LOGISTICS REPORT

K049 NZ ITASE – Holocene Climate Variability along the Victoria Land Coast
ANTARCTICA NEW ZEALAND 2003/04

Event Personnel :

Dr. Nancy Bertler	Antarctic Research Centre, Victoria University
Mr. Alex Pyne	Antarctic Research Centre, Victoria University
Mr. Matt Watson	ScanTec
Mr. Matt Wood	School of Earth Sciences, Victoria University
Ms Louise Christie	School of Earth Sciences, Victoria University
Mr. Ewan Paterson	Antarctica New Zealand

Name of compiler: Nancy Bertler Signature of compiler:

*AIMS

Seven key locations were identified for the NZ ITASE (International Transantarctic Scientific Expedition) programme. The analyses on the ice core from the first site, Victoria Lower Glacier in the McMurdo Dry Valleys, have almost been completed. For the 2003/04 field season we proposed to carry out a detailed reconnaissance and to recover intermediate length cores from sites 2 and 3: Evans Piedmont Glacier and Mt Erebus Saddle. Due to logistical constraints of Antarctica New Zealand the drilling was deferred to the 2004/05 season, but the reconnaissance was conducted.

The programme has five objectives:

1. ITASE-Objective
   The focus of the New Zealand ITASE group is to provide information from the climate sensitive, low altitude, coastal sites. This will capture the climate signature of the troposphere, which represents a regional account on the Ross Sea climate. The ice core data are expected to provide a record of air temperature, snow accumulation, precipitation source, atmospheric circulation strength, storm frequency, sea ice variation, ocean productivity, and anthropogenic influences. The results will help to decide whether the Ross Sea region is currently cooling or warming with a longer-term prospective, taking low frequency climate variability (100 to 1000 year cycles) into account. Furthermore, proposed tele-connections such as the Amundsen Low-ENSO correlation [*Meyerson et al.*, 2002; *Bertler et al.*, submitted] or the Southern Hemisphere Annual Mode [*Thompson and Solomon*, 2002] can be further constrained.

2. Latitudinal Gradient Project Objective
   The project is expected to contribute substantially to the Latitudinal Gradient Project, as it can provide a history of temperature, humidity, sea ice cover, precipitation source, atmospheric circulation, and ocean productivity along the Victoria Coast for the last 200 to 10,000 years. Furthermore, the timing and velocity of the Ross Ice Shelf retreat some 9 to 5ka years ago is still discussed controversially [*Steig et al.*, 1998; *Hall and Denton*, 2000; *Steig et al.*, 2000].

3. ANDRILL Objective
   The ice core locations 2 and 3 (Evans Piedmont Glacier and Mt. Erebus Saddle) are in the vicinity of planned ANDRILL coring locations (Granite Harbour and Windless Bight). The ice core records will provide a high resolution climate dataset, which serves as a reference for the younger part of marine record recovered through ANDRILL.

4. Longer-Term Mass Balance Objective
   During the 1999/2000 season mass balance measurement devices (submerge velocity method [*Hamilton et al.*, 1998; *Hamilton and Whillans*, 2000]) have been deployed at Victoria Lower Glacier. The device has since been revisited during season 2000/2001 and 2001/2002. The measurements show that the glacier has a slightly negative mass balance, losing around 12cm thickness per year. A continuation of the measurements will allow monitoring changes in the ablation intensity of the McMurdo Dry Valleys.

5. The Antarctic – New Zealand Connection Objective
   New Zealand's future economic and social development, environmental sustainability, and infrastructural planning relies critically upon the accurate assessment of the impact of "global warming" in our sector of the planet. Future climate change is a result of both natural variability and anthropogenic influence. A joint programme between IGNS, University of Maine, Victoria

University is investigating ice core records from New Zealand (Tasman Glacier and Mt. Ruapehu ice field). The comparison between our NZ and Antarctic ice core records will provide much needed data for the development of realistic regional climate models to predict NZ climate in the 21th Century [*Mullan et al.*, 2001].

*PERSONNEL

Name	Designation	Organisation	Departed Chch	Returned Chch
Nancy Bertler	PI	Antarctic Research Centre, Victoria Uni	7 Nov	8 Dec
Alex Pyne	Drilling Specialist	Antarctic Research Centre, Victoria Uni	7 Nov	6 Dec
Matt Watson	GPR Specialist	Scan Tec	12 Nov	6 Dec
Louise Christie	Student Assistant	School of Earth Sciences, Victoria Uni	7 Nov	6 Dec
Matt Wood	Student Assistant	School of Earth Sciences, Victoria Uni	7 Nov	6 Dec
Ewan Patterson	Glacier Travel Specialist	Antarctica New Zealand	NA	NA

*PLANNING

- *Application process*

  The application process was organised in professional and efficient manner. However, it would be of advantage if the NZ review of a science proposal was transferred to an overseas reviewer if there is no NZ expert can be found. The assessment of the value of the proposed science from a non-expert is likely to be misleading.

