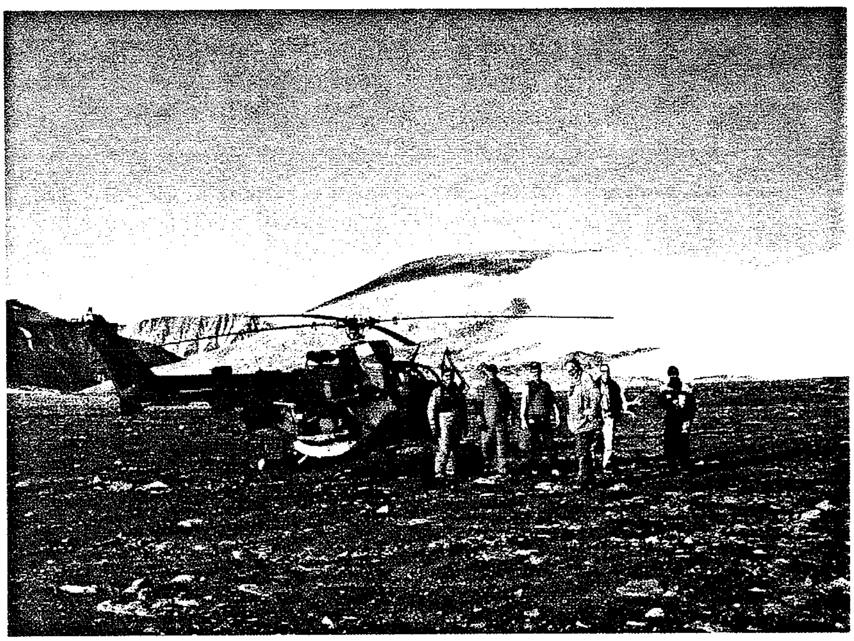

Fig. 57. *Fly-camp in Northumberland Island, Greenland. Adrian and Harrison in pilot suits; Sandy, Henry, Jason and Jimmy. Marcos took the picture.*

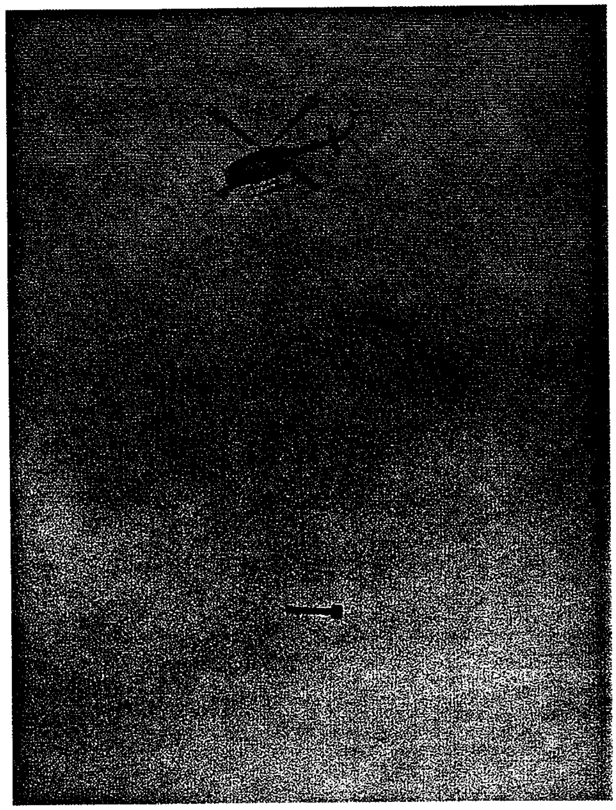

Fig. 58. *Helicopter with "bird" for the magnetic survey. They fly at night at 2000 feet.*

Fig. 59. *The Nares Strait Geo-Cruise 2001 Logo*

Fig. 60. *Our whole group, almost. We are in the front row, left of centre.*

Fig. 61. *This bear came close to the ship when we were waiting for the group near Resolute.*

Navigation Logging

Navigation data were logged from day 221 (Kane Basin) to day 251 (Thule) using the REGULUS logging system on a pc. Raw data ('e' format) files were written for each day, and written to CDs for archival. Interpolated files showed positions interpolated at 10 second intervals were created using program 'ETOA' to convert 'e' to 'a' format, and then program 'INTA' to interpolate. Note that as of day 227 at approximately 1600 h UTC, bathymetry data were added to the NMEA string being recorded by Regulus. Bathymetry data and navigation were also logged throughout the cruise by Arnold Welmers, CHS, using Hypack software. These values are included in the archived data for this cruise, and were used to fill gaps in the Regulus record.

A cruise.par file of underway operations was created to show start/stop times for Huntec, multichannel and refraction data recording. Other operations, recorded in the written log, included CTD and XBT water sampling, piston and box coring, and IKU grab sampling.

