K042

1991/92

IMMEDIATE SCIENCE REPORT

K042: ROV Grounding Line Study of the Mackay Glacier Tongue

New Zealand Antarctic Research Programme 1991/92

Event Personnel: A.R. Pyne (Leader)

R. Powell

E. Broughton

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D. Statham

G. Falloon (K191)

November 1991 - December 1991

NZARP REPORT No.1. IMMEDIATE SCIENTIFIC REPORT.

Event K042 - ROV grounding line study of Mackay glacier.

Abstract

In November-December 1991 we explored the Mackay Glacier Tongue with a submersible remotely operated vehicle (ROV) to see whether sediment was being shielding by freezing or melting out onto the sea floor in the area of the grounding line. The ROV made ten dives at three sites, one on the southern side, and two on the northern side of the tongue. The tongue was grounded at both of the latter sites at a depth of 100 and 200 m, showing that the glacier was touching the sea floor for at least 1.9 km of the length of the tongue. This was unexpected, and shows that the debris transported beneath the ice and released can build up and out at a measurable rate, accommodating at least low rates of rising sea level. The sea floor on the south side has an abundant biota including bryozoans attached to the stones, indicating that this area has been ice free for a significant period of time.

The sea floor comprises a mixture of sand and mud with scattered cobbles and boulders (diamicton) draped with a thin layer of mud in many places. Transverse ridges and crag and tail features on the sea floor close to the grounding line suggest that shearing and lodgement are important processes when the ice is grounded.

Layers of debris rich ice in the basal zone of the tongue were observed and are similar to those in glaciers in more temperate settings and confirm that freezing on and erosion of debris is occuring in Mackay Glacier.

Two dives were made at the Blue Glacier and confirm that this glacier is a significantly different type of polar glacier. The Blue glacier terminus calves periodically into the marine environment but it is slow moving and free of basal debris where we observed it. No lodgement processes occur but a small (3 m high) push moraine is present immediately in front of the underwater terminal cliff.

Proposed Programme

This season we had proposed to run two programmes together; 1.,vibrocorer sampling of the sea floor in Granite Harbour and 2., the study of the Mackay Glacier Tongue grounding line with a remotely operated submersible vehicle (ROV). At the end of September we postponed the vibrocorer programme because the equipment was not ready and satisfactorily tested but received RDRC permission to continue with the ROV-grounding line study.

Mackay Glacier forms a 3 km wide, 300 m thick, "floating" glacier tongue that moves seaward at 250 ma^{-1} when it enters Granite Harbour, an embayment up to 900 metres deep on the Victoria Land coast. The project is to observe and describe, for the first time, the interaction between a polar glacier tongue, sediment and sea water at the detachment point (grounding line) using a remotely operated submersible vehicle (ROV).

We propose to study the subglacial delta presumbed to have formed as basal debris carried in the glacial tongue melts out. (Macpherson 1987, Alley et al. 1989). The existence of subglacial deltas and sedimentation processes requires testing to provide better models to compare with seismic data from the Antarctic continental shelf where a number of examples of delta like sedimentary bodies have been observed (Cooper et al. 1990).

The principal objectives for this seasons research are;

1. Determine the character and thickness of the basal debris layer in the glaciers.

2. Evaluate grounding line processes including debris meltout, sediment deformation, meltwater production (if any) and grounding line stability.

3. To check if a subglacial delta exists.

3. Scientific Endeavours & Achievements
Mackay Glacier Tongue

Ten days were spent working around the Mackay Glacier Tongue (23 November - 2 December) at three dive sites, site 1 on the southside of the tongue, and Sites 2 & 3 on the north side (Figure 1).

Access holes (1.8 m x 1.2 m minimum) were made in the sea ice for the ROV by a combination of drilling with the 0.6 m auger on the NSF nodwell and explosives. In each case holes were made in existing ice cracks. Near the ice tongue several platelett cubic metres of platlett ice was cleared from holes at sites 2 & 3 especially before the holes were clear for the ROV.

The Phantom DHD2 ROV which belongs to Dr Ross Powell is equipped with colour and low light black and white video cameras. A sea bird CTD, an electromagnetic current meter, a optical back scatter sensor and still stereo photography comprise the instruments which were on the vehicle. In addition we designed and built a 5 bucket min-dredge at Victoria University to sample the sea floor for the ROV.

A total of 10 dives were made at the Mackay Glacier Tonge sites.

Site 1.