- *Communications with Antarctica New Zealand staff*

  Antarctica New Zealand staff appears very competent and helpful. The planning for this event required significant time and resources and logistic re-evaluation, especially when Antarctica New Zealand logistic constraints limited this seasons programme to site survey only. It was an understanding that Antarctica New Zealand agreed that the drilling component would be supported the following season.

- *Provision of maps and aerial photographs*

  N.A.

- *Pre-season information*

  The information received was timely and valuable

- *Medicals, documentation and flights to Antarctica*

  The information received was timely and valuable

*PREPARATIONS FOR THE FIELD

- *Reception and planning for your event*

  The reception was well organised, friendly and efficient. The main issues of the event were promptly discussed and organised

- *Availability and condition of equipment received*

  The equipment requested from Scott Base was supplied in time and in good condition. This included two skidoos, one nansen sledge, two generator and field equipment including a polar haven tent.

- *Field training*

  The field training was helpful and appropriate for the new members of our team. The full AFT training for Pyne and Bertler was unhelpful and a waste of resources and time. The additional crevasse rescue training was appreciated and very efficient. The frequency of full AFT requirements for experienced people should be reviewed to take account of personal experience and regular Antarctic activity that includes fieldwork. The “current” 3 year frequency is too short.

- *Field party equipment 'shakedown' journey*

  N.A.

- *Delays at Scott Base, whatever the cause*

  All staff at Scott Base were very helpful and supportive, allowing a smooth operation of our project. The only reason for prolonged delay at Scott Base was bad weather conditions postponing helicopter moves.

- *Safety and Risk Management processes*

  The safety and risk management appears sound and efficient

- *General comments about Scott Base*

  The staff at Scott Base create a very friendly, supportive environment. We are grateful for the helpful and professional support we received from Scott Base staff.

FIELD TRANSPORT

- *Vehicles*

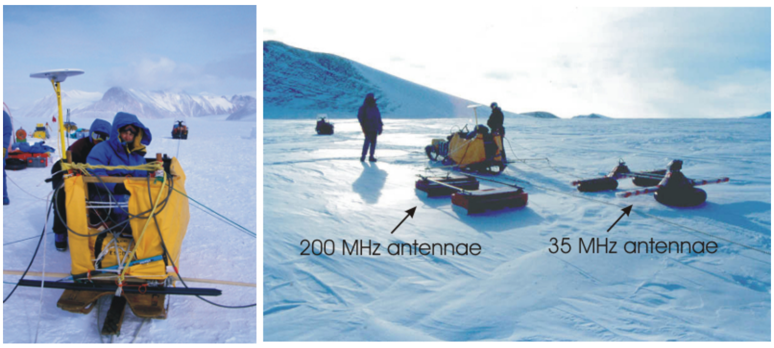


Fig.3: GPR/GPS set-up. A 400MHz antenna travels in front of the first skidoo. A second skidoo tails the set-up for crevasse safety.

The two allocated skidoos (Alpine II) were in good condition and performed well. However, our GPR traverses on the Evans Piedmont Glacier were reduced due to rough surface conditions, which proved too demanding on the skidoos and the technical equipment mounted on the Nansen sledge. The skidoos and Nansen were used primarily for GPR survey in a crevasse travel configuration. This is a relatively light weight operation and could be improved with lighter vehicles and sledge, especially when vehicles are flown to site. The GPR setup on the sledge could also be improved if a suitable sledge was pre-dedicated.

- *Aircraft Operations*
- All our helicopter moves were done by HNO. We enjoyed the professionalism, friendliness and efficiency of the HNO staff, Rob McPhail and Richard Desborough. Difficult cargo such as skidoos, nansen sledge and fuel barrels was handled in a very professional and safe manner. None of our loads got damaged or lost although the underslung Nansen sledge was a slow load to fly.

Date	Location	PAX	Total Weight (lbs)
11 Nov	SB to CR	4	1830
11 Nov	CR to VLG (failed due to lack of surface definition) – unload at MP	3	1800
12 Nov	MP to VLG	3	1800
12 Nov	CP to VLG (pick up of traversed equipment)	0	800
14 Nov	VLG to EPG (via CR)	4	2800
15 Nov	SB to EPG	2	3200
21 Nov	EPG to CR (Pyne and Wood transfer to K042)	2	1000
25 Nov	EPG to SB	4	5100
4 Dec	SB to MES to SB (reconnaissance)	4	1200

