END-OF-SEASON REPORT CRP 1996/97

K001: CAPE ROBERTS PROJECT

EVENT PERSONNEL

J.W. Cowie Ant NZ CRP Manager
A.R. Pyne VUW Science Support Manager
P. Cooper Ant NZ Drill Manager
J. Ridgen Ant NZ Mechanic
B. Reid Ant NZ Electrician
P. Sinclair Ant NZ Carpenter
B. Howat Ant NZ Engineer
J. Alexander Ant NZ CRP Liaison Officer
J. Marcussen Ant NZ Senior Driller

P. Lynch NZ Army Plant Operator
E. Tripp Telecom NZ Technician
K. Roberts Telecom NZ Technician
M. Mahan Ant NZ Science Technician
R. Rogers Ant NZ Facilities Officer/Mechanic
E. Waterhouse Ant NZ Environmental Manager

INTRODUCTION

1. The 1996/97 summer season for the Cape Roberts Project (CPR) was scheduled as the first of the two drill seasons. Unfortunately drilling was postponed because of unstable and potentially unsafe sea ice along the Cape Roberts coast after a major breakout of the sea ice in early July 1996. The Project Manager decided to utilise the extra time resulting from the postponement and continue to improve and test facilities, equipment and operating procedures at Cape Roberts.

2. CRP personnel worked at Cape Roberts on two separate occasions during the season. The main effort was in November and early December and then a smaller team returned in mid January 1997. The main tasks undertaken during the season were:

a. Deploy the drill rig and associated buildings onto the sea ice and trial the drilling system.
b. Deploy the main camp buildings onto the sea ice and erect the cold porch and mess and recreation tents.
c. Construct three frames or platforms on which to store drummed fuel.
d. Install 110 volt wiring system in both laboratories.
e. Test radio, microwave and computer links between Cape Roberts (CR) and Scott Base (SB).
f. Refuel empty drums at Marble Point.

3. Antarctica New Zealand's Environmental Manager visited CR as did New Zealand's Environmental Assessment Review Panel (EARP). Water and soil samples were collected for testing as part of the on-going environmental monitoring of the Project and its impact on the CR and the surrounding area. Separate environmental reports and returns have been filed by the Project Manager, the Environmental Manager and EARP.

4. This year no Science Report has been done on the Project for obvious reasons.

SUMMARY PHASE 1: 21 OCTOBER - 13 DECEMBER 1996

5. **21 October - 12 November**. Reid and Ridgen deployed to SB to begin preparing equipment, food and sledges. Two loaded Cantago sledges were hauled McMurdo (McM) - Marble Point (MPt) by USAP on 29 October. Cowie, Pyne, Sinclair and Alexander arrived SB 06 November followed by Cooper, Howat and Marcussen on 08 November. Helicopter sea ice reconnaissance completed on 07 November. Tripp reactivated radio system and Pyne, Reid and Ridgen remained at CR to prepare vehicles and sledges for trip to MPt. At SB others involved in AFT, vehicle training and finalising Hagglunds sledge loads (x2).

6. CR party departed CR for MPt with D6, Kassbohrer 170 and Aalener sledge (73 empty fuel drums) at 1000 on 10 November arriving there 2000 hours. This was good time given rough condition of sea ice in places and need to replace a tire on Kassbohrer. Meanwhile Alexander, Howat, Marcussen, Lynch and Sinclair departed SB on 11 November in Haaglunds H1 with one sledge to rendezvous with Pyne party at MPt later that day. This party took 6.5 hours. The other Haaglunds sledge was hauled to MPt on same day by the Americans. The two parties rendezvoused late on the afternoon of 11th, the Pyne party having had to replace a track on the Kassbohrer, which in the end took eight hours (60 man-hours in very unpleasant conditions). On 12 November the empty drums were refilled directly from the tanks at MPt in a clumsy operation that involved off-loading the Aalener at the transition, transporting the drums up to MPt depot where they were filled and then returning them to the transition to be reloaded on the Aalener using the Americans' 'T-Rex'. American hospitality at MPt much appreciated. The enlarged sledge train departed MPt for CR at 1315, arriving CR at 2145 (8.5 hours). Cowie and Cooper had meanwhile flown SB to CR in a 'maxed out' K03 (RNZAF Iroquois).

7. **13 November - 13 December**. No time was wasted in getting to work and over the next two days containers were shifted onto the sea ice. The drillers began checking and reorganising their equipment, sledges were unloaded and installation of shelving, heaters and 110 volt electrical supply began.

8. By 15 November the drill rig had been set up on 2.3m thick sea ice about one kilometre northwest of CR and the first 1.2m hole cut in the ice using 'Alex's Auger'. The trailing of the drill system was the main objective of the season and this occupied the majority of personnel over the next nine days.

9. On the first day of drill operations a low-level noise and vibration was detected in the transmission of the drill power pack supplied by the Institute of Geological and Nuclear Science's (IGNS). This transmission had been completely reconditioned with almost all new parts. The source of the noise was easily located although the exact cause of it was uncertain. The noise, although of concern, was not considered to be serious enough to halt operating the rig and it was decided to continue with the trial. At the time of writing transmission parts have been tested in New Zealand for their trueness and new parts may purchased.

10. By the 20th the sea riser and guide base had been deployed onto the sea floor in 34m of water and the submarine video camera, attached to the sea riser, had been successfully trailed producing excellent underwater photography. The mud system (using only water) and glycol heating loop was working well by 22 November with very good circulation and heating of the 'mud'.

11. Unfortunately the trial of the drill system came to an abrupt and premature end on the 22nd when the sea riser could not be embedded in the sea floor because the eccentric under-reamer failed. This was a major set back and cause for concern. On the positive side we can be thankful it occurred in the situation it did and not in deeper water on the first of the 'real' holes. Dismantling of the drill site camp was spread over period 23 to 28 November.

12. Once most of the drill site work was done the focus shifted back to CR itself and to the main camp 'parked' about 500m out from South Beach. On CR three fuel frames were constructed, two of scaffolding tube (to an approved plan) and the third of heavy timber. The scaffolding frames take almost 200 full drums of fuel while the other about 40. All drummed fuel is now either stored on the two dedicated Aalener fuel

sledges (74 drums maximum each) or above ground on the frames. This reduces the environmental risk of drums being frozen in or lost in the snow on the ground and makes for much easier and safer handling (refer attached CRP environmental report).

13. Adding the cold porch and marrying the two large polar tents onto the main CR camp buildings proved a bigger task than first envisaged. Work began in earnest on this task on 29th and didn't finish till 09 December. Keith Roberts. SB Telecom Technician worked on communication system at CR 03 to 06 December checking out the system and rectifying some minor faults.

14. On the personnel side Drs Scott Borg NSF and Terry Wilson Ohio State accompanied by Peter Brookman SB Manager, visited CR and the drill site on 18 November. Lynch returned to SB on their helicopter but returned to CR on 25th for another eight days. On 25 November Cooper, Howat and Marcussen departed CR for SB but ended up at MPt for two days due to bad weather. Antarctica New Zealand's Environmental Manager, Emma Waterhouse, arrived at CR on 30 November and stayed till 03 December when she returned to SB with Lynch. On 5th Waterhouse returned with three members of EARP (Prof. Vernon Squires, Dr Alan Hemmings and Ms Louise Sparrow) for a two hour inspection and familiarisation visit. At 1200 on 11 December the remaining members of CR 'county' (Alexander, Cowie, Pyne, Reid, Ridgen and Sinclair) departed CR for SB in Haaglunds H1 with two laden Haaglunds sledges in tow. MPt was passed at 1600 and arrival at SB was at 2200, a trip of 10 hours. A day was spent cleaning up at SB and visiting the Crary Laboratory and all members of the team returned to NZ on Friday 13 December.

15. CRP personnel were joined at CR this season by members of two other events. The first was a United States Geological Survey team who visited regularly to service their equipment during November. The other was K191, four surveyors, who based themselves at CR from 06 to 12 December. Assistance was given both these parties wherever possible.

SUMMARY PHASE 2: 10 - 22 JANUARY 1997

16. Reid and Ridgen both remained on the CRP payroll over the Christmas period and returned to Antarctica on 10 January with Ron Rogers, all three flying to CR on 11 January. Cowie flew SB on 16 January and following day to CR with Mike Mahan, SB Science Technician. The main tasks were:
a. Complete service of vehicle fleet, mainly Skidoos.
b. Reassemble drill transmission.
c. Install safety rail atop drill rig.
d. Complete environmental monitoring for season, including skua count (refer CRPM's environmental report).
e. Complete and test computer link and download tide gauge data.
f. Winterise facilities.

17 After completing his work Mahan returned SB on 18 January on helicopter that brought John Hall, Operations Manager for British Antarctic Survey, for overnight visit, as well as Jill Veryiken, ASA, Robert Newstubb, NSF Environmental Compliance Officer, and John Haywood, ASA Science Support Construction Coordinator for familiarisation visit.

18. Cowie, Reid, Ridgen and Rogers returned SB on 19 January. On 20th visited Haywood at McM to view and discuss the two Uninterrupted Power Supply (UPS) units that are to go to CR for laboratories at beginning of next season. Cowie briefed SB winter-over staff on Project and how it will affect them from Winfly on next season. Cowie and Reid returned NZ on 22 January. Also worth noting is that the Prime Minister and some members of Antarctica New Zealand's board of managers visited CR soon after - feedback about the facilities and project in general was very positive.

SEA ICE REPORT

19. The sea ice reconnaissance of 07 November concentrated on finding a safe route from MPt to CR. Much of the ice to be traversed was extremely broken and rough. The largest crack encountered trended southeast from Dunlop Island and was almost certainly the line along which the July breakout occurred. It was 10 metres wide, snow filled and the ice only 1 metre thick compared to the surrounding ice which was 1.5 metre plus. At the time we didn't have the time or helicopter resources to confirm it but we suspected that much of the sea ice along the coast was a mosaic of plates joined by thinner and weaker snow-filled cracks. As expected, on the return traverse to SB on 11 December we encountered about six significant cracks that were becoming quite active.

20 On 25 November a helicopter-supported sea ice reconnaissance was made over the proposed drill sites. Nine holes were drilled in the area of the proposed drill holes. Ice thickness was between 1.6 and 1.8 meters. This thickness exceeded the Project's minimum operational requirement but it is unlikely that it would have been thick enough to operate on in early October. A feature of approximately half the holes drilled was that there was a weak wet zone in the ice at just over 1 meter which suggested late formation. (Refer attached sea ice report by Pyne).

21. The ice edge this season in the vicinity of Cape Roberts was indeterminate and clearly thin, 'watery' and well broken up. The 'Cape Roberts crack' was, as expected, clearly in evidence about 1.5 kilometres off the Cape. It was the probable boundary of the July breakout and this season appeared to be very active, wider than usual with lots of water exposed and longer than usual, extending much further south than in the last three seasons. Associated with it was a large pressure ridge system. Given the state of the ice edge, the extent of the annual Cape Roberts crack and the uncertain strength of the cracks joining the large ice platelets, we doubt that a ship off-load operation of the type done in January of the previous two seasons could have been undertaken in November let alone later.

22. When we returned to CR on 11 January 1997 the transition had collapsed and the sea ice inland of the Cape Roberts crack had broken up exposing watery cracks and small areas of open water. Vehicle operations on the sea ice were impossible yet in the previous year and a week later we had carried out a major ship off-load nearly 20 kilometres from land. The longer term affect of the mid-winter breakout and the ensuing instability probably played a significant part in the early breakup of the sea ice both to the north and south of CR.

VEHICLE OPERATIONS

23. Vehicle usage was relatively light across the fleet and there were no major breakdowns or damage. Most work, other than servicing, was done on the Kassbohrer - a new tire, new tracks and new hydraulic blade hose - and the four Skidoos which Ridgen and Rogers spent about six days thoroughly servicing, in particular the undercarriages. The Kassbohrer had one major hydraulic failure which drained about 50 litres of fluid onto the sea ice and a number of minor leaks (up to 10 litres lost). Experience tends to indicate that the greatest pollution risk we run on CR is from a hydraulic spill (line burst or leakage) on a vehicle or the drill rig. Closer monitoring of hydraulic systems will be undertaken in future.

HELICOPTER OPERATIONS

24. Twenty five hours helicopter time was allocated to CRP for the season and 16.5 hours actually used/'charged' against K001. Overall pleased with way helicopter operations were integrated into the effort this season - number of flights, and therefore hours, were minimised. Cooperation and timing between SB and CR was very good and the helicopter crews positive and helpful, with one isolated exception - RNZAF's K03 about which SB Manager was notified. One positive point about the new civilian operator that became apparent with time was that because of their policy of 'shutting down' as a matter of course there was better communication between us and them, almost no hassle and stress operating around the helicopter and more effective loading and unloading of it.