This site was on the south side of the tongue approximately 2.7 km east (seaward) of Cuff Cape. 705 , 676.4 m N, 280 , 347.0 m E (Location based on a local plane grid, origin Cape Roberts @ 700 000 m N 300 000 m E). Parts of the glacier tongue in this region appeared to be in the process of detaching from the main ice mass. The ice tongue did not contain debris and was floating with a minimum of 10 m of ice water above the sea floor.

The sea floor shallows to 150 m south away from the ice tongue side, and appeared to be in part a basement ridge parallel to the side of the ice tongue probably extending out from Cuff Cape. The sea floor comprises a rubbly diamicton with mud drapes in places and areas of well established encrusting benthos indicating the present sedimentation is primarily from suspension and that the ice tongue has not grounded in this area for a significant time period.

Site 2.

This site was the most westerly site occupied on the northern side of the glacier tongue (708 334.6 m N, 277 619.7 m E), as close as possible to the "change in slope" of the main ice flow. An embayment in the tongue has formed because the edge of the ice is slowed in velocity by a sub ice basement high creating a small icefall on this north side of the tongue.

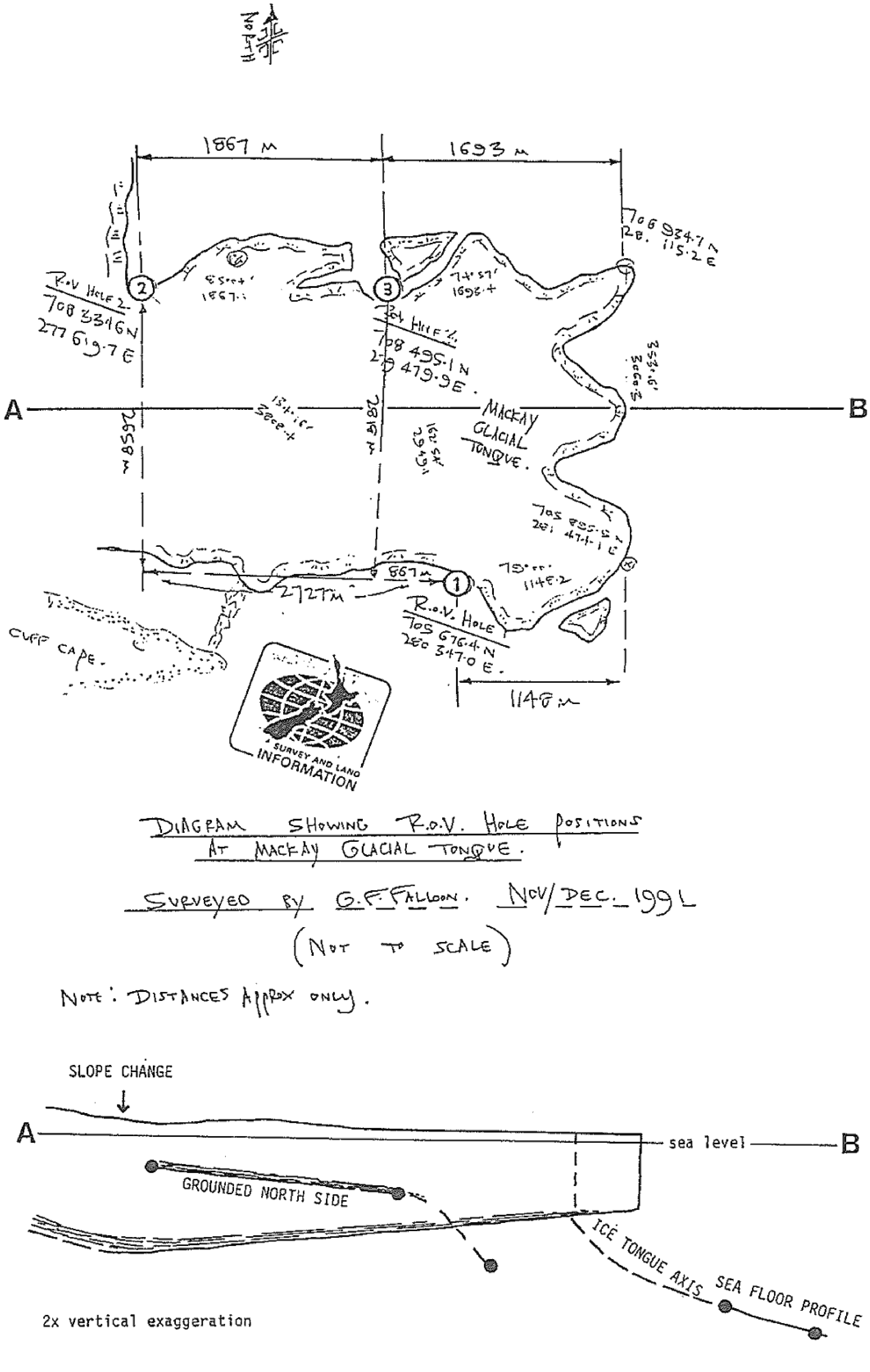

Figure 1. Sketch map and cross section of the Mackay Glacier Tongue showing positions of ROV dive sites and interpretation of the sea floor grounding zone along the ice tongue axis.