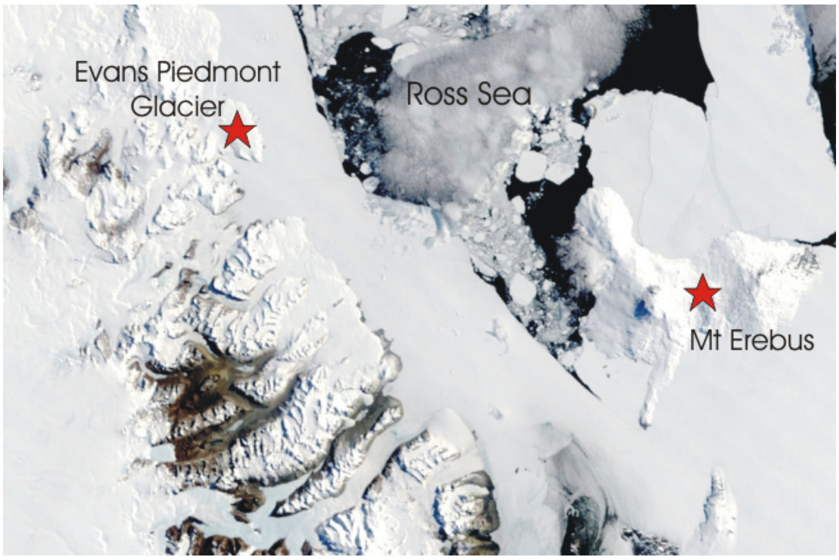
SB = Scott Base, CR = Cape Roberts, VLG = Victoria Lower Glacier, MP = Marble Point, EPG = Evans Piedmont Glacier, MES = Mt. Erebus Saddle

*EVENT DIARY

Date	Main Activities and Location	Other Comments
07 Nov	Arrival at Scott Base	
08 Nov	AFT training for all K049 members	
09 Nov	AFT training for all K049 members	
10 Nov	Equipment shake-down and field preparation	
11 Nov	First attempt to put-in to first site, Victoria Lower Glacier. Lack of surface definition prohibited landing and Bertler, Christie, and Wood are dropped at Marble Point. Pyne was moved to Cape Roberts for work on the tide gauge (K042)	
12 Nov	Put-in to Victoria Lower Glacier, camp set-up, deployment of base station at 3km distant Staeffler Ridge, commencement of first mass balance measurement	
13 Nov	Continuation of mass balance survey at 4km distant Victoria Lower Glacier II site	
14 Nov	Bertler, Pyne, Christie, and Wood move camp to Evans Piedmont Glacier after site reconnaissance. Camp set-up, deployment of GPS base station	
15Nov	Watson and Paterson arrive at Evans Piedmont. Set-up of traverse equipment (ground penetrating radar and GPS) on Nansen sledge. Set-up of traverse line (skidoo-sledge-skidoo). Preparation for snow pit work.	
16 Nov	Excavation of 4m deep snow pit. Assemblage of GPR and GPS equipment .	
17 Nov	Bertler, Watson, Paterson, Wood start GPR traverse;	

	Pyne and Christie commence snow density and temperature measurement in the snow pit.	
18 Nov	Bertler, Watson, Paterson, Wood continue GPR traverse; Pyne and Christie continue snow density and temperature measurement in the snow pit.	
19 Nov	Pyne, Watson, Paterson, Christie continue GPR traverse; Wood continue snow density and temperature measurement in the snow pit, Bertler commences snow sampling in the snow pit.	Due to bad weather conditions all activities were aborted at lunch time.
20 Nov	Confined to tents, hourly sampling of snow precipitation	Due to bad weather conditions all activities were aborted
21 Nov	Pyne and Wood move to Cape Roberts (K042). Bertler, Watson, Paterson, and Christie continue GPR traverse. Bertler and Christie continue snow pit work	Visit by NZ Herold and Lou Sanson
22 Nov	Bertler, Watson, Paterson, and Christie continue GPR traverse. Bertler and Christie continue snow pit work	Radio interview with NZ Harold, Simon Collins
23 Nov	Bertler, Watson, Paterson, and Christie continue GPR traverse. Bertler and Christie continue snow pit work	
24 Nov	Bertler, Watson, Paterson, and Christie continue GPR traverse. Bertler and Christie continue snow pit work	
25 Nov	Bertler, Watson, Paterson, and Christie move to Scott Base.	
26 Nov to 3 Dec	Scheduled reconnaissance for Mt Erebus Saddle is deferred due to bad weather. GPR, GPS, and density data processing at Scott Base.	
4 Dec	Bertler, Pyne, Watson, and Paterson conduct 5 hour reconnaissance at Mt Erebus Col and Mt Terra Nova	
6 Dec	Pyne, Watson, Wood, and Christie return to NZ	
8 Dec	Bertler returns to NZ	

EVENT MAP



*WEATHER

In total we lost 12 days of fieldwork due to bad weather conditions, which amounts to 43% of our time in Antarctica. However, due to the commitment of each member of KO49 and the exceptional support by Scott Base and HNO staff we were able to conduct most of what was proposed nonetheless. We encountered two snow storms while based at Evans Piedmont Glacier, which provided us with the possibility to hourly snow sampling for airmass trajectory reconstruction. The longest delay due to weather conditions for us occurred when we tried to put in to Mt Erebus Saddle for 8 days, which caused the early termination of our season this year. However, a 5hour weather clearance allowed us a reconnaissance in which we gathered the necessary information to conduct the drilling at this site during 2004/05.