ENVIRONMENTAL SUMMARY

25. A separate environmental report is attached. In brief the key points were:
a. All fuels, oils and lubricants (FOL) are now stored above ground on three new platforms or racks away from the main vehicle thoroughfares and storage areas and close to the shoreline.

b. Nine soil samples and five water samples were taken for hydrocarbon analysis from the storage area of CR. Results received so far from eight soil samples show no evidence of contamination.

c. A survey of the skua population around the CR storage area was done in mid-January. The number of birds and chicks was up considerably on last year's count.

d. Ground disturbance by heavy plant and sledges within the storage area while unavoidable continues to be of concern.

e. There was a hydraulic fluid spill of about 50 litres on the sea ice off the South Beach and minor leakage of hydraulic fluid at about four locations in the storage area. These all came from the same vehicle, the crane-mounted Kassbohrer, which was in constant use throughout the period.

f. All rubbish accumulated during the season was returned to SB with the exception of waste oil which will be done on an 'as required basis'.

WEATHER

26. Although the weather at CR this season was more variable than the two previous seasons - about third of days heavy overcast with winds - the work schedule was unaffected.

SAFETY AND HEALTH

27. No accidents were reported during either phase at CR this season. There were however two instances of ill health. Over the period 19 - 22 November about half of the team were affected in varying degrees by 'flu-like symptoms (off-colour, elevated temperature, joint/muscle aches, sinusitis). One person was confined to bed for two days otherwise the others were not affected severely enough to stop work or forgo their recreation trip on their day-off. The second 'flu incident occurred in January and coincided with a major outbreak at McM and SB. One person was moderately incapacitated for about four days at CR and the other 'crashed' upon returning to SB.

28. There was one incident which resulted in irreparable damage to a video recorder unit in the Video Hut at the drill site. Electronic equipment had not been stored or secured when a plant operator decided to move the Video Hut when dismantling the drill rig. Compounding the loss of the equipment (and it could have been much greater) was the fact that shifting the Hut was attempted without first getting the OK from Science Support Manager and without assistance to ensure everything was secure and there was no danger to anyone in the vicinity. The situation was made worse by the use of a nylon strop which stretched on take up because the skis were iced in. When they suddenly released the building jerked forward violently. This incident provided the opportunity to reinforce the need for safe operating procedures which include having a buddy to direct the operation and ensure people and equipment are not endangered, and to use a rigid draw bar when freeing up a frozen sledge.

28. There was an incident at SB that CRP personnel will be made aware of. The SB Plant Operator was decoupling an empty Hagglunds sledge from the Hagglunds vehicle after CR personnel had returned to SB in December. He failed to deploy the jockey wheel of the sledge to take the sledge's weight so that when he lifted the draw bar off the vehicle the 'box' or upper part of the sledge cantilevered forward and the draw bar struck his leg (thigh/knee?). The blow and subsequent bruising incapacitated him for a few days.

COMMUNICATIONS

29. The phone line and VHF links to SB were again effective. No attempt was made to install a fax this time. The headset intercom system on the drill rig was used for the first time and proved very good. One area of communications that needs addressing is a headset system for use in the Hagglunds to overcome the noise while driving. In coming radio messages can't often be heard and it is difficult to communicate with the passenger/navigator as well.

Jim Cowie
Cape Roberts Project Manager

Enclosures:
1. CRP 1996/97 Environmental Report by CRPM dated 12 Mar 97.
2. Draft CRP Sea Ice Report by Alex Pyne dated 12 March 97.

CAPE ROBERTS PROJECT
1996/97 ENVIRONMENTAL REPORT

INTRODUCTION

1. Under the revised Comprehensive Environmental Evaluation (CEE) schedule for the Cape Roberts Project (CRP) the 1996/97 Summer Season would have seen two holes drilled in the sea floor some 15 kilometres east of Cape Roberts. Unfortunately, in August 1996 drilling was postponed for this season for safety reasons after the fast sea ice along the Cape Roberts coast had broken out in early July.

2. It was decided to use this 'extra' season to further improve the facilities already stored at Cape Roberts and to do a trial run of the drill system, something that the Project Manager and his team had been unable to do either in New Zealand or at Cape Roberts because of tight time constraints. The additional time offered by the postponement proved valuable in ironing out many small problems related to the operation of the main camp and, more importantly, the drill rig. It also gave the support team and drillers time to reflect on operating procedures with a view to increasing efficiency and safety and reducing environmental risk.

3. The main tasks undertaken in two periods of occupation at Cape Roberts (November and part December 1996 and mid-January 1997) were to:
a. deploy the main camp buildings onto the sea ice 500 metres out from South Beach and erect the cold porch and mess and recreation tents;
b. deploy the drill rig and associated buildings onto the sea ice about one kilometre north west of Cape Roberts and trial the drilling system; and
c. construct three frames on which to store drummed fuel.

4. Numbers of personnel at Cape Roberts varied during the season as people came and went. During the summer people were at Cape Roberts for a total of 42 nights. In all this amounted to some 300 person-nights (including the surveyors). Two other scientific events, unrelated to CRP, used Cape Roberts during the summer. The first was an American event ('S' number unknown) which in mid November set up GPS equipment on the flat rock outcrop about 100 metres from the hut and then proceeded to monitor it with regular helicopter visits (about five) for the next three weeks. The second group was K191 surveyors, four of whom lived at Cape Roberts for a week in early December. They utilised helicopters daily.

5. As in the previous summer Emma Waterhouse, Antarctica New Zealand's Environmental Manager, visited Cape Roberts for four days to observe operations and collect soil samples. Later, on 05 December, she accompanied three members of the Environmental Assessment Review Panel (EARP) who were given a tour of Project facilities and briefed on the CRP operation by the Project Manager. Both the Environmental Manager and EARP will complete independent reports based on their visits.

ENVIRONMENT INCIDENT REPORT FOR 1996/97 SEASON

6. **Ground Disturbance**. The CEE acknowledges that the 7,000 square metre storage area approved at Cape Roberts has a history of human and mechanical impact and probably some small degree of pollution from fuel spills and human waste. The CEE also acknowledges that continued impact and possible pollution is likely to occur during the Project adding to the cumulative impacts of the last 30 or so years. To help measure the impact and possible hydrocarbon pollution soil and water samples have been taken and monitoring plots set up both within and outside the storage area.

7. In his 1995/96 End-of-Season Report the Project Manager reported that an area of approximately 1,000 square metres had been cut up by tracked vehicles and sledges. Because of a thinner snow cover and an early thaw the ground disturbance was even greater this summer. The area affected probably extends to 2,000 square metres, mostly to the west and north west of the permanent huts. The Project Manager, while concerned at the extent of the disturbance, is nonetheless confident that the area can be physically restored to its pre-Project state when all equipment is finally removed.

8. **Fuel, Oil and Lubricant (FOL) Spills.** No fuel spills were observed by or reported to the Project Manager during this summer season either on Cape Roberts or on the sea ice. Refer to Fuel Management section of the EARP Checklist Report January 1997.

9. There were however, spills of hydraulic fluid ranging from minor to medium size. The largest spill (14 November 1996) was approximately 50 litres (the size of the hydraulic reservoir) onto the sea ice off South Beach. It was caused by the rupturing of a low pressure hydraulic line underneath the PB 170 Kassbohrer while it was being driven. The spill was spread over a 300 metre trail about 300mm wide. It was undetected for about one hour. A thin yellow line was then observed across the exposed sea ice. A clean up team of five was quickly on the job. Where the hydraulic oil had contaminated snow covering the ice, this was shovelled up and loaded into the two available skidoo sledges. Because the quantity of contaminated snow was big the decision was made to dump it in an active crack about one kilometre further out on the sea ice. By doing this all contaminated snow was removed as quickly as possible from close into shore. The oil that landed on the exposed hard sea ice had penetrated the ice and proved impossible to recover. Three weeks later evidence of the spill on this hard ice was hard to detect.

10. The other hydraulic leaks detected were from the same vehicle at four sites on land. The mechanic calculated 12 litres was lost but it can be assumed that up to half of this would have been on the sea ice where the Kassbohrer spent a lot of time operating. The leaking oil is difficult to detect because it leaves only a tell-tale hole in the snow. Days later a yellow honeycomb patterns appears in the snow as it thaws. This was cleaned up.

11. Hydraulic systems such as the Kassbohrer has are prone to 'weeping' type leaks and sudden failures, especially in Antarctica because of the cold. Often there is no sign of wear or damage prior to the failure of a line or connection. 'Slow' leaks are often difficult to detect in their early stages. As a result of the experiences associated with the Kassbohrer this season the vehicle fleet is being regularly checked for hydraulic leaks and possible damage or wear to hydraulic parts. Drip trays are available as a temporary measure to deal with leaks. The drill rig has a large hydraulic system and to reduce the risk of leaks or a sudden failure a large tarpaulin has been designed to hang under the drill floor to collect oil that might leak or flow.

J.W. Cowie
Cape Roberts Project Manager - 12 March 1997

Enclosures:
1. EARP Checklist For Inspection Jan 97.
2. Selection of photographs of Cape Roberts storage area 19 Jan 97.
3. Map of skua population. Cape Roberts 18 Jan 97.

K 043
1996/97

LOGISTICS REPORT

K 043 : Raised Antarctic Beaches, Isostasy and Dating

Antarctica New Zealand 1996/97

Event Personnel: J Shulmeister (Leader)
J Quinn
E Butler
P Webb

December 1996 - January 1997

1. Aims

The aim of this event was to look at raised beaches along the Scott Coast from Cape Bernacchi to Dunlop Island. These features have developed since the last glacial maximum approx 18,000 years ago when the ice sheets were at their greatest extent. The weight of the overlying ice depressed the land which has been slowly rebounding after melting of the ice. While rebounding a series of beach ridges were formed.

One part of the project is to date the beach ridges and associated rock platforms by three different methods and obtaining their relative heights above sea level today. This will allow modelling of the volume and extent of the ice during the last glacial maximum.

To obtain a height above sea level today it is necessary to know where sea level was on the raised beach ridges. The second part of the project looks at the modern beach formation. Linking processes found here to features in the raised beaches should give an accurate position of sea level on the raised beaches.

The third part of the event was to use glacial striations, moraines and cosmogenic dating to work out whether the ice depressing this part of the coast came from an expansion of the Wilson Piedmont Glacier or an advancement of the Ross Ice Shelf onto the coastline.

2. Planning

(i) Application: No problems.

(ii) Antarctica New Zealand staff: The staff were very helpful with requests.

(iii) Maps etc: The librarians were very helpful in providing the few air photos available in the library and putting us onto other contacts.

(iv) Pre-season training course: This could do with some revision. The weekend course in Christchurch involved a lot of lectures which did not seem to be particularly relevant. In terms of the science side of things, the brief five minute talks given to everyone is possibly all that is required to advise other science parties. At this point, if there are other groups doing science of interest this can be followed up in person.

The practical sessions were ok, but it may be preferable to ask people to do a first aid course instead of trying to teach everything in such a short length of time (Christchurch component).

An alternative bad weather option needs to be considered for the Flock Hill training. The science parties had no proper training in setting tents up in a field situation due to the bad weather which makes things more difficult in Antarctica.

(v) Medicals etc: These all went smoothly with no problems.

3. Cargo

Two boxes of equipment were shipped to Antarctica before the event. These were non-delicate equipment and very tough cardboard boxes were suitable. They arrived in Antarctica in good condition. We required excess hand carry for equipment such as computers. Getting the excess weight allowance was not a problem and went smoothly. It is suggested that it is made clear this is likely to be taken off the person so should be packed accordingly (ie.. packaging around the computer).

4. Personnel

Dr James Shulmeister
Lecturer
Department of Geology, Victoria University of Wellington,
P.O. Box 600, Wellington, New Zealand
Dr Shulmeister is the supervisor of Edward Butler and adviser to Julie Quinn.

Julie Quinn
PhD Student
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Edward Butler
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Peter Webb
Honours Student / field assistant
Department of Geology, Victoria University of Wellington,
P.O. Box 600, Wellington, New Zealand

5. Preparations for the Field

Despite a delay in arriving at Scott Base everything at went smoothly in the time before we went into the field. We were warmly welcomed to Scott Base and the staff were most helpful with the endless questions. Our equipment had arrived and was in order. The field training seemed to take up a great deal of the time we had due to the overnight exercise being delayed (New Years Eve). Excusing Julie Quinn from the overnight exercise allowed the science preparation to be done without a last minute panic. The equipment the party received was in good condition and it was easy to change

our requirements after discussion with Mess. Being able to organise a resupply of frozen food with the Scott Base staff was most useful as we had difficulty keeping food frozen. This was easily done due to the helpful nature of the staff.
Parts of the field training were not particularly useful to our event (much of the snowcraft was not required as we were never on any permanent snow). However, there were other groups on our AFT who needed this training. We had a brief rundown (10 minutes) on the sea ice which was the most important part of our training. Perhaps next summer if there was a second AFT training person the crevasse part of the course could be dropped and this time spent on sea ice training. A fuller brief to the AFT people beforehand may allow this to be organised.

6. Field Transport - Aircraft Operations

Our event was supported by both American and New Zealand helicopters. We had 5 double shuttles in total, 2 by K03 and 3 by the Americans as well as other contact, such as resupply and taking rocks out of the field. We were most impressed by both crews, finding them friendly and professional in their approach. Baring one move the helicopters shut down initially to organise gear which was useful as it gave us a chance to describe where we wanted to be placed and other such details. The crews were helpful in choosing a suitable site on the ground, giving us plenty of time (considering we were only seeing it for the first time) and consequently we had excellent camp sites. When working with the American helicopters we had sling loads. No training had been given to us in New Zealand about to how to load a sling load etc. This was not a problem once the pilot had explained what he wanted but it would be a useful part of the pre-season training. A little more communication from Scott Base as to when the helicopter is arriving, should the schedule be changed, would be useful instead of us needing to contact Scott Base. This caught us out on one occasion when the weather was bad at Scott Base and we were not aware (packed up camp), only to be told later after calling Scott Base. Overall we were very happy with our helicopter operations.