The glacier tongue at this site is grounded approximately at 100 m depth although local edge rebound exposes areas of the sea floor under the ice cliffs. Ridge and trough relief on the sea floor trends across glacier showing active coupling of the sea floor and moving glacier tongue. Sedimentation is active with mud drapes on boulders and ice contacting the sea floor was observed in several places. No significant conductivity or temperature change in the water column or at the ice contact were measured confirming the absence of measureable meltwater discharge. Encrusting benthos was generally absent indicating much more active sedimentation than at site 1. The basal debris layer (alternating layers of debris rich and poor ice) in the tongue was 20m thick.

Site 3.

This site is also on the northern side of the tongue (708 495. m N, 279 479.9 m E) about 1.9 km east of site 1. The tongue is also grounded here but at a depth of 200m. The seafloor is similar to site 1 with mud drapes on many of the boulders, although in general there are less large boulders observed. A strong trough fabric was observed on the sea floor showing that coupling with the glacier and lodgement processes occur here also. The basal debris layer at this site had thinned to about 10 m thick compared to site 2.

Blue Glacier

About a 1.5 days (6 - 7 December) were spent at the Blue Glacier tide water terminus and 2 ROV dives were made from one site approximately at the centre of the terminus cliff. At this site water depth was about 100 m and the sea floor covered with fine mud. A small (3 m high) push moraine is present infront of the underwater cliff which has recently calved and rebounded a few metres (less than 5 m) off the sea floor. Some current was observed but we are unsure if there was any associated salinity changes because the CTD was inoperative.

The ice cliff and sole of the glacier is free of basal debris and only clean "white" ice was observed.

Very little encrusting biota were present on the muddy sea floor but sea cucumbers were present on the sea floor under the sole of the ice cliffs.

Cape Roberts

Data from the tideguage - metmast was retrieved on 22 November and 4 December. We now have a continuous tidal record from this site in excess of 1 year. The transducer depth was measured with a small underwater camera and a 24 hour levelling done by the K191 surveyor. These tests should be carried out annually to check the transducer mounting and calibration.

A. Pyne meet NZARP visitors to Cape Roberts in the afternoon of 2 December to outline the CIROS II drilling proposal and specifically the requirement for a camp at Cape Roberts to support drilling offshore.

The very successful ROV programme was made possible by inviting Dr Ross Powell (and his ROV) as a collaborative foreign scientist into our NZARP event. Dr Powell who is a Masters graduate of VUW now at Department of Geology, Northern Illinois University, USA has been working on similar glacial studies to us but in Alaska. This last season has enabled both our groups to work together in Antarctica and in proving how valuable a tool the ROV is to understanding polar glacial processes. We hope to continue collaboration in the future (1993-94) in a similar programme jointly supported by NZARP and USARP.

Publications

We are in the process of preparing a short paper to Nature on the Mackay Glacier Tongue. In the longer term we intend to sumitt a detailed article to Marine Geology.

Environmental Impact

No lasting impact has occured from this programme. All activity was carried out on the seasonal sea ice except K024 cargo unloading at Cape Roberts. Human and cooking wastes were consigned to sea ice holes and burnable and non-burnable materials all returned to Scott Base. Small quantities of explosives (less than 1 kg per shot) were used to enlarge the ROV access holes in sea ice and these were over 2 km away from ice cracks used by seals.

Future Research and Management of Science in the Ross Dependency.

We hope to continue the vibrocorer programme in 1992-93 which was postponed this season. NZARP will also be in a better position to support this programme with a N.Z. nodwell-hiab crane vehicle at Scott Base in the 1992-93 season.

In the 1993-94 we hope to continue collaboration with Dr Powell and use the ROV to study the Mackay Glacier Tongue sedimentation processes and "retreat" in greater detail and then compare this to the much longer Nordenskjold Ice Tongue 80 km north of Granite Harbour.

Acknowledgements

We would like to thank the following people and organisations who contributed to the success and implementation of this programme.