Science Operations Log

LAT	LON	DAY/TIME	DEPTH	OPERATION	LINE/STA
77.4869 N	74.0740 W	220/2116	454	XBT station	10
77.5738 N	73.9482 W	220/2157	249	XBT station	11
77.8741 N	73.3160 W	221/1622	187	XBT station	12
77.7776 N	73.6143 W	221/1651	234	XBT station	13
77.7567 N	73.6615 W	221/1724		CTD station	14
77.7672 N	73.4861 W	221/1916		Core/grab	15
76.8802 N	74.1989 W	223/0045	501	MCS start line	1
76.8393 N	76.8656 W	223/0840	161	MCS end line	1
76.8393 N	76.7579 W	223/1013	141	MCS start line	2
76.8949 N	76.5321 W	223/1110	119	MCS end line	2
76.9364 N	76.3764 W	223/1214	149	MCS start line	2A
77.2007 N	75.3411 W	223/1658	555	XBT station	16
77.6105 N	73.6151 W	224/0103	232	MCS end line	2A
77.5321 N	73.5970 W	224/0330	181	XBT station	17
77.5473 N	73.8499 W	224/0450	256	MCS start line	3
77.5567 N	73.9726 W	224/0515	274	XBT station	18
77.5839 N	74.3433 W	224/0630	358	XBT station	19
77.6182 N	74.7048 W	224/0745	480	XBT station	20
77.6582 N	75.1715 W	224/0915	651	XBT station	21
77.6629 N	75.5261 W	224/1018	659	XBT station	22
77.6646 N	75.5886 W	224/1029	658	MCS end line	3
77.6449 N	75.7142 W	224/1100	662	XBT station	23
77.6337 N	75.5452 W	224/1209	648	MCS start line	4
78.2859 N	73.0080 W	225/0018	183	MCS end line	4
78.3014 N	73.0663 W	225/0052	216	MCS start line	5
78.3128 N	73.4987 W	225/0208	468	MCS end line	5
79.1873 N	71.4854 W	225/1940	173	XBT station	24
79.1891 N	71.4428 W	225/2055	175	CTD station	25
79.3702 N	70.0790 W	228/1258	186	XBT station	26
79.5449 N	69.7605 W	228/1458	162	XBT station	27
79.6755 N	70.3252 W	228/1640	177	XBT station	28
79.8392 N	70.4677 W	228/2239	238	XBT station	29
80.0046 N	70.1733 W	229/0055	224	XBT station	30
80.1284 N	69.9000 W	229/1145	193	Core/grab	31
80.1360 N	70.2298 W	229/1410	99	Core/grab	32
80.1505 N	71.9420 W	229/1747	118	Huntec start	
80.1076 N	71.7747 W	229/1827	61	Huntec end	
80.1620 N	72.0387 W	229/1934	79	XBT station	33
80.1420 N	71.9311 W	229/1958	96	Huntec start	
80.1123 N	71.7803 W	229/2030	90	XBT station	34
80.0913 N	71.4522 W	229/2124	102	XBT station	35
80.1256 N	71.0407 W	229/2237	117	XBT station	36
80.1491 N	70.6660 W	229/2335	74	Huntec end	
80.1503 N	70.5175 W	229/2357	87	Huntec start	
80.1516 N	70.4014 W	230/0014	83	XBT station	37
80.1401 N	70.1994 W	230/0045	94	Huntec end	
80.1596 N	70.8343 W	230/1133	188	Core/grab	38
80.1591 N	70.8363 W	230/1356	189	Core/grab	39

80.1455 N	70.3128 W	230/1515	89	XBT station	40
80.1087 N	70.1137 W	230/1633	143	Huntec start	
80.0566 N	69.7229 W	230/1739	226	Huntec end	
80.0854 N	69.4400 W	230/1820	244	XBT station	41
80.4809 N	68.4131 W	230/2300	335	XBT station	42
80.7160 N	67.4143 W	231/0216	421	XBT station	43
80.8380 N	67.2890 W	231/0351	377	XBT station	44
80.8740 N	67.2891 W	231/0438	345	CTD station	45
80.8733 N	67.2867 W	231/0536	344	CTD station	46
80.8579 N	67.1053 W	231/0620	369	XBT station	47
80.8547 N	67.0660 W	231/0635	389	CTD station	48
80.8647 N	67.0840 W	231/0835	359	CTD station	49
80.8161 N	66.7508 W	231/0942	435	XBT station	50
80.7972 N	66.6736 W	231/1003	400	CTD station	51
80.7889 N	66.7275 W	231/1145	407	CTD station	52
80.7381 N	66.3163 W	231/1352	220	CTD station	53
80.7471 N	66.3038 W	231/1434	229	CTD station	54
80.7204 N	66.1084 W	231/1624	193	CTD station	55
80.9503 N	65.6978 W	231/2256	392	Huntec start	
80.9499 N	65.9432 W	231/2330	463	MCS start line	6
80.9577 N	66.6604 W	232/0109	349	MCS end line	6
80.9612 N	66.6375 W	232/0117	350	MCS start line	7
80.8322 N	65.8360 W	232/0416	219	Huntec end	
80.8322 N	65.8360 W	232/0416	219	MCS end line	7
80.9231 N	65.1864 W	232/1708	170	MCS start line	8
80.7917 N	67.5054 W	232/2232	388	MCS end line	8
80.7419 N	67.7838 W	233/0148	1202	Refraction start	R_1
80.7431 N	65.8305 W	233/0713	151	Refraction end	R_1
80.7578 N	65.7930 W	233/0726	158	Refraction start	R_2
80.8403 N	66.3246 W	233/0854	316	Refraction end	R_2
80.7999 N	67.1917 W	234/1730		Core/grab	57
80.7331 N	67.4515 W	234/2100	416	MCS start line	9
80.7054 N	66.2469 W	235/0018	192	MCS end line	9
80.7135 N	66.2264 W	235/0027	198	MCS start line	10
80.8306 N	66.6311 W	235/0250	337	MCS end line	10
80.8384 N	66.6323 W	235/0305	322	MCS start line	11
80.9635 N	65.3495 W	235/0907	269	MCS end line	11
80.9642 N	65.3395 W	235/0909	264	MCS start line	12
81.0723 N	64.5915 W	235/1139	226	MCS endline	12
81.3016 N	63.1182 W	235/1615	580	MCS start line	13
81.2112 N	62.7176 W	235/1802	412	MCS end line	13
81.2061 N	62.6436 W	235/1815	383	MCS start line	14
81.2450 N	62.3280 W	235/1925	475	XBT station	58
81.3246 N	62.3178 W	235/2038	401	XBT station	61
81.4148 N	62.3033 W	235/2150	525	XBT station	64
81.4953 N	62.2559 W	235/2250	529	XBT station	67
81.5718 N	62.2298 W	235/2348		XBT station	70
81.6669 N	62.1315 W	236/0104	536	XBT station	73
81.7045 N	62.0384 W	236/0140	308	MCS end line	14
81.7150 N	62.0374 W	236/0156	261	XBT station	76
81.6704 N	62.0953 W	236/0523	483	Huntec start	
81.6278 N	62.0491 W	236/0634	342	MCS start line	15
81.5732 N	62.5878 W	236/0802	397	MCS end line	15
81.5676 N	62.6419 W	236/0810	414	MCS start line	16