7. Event Diary

3 January 1997	Flown Scott Base to Marble Point in a double shuttle. Set up camp and walked around Marble Point for familiarisation. Fine, warm, S breeze.
4 January	From Marble Pt to Gneiss Pt, reconnaissance and initial work. Helo trip with surveyors taking air photos. Fine, calm, hot.
5 January	From Marble Pt to C. Bernacchi, reconnaissance and initial work. Fine, cool, light S. breeze.

6 January	Survey from Marble Pt along beach, work done on profiles AC1 and AC2. Fine, cool, light NE breeze.
7 January	Work in Surko St. area, surveying and profile AC4. Sunny, part cloud, light N. breeze, warm.
8 January	Continued AC4 profile, surveyed to Gneiss point, glacial striations on Gneiss point, pits dug at AC3. Cool/cold, S wind ~10 knots, cloudy with light snow flurries, low ceiling.
9 January	Samples from pocket beach, Marble point, AC3 holes logged. Snowing, S wind ~15 knots, cool.
10 January	Samples from AC6, AC3 holes logged, glacial striations/samples from Gneiss point. Overcast, lightly snowing, calm.
11 January	Surveying back to Marble Pt, Glacial moraines at Hogback hill. Fine, warm, light breeze to calm.
12 January	Survey of Pocket beach Marble Pt, ACB4 holes dug/logged, South St glacial striation work. Snowing, S breeze 15-20 knots, cold.
13 January	Marble Pt transect surveyed, ACB4 holes dug, South stream section cleared. Sunny to cloudy, light wind, warm.
14 January	South Stream samples and section, ACB4 holes logged. Sunny, light S 0 - 2 knots breeze, warm.
15 January	Marble Pt transect described and sampled, hole dug and logged. Fine - overcast, light S breeze, warm.
16 January	Triple shuttle to Kolich Pt, camp set up and reconnaissance. Fine, calm to light NE breeze, hot.
17 January	Kolich Point survey and beach work. Fine, cool, light but cold S breeze.
18 January	Kolich Point beach section, beach surveying. Fine, calm to light NE breeze, hot.
19 January	Kolich Point beach section, sample collection, glacial striation work. Overcast, S breeze 5 - 10 knots, cool.
20 January	Double shuttle to Spike Cape. Camp set up and reconnaissance. Fine, some cloud, S breeze, cool.
21 January	Surveying Spike Cape, samples from southern platform, look at southern active beach. Fine, cool S breeze 10 knots, warm.
22 January	Surveying Spike Cape, samples from northern platform, holes dug on mainland. Overcast, calm, cool. Sea ice broke out from bay at Spike Cape.
23 January	Surveying Spike Cape, holes dug and logged on mainland. Overcast, slight N breeze, cool.
24 January	DV visit, TL sample and hole logging, glacial moraine/striations. Overcast/fine, cool, slight N breeze.
25 January	Shuttles to Dunlop Island (helicopter problems). Camp set up and reconnaissance. Light S breeze to calm, warm, overcast to fine.
26 January	Samples from Eastern end, surveying to the NE, beaches logged. Cool, overcast, gloomy, snowing from midday with S breeze.

27 January	Surveyed to the south, samples from top of island, beaches logged. Fine, cold S breeze 10 - 15 knots, cool.
28 January	Surveyed to West, holes dug and logged. Fine, S breeze 10 - 15 knots, cold.
29 January	Double shuttle back to Scott Base. High overcast, S breeze, cool.

8. Event Map

Attached are four maps detailing camps and sites where holes were dug and rock samples taken. Also attached is a copy of a section from the USGS topographic map which has inaccuracies close to Kolich Point and between Kolich Point and Spike Cape.

9. Weather

We had no meteorological equipment to provide a detailed account of the weather encountered. In general the range of temperatures experienced were quite warm. On a few occasions the temperature may have reached +5° C but on most days was between -5° and 0° C. Wind chill was usually the only thing that made the temperature feel cold. We had a variety of cloud cover, with considerable variation during the day from 0/8 to 8/8. In general the coast seems to be in a fringe zone between the weather that the dry valleys and mountains receive and the weather of the Ross Sea/Ross Island area. Often this fringe zone meant the weather would look bad elsewhere while still being good over the coast. We had three spells when there was snow. These were short lived (1/2 to 1 day) and were not bad enough to hinder work to any great extent. The second snowfall put an estimated 10 - 15 cm of fresh snow (undrifted) on the ground while the others were considerably less. The weather was of little hindrance except where the snowfall covered rocks!

10. Accidents, incidents or hazards

There were no accidents during the field season.

11. Field Equipment

(i) Field Clothing: Overall we were happy with the field clothing issued. Some of the small clothing sizes were too large for Julie Quinn, and would be a problem for smaller females. The anoraks are not particularly useful in the field and are not very warm. It is suggested that these are not recommended over the windproof jacket. For people working on the coast it would be useful if Antarctica New Zealand suggested leather boots as well as the sorrels as footwear. The three people who took theirs found them to be a valuable addition to the boots supplied. The hats supplied were not very popular with everyone wearing their own for most of the time. The insistence of people wearing woollen underwear on aircraft seems a little excessive. In the event of a fire on an aircraft, should the fire be sufficient to get through the other layers it is going to be serious enough to be life threatening in other ways.

(ii)Tents etc: We understand we were the last party to use the tents that were given to us. The lack of side pockets and small door in one of them was not liked. All other equipment was in excellent order and functioned well. The only thing we were not supplied with which would have been useful was waterproof groundsheets. The ground where we were camping was not frozen and consequently damp in places. Fortunately we had our own tarpaulins (for other purposes) which were used in addition to the existing groundsheet.

(iii)Ration Boxes: Overall these are great! A few items that could be added to the boxes without great changes are some more sachets or similar to make the main meal interesting (such as "cook-in-the-pot" sachets). For milo drinkers it was disappointing to see that this is not standard in the boxes as well as tea and coffee. The additional items selected to take into the field are important in keeping variety in the food (and hence interest). We found the small bags of scroggin were not as popular as muesli bars and chocolate as they tended to burst and fill pockets/packs with peanuts etc.
The only risk with the Scott Base diet is getting fat! The few days at Scott Base were great with lots of variety and choice, all done to a high standard.

(iv)Specialised Equipment: The small 650 - 800 watt generator given to us was perfect. It started with no problems, usually on the first pull, and kept on running faultlessly. The poinjar was an essential piece of equipment for digging the bottom of holes. This worked really well with no problems.

12. **Radio Communication**

(i)Equipment: We were supplied with two VHF radios and a whip. The whip was never required and hence untried. With a second battery we were able to have one of the radio's on for most of the day listening (as turned out to be useful on the odd occasion). Batteries worked well with charging from the solar panel and occasionally the generator.

(ii)Reception: We had no problems talking and receiving Scott Base and hearing other field parties. The timing of skeds worked well with a sked in the evening.

(iii)Scott Base: The three operators at Scott Base were excellent. Any news for us was passed on and weather and news offered. We found though that the weather forecast for field parties is not very helpful as it is an extremely localised one to Scott Base. In terms of the odd phone call out and in to the field the operators were very good at trying to get these through. The only thing we found frustrating was getting answers to queries. We are not sure at what point the messages got hung up but a reply on the next sked along the lines of: "the person had received the message and it is being worked on" would be helpful. Then we would not feel like we had to keep asking.

13. Environmental Impact

See attached pages.

14. Historic Sites

While at Scott Base the historic hut at Hut Point (Scott's 1902) was visited (1 January 1997). General observations were that it has been kept in good order, both inside and out.

15. Management of Science in the Ross Dependency

This event was the first year of a two year plan of field work in the area. It was difficult for the second year to be planned well without the knowledge obtained from the first seasons field work. For a project like this I think that it is important that both seasons work is evaluated in peer review as a single event. This does not put the second seasons field work in jeopardy when the whole project requires both.
Antarctica New Zealand is in the ideal position to cater for this event, the location of Scott Base allows easy access to the ice free coast where post-glacial rebound is occurring. With the combined logistics of the Americans the potential support is far greater than anyone else could offer. The project is a joint effort between Victoria University of Wellington and The Australian National University. This is a valuable collaboration as it allows the experience and knowledge of scientists working on the same ice sheet reconstruction problem in East Antarctica to be applied to the Scott Coast to provide a more holistic approach to the problem.

Antarctica New Zealand
Environmental Return

1996-97 SEASON

Complete all relevant sections and include in Logistics Report

Event no. K043

Permit no. __________ (if applicable)

Use of chemicals including radionucleides in Antarctica.

Complete the following for each chemical and radionucleide taken to Antarctica

Chemical form	Locations used (long, lat)	Quantity (u Curies where applicable)

Were all chemicals returned to New Zealand.. ☐ Yes ☐ No

If NO detail why, location, quantities of material released or stored

Did the use of the radionucleide(s) comply with permit.. ☐ Yes ☐ No

If NO detail why non-compliance

Use of explosives.

Detail any use of explosives.

Date	Location (long, lat)	Explosive type	Size of charge kg	Number exploded

Importation of animals, plants (includes seeds), microorganisms or soil to Antarctica.

Detail each species and quantities taken to Antarctica

Species | Quantity

Were all these returned to New Zealand........ ☐ Yes ☐ No

If NO detail why, locations (long, lat) and quantities released.

Did importation comply with permit........ ☐ Yes ☐ No

If NO, detail why non-compliance

Collection, tagging, killing, restraining or handling any terrestrial, freshwater or marine, plant or animal, or collection of geological material.

For each location eg Cape Evans, Cape Bird, SE Bull Pass etc detail each species handled in any way, or material collected

		Numbers or amounts in each category				
Species or geological specimen type	Location (long, lat)	Caught or collected	Tagged or banded	Killed	Restrained	Differ from permit Y/N
eg Adelie Penguin	Cape Bird	25	25	0	25	N
eg Ventifacts	SE Bull Pass	2				N
Rock Samples	**	730 lb				N
Sediment Samples	**	30lb				N
Shell Samples	**	20 shells				N

If collection etc differed from any permit issued in accordance with the work, please state how:

The amount of rock sample was greater than originally estimated due to better than expected exposure (to sample from).

** Samples were taken from four sites; Marble Point, Kolich Point, Spike Cape and Dunlop Island.

Summary of locations occupied

Complete the following for each site occupied by your event

Sites Occupied or visited	Field Camp Location (For field camps give longitude and latitude or map reference)			Dates Sites Occupied		Total Days	Number of people	Total person-days at location	Previously used camp site Yes/No
	Latitude	Longitude	Map and Ref	From	To				
Scott Base	77°51.0S	166°46E							
Vanda Huts	77°31.35S	161°41.38E							
Cape Bird	77°14.0S	166°28.0E							
Marble Point	77° 26.2 S	163° 46.5 E		3/1/97	16/1/97	13	4	52	NO but in a disturbed area
Kolich Point	77° 21.5 S	163° 33.1 E		16/1/97	20/1/97	4	4	16	NO
Spike Cape	77° 18.7 S	163° 32.7 E		20/1/97	25/1/97	5	4	20	NO
Dunlop Island	77° 14.3 S	163° 48.0 E		25/1/97	29/1/97	5	4	20	NO

Notes:

Details of entry to Protected Areas.

List any protected area, Specially Protected Area (SPA) or Site of Special Scientific Interest (SSSI) you entered.