*ACCIDENTS, INCIDENTS OR HAZARDS

None of the above occurred or were observed

FIELD EQUIPMENT

- *Quality, suitability and performance of field clothing*

  The issued field clothing was appropriate and functional.

- *Performance and design of tents, technical climbing equipment, kitchen gear and sledges*

  The supplied field equipment was in good condition and very reliable. We are especially grateful for the allocation of the polar haven tent, as it allowed us to maintain and repair our electronic and computer equipment. The polar haven tent was set up with a VUW sigma heater and a LPG gas cooker. The crevasse safety and rescue equipment was in good condition and efficient.

- *20 person day ration box system*

  The food boxes were well packed in terms of quantity and nutrition. The provision of bulk food supply for medium sized field parties still has scope for improvement and development.

RADIO COMMUNICATIONS

- *Suitability and effectiveness of the radio equipment*

  The radio equipment was in excellent condition and we appreciated the professional advice by Keith Roberts

- *Reception/transmission conditions and suitability of radio schedule timing*

  Reception and transmission were generally good and the timing of the radio schedule convenient

- *Scott Base's general efficiency during radio schedule*

  Radio communication was mainly very efficient, professional and appreciated

COMPUTER FACILITIES

- *Suitability and effectiveness of computer network*

  The computer network met our needs satisfactorily. A possibility to connect laptops to the Scott Base external net connection would be highly appreciated, especially during prolonged delays at Scott Base.

- *Quality, suitability and performance of public computers*

  The quality and suitability of public computers was sufficient and appreciated, albeit somewhat busy.

*ENVIRONMENTAL IMPACT

*Sites Visited

Site name	Victoria Lower Glacier
Site location (coordinates/description)	77°43.7S, 162°33.7E, glacier surface
Dates occupied	12 Nov 2003 – 14 Nov 2003
Total days (or hours) at site	3 days
Maximum number of people at site	3
Total person-days (or person-hours) at site	9
Main activity undertaken	Mass balance measurement

Equipment installed/left in field

Type of equipment/marker installed	Submergence velocity device for mass balance measurement (Fig.2)
Location of installation left in field	VLG Ia 77º19’48.3245S, 162º31’55.5141E VLG Ib 77º19’48.3243S, 162º31’55.4501E VLG II 77º20’49.1079S, 162º29’32.2241E
Size of items left in field	3m stainless tube, 0.4x0.4m plywood
Number of items left in field	3
Date of intended retrieval	End of project

*Other environmental impacts

None

*Differences from original Preliminary Environmental Evaluation (PEE)

None

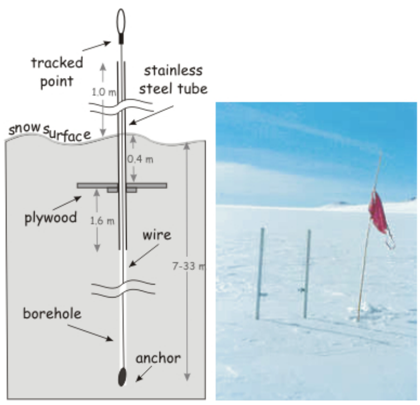


Fig.2 Mass balance measurement device at Victoria Lower Glacier

*Sites Visited

Site name	Evans Piedmont Glacier
Site location (coordinates/description)	77°43.7S, 162°33.7E, glacier surface
Dates occupied	14 Nov 2003 to 25 Nov 2003
Total days (or hours) at site	12 days
Maximum number of people at site	6
Total person-days (or person-hours) at site	60
Main activity undertaken	Ground penetrating radar survey and snow properties analysis

Geological Material

Location	77°43.7S, 162°33.7E
Specimen type	Snow samples
Quantity (kg)	20 kg

*Other environmental impacts

Exhaust fumes and noise from skidoos and generators used to conduct the site survey