81.5292 N	61.7363 W	236/1033	1006	MCS end line	16
81.5245 N	61.7010 W	236/1040	1898	MCS start line	17
81.4352 N	63.1376 W	236/1402	535	MCS end line	17
81.4160 N	63.1270 W	236/1420	600	MCS start line	18
81.3625 N	62.2373 W	236/1642	503	MCS end line	18
81.3594 N	62.2261 W	236/1645	509	MCS start line	19
81.3073 N	63.3826 W	236/1930	586	MCS end line	19
81.3082 N	63.3954 W	236/1932	585	MCS start line	20
81.5716 N	62.1505 W	237/0116	403	Huntec	end
81.5739 N	62.1143 W	237/0121	454	MCS end line	20
81.4716 N	62.2717 W	237/0352	550	Core/grab	79
81.3743 N	62.3148 W	237/0820	641	Core/grab	80
81.2327 N	65.2373 W	238/0001	378	XBT station	81-83
81.1231 N	65.0051 W	238/0120	467	XBT station	84-85
80.3503 N	68.7155 W	238/1206	370	XBT station	86-88
80.3300 N	69.5046 W	238/1643	204	MCS start line	21
80.2593 N	69.2142 W	238/1749	317	MCS end line	21
80.2544 N	69.2709 W	238/1924	310	MCS start line	211
80.2078 N	69.1949 W	238/2000	277	Huntec start	
80.0010 N	69.1347 W	238/2247	249	MCS end line	211
79.9844 N	69.1967 W	238/2310	246	Huntec end	
78.8671 N	72.1392 W	240/1228	266	XBT station	89-90
78.7475 N	72.3657 W	240/1324	407	XBT station	91-92
78.5459 N	72.5881 W	240/1517	248	XBT station	93-94
78.3500 N	73.1786 W	240/1645	261	XBT station	95-97
78.3255 N	73.2583 W	240/1808	388	CTD station	98-99
78.3309 N	73.6180 W	240/1957	647	XBT station	100-101
78.3278 N	73.6503 W	240/2015	1053	CTD station	102
78.3325 N	73.5963 W	240/2122	646	CTD station	103
78.3349 N	74.0544 W	240/2249	579	CTD station	104
78.3493 N	74.4209 W	241/0215	489	CTD station	105
78.3284 N	74.8566 W	241/0430	450	CTD station	106
77.0486 N	75.9385 W	242/1426	348	OBS deploy	08
77.0070 N	75.1590 W	242/1539	524	OBS deploy	09
76.9642 N	74.3874 W	242/1704	545	OBS deploy	10
76.9177 N	73.6313 W	242/1802	217	OBS deploy	11
76.8664 N	72.8600 W	242/1856	157	OBS deploy	12
76.8104 N	71.9377 W	242/2033	805	OBS deploy	13
76.7608 N	71.3438 W	242/2116	33	OBS deploy	14
76.7033 N	70.6079 W	242/2210	194	OBS deploy	15
76.6203 N	69.3261 W	243/1621	111	Refractionstart	3
76.6516 N	69.8066 W	243/1823	72	XBT station	109-110
76.6904 N	70.3727 W	243/2040	137	XBT station	111-112
76.7228 N	70.9577 W	243/2255	296	XBT station	113-115
77.0615 N	77.0814 W	244/1911	227	Refraction end	3
77.2603 N	81.6044 W	245/1235	164	Refraction start	3
77.2826 N	81.3714 W	245/1330	232	XBT station	116-117
77.3056 N	81.1354 W	245/1425	244	XBT station	118-119
77.2990 N	80.7546 W	245/1544	438	XBT station	120-121
77.2715 N	80.5092 W	245/1642	543	XBT station	122-123
77.2665 N	80.2261 W	245/1740	563	XBT station	124-125
77.2600 N	79.9419 W	245/1839	660	XBT station	126-127
77.2474 N	79.5695 W	245/1952	333	XBT station	129-129
77.2376 N	79.4948 W	245/2010	306	Refraction end	3