At Victoria University. The mechanical workshop who built the prototype ROV dredge. Allison Thwaite (Teaching Aids) copied the video tapes during the Christmas 91 period.

At Northern Illinois University. Bob Bailey who prepared the ROV before shipment to New Zealand.

Mike Chapman (MECCO) who provided information on the ROV to help design the bucket dredge. Helen Phillips, Graham Shelly, Pete Baxter (DSIR) and Rodger Hargraves (Pengalleys) all helped to get our late cargo through customs and to Antarctica.

Dr Rob Dunbar (Rice University) and Dave Geddes (DSIR Antarctic) for help arranging for the use of the NSF nodwell.

All the staff of DSIR Antarctic and at Scott Base and in particular Phill Robins (Scott Base Operators Manager).

Lastly special thanks to our field personnel Sean Heaphy our "gourmet" mechanic/field assistant and Dave Statham N.Z. Army plant operator.

Figure 1. *Sketch map and cross section of the Mackay Glacier Tongue showing* positions of ROV dive sites and interpretation of the sea floor grounding zone along the ice tongue axis.

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LOGISTICS REPORT

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New Zealand Antarctic Research Programme 1991/92

Event Personnel: A. Pyne (Leader)
R. Powell
E. Broughton
S. Heaphy
D. Statham
G. Falloon (K191)

November 1991 - December 1991

K042 91-92 LOGISTICS REPORT #2

1. AIMS.

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The principal objectives for this seasons research are;

1. Determine the character and thickness of the basal debris layer in the glaciers.

2. Evaluate grounding line processes including debris meltout, sediment deformation, meltwater production (if any) and ground line stability.

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2. PLANNING.

Planning this seasons programme was more difficult than usual because of the uncertainty about the completion of the vibrocoring equipment. We were very pleased that DSIR Antarctic and RDRC understood the developmental problems with the vibrocorer and responded positively to allow us to complete the ROV part of the programme when it became clear the vibrocorer programme could not proceed this season.

We had arranged a "final decision" date with DSIR Antarctic in late September and appreciated that this was a very late date to decide on programme changes for logistic planning.

DSIR Antarctic arranged with NSF for K042 to borrow a Nodwell vehicle with Hiab crane from McMurdo station since it was not possible to air lift the equivalent NZARP vehicle this season. Early inquiries had been made by Dr Rob Dunbar to NSF for the use of the vehicle by K042 in a cooperative programme and this probably assisted DSIR's request.

Our flight date to Antarctica was put back 7 days because of the delay of the ROV cargo arriving in Christchurch from United states (see below for details). This was a sensible delay for the K042 group, however the surveyor (K191) was also delayed because his first main task was the K042 programme. In retrospect the surveyor should have carried out some of his Scott Base programme before K042 arrived.

3. Cargo

The event cargo that originated in Wellington was transported efficiently to Scott Base. The ROV cargo which originated in the United States was however delayed in reaching Christchurch. This cargo was consigned from Illinois with the shippers guarantee that it would be on a ship due to arrive in Lyttleton on 1 November, six days before K042 scheduled departure to Antarctica. The cargo was incorrectly manifested in Los Angeles and then would not have arrived in Auckland until early December. The shipping company did not admit the problem until early November when the cargo did not arrive in New Zealand. The ROV cargo was unloaded off the ship and docked in Los Angeles on 5 November then airfreighted at the shippers expense and arrived in Christchurch on 10 November.

We appreciated the flexibility and efficiency shown by DSIR Antarctic personnel to finally get our equipment to Scott Base in a situation outside our control.

The return of the ROV equipment from Scott Base to Christchurch was also delayed until late January and it was disappointing that it was not given a higher priority at Scott Base when it was ready on 9 December. Because of this planning winter field work in Alaska in March where the ROV could next be deployed was cancelled.

In the future we would hope to plan on air freighting this equipment between USA and NZ which should avoid our major freight problem this year. A more formal system to return <u>priority</u> equipment such as the ROV to New Zealand would also assist future programmes and should be coordinated by the Operations Manager at Scott Base.

Table 1. Cargo to Scott Base.