Name of SPA or SSSI	Date Visited	Party Size	Total Person-days in Area

Did your activity in the area differ from that stated in your permit ☐ Yes ☐ No

If YES detail why non-compliance

Details of equipment left in the field

Include any equipment, markers, stakes, cairns, human waste or fuel (including spills)

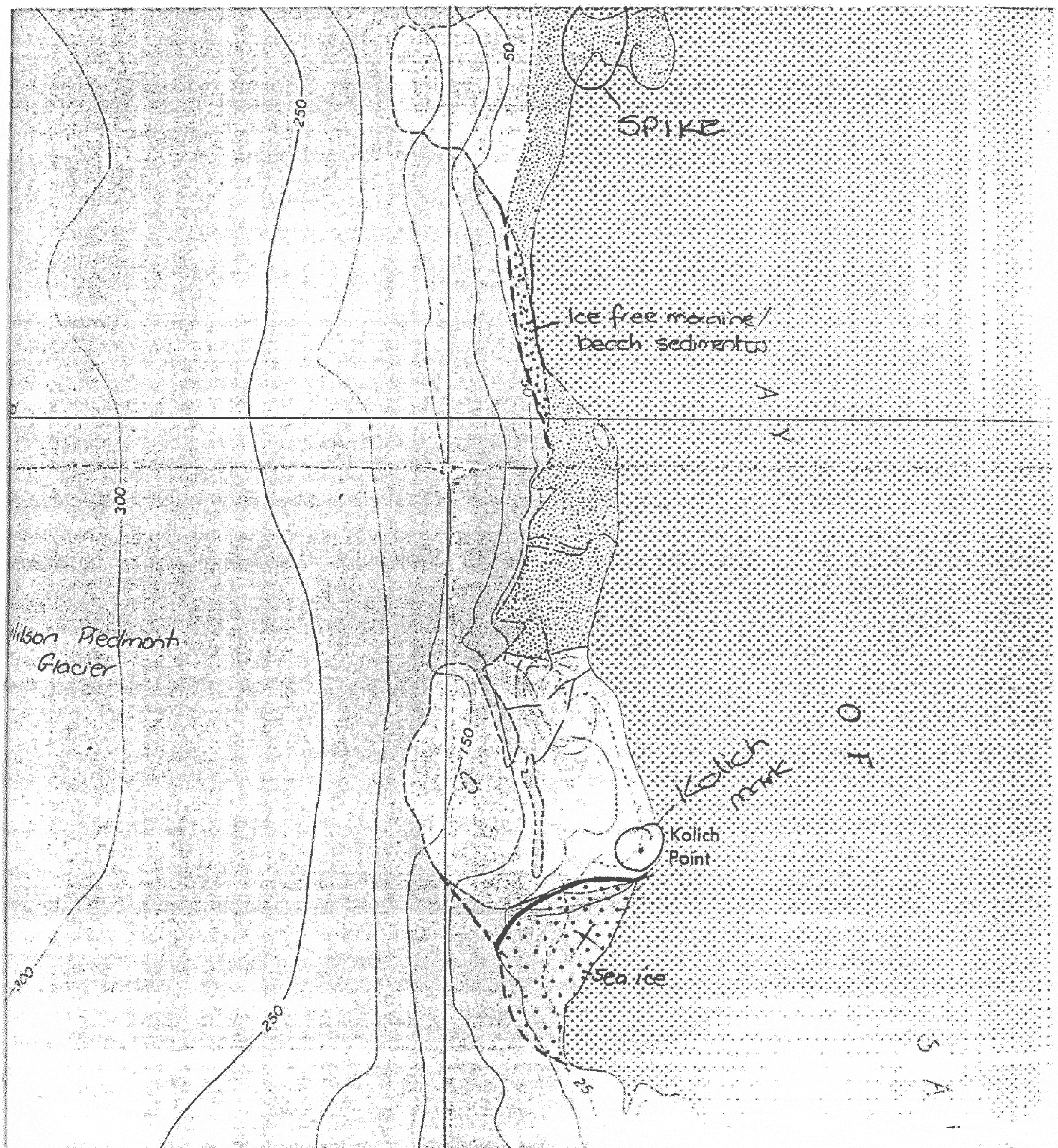
Item	Size, Number, Quantity	Location (long,lat)	Reason

Other impacts (e.g. disturbance by sampling, trampling, camp operations, installation of equipment, buildings, cumulative impacts)

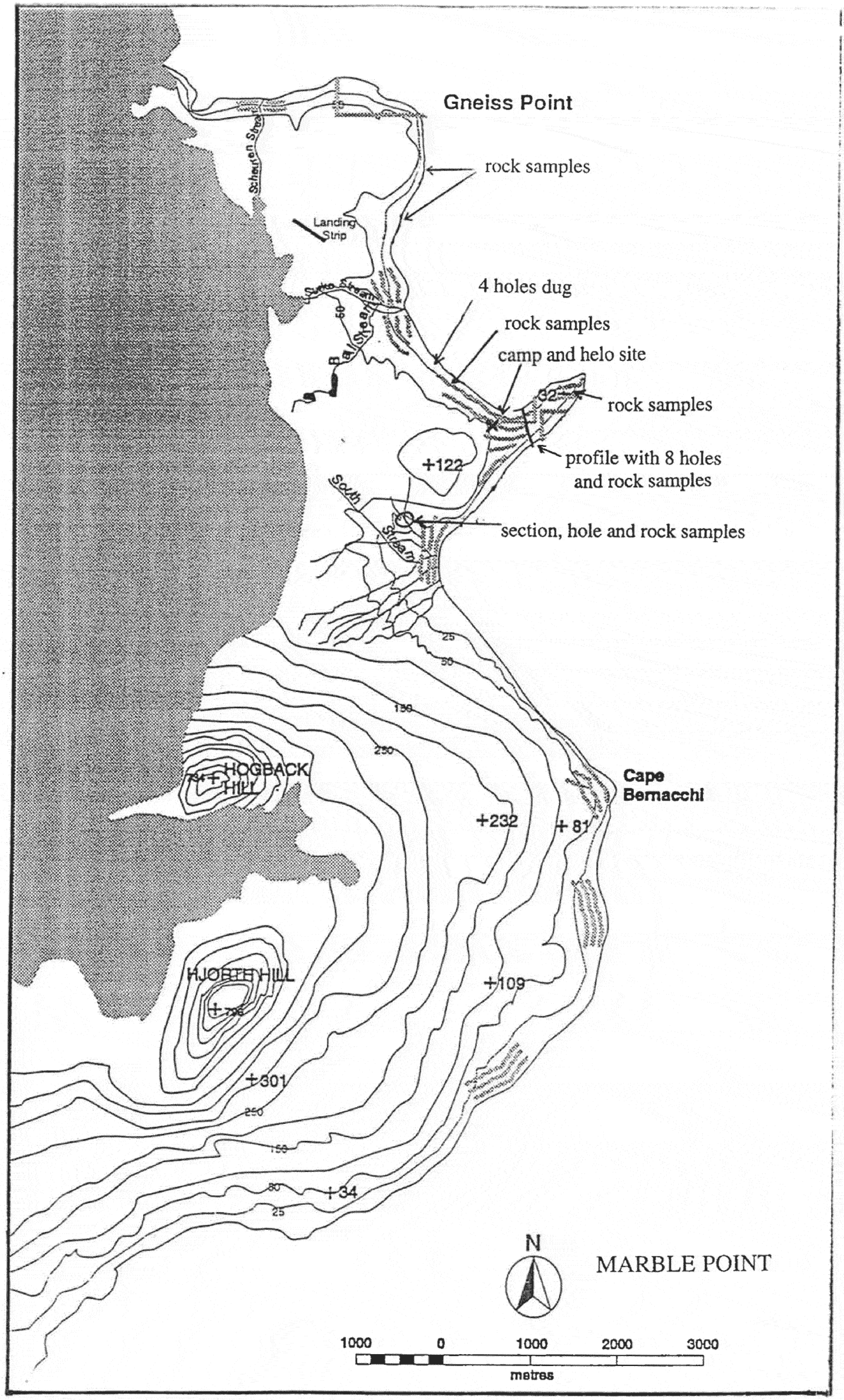
Detail any other environment impacts from your activity. In particular detail those impacts which differed from those stated in your pre-season environmental evaluation.

Twenty-six holes were dug. These were typically 1.5 - 2 m long, 0.5 m wide and 1.5 m deep. This was a smaller impact than previously stated pre-season. Holes were filled in and returned as close to the original state as possible. Two sections were cleared. Each of these were ~5 m long/high and 1 m wide. All this consisted of was taking the surface off existing profiles. They were covered again as well as possible. Approximately 50 rock samples were taken - small areas of rock typically 15 cm by 15 cm.

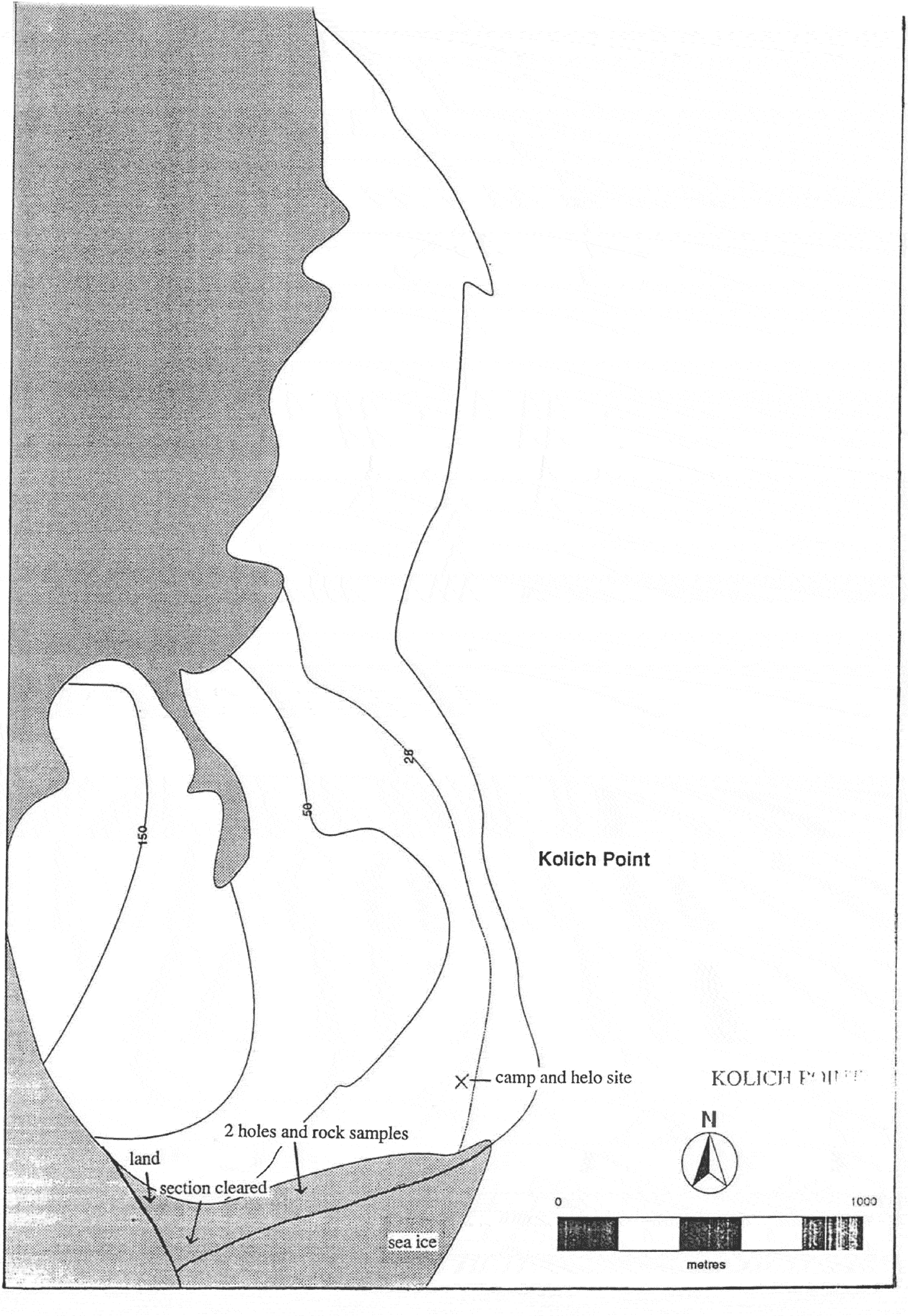
Approximate corrections to the topographic map.



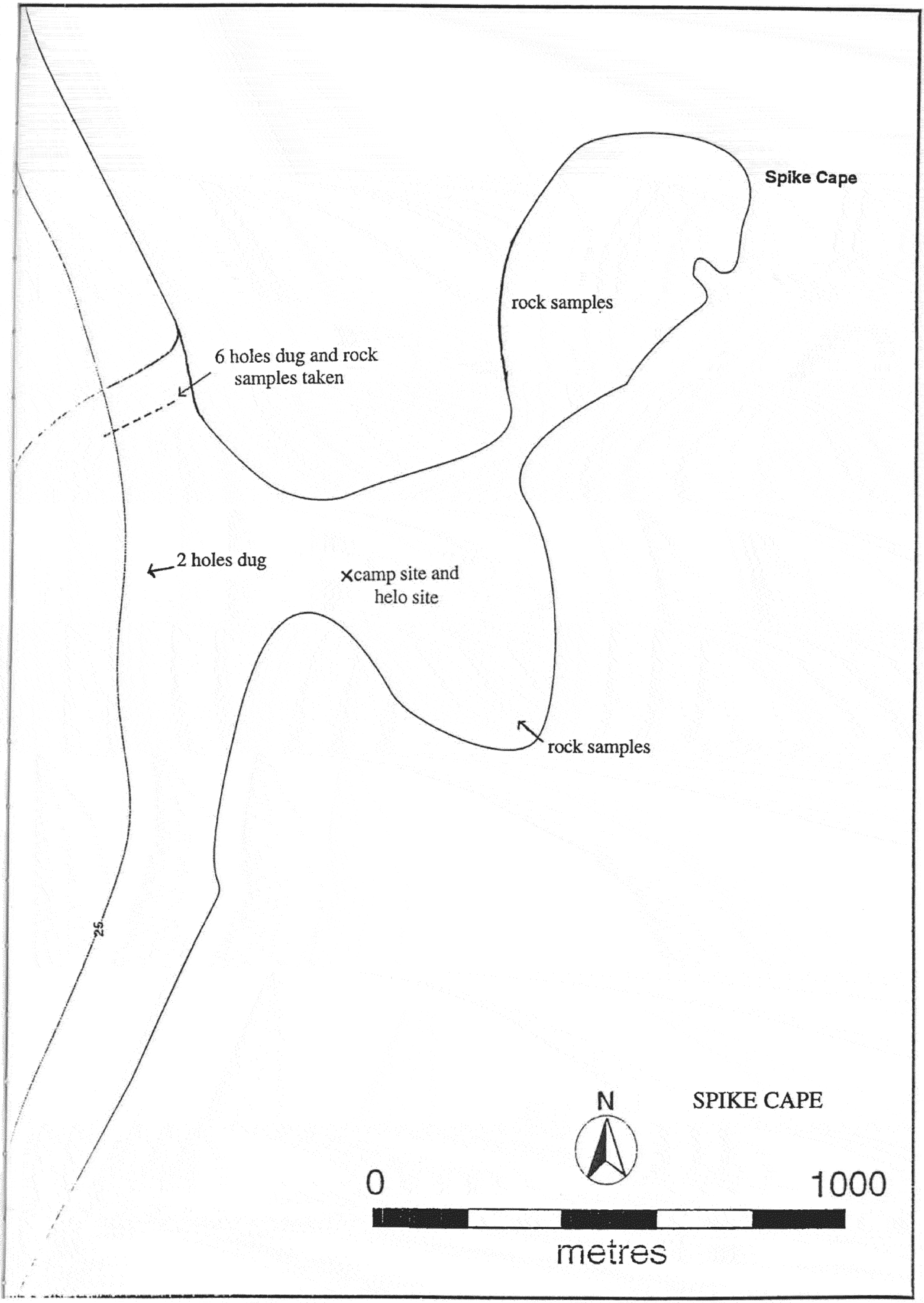
Map: USGS 1:50,000 series
Marble Point
1977