77.2661 N	79.6638 W	245/2235		Core/grab	130
77.2024 N	78.6886 W	246/0148	623	XBT station	131-132
77.1203 N	77.5913 W	246/0430	195	XBT station	133
77.1154 N	77.1393 W	246/0530	203	XBT station	134-135
77.0746 N	76.4228 W	246/0610	299	XBT station	136-137
77.0381 N	75.8883 W	246/0640	399	XBT station	138-139
76.9932 N	75.3176 W	246/0712	516	XBT station	140-141
76.9444 N	74.7763 W	246/0743	579	XBT station	142-143
76.9042 N	74.2271 W	246/0814	521	XBT station	144-145
76.8764 N	73.7048 W	246/0843	252	XBT station	146-147
76.8483 N	73.1360 W	246/0915	149	XBT station	148-150
76.8231 N	72.6042 W	246/0945	201	XBT station	151-152
76.7950 N	72.0625 W	246/1015	640	XBT station	153-154
76.7623 N	71.5339 W	246/1045	782	XBT station	155-156
76.7003 N	70.6041 W	246/1157	83	OBS recover	15
76.7593 N	71.3430 W	246/1342		OBS recover	14
76.6348 N	69.5604 W	246/2151	41	MCS start line	22
76.7380 N	71.2832 W	247/0330	710	MCS end line	22
76.7419 N	71.3022 W	247/0335	718	MCS start line	23
77.2156 N	72.1194 W	247/1116	488	MCS end line	23
76.8052 N	71.9235 W	247/1530		OBS recover	13
76.8509 N	72.7532 W	247/1630	148	OBS recover	12
76.9164 N	73.6285 W	247/1805	209	OBS recover	11
76.9597 N	74.3788 W	247/1920		OBS recover	10
77.0018 N	75.1544 W	247/2049	522	OBS recover	09
77.0430 N	75.9222 W	247/2205	375	OBS recover	08
77.2253 N	71.5460 W	248/0613	809	MCS start line	24
77.2041 N	74.6604 W	248/1623	657	MCS end line	24
77.2111 N	74.6846 W	248/1634	655	MCS start line	25
77.3141 N	74.6049 W	248/1826	262	XBT station	157-159
77.5687 N	74.5732 W	248/2308	637	MCS end line	25
77.5750 N	74.5492 W	248/2315	607	MCS start line	26
77.9432 N	73.0471 W	249/0543	126	MCS end line	26
77.9399 N	73.0547 W	249/0813	129	MCS start line	27
77.6659 N	73.0508 W	249/1143	183	Huntec start	
77.6498 N	73.0512 W	249/1156	181	MCS end line	27
77.6524 N	73.1012 W	249/1241	187	MCS start line	28
77.5850 N	71.9377 W	249/1628	79	MCS end line	28
77.5788 N	71.8781 W	249/1640	69	Huntec end	
77.7173 N	74.8554 W	249/2220	496	XBT station	160-161
77.7186 N	75.0184 W	249/2306	748	CTD station	162
77.7016 N	75.0725 W	250/0035	658	Core/grab	163
77.5687 N	73.6700 W	250/0847	220	MCS start line	29
77.5055 N	73.6973 W	250/0937	225	Huntec start	
76.9015 N	74.3901 W	250/1845	495	MCS end line	29
76.8418 N	74.3489 W	250/1930	538	MCS start line	30
76.7426 N	71.2640 W	251/0501	715	Huntec end	
76.7426 N	71.2640 W	251/0501	715	MCS end line	30

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Huntec Data Tapes and Paper Records

Paper records

Line 1	Day 229/1749 230/0045	80^0 08 N 70^0 12 W SOL	John Richardson Bay
Line 2	Day 230/1630-230/1739	80^0 06N 70^0 07 W SOL	John Richardson Bay to Kennedy Channel
Line 3	Day 231/2340-232/0415	80^0 57N 66^0 02 W	Greenland to Ellesmere Island across Kennedy Channel near Hans Island
Line 4	Day 235/2038-Day 236/0140	81^0 19 N 62^0 19 W SOL 81^0 42 N 62^0 02 W	Petermann Fiord to Hall Basin
Line 5	Day 236/0515-237/0116	81^0 40 N 62^0 06 W 81^0 34 N 62^0 09W	east side of Hall Basin zigzag course
Line 6	Day 238/2000-238/2300	80^0 12 N 69^0 11W 79^0 59 N 69^0 10W	Cape Lawrence to Kennedy Channel
Line 7	Day 249/1143-249/1640	77^0 39.9N 73^0 03.0W 77^0 34.7N 71^0 51.7W	Between Northumberland Island and Greenland
Line 8	Day 250/ 0939	$77^0$30.1 N 73^0 42.1W	Northern Baffin Bay west of Northumberland Island

Data tapes

Line 1 tape 1	SOTape approximately 229/1811	EOTape 229/1935	John Richardson Bay at the head of the fiord
Line 1 tape 2	SOT 229/1938		John Richardson Bay near mouth of the fiord
Line 2 tape 3	1230/1645	230/1739	John Richardson Bay to Kennedy channel
Line 3 tape 4	230/1721	232/0416	Kennedy channel near Hans Island
Line 4 tape 5	235/2038	236/0140	Petermann Fiord to Hall Basin
Line 5 tape 6	236/0500	237/0115	east side of Hall Basin
Line6 tape 7	238/ 1959	238/2254	Cape Lawrence to Kennedy channel
Line 7 tape 8	249/1143	249/1640	Northern Baffin Bay west of Northumberland Island
Line 8 tape 9			