*Differences from original Preliminary Environmental Evaluation (PEE)
None

*Sites Visited

Site name	Mt Erebus Saddle and Mt Terra Nova
Site location (coordinates/description)	77° 30.832S, 167°40.216 and 77°31.375S, 167°55.864E
Dates occupied	04 Dec 2003
Total days (or hours) at site	5 hours (total)
Maximum number of people at site	5
Total person-days (or person-hours) at site	25 person-hours
Main activity undertaken	Ground penetrating radar survey and snow properties analysis

*Other environmental impacts

None

*Differences from original Preliminary Environmental Evaluation (PEE)

None

IMMEDIATE SCIENCE REPORT

K049 NZ ITASE – Holocene Climate Variability along the Victoria Land Coast
ANTARCTICA NEW ZEALAND 2003/04

Event Personnel :

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Mr. Alex Pyne	Antarctic Research Centre, Victoria University
Mr. Matt Watson	ScanTec
Mr. Matt Wood	School of Earth Sciences, Victoria University
Ms Louise Christie	School of Earth Sciences, Victoria University
Mr. Ewan Paterson	Antarctica New Zealand

1 Popular Summary of Scientific Work Achieved

Unprecedented changes are occurring in the Earth's climate. The 1990's were the warmest decade in the last 2000 years and average global temperature is projected to rise between 1.4ºC and 5.8ºC by 2100 [*IPCC*, 2001]. Although the scientific evidence of global warming is now widely regarded as incontrovertible, predicting regional impacts is proving more problematic. Especially, conclusions of the Southern Hemisphere record are limited by the sparseness of available proxy data at present [*Mann and Jones*, 2003].

While meteorological records from instrumental and remote sensing data available display the large intercontinental climate variability, the data series are insufficient to infer trends or to understand the forcing, which renders prediction difficult [*Jones et al.*, 1999; *Mann and Jones*, 2003]. The long ice core records from the Antarctic interior and Greenland revolutionised our understanding of global climate and showed for the first time the occurrence of RCE (Rapid Climate Change Events) (for review e.g. Mayweski and White [2002]). To understand the drivers and consequences of climate change on timescales important to us humans, a new focus of ice core work is now moving to the acquisition of 'local' ice cores that overlap with and extend the instrumental records of the last 40 years back over the last several thousand years.

This has been a key motivation behind the US-led International Transantarctic Scientific Expedition (ITASE) of which New Zealand is a member. The NZ ITASE objective is to recover a series of ice cores from glaciers along a 14 degree latitudinal transect of the climatically sensitive Victoria Land coastline to establish the drivers and feedback mechanism of the Ross Sea climate variability. Furthermore, the ice core records will provide a baseline for climate change in the region that will contribute to the NZ-led multinational Latitudinal Gradient Project as well as providing a reference record for the NZ-led ANDRILL objective to obtain a high-resolution sedimentary archive of Ross Ice Shelf stability.

During the 2003/04 field season a site reconnaissance for two of the proposed sites, Evans Piedmont Glacier and Mt Erebus Saddle, has been carried out, using ground penetrating radar and snow properties analyses. The survey shows that both sites are excellent drilling locations with adequate ice thickness to potentially provide as much as 10,000 year long records. Furthermore, Victoria Lower Glacier, the first ice core site of this programme has been revisited to maintain the longer-term mass balance measurement time series, that commenced in 1999. Our 3 year results show that this glacier is ablating by about 12cm per year.

2 Proposed Programme

Seven key locations were identified for the NZ ITASE (International Transantarctic Scientific Expedition) programme. The analyses on the ice core from the first site, Victoria Lower Glacier in the McMurdo Dry Valleys, have almost been completed. For the 2003/04 field season we proposed to carry out a detailed reconnaissance and to recover intermediate length cores from sites 2 and 3: Evans Piedmont Glacier and Mt Erebus Saddle. Due to logistical constraints of Antarctica New Zealand the drilling was deferred to the 2004/05 season, but the site reconnaissance was conducted. Furthermore we continued our longer-term mass balance measurement time series at Victoria Lower Glacier.