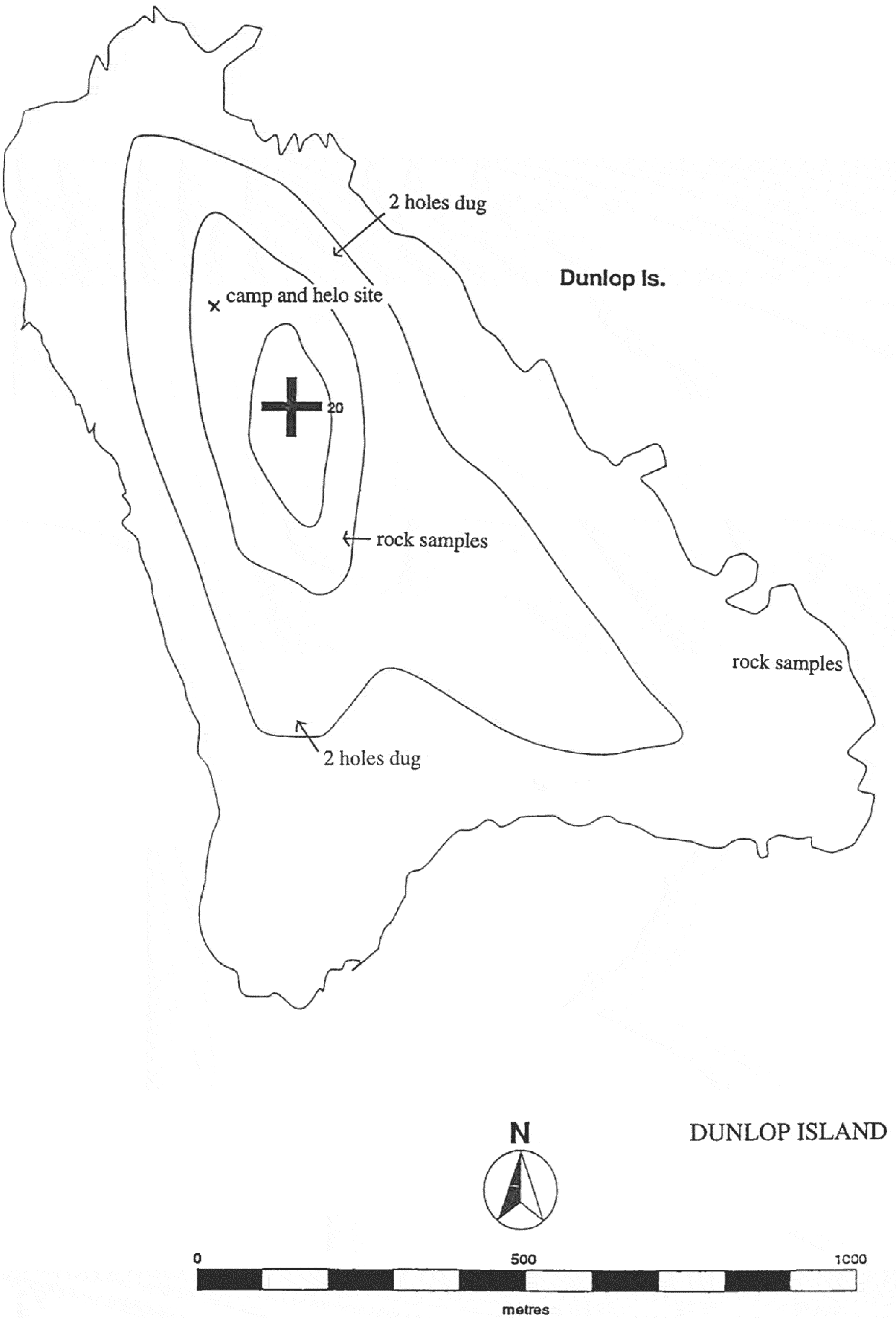


Gneiss Point
rock samples
Scheuren Stream
Landing Strip
Surko Stream
Bull Stream
4 holes dug
rock samples
camp and helo site
rock samples
profile with 8 holes
and rock samples
+122
South Stream
section, hole and rock samples
25
50
150
250
HOGBACK HILL
Cape
Bernacchi
+232
+81
HJORTH HILL
+109
+301
250
150
50
+34
25
N
MARBLE POINT
1000
0
1000
2000
3000
metres



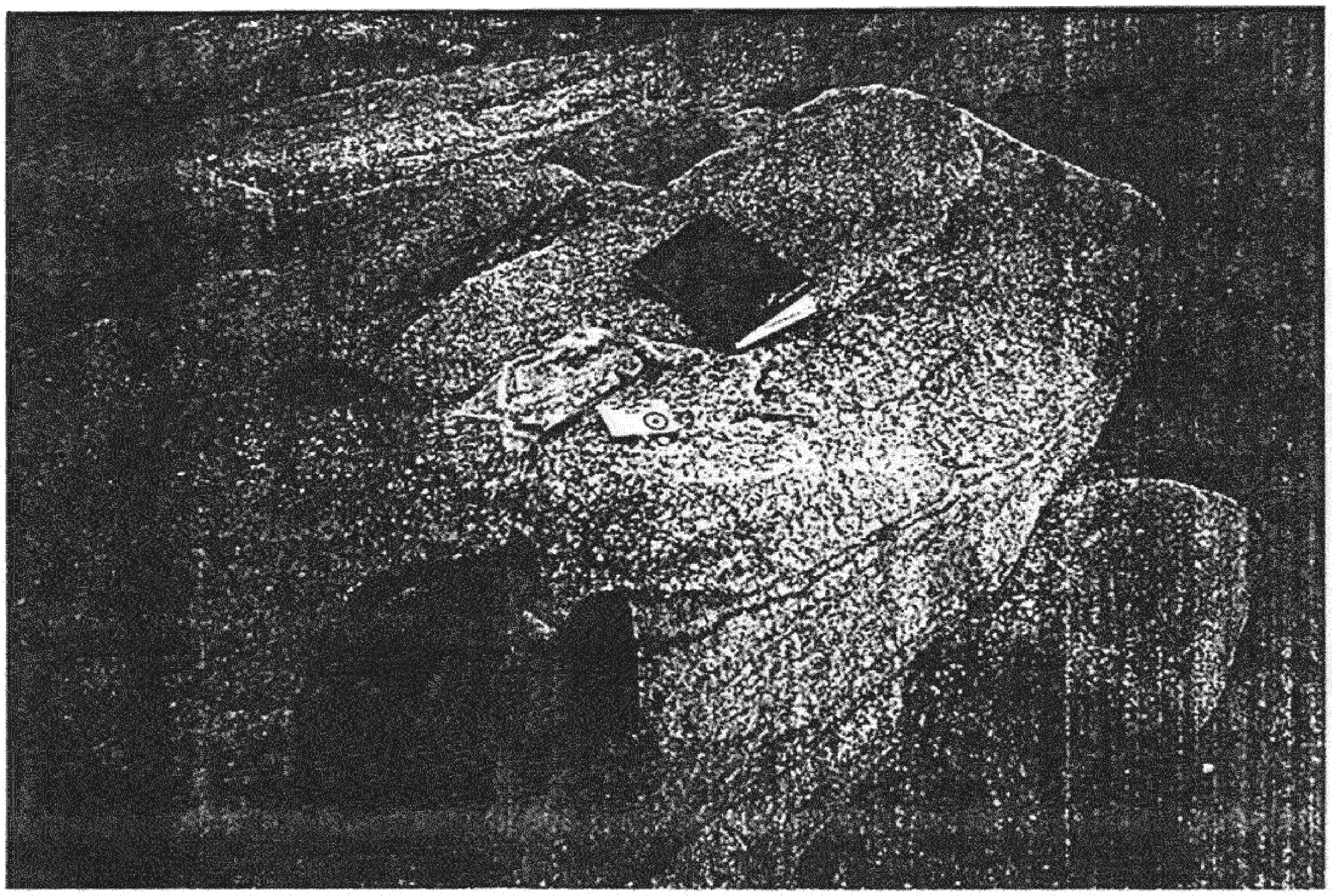
150
50
28
Kolich Point
camp and helo site
KOLICH POI
2 holes and rock samples
land
section cleared
sea ice
N
0
1000
metres

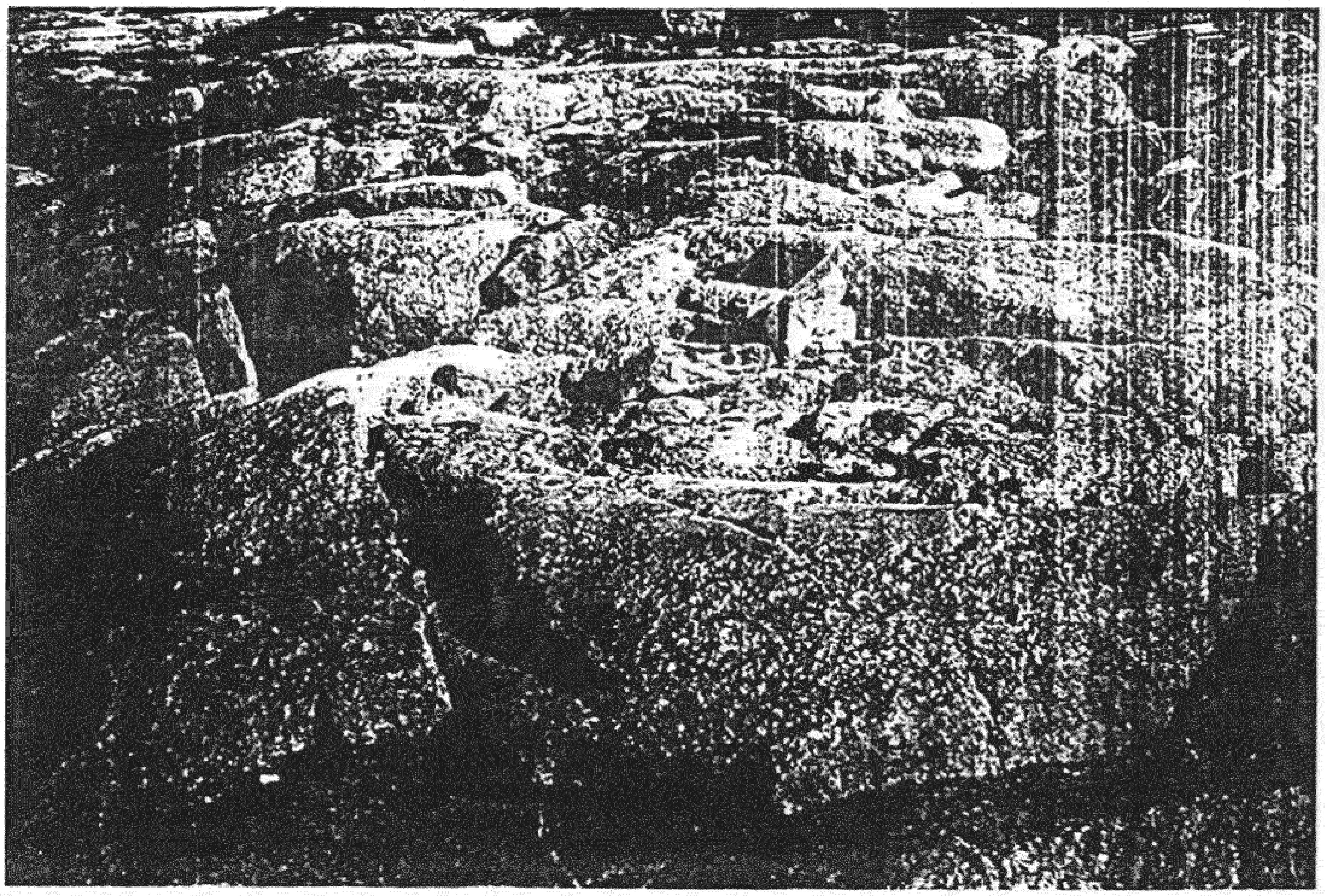

Spike Cape
rock samples
6 holes dug and rock samples taken
2 holes dug
camp site and helo site
rock samples
25
N
SPIKE CAPE
0
1000
metres



DUNLOP ISLAND

Environmental impact of rock sampling:





K 043
1996/97

IMMEDIATE SCIENCE REPORT

K 043 : Raised Antarctic Beaches, Isostasy and Dating

Antarctica New Zealand 1996/97

Event Personnel: J Shulmeister (Leader)
J Quinn
E Butler
P Webb

December 1996 - January 1997

1. Popular Summary of Scientific Work Achieved

The aim of this event was to look at raised beaches along the Scott Coast from Cape Bernacchi to Dunlop Island. These features have developed since the last glacial maximum approximately 18,000 years ago when the ice sheets were at their greatest extent. The weight of the overlying ice depressed the land which has slowly rebounded after the ice melted. While rebounding a series of beach ridges were formed.