Appendix I

Watch Schedule
0000-0400 Vincent Helfferich
0400-0800 Rutger van der Vliet
0800-1200 Thomas Funck
1200-1600 Ian Reid
1600-2000 Jane Eert
2000-2400 Fred Jodrey

Attendees of Sunday supper with the Captain
Supper in the Captains dining room
Franz Tessensohn, Ruth Jackson, Henry Halls, Anna Jensen
Franz Tessensohn, Pat Hall, Thomas Funck, Justin Sapey
Ruth Jackson, Marcus Zentilli, Soenke Neben, Vincent Helfferich
Franz Tessensohn, Detlef Damaske, Tom Brent, Henry Hall

Meeting of Nares Strait 2001 Scientific Party to discuss future publications and meetings

Wednesday September 5, 2001
onboard CCGS Louis S. St-Laurent

Agenda

(1) Cruise report
(2) Contributions to workshop and publications
(3) Press release

Cruise Report

An informal report on cruise objectives, activities and data collection is being prepared for release as a GSC Cruise Report. This publically-available document will include a project overview, a daily summary of activities and related information, and detailed descriptions of the objectives and accomplishments of the various groups. Information such as sample locations, times of survey activities, and specific objectives for each group should be provided to Ruth Jackson before the end of the cruise. Copies will be available later for all participants.

Contributions to workshop

(a) Publication restrictions and commitments

Publication and dissemination of results from the Nares Strait cruise are subject to certain restrictions stated in the GSC-BGR Memorandum and in invitations to participants. The GSC-BGR Memorandum states that initial results will be published in a joint volume of the Geologisches Jahrbuch (an international journal written mostly in English), with later publications to acknowledge the cruise and participating organisations. The joint volume could be under the Polar Research section of the Jahrbuch, and it should be possible to have colour figures, pull-out sections and map folders. A decision may be made at the workshop to publish in a different journal if more appropriate.

Individual participants are obligated to make scientific contributions to the workshop planned for Hannover, and to publish first results in a joint scientific volume. Papers are to be completed by spring 2003. Earlier publication is possible, with appropriate authorship, upon approval of BGR and GSC if results warrant early release. Publications after the initial joint publication require only a reference to the cruise and acknowledgements of BGR and GSC.

(b) Workshop topics and group commitments – Hannover, September 2002

Refraction seismic: a model of crustal structure will be developed. The group consists of Ruth Jackson, Sonya Dehler, Thomas Funck and Ian Reid.

Reflection seismic: processing will be complete and initial interpretation finished. This will be done by Sönke Neben and Franz Tessensohn. Tom Brent suggested reprocessing industry field tapes, owned by Talisman, for the area south of Cape Lawrence to Dobbin Bay, and others in northern Baffin Bay. Integrating the new data with the old may lead to improved interpretation. Tom Brent will act as principal to assemble old data resources.

Aeromagnetic data: processing will be complete and preliminary interpretation finished. The group consists of Detlef Damaske, Gordon Oakey and Dieter Möller.

Quaternary marine sediments: preliminary discussion of Quaternary marine sediments based on the 4 new cores and Huntec data will be presented. Peta Mudie, with Brian MacLean and GEUS colleagues, will do this interpretation.

Seafloor mapping using new bathymetry and Huntec: information on seafloor features and possible geologic controls could assist geologic interpretation. This work would require gridding of bathymetry data and interpretation of Huntec data. No one volunteered for this task, but Marcos Zentilli suggested that it could be a good M.Sc. student project.

Oceanography: data collected by Jane Eert will be used by Peter Jones. Ruth Jackson will contact him about contributions to the workshop.

Geodesy: the work by Bob Morris, Anna Jensen and Lasse Nielson to be included in the workshop and publication.

Fission track: the analysis will focus on 3 main areas (rifted zone, Eurekan orogeny and timing of the thrust, and tertiary sediment correlations). One of these topics will be prepared for the workshop, topic to be chosen after discussions with Chris Harrison. This work will be done by Marcos Zentilli and Sandy Grist.

Geological framework: an easy summary and overview of Ellesmere and Greenland geology will be prepared by Chris Harrison, for use also in geophysical interpretation. Chris also suggests revisiting the arguments for and against major strike-slip displacement across Nares Strait, such as the 21 points of evidence of Peter Dawes.

Dikes: a progress report on the analysis of the 8 cores collected on this cruise will be prepared by Henry Halls.

Physical property measurements: Measurements of velocity, density and magnetic susceptibility can be done on selected rock samples to complement geophysical interpretation. Matt Salisbury (GSC) will be asked to do this work. Marcos Zentilli has offered to provide some of his rock samples for analysis.

Plate tectonic summary: an overview of plate motions in this region will be prepared by Gordon Oakey.

Summary paper(s): contributions from all participants in one or more summary papers. Franz Tessensohn will co-ordinate the preparation of the paper(s).

Tertiary deformation of Spitsbergen – North Greenland into Ellesmere: This topic will be re-examined by Franz Tessensohn and colleagues in Germany in light of new observations from the Nares Strait cruise.