Evans Piedmont Glacier Ice Core Record

To our knowledge the Evans Piedmont Glacier site is, with 380m asl, the lowest elevation site identified for drilling in Antarctica. As such it has the potential to provide a climate record with unprecedented sensitivity for tropospheric climate variability and hereby contributing directly to the discussion on the dominant driving force of Antarctic climate variability [*van den Broeke*, 2000; *Hall and Visbeck*, 2002; *Thompson and Solomon*, 2002; *Venegas*, 2003].
The Evans Piedmont Glacier is located in the vicinity of the proposed ANDRILL site in 'Granite Harbour', which is expected to provide also a Holocene record. The comparison of the overlap between the two records provides us with the unusual opportunity to distinguish between the terrestrial and marine signal. This will add significantly to the discussion on the relative importance of the ACW (oceanic), SAM (atmospheric), and ENSO (both); their forcing and feedback mechanism. Furthermore, the sub-annual to decadal ice core record from Evans Piedmont Glacier can help to tune the marine Granite Harbour record and potentially provides a record of the final retreat of the Ross/McMurdo Ice Shelf.
The regional climate record contained in the ice will provide background information for the Latitudinal Gradient Project site 'Granite Harbour', especially for temperature, precipitation, sea-ice extent, storminess, seasonality, and snow accumulation. As mentioned before, this will help to determine if the current ecological system found has evolved under prevailing climate, or how much time the ecological system had to adjust to potential climate change in the recent past.
In collaboration with the US ITASE effort (a traverse from South Pole to Northern Victoria Land along the plateau side of the Transantarctic Mountains) we aim to provide continentality and elevation gradients, to compliment to our understanding of deep ice core records from the Antarctic interior. Furthermore, the importance of katabatic winds and the intrusion frequency of marine airmasses into the Antarctic interior through time can be established.

Mt. Erebus Saddle Ice Core Record

Mt Erebus Saddle lies in the pathway of the ENSO initiated katabatic surges across the Ross Ice Shelf [Cullather et al., 1996; Bromwich et al., 2000] and also of enhanced cyclonic activity from the Southern Ocean [Bertler et al., submitted]. Therefore, a Mt Erebus Saddle ice core record is likely to show the strongest ENSO influence of all proposed sites. The ENSO record (Southern Oscillation Index) is short and various proxies have been tentatively proposed to reconstruct ENSO variability [Adams et al., 2003; Tudhope and Collins, 2003]. The ice core record from Mt Erebus Saddle potentially provides a mean to reconstruct ENSO since its initiation in the early Holocene. Furthermore, the comparison between Mt Erebus and Mt Prior at Cape Hallett will provide a mean to distinguish ENSO driven climate variability from SAM and ACW forcing.
The semi-permanent Ross Ice Shelf polyna, just east of Ross Island, is also the result of these katabatic winds and is an important area for the production of sea-ice [King and Turner, 1997] and Antarctic Bottom Water [Bromwich et al., 1993]. The Mt Erebus ice core is likely to provide a record of the winter polyna activity through time, via the marine fingerprint in the ice chemistry.
Moreover, the Mt Erebus Saddle is located in the vicinity of the proposed ANDRILL location 'Windless Bight'. The sub-annual to decadal ice core record provides a high resolution Holocene record for the much longer but overlaying ANDRILL ice shelf and marine record.
Additionally, the site is only 37km from Scott Base and McMurdo Station and will provide a long-term perspective on climate variability and iceberg discharge, relevant for both, Evans Piedmont Glacier and Mt Erebus sites.

3 Scientific Endeavours and Achievements

During the 2003/04 season we visited three sites: Victoria Lower Glacier, Evans Piedmont Glacier, and Mount Erebus Saddle.

Victoria Lower Glacier

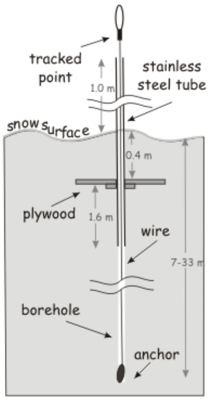


Fig.2 Mass balance measurement device at Victoria Lower Glacier

During the 1999/2000 season three submergence velocity devices [*Hamilton and Whillans*, 2000] for mass balance measurements in the McMurdo Dry Valleys were installed (Fig.2). This method is used to determine mass balance by comparing vertical velocity of a marker in firn or ice with long-term, average snow accumulation rates. The movement of the marker is the result of three motions: firn compaction, gravitational glacial flow, and changes in mass balance. The device (Fig.2) consists of a non-stretchable, stainless steel wire attached to a metal anchor that is heated and placed into a drilling hole drilled in firn (or ice). The anchor melts the bottom ice and freezes in. A wire is stretched tight and guided by a stainless steel tube from the top of the drilling hole. A rod is held in place using plywood that has been buried ~40cm into the snow to avoid melt around the darker wood surface. The top end of the wire has a loop and permanent marker, the tracking point. High precision GPS measurements are used to determine absolute position of the tracking point during subsequent years. Density measurements are made on the core recovered from the drilling. To calculate the surface slope in the direction of the glacier flow, the ice surface topography is surveyed using GPS in the vicinity the device. We revisited the three sites to measure current mass balance in continuation of the time series over the last 4 years. A GPS base station was deployed for the time of our visit at Staeffler Ridge. Our time series indicates a negative mass balance of about 12cm per year.

Evans Piedmont Glacier

Evans Piedmont Glacier is one of the three drilling targets planned for season 2004/05. The site reconnaissance included a GPS and GRP survey and closer investigation of the snow properties from a snow profile.