One part of the project is to date the beach ridges and associated rock platforms by three different methods and obtaining relative heights above sea level today. This will allow modelling of the volume and extent of the ice during the last glacial maximum. There has been approximately 120 m of sea level rise since the last glacial maximum, with the well constrained northern hemisphere ice sheets contributing about 90 m. The Antarctic contribution is less well constrained, so by this study combined with other similar studies from East Antarctica a better idea of the amount of ice in Antarctica during the last glaciation should be obtained.

To obtain a height above sea level today it is necessary to know where sea level was on the raised beach ridges. The second part of the project looks at the modern beach formation. Very little work has been done on Antarctic beaches and the processes which form them. Studying the modern beaches along the Scott Coast will add enormously to this knowledge. By linking processes found on the modern beaches to features in the raised beaches should give an accurate position of sea level on the raised beaches.

The third part of the event aims to identify the provenance of glacial moraines along the Scott Coast and to provide a chronology for retreat of ice from this area using surface exposure dating techniques.

The work was carried out from a series of four camps along the Scott Coast, one at Marble Point which covered the area from South Stream to Gneiss Point, one at Kolich Point, one at Spike Cape which covered both tombolos and the mainland and finally one at Dunlop Island.

There are well developed boulder beaches along most of the coast which are dominantly storm deposits with very little ice influence. A good correlation was able to be established between the size of ridges and materials to the energy of formation. Links were established between active processes and sediments found in the raised beaches, such as the evidence of a shallow tidal channel features on Marble Point. Well developed raised rock platforms between the beaches should provide the key dating tool (surface exposure dating). These will allow a better record of relative sea level fall in the area than has previously been available. Links have been established between the various dating techniques. Surveying of marine limits and beach profiles should be more accurate than in previous surveys due to better controls. Preliminary observations of volcanic erratics indicate the Ross Sea ice extended to an approximate altitude of 350 m on Hjorth Hill and covered Marble Point and Spike Cape. Moraine deposits imply a more recent advance of the Wilson Piedmont Glacier which may overrun earlier Ross Sea moraine.

2. Proposed Programme

The principal objectives for the field season were:
(1) survey the height of the marine limit and provide profiles of the beach ridges and associated rock platforms.
(2) discover what alternative dating methods are viable in this coastal area.
(3) find a correlation between the different dating techniques.
(4) collect datable material (radiocarbon, thermoluminescence or surface exposure) to date beach ridges, preferably in sequences.
(5) describe the variation in beach forms along the coast.
(6) describe the raised beaches from a geomorphologic point of view.
(7) attempt to see the active beach forming and describe the processes.
(8) discover what influence ice plays in the formation of the antarctic beach.
(9) identify the provenance of glacial moraines along the Scott Coast.
(10) provide a chronology for retreat of ice from this area using surface exposure dating techniques.

3. Scientific Endeavours and Achievements

Surveying of Beach Ridges:

Four benchmarks were put in for the event by the surveyors (K191) which were linked to sea level via the tide gauge at Cape Roberts. These were a combination of existing marks and two new ones at Dunlop Island (iron rod on top, by the large cairn), Spike Cape (on a large boulder near the isthmus connecting the mainland to the two tombolos), Kolich Point (on the 4th raised ridge at the point) and at Marble Point (WAL0). This gave us a good starting point to run a GPS base station from, as well as a point to tie the levelling to for good height control. The GPS run was a Trimble Pro-xl and was used to give approximate locations for each surface exposure sample site, sites of each hole dug and other significant point.

Levelling was done using a dumpy level to reduce problems with battery power and reliability in cold weather which may have occurred using an EDM (electronic distance meter). This did mean a lot more time was spent on surveying than may have otherwise been needed but gave us height locations within 10 cm. A line was run out from the survey marks along the beaches to pre-selected locations where profiles were to be done. From pegs at each pre-selected location a profile was run from the water's edge (or shore attached ice) up to the marine limit. Each profile was closed to the pegs which were in turn closed back to the survey mark.

When these data are fully reduced there will be profiles of the beach ridges extending laterally over varying energy conditions along the coast. This should give an idea of the relationship between energy and height, as well as starting to give an idea of any differential uplift occurring on the coast. Where the marine limit was previously poorly constrained these surveys should give the height with more accuracy.

Dating the Raised Beaches:

Some of the beaches in this area have been dated previously using radiocarbon from shells, bones, and other organic remains. There are difficulties in the Antarctic with calibration of these dates due to the long mixing time of Antarctic Ocean water. But they still remain a viable dating tool. This was one method used. Where shells were found to be *in situ* these have been taken. Two species were found to be dated, *Laternula elliptica* and *Adamussium colbecki* . These were only found in the lower energy, sandier beaches.

Lower energy beaches are also ideal sites for the second dating method attempted, that of thermoluminescence dating of sediments. Thermo-luminescence (TL) dating requires sandy material (preferably quartz rich) that has seen sunlight then been buried, such as in a beach ridge. Samples were taken in the sandy ridges and in one site where there were shells, a TL sample was taken alongside. Having the two dating methods in the single place should allow a correlation between the dates obtained. The method for collecting TL samples was changes very little to adapt to Antarctic conditions. Site selection was important as it was impossible to drive a tube to collect sediment into permafrost. A block of wood to place over the end of the tube that could be pounded into slightly frozen ground was useful. We found that if a hole was dug that was suitable, yet frozen, often waiting a day to allow some thawing of the surface layer was enough to get a tube into the sediment. When taking dose rate readings with the gamma spectrometer, to get the probe far enough into the sediment required the use of a small portable hand auger.

The main method of dating used was surface exposure dating using cosmogenic isotopes in the rock platforms associated with the beaches. Cosmogenic isotopes record the build up of cosmogenic radiation from hitting the Earth's surface. If a site has been eroded then exposed at the surface it will start building up the isotopes from the time it was exposed. By collecting surface samples of rock (preferably calcite or potassium rich rocks) a time since exposure can be obtained. This part of the coast was ideal for attempting this method as there are rock platforms extending from sea level to the marine limit. Collecting the rock is a relatively simple task of removing a 1 - 2 kg sample from a piece of flat lying rock with chisels and hammers.

No results have been obtained so far on any of the dating methods as the samples are not back from Antarctica at the time of writing, but the surface exposure dating appears to be a promising tool for recording uplift.

Geomorphology of Beaches:

Detailed descriptions were made from sections, using evidence at the surface as well as digging holes in strategic locations. It would have been nice to have trenches through the ridges, as may be possible in a temperate environment, but frozen ground did not make this possible. An essential tool in many holes, where digging below the permafrost level was desirable, was the use of a poinjar. This worked effectively to remove material, otherwise various shovels, spades and picks were employed. Along this part of the coast the permafrost level is about 0.5 m, but is extremely variable with water being struck in one hole. Information from the holes included the structure of the beach ridge, pebble counts to work out maximum energy and development of the beach from imbrication. Indications that there was little, if any, ice influence in most of the beaches could be seen by a lack of ice features in the holes.

Where holes were not dug surface pebble counts gave approximations to the same things. Holes were not able to be dug where the whole beach ridge was boulders. Other large scale measurements were made such as cusp sizes. Profiles of high energy sites and lower energy sites were made for comparison.

Measurements of the same features on the active beaches provided a basis for comparison to the raised beaches. After the sea ice broke out there were opportunities to watch the beach processes in action with waves and ice. Earlier, it was attempted to use an underwater camera to observe any processes occurring while there was still shore attached ice. This was not particularly successful but it is believed that the ground is covered in ice at this stage and not active. Future work, next season, will include a lot more process observations and measurements of the open water conditions.

Glacial Mapping:

Observations of the glacial moraines were done by mapping the extent of the various rock types that made up the moraines by a combination of noting where volcanic erratics were found with line counts and area counts. Surface exposure dating is to be done using cosmogenic isotopes from large erratics dropped out of the glaciers as they retreated.

Preliminary observations from the extent of volcanic erratics (derived from Ross Island and further south) indicate that the Ross Sea ice mass extended up to ~350 m altitude on Hjorth Hill above Cape Bernacchi, it also covered Marble Pt and Spike Cape. These observations place the limit of Ross Sea ice a minimum of 20 km further north than that previously reported (Hall and Denton, 1994. Antarctic Journal pp 20 - 22).

Moraine deposited by the Ross Sea ice appears to be significantly older, based on weathering and appearance of striations, than moraine deposited by the Wilson Piedmont Glacier. This implies a more recent advance of the Wilson Piedmont which may have overrun earlier Ross Sea moraine.

Future work intends to extend this work further along the coast, which will give an overall picture of the way the coast is rebounding with distance from the Ross Ice Shelf. Studying the beaches on Ross Island, and possibly Beaufort and Franklin Islands will enable a test of the source of the ice causing the isostatic rebound. There may be an isostatic response to expanding local ice on the Victoria Land Coast as well as to grounded ice in the Ross Sea. The beaches on Ross Island have a longer ice free season than elsewhere so will not only provide a comparison on levels of development, but also allow process measurements to be made over a length of time.

4. Publications

There are intentions to publish results from this work. Below are the topics that should become papers.

Expansion of the Ross Ice Sheet over the Scott Coast during the Last Glacial Maximum.

Presenting results that show the extent of the volcanic erratics found along the coast from Hjorth Hill to Spike Cape and the relationship to the Wilson Piedmont Glacier.

Antarctic Beach Geomorphology.

Presenting a description of the boulder beaches and how they are formed.

Alternative Dating Methods on Antarctic Beaches.

Presenting the results of trying thermoluminescence and cosmogenic isotope dating on beaches where traditionally only radiocarbon has been used.

Further publications will result as this seasons and next seasons work are combined.

5. Acknowledgments

This event was supported by funding from The Australian National University in collaboration with Victoria University of Wellington. Edward Butler is being supported by a New Zealand Post Antarctic Science Scholarship. The support of event K191, the survey team from Terralink NZ Ltd were very helpful in placing benchmarks. The Quaternary Dating Research Centre at the Australian National University lent their gamma spectrometer for use with the thermoluminescence dating. The Antarctic Research Centre at Victoria University of Wellington lent their GPS equipment and underwater camera.

K047
1996/97

LOGISTICS REPORT

K047: Petrology of Sirius Tillite

Antarctica New Zealand 1996/97

Event Personnel:	Warren Dickinson (leader) Pat Cooper Jon DeVries James Goff Ian Jennings Bain Webster

November 1996 - December 1997

1 Aims

The main goal of the project is to understand the Sirius Group tillite in the Dry Valleys area. The significance of this deposit centres on an intense international debate concerning the extent of the East Antarctic ice sheet three million years ago. The dynamic view in the debate favours a nearly complete deglaciation, while the stabilist view favours an ice sheet which formed nearly 14 million years ago and retained its shape through until the present day.

The aims of the field work, as established by the PGSF grant in December 1995, were to collect data for a geologic and geomorphic map of the Sirius Group at Table Mt and Mt Feather. Cores at least one metre long of the Sirius Group outcrops were to be obtained from at least three sites each at Table Mt and Mt Feather. Coring locations were to be selected on the basis of geomorphic mapping and previous sites where study samples were taken.

The achievements of the November - December 1996 field season were significantly greater than the initial goals of the project established in December 1995. Over the 23 field days, enough geologic and geomorphic data were collected to provide a detailed map of about four square kilometres on the northwest flank of Table Mt. Detailed glacial fabric analyses of the Sirius were made at 12 sites. Hand-held aerial photographs were taken of the area from an altitude of about 3000 metres. Included in the photographs were four GPS positions, accurately surveyed to within 0.5 metres with reference to the Table Mt trig.

A total of about 49 metres was drilled at seven locations on Table Mt. Of this, about 42 metres of core was collected, giving an average recovery rate of 87%. On average, the core holes were 3.5 metres deep, but two of those reached a depth of 9.5 and 8 metres. The significant amount of ice in the pores and fractures of the core was a surprise. The age and origin of this ice is open to much speculation and research.