Description	Cube	Weight	Freight Type.
Origin Wellington			
Green box; scientific equipment	1.18m^3	460 kg	Air, cargo
Green box; scientific equipment	0.25 m^3	≈ 70 kg	Air, cargo
Alloy tubing (3 cm long)	0.015 m^3	≈ 10 kg	Air, cargo
S4 current meter	0.073	20 kg	Air, accompanied
Laptop computer-printer (2 cases)	0.05	15 kg	Air, accompanied
Chilly bin (ROV dredge)	0.1	40 kg	Air, accompanied
Underwater camera (2 cases)	0.1	20 kg	Air, accompanied
Origin USA			

ROV equipment 1 crate	1.13	}	Air, cargo
ROV equipment 2 crate	1.26	}	Air, cargo
ROV equipment 3 crate	1.01	}	Air, cargo
ROV equipment 4 crate	0.056	}	Air, cargo
ROV equipment 5 crate	0.056	}	Air, cargo
ROV equipment 6 crate	0.022	}	Air, cargo
ROV equipment 7 grey suitcase	0.25	}830 kg	Air, cargo

Table 2. Cargo from Scott Base.

Description	Cube	Weight	Freight Type.
Destination Wellington			
Green box; scientific equipment	1.18 m^3	460 kg	Air, cargo
Green box; scientific equipment	0.25 m^3	≈ 70 kg	Sea, cargo
1 pallet & box (LTS container equipment)	2.0 m^3	≈ 450 kg	Sea, cargo
S4 current meter	0.073	20 kg	Air, accompanied
Laptop computer-printer (2 cases)	0.05	15 kg	Air, accompanied
Chilly bin (ROV dredge)	0.1	40 kg	Air, accompanied
Underwater camera (2 cases)	0.1	20 kg	Air, accompanied
Destination USA			
ROV equipment #1 crate	1.13	}	Air, cargo
ROV equipment #2 crate	1.26	}	Air, cargo
ROV equipment #3 crate	1.01	}	Air, cargo
ROV equipment #4 crate	0.056	}	Air, cargo
ROV equipment #5 crate	0.056	}	Air, cargo
ROV equipment #6 crate	0.022	}	Air, cargo
ROV equipment #7 grey suitcase	0.25	}830 kg	Air, cargo

4. Personnel

Alex Pyne	Leader	ARC, Victoria University
Eric Broughton	Science technician	Geophysics, Victoria University
Ross Powell	US Scientist	Geology, Northern Illinois Unviersity
Garth Fallon	NZARP Surveyor (K191)	Dept of Survey and Land Information
Sean Heaphy	Field/Mechanic	DSIR Antarctic
Dave Statham	Plant Operator	N.Z. Army

Our group of field personnel were compatible, enthusiastic and worked well together. The success and enjoyment of the field programme is a consequence of a good field group. It was also pleasing to note that all personnel showed individual initiative when needed to get the work completed.

5. Preparations for the Field

i) Our initial reception, planning and liaison principally with the operations manager at

Scott Base was good. The opportunity ice reconaissance helo flight during a RNZAF helo testflight and pilot familiarisation was a good example of Scott Base management planning and flexibility.

ii) We were very appreciative of the space made available to us in the Scott Base garage. Without this is would have been impossible to assemble and test the ROV systems for the field. Space such as this is obviously a requirement for field events who have complicated equipment to assemble and we hope that a warmed area can be made available to field groups in the future. As expected the testing of ROV took several days and would be likely to take a similar period in a future programme.

iii) The field training programme was more personalised this season because it did not have to accommodate US personnel who often have very different requirements to our own. Our new and old members enjoyed the course however in some cases a course could still be tailored more to the event requirements and skills of event personnel. The question of an appropriate course is also raised each season when experienced personnel are considered who visit Antarctica regularly (each season).

6. Field Transport

ia) NZARP Vehicles.
D5 Bulldozer. This vehicle performed reliably in the field with no major problems. A small glycol leak developed in cab heater but this seems to occur each season. A normal maintenance schedule was carried out in the field.

ib US Vehicles. A Nodwell tracked vehicle with Hiab crane was made available by NSF to this project. The vehicle was checked before departing Scott base and rechecked before return to McMurdo. No significant problems occurred with this vehicle and a small hydraulic leak in the auger circuit was present the entire time that we had use of the vehicle. A normal maintenance schedule was carried out during the field period.

ii) Bombardier Alpine II skidoos. Two vehicles with two VUW boxsledges were used by this programme for reconaissance; surveying and movement of small equipment. The skidoos were sledged most of the way to Cape Roberts on the larger "Italians" Maudheim sledge. The skidoos were used mostly in Granite Harbour and on the return journey to Blue Glacier and Scott Base. Most of the travel was on snow covered sea ice except the bare sea ice around the Mackay Glacier Tongue and South of the Stranded Moraines. Two problems occurred with the running gear of the skidoos. On one machine the steering rod-ski connection sheared at the ski and on the other machine a set of idler wheels became disconnected. Both these problems have occurred on the same model machines used at McMurdo. Travelling on sea ice especially when there is little snow cover is naturally hard on the running gear of skidoos and this type of occasional breakage should be anticipated if the running gear is not strengthened in subsequent models.