Ground Penetrating Radar (GPR)

Ground penetrating radar (GPR) measurements provide an image of the internal layering of a glacier and the topography of the ice-rock interface beneath. We applied low and high frequency radar pulses (35 MHz, 200MHz, and 400MHz) to map the bedrock interface and internal flow structures in the glacier. Those features are identified through reflectors that result from changes in physical and chemical properties, such as dust layers or aerosol and density variations and are thought to represent isochrones [*Morse et al.*, 1998; *Vaughan et al.*, 1999]. The choice of antenna frequency involves a trade-off between penetration depth and mapping resolution. The control units were mounted on a Nansen Slege, pulling transmitter and transceiver antennae.

The sledge also carried high precision GPS antenna, which is tied to the temporary GPS base station deployed at the Evans Piedmont Glacier camp.

Fig.3: GPR/GPS set-up. A 400MHz antenna travels in front of the first skidoo. A second skidoo tails the set-up for crevasse safety.

Traverses totaling approximately 30km have been surveyed with GPR. The measurements show that the glacier thickness exceeds on average 150m (Fig.4) and is well over 200m deep at the identified drilling location. Excellent isochrone reflections are visible throughout the profile (Fig. 4), which will also be used to investigate geographical and chronological accumulation changes. Further post-processing will enhance the reflectors and will correct for surface topography.

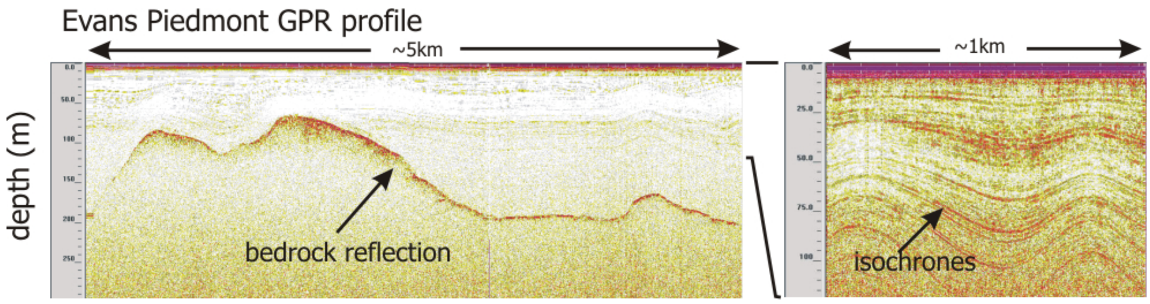
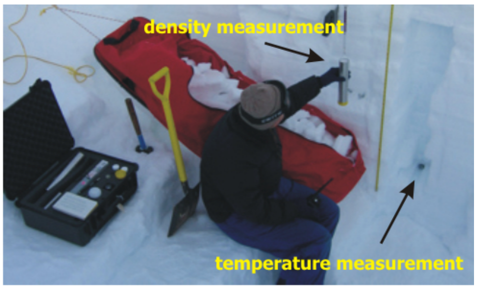


Fig.4: Radar profile from Evans Piedmont Glacier showing bedrock topography, ice thickness and internal flow structures

Analyses of Snow Properties

A 4m deep snow pit was excavated to allow high resolution snow analysis. The snow profile was sampled with 1cm resolution for analysis on snow chemistry (Na, Ca, K, Mg, Cl, NO_3, SO_4, MS, Al, Fe, Si, Sr, Tr, Zn) and isotopic composition ($\delta^{18}O$ and δD), dust content and mineralogy (Fig.5). The data are used to establish transfer functions between meteorological records and the snow/ice core record, for temperature, precipitation, airmass origin, wind strength and direction, storm frequency, etc. The high sampling resolution provides sub-annual resolution of the climate record. Furthermore density and temperature of the snow pack was measured with 5cm resolution (Fig.5), and snow crystal structure was investigated. This information is important to calculate annual accumulation rates and to evaluate the potential of re-crystallisation in the snow pack. Our initial results suggest excellent characteristics for ice core analysis.

Fig.5: Analysis of snow properties including high resolution snow sampling (left), and density and temperature measurements with 5cm resolution (right).



During our stay at Evans Piedmont Glacier two snow precipitation events occurred which provided the opportunity to sample hourly throughout the snowfall (Fig.6). This will allow us to fingerprint snow chemistry and isotopic composition with the meteorological situation as seen in the satellite image, enabling airmass trajectory reconstruction in ice core material from this site. While the first event was caused by mesoscale cyclonic activity and consisted of blowing and precipitating snow, the second event was caused by intrusion of local moist, marine airmass, leading to crystal growth at the snow surface.