Ground temperatures from the surface to a depth of 3.5 metres were measured in four holes. Measurements were taken at 25 cm spacings down the hole. These were taken for a duration of five days at one hole but for only one to two days at the other holes.

A full camp move to Mt Feather was not made due to the condition of the drilling equipment and high risk of minimal core recovery. Instead, we made a reconnaissance of Mt Feather with a light amount of drilling equipment. With a helicopter standing-by, two holes were drilled to a depth of 0.8 and 0.4 metres. This drilling established that the coring characteristics of the Sirius at Mt Feather were similar to those at Table Mt. We also established that the success of coring depends largely on the use of compressed air as a cooling and flushing medium for drilling these types of ice-cemented glacial deposits. Prior to leaving Table Mt, a reconnaissance was made for Sirius deposits at the same elevation as Table Mt and directly across the Ferrar Glacier on Knobhead. Outcrops of Sirius were not found, but the soil regolith on Knobhead was identical to that on Table Mt suggesting that Sirius may have also been deposited on Knobhead.

2 Personnel

Warren Dickinson 101 Beauchamp St Karori, Wellington	Event leader/coordinator, responsible for overseeing and assisting with all of the duties performed by event personnel
Jon DeVries 62 Buckley Rd Melrose, Wellington	Field leader, mountaineer, safety officer, loadmaster, mechanic
James Goff School of Earth Science Victoria University PO Box 600 Wellington	Site geologist, geologic/geomorphic mapping, assisting with coring, core analysis; provide compiled base maps for field mapping
Ian Jennings School of Earth Science Victoria University PO Box 600 Wellington	Mapping and measuring of field data, logging/packing/processing of core, core analysis
Pat Cooper Cooper Drilling Services Rapid Creek Waimangaroa, Westport	Driller and mechanic
Bain Webster Webster Drilling PO Box 50-354 Porirua	Drilling contractor and designer of drilling equipment

3 Event Diary (Nov - Dec 1996)

Nov 14	Dickinson, Goff, Jennings, and Webster depart (13:00) Wellington for Christchurch; fitting of field clothing; night at Windsor
Nov 15	Christchurch to Scott Base (Dickinson, Goff, DeVries, Webster, Jennings)
Nov 16-18	Antarctic Field Training (Dickinson, Goff, Jennings, DeVries-assistant instructor); Webster unpacking and setting up drilling equipment
Nov 19-21	Tested drill equipment on permafrosted ground at Scott Base and on sea ice; Dickinson and Webster packing and testing drill equipment for field; DeVries, Jennings and Goff packing food, and field equipment. Webster returns to Wellington Thur, 21 Nov.
Nov 22-24	All equipment staged into four loads on helio pad. Dickinson, Goff, Jennings, DeVries, R & R Scott Base
Nov 25	Goff and DeVries depart for Table Mt 10:00 from McMurdo; Dickinson and Jennings depart for Table Mt 14:30 from McMurdo arrive at Table 15:30.
Nov 26-27	Set-up and establish camp; reconnaissance of area, drill site selection; start geologic and geomorphic mapping

Nov 28	Cooper arrives with load #2 at Table Mt; final load #4 arrives at 16:30. Sent back rock for Thornley memorial and Nerida Bleakley's samples from Dec 1994. Set-up kero heater in Pol-haven tent. Set up drill rig after dinner.
Nov 29	Set-up and drilling by 12:30 and first metre is very slow. Become stuck in hole at 17:30p, break for dinner to make plans.
Nov 30	Whole day spent trying to recover frozen bit; recovered core barrel drill rod but unsuccessful with bit and reamer and decided to continue with productive drilling.
Dec 1	Recovered 6.05m (nearly 100%) at site TM-1C.
Dec 2	Requested 9m of NQ drill rod from Cape Roberts Project so we can reach bedrock contact. Did not have more pipe because did not expect to be able to drill this deep.
Dec 3	Decision made to not take camp to Mt Feather. Equipment is stressed and time would be better spent doing complete job at Table. However, a reconnaissance with light drilling equipment should be made to Mt Feather.
Dec 4	Helio arrives 13:30 with additional pipe and Terralink crew (Belgrave, Cairns, and Simonson) run GPS survey and photograph NW Table Mt area.
Dec 5	TD hole TM-1C at 7.29m in bedrock. Sledge compressor down hill to site TM-6.
Dec 6	Site move to TM-7 using helio to carry compressor.
Dec 7-9	Drilling slow due to many repairs and complications in drilling unfrozen clast-rich material near the surface.
Dec 10	Resupply helio due to arrive at 14:00 but delayed by mechanical problems. The NSF, Bell 212 arrives 20:30, and Dickinson, DeVries, & Cooper travel to Mt Feather for reconnaissance and test coring; Return Table Mt at 01:00 (Dec 11) to pick up Terralink GPS; Goff returns (01:30) to Scott Base for treatment of eye injury.
Dec 11	Late start! Move core box to upper helio pad. Start drilling of TM-8B. Early dinner as three of us are still quite tired.
Dec 12	BBC (Kate O'Sullivan) arrives unannounced 09:00 to film. TD hole TM-8B at 5.9m in hard dolerite clast; much core loss in this hole due to gravels.
Dec 13	Reach 9.52m in TM-7B without penetrating bedrock contact, but equipment won't allow deeper drilling.
Dec 14	Goff arrives back at Table Mt; Jennings and Goff reconnaissance of Knobhead; Cooper and load #1 of drilling equipment return to Scott Base
Dec 15	Continue temperature measurements, Goff and Jennings recon south end of Table Mt and in the afternoon recon they recon to the north. We all fill in Prentice trench dug in 1993 to look at Sirius. Light snow in late afternoon.
Dec 16	Continued temperature measurements, clean up of drill sites and reclamation of tracks with rake and broom. Finest weather day of the trip.
Dec 17	Scheduled field departure and return to Scott Base delayed because of light snow and cloud.

Dec 18	Dickinson, Goff, DeVries and Jennings depart (10:45) Table Mt arrive Scott Base; field gear unpacked and returned by 17:00.
Dec 19-20	R & R Scott Base while waiting for flight to Christchurch
Dec 21	Flight to Christchurch (clear skies, light wind) 11:30-18:30; night at Windsor Hotel
Dec 22	Dickinson, Goff, DeVries and Jennings depart Christchurch 08:30 for Wellington.

4 Event Maps

Table 1. GPS Positions[1]

STATION	LATITUDE (South)	LONGITUDE (East)	MSL ELEVATION	MAP DISTANCE
Table Mt Trig*	77 58 05.46687	162 02 34.71533	2185.0 m	
Camp	77 57 45.31151	161 58 16.49335	1915.4 m	
Sta-1	77 57 43.00383	161 58 45.58826	1947.9 m	
Sta-2	77 57 37.24841	161 59 24.57931	1963.0 m	
Ian's Rock	77 57 32.69082	161 58 02.01206	1863.0 m	
Sta-1 to Camp				201.4 m
Sta-1 to Sta-2				309.0 m
Ians's to Camp				402.5 m
Ian's to Sta-1				426.4 m
Ian's to Sta-2				552.7 m

[1]Data surveyed by Belgrave, Cairns, and Simonsen 4 Dec - 10 Dec, 1996
*Used as fixed control for the other sites.

The accuracy of the positions stated by Belgrave (pers. comm. 1997) is as follows:

> Latitude is accurate to the nearest 0.5 seconds and the longitude is accurate to about 2.0 seconds. These equate to around 15 metres on the ground. The absolute height relative to mean sea level is within 20 metres. This is absolute position on the earth's surface relative to the coordinate of the Table Mt trig which has the above tolerances. Each of the four stations measured at Table Mt are, however, accurate relative to each other to within 0.10 metres for position and height.

Maps on the following two pages were compiled and drafted by Ian Jennings.

5 Cargo

Approximately 800 pounds of equipment was shipped from Wellington to Antarctica prior to the event. All equipment arrived on schedule and was found to be in good condition at Scott Base. Major pieces of equipment included:

1) Crate containing five Stihl chainsaw motors, with spare parts, assortment of drill bits and reamers, drilling tools
2) Air compressor
3) Sling container of drill rods and core tubes
4) Six insulated core storage containers

6 Field Preparations

Because Jon DeVries was involved in field training with the event personnel, it was possible to cover exercises that were directly applicable to the conditions relevant to the field area of the event. Day one of Antarctic field training followed the standard exercises, but the use of fixed ropes on the steep rocky terrain of Observation Hill was covered on day two.

All of the drilling equipment was assembled, tested, and checked out in the vicinity of Scott Base. All other equipment (tents, radios, stoves etc) was checked at Scott Base and was fully operational before departure to the field.

7 Field Equipment

Generally all of the necessary field equipment was at Scott Base and in good working condition. All equipment was thoroughly checked before the event left for the field. Two of the primus stoves, which were issued, were found to be faulty. Of note is that one of them was brand new and had a faulty thread (manufacturing fault) where the burner screws into the fuel tank. This fault was not obvious and only showed up when the stove was hot which caused the thread to loosen and bleed off gas pressure.

The Polar Haven tent was a real bonus on this trip and made it possible to have a warm communal area for cooking and discussion of the day's events. In this particular case, we only set up camp once for the duration of the field season. The following points should be taken into consideration when using a Polar Haven:

1) Erect any other available tents (polar, mountain) before setting up the Polar Haven. This is in case the weather deteriorates.
2) Allow 2 hours to fully erect the tent with at least two people and ideally three.
3) Reasonably calm conditions are needed to erect the tent.
4) Allow 1 hour to take the tent down and pack it away with at least two people and ideally three.

Due to the nature of our field event which involved constant use of drilling gear, we requested extra spill kits and a tarpaulin to minimise environmental damage which could result from leaking oil or gas. However, we were only able to get one very old canvas tarpaulin and one extra spill kit (small size) before deployment. We finally acquired the large size, spill kit refills three days before returning to Scott Base.

To minimise the risk of environmental damage from this type of project, any machinery which is likely to have oil or fuel leaks should if possible have a drip tray. Further protection could then be given by the use of a tarpaulin.

One of the 20 litre containers of kerosene was contaminated with mineral turpentine which appeared to cause incomplete combustion in the primus stoves. All fuel containers 10 litres or larger should be able to either be fitted with a spout or a tap. All human waste needs to be triple bagged to be safe for handling and transportation.

8 Field Transport Operations

On the whole helicopter operations ran smoothly once schedules had been worked out. Our main camp moves and some of the drill site moves were done with the 3 Squadron UH-1H and went very smoothly and efficiently. There was a one day delay, due to weather, for our pull-out of the field.

The set-up in the BH 212, with the rear facing seats and the permanently fitted auxiliary fuel tank, limited its effectiveness when it came to moving cargo as an internal load. The other problem with the rear facing seats was that it was difficult to give the pilot directions when trying to locate a landing site for close support work. The lack of any ground to air communication with the BH 212 made it difficult to work with when the helicopter was approaching our camp or drill site and when moving drill gear from site to site.

For a moderate sized event such as this one, it was extremely useful and efficient to have a spread-sheet with all the helicopter loads for the put-in (Table 1). This information was also made it much easier to figure out loads for the pull-out. A copy of Table 1 was given to Rex Hendry.

9 Field Communications

After initial problems with an intermittent transmitter, communications with the Tait handheld radio and high-gain aerial, using the Mt Newall (Ch. 5) repeater, proved to be reliable from our camp site. High frequency communication was not successful from our location. The Tait radios were also used for communication between team members away from base camp.

In general the transfer of requests and information given over the radio were passed on to the appropriate people at Scott Base. However, on occasion this did not appear to happen. The format of the scheduled radio check-in was at times inconvenient for our event because we were still drilling. On numerous occasions when contacted for the evening check-in we explained our situation and requested leave of the weather and news. This was noted and given approval by the base operator. Then after the reading of the new and weather, we would be repeatedly called until we acknowledged the weather and news. This situation would not have been a problem except that we had to again stop work and go to the closest high point to transmit. A solution to this problem would be for Scott Base to contact all field parties and then pass on the weather and any messages to all parties, get an acknowledgment, and then anyone who wanted to listen to the news could do so. However, I believe the news is an important part of the communications set-up and should be continued.

10 Food

The quantities of food taken into the field were certainly adequate. With the addition of the extra food (tortillas etc.), which the event supplied, there was a good variety. Unfortunately, we didn't count on the meat eating appetite of the ravenous hell driller from the West Coast. Only major complaints were not enough cheese due to a supply problem, and too many munchy bars which was our fault.

11 Drilling Operations

If the same system is used down to a depth of nine metres and at higher altitudes, the motor for the drill rig needs to be larger because it was working at its maximum capacity at 2000 metres. The Stihl 056 motor which was used to drive the compressor would probably be suitable. This system also needs modifications to the air cooling system. The simplest of these would be to extend the air intake away from the warm air environment created by the compressor.

The Winkie Drill tripod supplied by ANTNZ was also used beyond its safe working load at these depths. Unless the legs of the tripod can be braced at mid-height, the leg with the attached winch will bow out dangerously. The loading on the tripod was also increased by the addition of a block in the system to give a 2:1 ratio. The winch on the tripod is reasonably light weight and should be more robust for future drilling projects of this nature.