Natural resources: an examination of the implications that work done on this cruise will have for oil and gas resource assessment. For example, the fission track work will complement vitrinite reflectance estimates of organic maturity, and the coal beds if buried at several kilometres depth in some regions may have gas potential. Marcos Zentilli and Chris Harrison will work on this angle.

(c) General comments

It is important to frame cruise results in terms of significant contributions to major scientific questions, not just new data. An example is the identification of a major lineament on the aeromagnetic data, with coincident narrow Tertiary basins, probably signs of a major fault. The data show no evidence of other major faults in Kennedy Channel, contrary to expectations. Also, the reflection seismic data in Kennedy Channel and Hall Basin show evidence of thrusting rather than strike-slip motion. The Greenland side is an undeformed platform, whereas the Ellesmere side shows beds dipping and folded. This could mark the front of Ellesmerian deformation. Based on plate motion models, if convergence followed sinistral strike-slip motion, the shear zone could have been overprinted or re-activated by the thrust front. The timing of the Eurekan orogeny needs to be worked out and additional onshore geologic observations are required.

There has already been a large investment in this collaborative science venture – perhaps this could be used as leverage for obtaining additional funding from industry, government or academia (e.g. NSERC). These funds could be used to work up some of the data or for follow-up projects. NSERC has an interest in Arctic research that could lead to funding.

Several objectives were not achieved in this cruise and these could be the target of a follow-up project. For example, the aeromagnetic survey could be completed, optionally from a helicopter and fly camp based in Alexander Fiord. Also, surveys need to be run in the ice-covered areas of Kane Basin and the Ellesmere coast, including a refraction survey over the large gravity anomaly low.

Press Release

A press release will be prepared and released on September 11, the day following our return to Halifax. The desired venue for a press conference would be BIO, but possible PSAC strike action may make it necessary to move to a hotel or Dalhousie University. The general wording prepared for the planning document could be expanded to include other items of public interest, such as the presence of the students Brian and Jimmy from Grise Fiord. Ruth and Franz will work on this release, with input from others.

An article will be submitted to EOS describing the cruise. An article had been prepared earlier and submitted prior to the cruise, but it was decided to wait until the program was completed.

Chris Harrison suggested submitting an item to the CSPG Reservoir to attract the interest of the Canadian petroleum exploration industry.

Meeting in 2003:

A follow-up meeting for presentation of final results can be held in conjunction with one of two conferences planned for Halifax:

1) Northeast section GSA meeting, March 2003 (Chaired by Marcos Zentilli): this would attract scientists outside the arctic community and would allow for a session focused on the Greenland and Ellesmere areas, but may be too early for final presentations.

2) ICAM meeting, fall 2003 (Organised by Ruth Jackson): this would be a focused meeting on arctic research attracting approximately 250 people.

Appendix II

Watchkeepers Notes for Seismic Reflection

FULL STREAMER LENGTH (OPEN WATER)

Launching the equipment:
Ship's speed : Min.
1. Launch Gun beams (contact/responsibility: Borden Chapman, Cabin/Tel.: 416/328)
2. Launch Streamer (contact/responsibility: Justin Sapey, Cabin/Tel.: 418/324)

Help needed by ship's crew: Bosun, crane operator & 2 deckhands

During measurements:
Ship's speed : ~5 kn (adjusted during first line than constant). No sharp turns, avoid drifting ice. Bridge contacts seismic lab (aft oceanographic lab, Tel. 196) before alteration of speed and/or course. Maximum speed for streamer: 7kn.
Towing parameters:

Streamer depth:	7m
Gun depth:	7m
Distance stern – 1st channel:	100m
Distance stern – guns:	30m
Distance last channel – tail ball:	75m
Distance stern – tail ball:	1375m

End of line and turn in open water:
1. Stop shooting
2. Heave beams close to ship (<u>not on board</u>)
3. Start turning with 5° per minute until streamer is straight behind vessel
4. Pay out beams and start shooting

Streamer Emergency Plan

Streamer cut off

1 The first observer notifies:

	Cabin:	Tel.:
Bridge	-	112
J. Sapey	418	328
B. Chapman	416	324
S. Neben	302	192
R. Jackson	310	220

2 Immediately fix the position and time; if possible bear position and distance of the tail buoy
3 GI-Guns on deck
4 Streamer (if any remnants) depth to 0 m, reduce wake speed to 2,5 kn
5 Get streamer remnants on deck
6 Make 180°-turn, approach tail buoy, keep security distance from floating streamer while observing currents, wind and sea
7 According weather and visibility approach tail buoy by Zodiak. In adverse conditions: standby until conditions improve

8 Pick tail buoy and make connection to streamer winch

9 Get tail buoy on deck and wind up streamer

WATCH KEEPERS GUIDE
2001 Louis St. Laurent
Nares Strait Project
2 August – 6 September 2001

Watches are kept to maintain digital and analog records of navigation and bathymetry during scientific programs, and to provide a record of operations and problems. During this cruise, watches will be kept primarily in the seismic lab on deck 4 and the forward lab on deck 3. Watch keeping duties will include monitoring the Regulus Navigation logging computer, providing time marks for the bathymetry chart, assisting in operations for water sampling and coring, and annotating the log book with position and operation notes as required for the different activities.
Stations will be numbered consecutively, regardless of the activity. Different measurements at the same location will have different numbers. In the log book, identify the type of activity, e.g. Benthos piston coring, CTD, XBT or Rosette water sampler.