(ii) Aircraft operations.
Helicopter sea ice reconaissance. One person in our event (A. Pyne) was manifested on a RNZAF opportunity helo to determine the best sea ice route to Cape Roberts and accessible ROV sites around the MacKay Glacier. This operation was

very successful and invaluable when we had to find an alternative route near Cape Bernaccahi on our return south. It was unfortunate that other members of the event could not participate on this flight because of USAP helicopter problems at this time. In future we would try to have our event personnel on this flight to help them familiarise themselves with the proposed route and other features.

7. Event Diary

13 Nov.	Pyne, Broughton, Powell and Falloon (K191 surveyor) to Scott Base, C141 with 2 RNZAF helos and crew.
14 Nov.	Unpacking ROV equipment and getting cargo ready for Cape Roberts including K024 cargo (2/3 of a cantago sledge). Pyne on sea ice helo reconn. (RNZAF helo in evening) to L. Fryxell, L. Bonney, Marble Pt. Mackay Glacier Tongue.
15 Nov.	Continue preparations at Scott Base.
16 Nov.	Broughton, Powell, Falloon on sea ice survival course in morning. Pyne and Statham with skidoos pick up Falloon at Turtle rock then restablish trig rock cairn at Tent island and survey McMurdo Mooring site.
17 Nov.	Broughton, Powell continue on survival course. Pyne on one day refresher course.. Continue work on ROV in evening and preparing cargo.
18 Nov.	Preparing ROV and cargo. Heaphy pick up T.REX nodwell from McMurdo and check for the field.
19 Nov.	Preparing ROV and in water tests in TVNZ hole in front of Scott Base.
20 Nov.	Final packing of ROV and cargo train. Depart Scott Base @ 1648 hrs in moderate visibility conditions. Visibility decreasing (1920 hours) navigating with GPS and sun. Stopped @ 2230 for night, no visibility @ 77° 47' 18"S, 166° 16' 31"E. Two American Navy Deltas following since Ice Runaway.
21 Nov.	Away @ 0907 hrs. Good visibility and clear ice to off Marble Pt. where Deltas left us 1300-1400. Continue on to Cape Roberts.
22 Nov.	Arrive Cape Roberts 0200. Unload cargo for K024 in afternoon. Check tide gauge and download storage module data. Visited by 3 Greenpeace personnel. Unload K024 cargo # C. Roberts beach. Leave fuel sledge of sea ice and Cape Roberts. Depart 2216 hrs. towing Apple sledge.
23 Nov.	Arrive Mackay Glaicer Tongue (MGT) on south side (site 1) @ 0130 hrs. Make ROV drive hole in tide crack next to MGT ice wall by drilling and explosives.
24 Nov.	Two ROV dives @ site 1 (MGT 91-1, MGT 91-2) Reconn. north side of MGT, all personnel with skidoos.
25 Nov.	Two ROV dives @ Site 1. (MGT 91-3, MGT 91-4).
26 Nov.	To north side (armpit) of MGT by 1320 hrs and make site 2 access hole. Masses of platlet ice at this site, cleared with 44 gal drum and T. REX.
27. Nov.	Preparing and checking ROV. Current meter found to be flooded probably due to leaking connector where repaired.
28 Nov.	Two dives @ site 2. (MGT 91-5, MGT 91-6).
29 Nov.	Two dives @ site 2. (MGT 91-7, MGT 91-8)
30 Nov.	Move to site 3, down glacier on north side. Prepare dive hole and check ROV.
1 Dec.	One dive @ site 3 (MGT 91-9). CTD instrument problems Falloon and Heaphy to survey at Dunlop Island by skidoos.
2 Dec.	One dive @ site 3 (MGT 91-10) CTD instrument problems. Pyne, Statham to