12 Safety

Any project which involves the use of machinery has industrial type risks. The project was completed without any injuries which is a reflection of the teamwork and competence of those involved in the project. The only medical problem was an pre-existing eye condition, which could have been aggravated by the exhaust fumes from the drill motor. Some thought needs to be put towards the modification of the exhaust system of the drill rig if the same system is used in the future, the exhaust system needs to be modified so that it is vented away from the drilling personnel. There is also a risk of burns from the present exhaust system.

A recommendation for future projects of this nature is that all personnel involved in drilling should wear steel capped Sorrels and safety helmets with attached grade 5 hearing protectors.

All party members were either in visual or radio contact at all times when we were doing field work on Table Mountain. The area covered during the time in the field was relatively safe terrain.

13 Weather

In general, weather conditions at Table Mt were mild enough to allow field work nearly the entire time (Table 2). However, the conditions were often very localised with warm coastal air masses moving up the Ferrar Glacier and cold Polar Plateau air masses flowing down the glacier. When these two air masses met in the Table Mt area, they would cause a local build-up of Stratus or Stratocumulus clouds. This would commonly occur from mid morning to late afternoon. This weather pattern occurred about 30% of our total time in the field. These conditions would sometimes result in light snowfall.

During the field season, no winds above 25 knots were experienced even though reasonably strong katabatic winds could be seen and heard blowing down the Ferrar and Tedrow Glaciers. The wind was predominantly 5 knots from the south west.

K047
1996/97

IMMEDIATE SCIENCE REPORT

K047: Petrology of Sirius Tillite

Antarctica New Zealand 1996/97

Event Personnel: Warren Dickinson (leader)
Pat Cooper
Jon DeVries
James Goff
Ian Jennings
Bain Webster

November 1996 - December 1997

1 Popular Summary of Scientific Work

The main goal of scientific research for the project is to understand depositional and post-depositional history of the Sirius Group tillite in the Dry Valleys area. The significance of this deposit centres on an intense international debate concerning the extent of the East Antarctic ice sheet three million years ago. In the debate, the dynamic view, which relies on the occurrence of rare marine diatoms in the Sirius, favours a nearly complete deglaciation of the East Antarctic ice sheet three million years ago. On the other hand, the stabilist view favours an ice sheet which formed nearly 14 million years ago and retained its shape through until the present day. Cores from within the Sirius will provide information not available from surface exposures that will help resolve this debate.

The goal of the field work was to test a diamond drilling technique and core as much as possible of the Sirius at Table Mt. During the 23 days in the field, a total of about 49 metres was drilled, and of this, about 42 metres of core was collected, giving an average recovery rate of 87%. On average, the core holes were 3.5 metres deep, but two of them reached depths of 9.5 and 8 metres. In addition, detailed glacial fabric analyses of the Sirius were made at 12 sites and enough geologic and geomorphic data were collected to provide a detailed map of about four square kilometres on the northwest flank of Table Mt.

Sirius Group deposits on Table Mountain appear to result from both advancing and retreating glaciers. Ice retreat has left an extensive ridge and hollow topography. Ridges generally consist of glacial diamictite, covered by a boulder lag, while the hollows consist of either conglomerate or sand. The deglacial environment is dominated by water-lain deposits of which the conglomerate and sand suggest that both high and low energy regimes were involved.

Petrographic analysis shows that authigenic zeolites, quartz, and calcite occur in various quantities throughout the pore network of Sirius sediments. Pores near the surface appear to result from freeze-thaw processes associated with periglacial activity, while those below three metres formed as the sediment was deposited. For authigenic minerals to precipitate, large volumes of water must have flowed through the pores. While this is inconsistent with present climatic conditions, the large amount of water is consistent with geomorphic observations and deposition of the sandstones and conglomerates. It is also consistent with the significant amounts of ice found in the pores and fractures of the core. Stable isotopic measurements of this ice may help determine the origin of this water.

In the future, more diamond coring of glacial deposits in the Dry Valleys area is needed to provide a detailed history of the Antarctic ice sheet. Modification of the core drilling equipment used in this project will make it lighter weight, more reliable, and allow a variety of sites to be cored in a single season.

2 Proposed Programme

The aims of the field work and subsequent research, as established by the PGSF grant in December 1995, were as follows:

1) To collect data for a geologic and geomorphic map of the Sirius Group at Table Mt and Mt Feather.
2) To obtain cores at least one metre long of the Sirius Group outcrops from at least three sites each at Table Mt and Mt Feather. Coring locations were to be selected on the basis of geomorphic mapping and previous sites where study samples were taken.

3) To complete a comparative petrological study of the vertical core sequences taken through the Sirius. This includes determining the cause and relative timing of mineral dissolution and precipitation (mineral diagenesis). In addition, the stable isotope ratios of ice in pores and fractures will be measured. These will provide important clues about the post depositional history of the Sirius.

4) To document the occurrence of diatoms through the vertical core sequence of Sirius. This will help determine the origin of the rare marine diatoms which may be crucial in determining the history of the East Antarctic ice sheet .

3 Scientific Endeavours and Achievements

On 10 April 1997, a meeting was held at the School of Earth Sciences, Victoria University of Wellington, to present the preliminary findings of Antarctic field work carried out in the summer of 1996/97. The abstracts of three talks, presented at that meeting, provide a summary of scientific endeavours and achievements of the field work completed at Table Mt.

3.1 A Preliminary Report on Sirius Group Deposits, Table Mountain

James Goff and Ian Jennings

Sirius Group deposits on Table Mountain appear to result from both advancing and retreating glaciers. The topography, however, is the result of glacial retreat and includes patterned ground, water-lain deposits, and mass movement features. Cores taken through the Sirius Group should help explain the role played by water in ice advance and retreat at the site, and in dating the event.

Fabric data from deposits at the southern end of Table Mountain indicate that this area was a confluence zone for ice emanating from the directions of the contemporary Tedrow and Ferrar Glaciers. However, the imprint of "Ferrar" ice dominates Sirius Group sediments at Table Mt. Other minor contributions of sediments were made from small mountain glaciers emanating from the saddle area between Table Mt and Navajo Butte. We believe that ice from these sources may have been sufficient to occupy the anomalous hollow (Figure 1) at Table Mountain which is devoid of glacial deposits.

Deposits that contain a small percentage of granitic clasts are found several hundred metres upslope from the prominent dolerite sill at Table Mt (Figure 1). The abundance of granitic clasts appears to increase down slope suggesting it was sheared up by glacial flow immediately downglacier of a confluence zone. Fabric measurements, taken from south to north along the length of Table Mt, indicate a reorientation of ice flow from west to southwest. Reorientation was caused by Table Mt obstructing ice flow which has resulted in the deposition of thrust-faulted lodgment tills and associated deposits. Lodgment and thrust-faulting may represent a period of glacial advance.

Ice retreat and down wasting has left an extensive ridge and hollow topography. Ridges generally consist of glacial diamictite, covered by a boulder lag, while the hollows consist of either conglomerate or sand. The deglacial environment appears to be dominated by water-lain deposits of which the conglomerate and sand suggest that both high and low energy regimes were involved.

Three distinct mass movement features cut across the ridge and hollow topography. Patterned ground, which is pervasive throughout the Table Mt area, is most prominent on these mass movement features but less prominent on the ridge and hollow topography. It is not clear if the degree of prominence expressed by the patterned ground, represents different degrees of activity, different ground materials, or different periods of generation.

3.2 On-Land Coring: New Developments

Warren Dickinson, Pat Cooper, Bain Webster

Core drilling of permafrosted sediments is common and well understood in most Arctic environments, but in the cold, dry

Antarctic environment it is at its infancy. Coring the Sirius deposits at Table Mountain was largely an on-site experiment because such permafrosted sediments do not exist in NZ or on Ross Island.

All drilling equipment had to be hand portable, and available in the field camp. Off the shelf HQ and NQ diameter core barrels and drill rods were used with a flushing medium of compressed air. The purpose-built, portable compressor could produce 50 cubic feet of air per minute at 30 psi which was pumped down the hole via an air swivel. The drill rods were rotated by a Sthil 056 motor mounted on frame with a torque bar which was pinned to the ground. Bit weight was controlled by the weight of the operator and any additional weight from the helpers. Pulling and lifting of the drill assembly was controlled by a hand winch via a single running block attached to a tripod.

Initial drilling showed that experimentation and modification of bit types was necessary to properly core the variety of lithologies contained in the Sirius. The flushing and cooling of the drill bit with compressed air was found to be critical. At all times the drill bit must be kept at sub zero temperatures to prevent melting of core and nearly instantaneous freeze in of the bit should rotation stop unexpectedly. Cooling of the bit depends on the temperature and volume of air entering the hole as well as the kerf and diameter of the bit. For a given air supply, a thin kerf and small diameter bit runs cooler than a thick kerf and large diameter bit. Diamond bits must be used to core hard and firmly cemented dolerite clasts, but tungsten bits must be used to core ice lenses and soft friable sands. Core recovery of conglomerates in ice-free horizons, which usually occur from the surface to 50 cm deep, was not possible. Loose clasts which are jarred from this horizon and fall into the hole must be either pulverized by further drilling or scooped out of the hole if core is to be recovered.

Considering the budget restraints and limited helicopter support the drilling project was extremely successful. With moderate adjustment and modification the existing equipment could be refined into a highly reliable and portable Antarctic drilling unit.

Final score at Table Mountain:

Total drilled:	49m
Total core recovered:	42m (86% recovery rate)
Total time in field:	24 days
Equipment loss:	1 diamond core bit and tungsten reamer
Cost of equipment and labour:	$28,000 (this excludes rental and depreciation of equipment) or about $650 per metre of core

3.3 Ice and Temperature Signals from Sirius Group, Table Mountain

Warren Dickinson

Core hole drilling of the Sirius Group at Table Mountain provided the opportunity to measure closely spaced (10-30cm) ground temperatures from the surface to four metres deep. These temperatures will provide background data for two areas of study. 1) Determination of the potential for periglacial or active ground movement that could produce patterned ground on Sirius Group sediments. 2) Calibration of oxygen isotope temperatures obtained from ice in fractures and in pores of the sediment. Although the Sirius was thought to have ice-filled pores below 50 cm, the amount and number of ice filled fractures found in the core was a surprise. Although this ice cannot be directly dated, stable isotopic measurements are critical to understanding its origin.

The equipment and methods used for measuring the temperatures were designed to be simple and economic. They also had to accommodate a range of unknown conditions. At the outset of the project, the depth and number of core holes was uncertain as well as the ability to actually measure the core hole temperatures.

The measuring system consisted of a digital thermometer calibrated for K-type thermocouples and 15 thermocouple wires from 0.5m to 4.5m in length. The core holes varied in diameter between 70 and 90mm and for this particular range a 50mm OD plastic pipe worked best for holding the wires down the hole. The relatively loose fit ensured that the plastic pipe would not get stuck in the hole. Thermocouple wires were brought down the centre of the pipe and out through holes at 0.25m intervals. The wires were taped to the outside of the pipe and bent to form whiskers protruding about 10mm outwards from the pipe. In this way, the wire whisker with the thermocouple junction on the end contacted the side of the core hole. Temperature measurements were taken over a period of five days at one hole but only for one day periods at four other holes.

Temperatures decreased with depth by 3.5_C per metre up to four metres depth (Figure 2). At four metres depth the average temperature, which varied by 2_C between the five holes, was -21.5_C. Temperatures measured 3-5cm below the surface in loose soil showed large variations. This was probably due to the degree of sunlight exposure at the surface. These variations appeared to affect temperatures down the hole to 0.5 m and possibly 1.0 metre deep. To confirm these temperature variations, measurements must be made over a period of weeks and probably through the winter.

4 Acknowledgments

As event leader, my most sincere appreciation and thanks are given to the five other members of the event who were largely responsible for the success of the field season. All of the personnel at Scott Base were extremely helpful and provided the support that made the field season possible. In particular, Paul Woodgate in Christchurch and Bridget Troughton at Scott Base were extremely efficient in shipping extra drilling equipment at the last minute. Numerous discussions with Alex Pyne greatly helped in organizing the field season. Graeme Claridge provided much needed background information as well as the spark that initiated the diamond core drilling. Nine metres of drill rod provided by Jim Cowie and the Cape Roberts Project made the drilling eight and nine meter holes possible. Jeff Ashby gave much needed assistance with the drilling reports, and Peter Barrett saved the PGSF bid from going under in the early stages. Funding for the event was provided by the Foundation for Research, Science and Technology under contract number DIC601.

Small cairns of one to two cobbles high were left to mark and cover open core holes at TM-1, TM-2, TM-6, TM-7, and TM-8 (see locations on drill hole map). These holes were left open for future monitoring of ground temperatures. In addition, it may be feasible in the future to deepen the hole at TM-7 to penetrate through the Sirius to the underlying bedrock contact.

The main impact at the Table Mt sites consisted of tramping over the fragile desert pavement. While this is unavoidable if field work is to be conducted in the area, such an impact is visible for perhaps 5 to 10 years after the event. This is because of slow the process by which the pavement forms. When working around a drill site, event personnel attempted to follow the same track. When the drill site was vacated, pavement stones were swept and raked over the tracks in an effort to reclaim the surface. In most cases this mitigation measure, significantly reduced the visual impact and should allow the pavement to reform completely in 3-5 years.