If you have questions, ASK for help.

Watch Keepers Guide for Bathymetry Logging

Note that the computer logging bathymetry is located at the back of the seismic lab on deck 4, while the chart recorder is in the forward lab on deck 3.

1) Every fifteen minutes, use the switch located next to the logging computer to send a time mark to the chart recorder. Press the switch for approximately 4 seconds. The time must be carefully noted from the computer screen, and then written on the chart record. It is preferable if time marks are made on the hour and quarter hours thereafter.

Watch Keepers Guide for CTD and XBT Water Sampling

<u>CTD sampling (Ship stopped):</u>

1) On the REGULUS navigation computer type "e" as CTD sampler hits the water to mark the event location. In forward lab, switch sounding plotters by turning small plotter system off, switching cable, and turning large system plotter ON and transmitter power switch to STANDBY. You should see a strong signal from the pinger on the CTD and a later signal from the bottom bounce.

2) When CTD signal and bottom reflection are approximately 40 m apart, notify the CTD winch team. When separation decreases to 20 m, notify the CTD winch team to STOP. Switch back to small bathymetry sounder plotting system (if digitizer alarm sounds, hit reset to cancel.) Standby in lab room to assist if required.

3) When sampling is complete, return to REGULUS system and note time and position of event marker in log book. Change label for marker on Regulus computer (e.g. SITE004). To do this, go to "Nav Elements" menu, select "Nav Manager", select marker to edit and press EDIT. Enter new name, press APPLY, press OK. Complete entry in log book.

<u>XTD sampling (ship moving):</u>

1) On the REGULUS navigation computer type "e" as XBT sampler hits the water to mark the event location. Note time and position of event markers and change label using Nav Manager to identify station number. Complete entry in log book.

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Helicopter Specifications

There are two. BO-105 helicopter onboard the ship for this mission. This machine is a 5 place twin engined light utility helicopter of German design. It was built by Messerschmidt Bolkow Bloe, a company that is now part of Eurocopter Ltd. The operational capabilities of the aircraft as configured for this experiment are an endurance of 2 hr 30 min with standard fuel tanks. The cruising speed is 115 knots with a range of 250 miles. The maximum payload is 1990 lbs. There are VHF, AM and FM , and HF radios. The navigation system includes CGS with automated search patterns.

Grise Fiord Hamlet Office 980-9959

Historical notes on Fort Conger

Fort Conger, located at 81 degrees latitude on the northeastern coast of Ellesmere Island, is now a national historic site lying within the boundaries of Quttinirpaaq National Park.

Its an isolated spot, across the strait from Greenland, and accessible only to hikers or chartered aircraft.

But more than one hundred years ago, this remote location on Discovery Bay was an important staging point for polar explorers.

The sailing boat Discovery, which wintered over here in 1875, is long gone but wooden plaques commemorating two sailors who died over that winter remain, as do small wooden structures and other remnants from later explorers visits.

According to Lyle Dick, a historian with the Society for the Study of Architecture in Canada, these relics tell a "fascinating story of hubris, disaster and eventual adaptation to winter shelter, and survival in one of the worlds more severe climates."

Learning from Inuit

They also reveal the "progression from ignorance to wisdom" made by explorers as they finally realized that they needed to adopt Inuit settlement patterns, architectural principles, and ingenuity in order to survive.

While this year, more than 20 scientific parties are conducting research around the High Arctic islands, Fort Conger was the site of the first major scientific expedition to the northern polar region.

Here, in 1881, A.W. Greeley and 24 men were dropped off to spend a winter working on research projects. But after two full years passed, with no resupply ships calling, the expedition members ended up abandoning their scientific collections to head towards a more accessible point.

On Pim Island, they founded what Dick has called "a dismal starvation camp." At Camp Clay Greeleys men built a makeshift lodge out of a whale boat that was cold and wet.

"Our sleeping bags and clothing were already frozen to the ground and their interiors were thawed only by the heat of our bodies, and froze solidly on quitting them. The roof and the walls speedily gathered frost, ice, as did every other article in our wretched hut," wrote Greely about Camp Clay life in November.

Cannibalism and violence erupted, and only six out the original group of 25, including Greely, survived. In the end, defeated by cold and hunger, the expeditions ambitious projects, which had included an magnetic observatory and a vegetable garden, amounted to nothing.

Right from the very start, his expeditions main problem was the simple challenge of keeping warm. Greelys Fort Conger was a long rectangular building, 18 metres by five metres, and three meters high.

Named after a US senator who had supported the expedition, the ungainly building was constructed in European fashion with long, vertical wooden boards covered with tar paper, and divided into three rooms.

The size of its exposed surfaces made it cold, and very hard to heat. In Sept. 1881, Greely noted five tons of coal had been burned for heat. During the first winter, the building was only banked with two metres of snow.

Fort Conger unfit

Explorer Robert Peary, who came upon the building a few years later, said in his 1917 book called "Secrets of Polar Travel" that Fort Conger was "grotesque in its utter unfitness and unsuitableness for polar winter quarters."

Peary eventually tore it down and built several smaller buildings, three of which still stand. These combined elements that Inuit used in building igloos and turf or stone houses. The buildings small size, clustering and interconnectness all reflected what Peary had seen in Greenland and elsewhere in the Arctic.

Peary, for example, used tunnels to join the dwellings, as well as packed snow and sod for insulation.