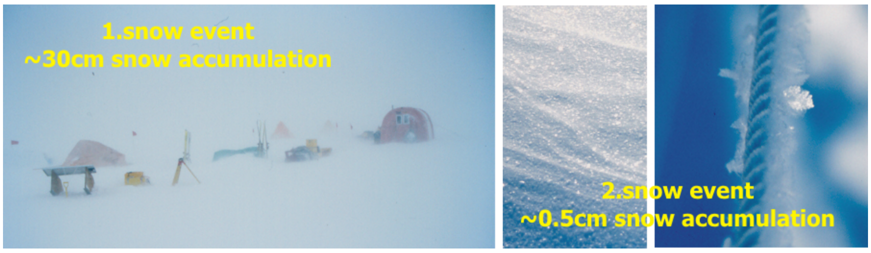


Fig.6: Two snowfall events at Evans Piedmont Glacier.

Mt Erebus Saddle

Mt Erebus Saddle is one of the three drilling targets planned for season 2004/05. Due to bad weather that shortened the field time available, we were not able to set up camp at this site. A one-day site reconnaissance included a GPS and GRP survey and initial investigation of the snow properties from a shallow snow pit and core. The results from this initial investigation suggest that the proposed drilling site has the necessary characteristics for a suitable drilling site.

Ground Penetrating Radar (GPR)

As bad weather prohibited a full camp set-up at Mt Erebus Saddle the GPR measurement was done by manhauling a lightweight version of our Evans Piedmont Glacier GPR setup (Fig.7). For this reason only one 35MHz antenna was used. An example of the raw data is shown in Fig.7. A strong bedrock reflection indicates that ice depth exceeds 200m. The prominent isochrones seen at about 50m are potentially tephra layers. The sparse coverage does not permit investigating spatial accumulation pattern. However, the persistence of isochrones throughout the profile, their horizontal direction and the total depth of the glacier at the proposed drilling site indicate promising characteristics for a potential ice core record from Mt Erebus Saddle.

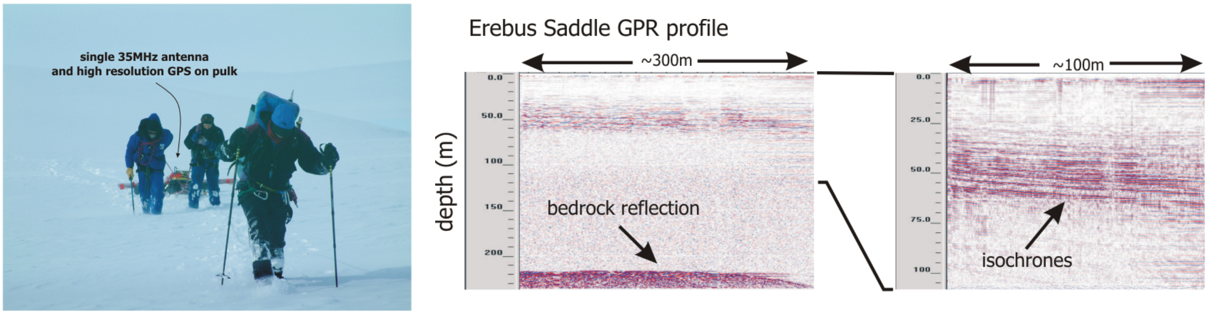


Fig.7: Manhaul of a lightweight GPR and high resolution GPS equipment (right). Radar profile from Mt Erebus Saddle showing bedrock topography, ice thickness and internal flow structures (left).

Analyses of Snow Properties

While high resolution snow sampling was not possible in the time available, investigation of a 2.50m firn core and a 1m deep snow pit indicates that Mt Erebus Saddle is a high accumulation site, likely in excess of 40cm water equivalent per year. For this reason Mt Erebus Saddle potentially contains a climate record of sub-seasonal resolution.

4 Publications

Planned publications from this work include:

Bertler, N., Barrett, P., Mayewski, P.: High resolution climate record from coastal Victoria Land.
Bertler, N.: What causes the McMurdo Dry Valleys glacier to retreat?
Bertler, N. & Watson, M.: Past and present mass balance and accumulation pattern as derived from ground penetrating radar
Watson, M. & Bertler, N.: Dielectric properties of a marine influenced glacier as recorded in ground penetrating radar profile.

5 Acknowledgments

We would like to thank Antarctica New Zealand staff based in Christchurch and Scott Base for their enthusiastic and innovative support with our project, especially Lou Sanson, Dean Peterson, Paul Woodgate, Julian Tangaere, Keith Springer, and John Roberts. We are grateful for the professional assistance of Ewan Paterson in the field. The crevasse safety training with Rob McBrearty was highly appreciated. We are indebted to Helicopter NZ staff, Rob McPhail and Richard Desborough. This project is funded by Victoria University of Wellington, FrST and the Trans-Antarctic Association Fund.

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