	Cape Roberts to visit helo & VIP partly in afternoon.
3 Dec.	Leave MGT (1243 hrs) for Cape Roberts (1515 hrs). Falloon leaves earlier to set up tide gauge leveling, then checked transducer with underwater camera. Pyne and Powell sampling MGT debris icebergs then to Cape Roberts
4 Dec.	Replaced metmast anemometer and downloaded CR10 storage modules. Returned 1 module for resetting in New Zealand to return to Cape Roberts with Falloon in Jan 92. Falloon complete 24 hour tide gauge leveling then Powell and Falloon to Dunlop Island with skidoo for surveying. TREX and D4 leave Cape Roberts ≈ 1400 hrs. Pyne and Broughton follow after clean-up @ 1515 hrs. Arrive @ Cape Bernacchi 1100 hrs @ John McDonalds camp near iceberg.
5 Dec.	Depart Cape Bernacchi 1312 hrs arrive 1915 hrs at Blue Glacier in light falling snow.
6 Dec.	Drill ROV dive hole with T.REX. Prepare ROV and two dives (BG 91-1, BG 91-2).
7 Dec.	Depart Blue Glacier @ 1219 hrs for McMurdo Mooring site arriving @ 1700 hrs. Prepare ROV for dive. Pyne and Powell check Blue Glacier surface runoff then follow on skidoo.
8 Dec.	Recover McMurdo mooring after releasing acoustic release with ROV. Return to Scott Base by 0130 hrs (9 Dec.).
9 Dec.	Packing and cleaning equipment for return to NZ and USA.
10 Dec.	Cleaned up equipment and T.REX for return to McMurdo. Didn't fly to NZ tonight as expected.
11 Dec.	Cleaned NZI. Pyne, Broughton clean out VUW equipment in university LTS container for ship return to New Zealand. Pyne, Powell, Broughton RTNZ 2330 hrs. Arrive 0830 (12 Dec.).

8. Event Routes

The helo sea ice reconn flight was invaluable when planning the vehicle route to Granite Harbour.

We had no major difficulties with the sea ice route and generally surface travel conditions were good. We crossed a crack (0.6m wide) trending east from Cape Bernacchi on route to Granite Harbour (21 November) without any problems. This crack was only 1-2 days old and continued to widen during the 12 days we were in Granite Harbour. This crack was crossed easily about 1 km offshore off Cape Bernacchi where it split and was only 0.5 m wide on the return journey (4 December). Another crack was crossed between the north end of Dunlop Island and Cape Dunlop going to Granite Harbour (21 November). This crack had widened on our return journey but a crossing place was found and T.REX crossed successfully. The crossing poing however was not suitable for the D5 and it crossed on a better area about 4 km offshore off Dunlop Island. A crack was also present trending southeast from the Stranded Moraines and this was also crossed at a suitable site without difficulty on the journey to Blue Glacier.

The sea ice in Granite Harbour was in very good condition with the normal pattern of cracks acoused by the Mackay Glacier Tongue. The ice in the Harbour would have remained suitable for surface travel well into mid December.

We believe that it would be feasible to work on Granite Harbour sea ice well into mid December if heavy vehicles could be wintered at Cape Roberts so that they did not have to make the return journey along the coast after early December.

9. Weather

Poor weather only hindered our operation on leaving Scott Base when visibility disappeared (≈ 20 km in route) and at the McMurdo Mooring site on our return.

The weather in Granite Harbour was very good with usually clear mornings and summer cloud developing in the mid afternoon.

11. Field Equipment

i The field clothing now available from DSIR Antarctic is very good and kept well up to date. We did find the new windproof bib trousers and jacket to be a bit stiff and the coarse material is very sticky and wet on snow. The older Fairydown material is better in this respect but the cut of the new garments are good.

Gloves are still a problem especially with our sea-sea ice based programmes. where hands get wet from working in the sea. We require finger gloves that are waterproof, flexible and insulating.

iii We were pleased to be able to add to the NZARP 20 manday ration box with some foodstuffs from Scott Base e.g. eggs, cream, yeast for bread; bread, fresh and frozen food. Wannigan living enables us to cook this type of food easily and we would hope to be able to still get these supplies in the future.

iv K042 used wannigan NZI as a kitchen-messing and sleeping unit. The wannigan is well set up for up to 4 people but is a bit more difficult with our 6 event personnel. We temporarily installed a microwave oven for our period in the field because NZI lacks an oven but it would still be better to have a small LP gas combination oven-cook top installed especially for 6 people Space is very limited in the wannigan and better sort of waste handling system could be provided such as 2 or 3 plastic "kitchen tidy" bins appropriately colour coded to split burnable, non-burnable and aluminium refuge before storing outside in larger plastic drums on the cargo sledges.

K042 also used the NZARP apple and sledge to set up the ROV control equipment. The apple was suitable for this purpose but its sledge is not very suitable. The sledge does not tow properly on a strop and had to be towed between heavy sledges to stop it crabing sideways. The runners are too wide for good towing and melt in to the ice when its sunny and the sledge transmitts excessive vibration into instruments in the apple so it had to be towed very slowly.

vi We used the NSF Nodwell vehicle (TREX) as detailed in section 6(ib) and also a 5kVA (110V, 60Hz) ONAN generator to operate the ROV.