The new smaller structures were relatively easy to heat, although they were more separate and perhaps less liveable during the long, dark season than the more communal dwellings Inuit favoured. Peary, nonetheless, used Fort Conger as a base from 1901 on, until he finally reached or came close to the North Pole in 1909.

Much of what Peary and Greely left behind can still be seen in a good state of preservation. There are the wooden dwellings, as well as the mounds of tin cans, bedsteads, Greelys garden circled by barrel hoops, broken ceramic pipes, and shards of coloured glass.

Some visitors still question why this site isn't cleaned up. "How long does junk have to stay around until it becomes historic, anyway," they ask.

Historic junk

But researchers use this junk to see how the explorers and their Inuit companions lived.

"Even the rusting piles of tin cans are valuable artifacts to the dedicated researcher," says a Parks Canada sheet on Fort Conger. "It is crucial, therefore, that this information not be disturbed. Please take only pictures, and leave only footprints."

Unfortunately, there are just a couple of small markers at Discovery Bay to tell about Fort Conger, and no detailed guide available at the site to explain about its importance or what visitors are seeing, although this information is available though Parks Canada offices.

So, even on one of summers finest days, Fort Conger, alone and unprotected, seems a bit fragile, a reminder that there are still limitations on what can and cant be done in the High Arctic.

Press Release

Canadian/German scientific expedition of Nares Strait successfully completed

Scientific staff and crew on board the CCGS Louis S. St. Laurent (LSL) have just returned (Monday evening, September 10, 2001) from a scientific expedition through Nares Strait, the northernmost waterway connecting the Arctic and Atlantic oceans. The ice conditions in the strait, the waterway between Greenland and Ellesmere Island, Nunavut, required the support of Canada's largest ice breaker. The ship was a versatile platform for 34 scientists to accomplish their marine investigation. The LSL has a history of supporting international scientific expeditions including an oceanographic transect of the Arctic Ocean in 1994 and a biological study of the Canadian Arctic Islands in 1999.

On the thirtieth anniversary of the German Canadian Agreement on Co-operation in Scientific Research, the geological surveys of Germany (Bundesanstalt fur Geowissenschaften und Rohstoffe, BGR) and Canada (Geological Survey of Canada, GSC) undertook a 5-week scientific cruise to survey and explore Nares Strait. Most of the funding for this expedition came from BGR who have a long term scientific interest in the Arctic region. The co-operative cruise, which had been planned over a period of 2 years, provided the basis for a wide range of scientific investigations, from marine seismic work and climate change studies through airborne magnetic investigations to geodetic survey measurements and geological sampling onshore.

The international boundary between Canada and Denmark is located in Nares Strait. Scientific participants from Denmark were an important part of the program. In addition there were also scientific staff and students from Britain and The Netherlands. Two students, Brian Atagootak and Jimmy Nungaq from Grise Fiord, Canada's northernmost community, actively participated in the experiments. They provided support for the field parties, participated in the science program and received certification for steering the ship through waters crammed with sea ice.

The major goal for the Canadian scientists was to map the seafloor in this northern area. Systematic geophysical offshore studies in this key area had not been undertaken before. Where towing of seismic equipment was not possible because of ice coverage, magnetic maps were made using a helicopter-borne magnetic sensor system.

The primary objective of the German scientists was the study of structural features relating to the formation of the Arctic Ocean and, in particular, the study of the Wegener Fault. This fault is a linear boundary between Greenland and Ellesmere Island which was noted by the German scientist Alfred Wegener in 1915 and later became the subject of a major scientific controversy.

The first important result from the expedition is the mapping of highly magnetic lines (a major lineament on the aeromagnetic data) with coincident narrow basins onshore along the Ellesmere Island coast and continuing offshore towards the Arctic Ocean. This could be the trace of a major fault.

The seismic profiles collected in the northern end of the strait (Hall Basin and Kennedy Channel) show evidence for thrusting rather than strike-slip motion, adding to the controversy on plate motions between Greenland and Ellesmere Island. Data on the nature and thickness of the earth's crust were successfully acquired but need further processing before the question can be answered on whether Greenland is geologically a part of North America or not. The new geological data also provide constraints for understanding the economic potential of the region.

Sediment and water samples taken during the cruise provide information on changes in climate and sea ice cover from the last ice-age to the present. An 11 m-long sediment core from outer Jones Sound is the longest core ever taken in the Canadian Arctic channels and holds clues to the detailed climate history of northern Baffin Bay.

Although the principle focus of the experiment was geological studies, the ship provided the capabilities and the berths to run a wild life observation program plus oceanographic, hydrographic and geodetic surveys. A variety of mammals including seals, walrus, narwhals, polar bears, muskox and Arctic hare were sighted. Other evidence of bear and fox came from damage to scientific equipment left onshore. Oceanographic measurements were made across the strait to provide information on the water flowing between the Arctic Ocean and Baffin Bay. New bathymetric soundings were collected to add to the sparse information in some parts of the hydrographic charts. Precise geodetic measurements of the positions of Ellesmere Island and Greenland were made to an accuracy of 1 cm in length and 1.5 cm in elevation and will show whether movement is taking place between the two areas. In addition, tidal data were collected so that sea level could be established more precisely as a base line for measuring the height of the surrounding mountains.

The Captain Stewart Klebert and the chief scientists Franz Tessensohn BGR and Ruth Jackson GSC are available for further information

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