All our equipment was returned to Scott Base in good condition. The return of equipment to Scott Base field storemen was generally satisfactory except that it seems that the science personnel are expected to increasingly do more of the work that was traditionally winter work for the field storeman. An example of this is the unpacking and cleaning of food boxes and airing of sleeping bags. Most event scientist personnel have a lot of work to do to clean and pack up their scientific equipment in a short time and they should not be considered free labour by Scott Base personnel during this critical time.

We used the 1 day delay at Scott Base before returning to New Zealand to sort and pack redundant VUW equipment stored in University LTS container.

12. Radio Communications

Communications were generally good this season. The Codan SSB unit installed in NZI never let us down when we were out of VHF line of site communication in Granite

Harbour and in some coastal areas. The coordination between Scott Base radio operators and the operations manager was also very good and it was reassuring that the operations manager was prepared to talk directly to field parties.

13.

K042 used space in the garage to prepare the ROV equipment. This area is a far more practical workspace than the Scott Base lab for field events with large items of equipment that require assembling and testing in a warmed area.

14. Refuge Huts

The Cape Roberts Hut was used by K042 for one day (22 November) while unpacking cargo for Botany Bay. Fuel unloaded or stored at Cape Roberts on 22 November was as follows.

JP8 (209 ℓ drums);	# A892 MT, #A894, #A90189, A8948
JP8 (1 x 60 ℓ);	old drum no code.
Mogas (209 ℓ drums);	#A8945, #A892
LPG	#NZB029

We picked up the apple hut and sledge and used this in Granite Harbgour then returned it to Scott Base.

15. Environmental Impact.

All burnable and non burnable waste was returned to Scott Base. To help manage these wastes in the field on this type of programme plastic barrels with lids could be provided to store separated wastes on the cargo sledges.

Human waste was deposited in augered holes in the sea ice. This is the cleanest and lowest impact method as the wastes are naturally macerated and dispearsed when the sea ice melts and breaks out.

NZARP REPORT #3 POPULAR SUMMARY.
GROUNDING-LINE SEDIMENTATION OF THE MACKAY GLACIER TONGUE

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The Mackay Glacier flows from the Antarctic ice sheet through the Transantarctic Mountains and into Granite Harbour, where it terminates as a floating glacier tongue up to 500m thick, 3km wide and 3.5 km long. In November/December 1991 we explored the tongue with a submersible remotely operated vehicle (ROV) to see whether sediment was being shielded by freezing or melting out onto the sea floor in the area of the grounding line. The question is important because it tells us how far sediment is likely to be carried offshore by polar marine glaciers, and also how the glaciers are likely to behave as sea level rises and falls.

The ROV made ten dives at three sites, one on the southern side, and two on the northern side of the tongue. The Tongue was grounded at both of the latter sites at a depth of 100 and 200m, showing that the glacier was touching the sea floor for at least 1.9 km of the length of the tongue. This was unexpected, and shows that the debris transported beneath the ice and released can build up and out at a measurable rate, accomodating at least low rates of rising sea level. The sea floor on the south side has an abundant biota including bryozoans attached to the stones, indicating that this area has been ice free for a significant period of time.

Sea floor photographs from the ROV show the sea floor to comprise a mixture of sand and mud with scattered cobbles and boulders (diamicton) draped with a thin layer of mud in many places. Transverse ridges and crag and tail features on the sea floor close to the grounding line suggest that shearing and lodgement are important processes when the ice is grounded. The mud layer is presumed to result from post-grounding rain-out. Samples of sea floor sediment were taken for analysis with a purpose built five bucket mini-dredge.

The north side of the ice tongue at the landward end contained numerous layers of rock debris in the lower 20 m. This zone thinned seaward to 10 m over 1.8 km, though it still remaineed coupled to the sea floor, indicating progressive basal melting and presumably deposition of debris by lodgement. However salinity measurements showed no significant deviation from marine values (range 34.66-34.68%.),indicating the very slow rate of basal melting.

The study has shown for the first time the physical conditions at the grounding line of polar glacier, that basal debris is emplaced by lodgement and that meltwater plays little if any role in sediment transport and deposition. It also shows the potential, given the moderate transport rate for basal debris, for marginal marine glaciers building up their beds of subglacial debris to maintain their grounding-line position as sea level rises.