Antarctica New Zealand

LOGISTICS REPORT

K049: NZ ITASE
ANTARCTICA NEW ZEALAND 2006/07

Event Personnel:

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Dr. Sepp Kipfstuhl	Alfred Wegener Institute, Germany
Dr. Dean Peterson	Antarctica New Zealand
Mr Alex Pyne	Antarctic Research Centre, Victoria University of Wellington
Mr Glen Kingan	Webster Drilling and Exploration Limited
Mr Matt Watson	ScanTec Limited
Mr Davie Robinson	GNS Science
Ms Julia Bull	Antarctic Research Centre, Victoria University of Wellington
Mr Rod Boys	School of Geography, Environment, and Earth Sciences, Victoria University of Wellington

Name of compiler: **Nancy A.N. 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 been completed. During the 2003/04 field season we carried out a detailed reconnaissance of sites 2 and 3: Evans Piedmont Glacier (EPG) and Mt Erebus Saddle (MES) and determined the most suitable locations of the ice core recovery. During the 2004/05 field season we recovered to intermediate length ice cores (180m and 200m, respectively) from these locations and conduct further in-situ measurements, such as borehole temperature and light penetration characteristics, snow density and stratigraphy and its geographical variability. Furthermore, we installed a weather station and mass balance devices at EPG and cased the borehole at MES for future measurements. During the 2005/06 field season we re-visited VLG and EPG to conduct GPS measurements of the submerge velocity devices and to sample shallow snow pits. Furthermore, we retrieved the meteorological data and carried out maintenance work on the automatic weather station at EPG. Lastly we deployed 6m snow stakes at the high accumulation site at Mt Erebus Saddle. During the 2006/07 season we conducted a field survey at Whitehall Glacier and recovered a 100m deep ice core and recovered another 180m deep ice core from Mt Erebus. In addition we revisited VLG and EPG for mass balance measurements and automatic weather station maintenance as in the previous year.

The NZ ITASE 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 [Bertler et al. 2004; Meyerson et al. 2002] 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 [Hall and Denton 2000; Steig et al. 1998; 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 (submergence velocity method [Hamilton and Whillans 2000; Hamilton et al. 1998]) have been deployed at Victoria Lower Glacier. The device has since been revisited. The measurements show that the glacier has a slightly negative mass balance, losing around 12-15cm 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 critically relies 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
N. Bertler	PI	ARC, Victoria University	19 Oct 2006	09 Jan 2007
S. Kipfstuhl	Glaciologist	Alfred Wegener Institute	19 Oct 2006	09 Jan 2007
G. Kingan	Drilling Expert	Webster Drilling	19 Oct 2006	04 Jan 2007
M. Watson	Radar Expert	Scan Tec	27 Oct 2006	20 Nov 2006
D. Robinson	Mountaineer		27 Oct 2006	12 Dec 2006
D. Peterson	Atmosph. Physics	Antarctica New Zealand	Transfer from K700 11 Nov 2006	Transfer to K700 01 Dec 2006
J. Bull	Student	ARC, Victoria University	11 Nov 2006	12 Dec 2006
R. Boys	Student	Victoria University	07 Dec 2006	07 Jan 2007
A. Pyne	Technical Support	ARC, Victoria University	Transfer from K001 04 Jan 2007	Transfer to K001 04 Jan 2007

*PLANNING

- *Application process*

N.A.

- *Communications with Antarctica New Zealand staff*

Communication with Antarctica New Zealand staff was professional, timely, and effective.

- *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

- *Environmental Advice*

  The information received was timely and valuable

- *Other comments*

*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. We would like to thank E. Barnes for his innovative and flexible approach and the successful organisation of our logistically challenging field programme.

- *Availability and condition of equipment received*

We would like to thank Scott Base field support crew, B. McDavitt and J. Burton for their exceptional support with the preparation of our field event as well as their assistance with all of our field and science cargo and ice core deliveries. B. McDavitt and J. Burton prearranged prior to our arrival a significant part of our field camping equipment in the Hillary Field Centre cages.

- *Field training*

The arrival of our group members was staged according the evolving needs and preparation requirements of the programme. For this reason, the first members of K049 to arrive were Bertler, Kipfstuhl, and Kingan to conduct the test drilling at Windless Bight as agreed on with Antarctica NZ as condition of shipping the ice core drilling during the previous season to Antarctica. The field manager suggested that the group would wait with the Antarctic field training until D. Robinson, the designated field safety expert, would arrive 8 days later with the second subgroup. This was welcome by the team as it provided a good and practical opportunity for a tailored shakedown journey, catering for the specific needs, such as skidoo travel in crevassed areas with their field safety expert. However, it became apparent, that as a consequence, the group was not allowed off-base until they could fulfil the requirement of a passing an Antarctic field training. Considering their considerable field deployment experience, this seemed unnecessary and posed a significant problem, to conduct the test drilling at Windless Bight in the available time. However, a compromise was found and the group participated in a refresher course and was subsequently allowed off-base to the Windless Bight ANDRILL location. However we suggest that previous experience will be taken into account when such requirements are determined.

The field training with R. Kirkwood and D. Robinson was excellent and catered for the specific needs of this group. Extensive crevasse extraction training, roped skidoo-travel, and management of extreme weather conditions were an important focus of the training. All members felt that the field training was very practical, helpful, and beneficial for the team. We are grateful to E. Barnes for the concept and excellent implementation of a modulised, tailored field training programme.

- *Field party equipment 'shakedown' journey*

The equipment shakedown journey was particularly useful as minor defects in the equipment were identified and repaired, as well as traverse routines practised and revised. When the team deployed to Whitehall Glacier, all science and field equipment was thoroughly tested and checked.

- *Delays at Scott Base, whatever the cause*

Weather conditions delayed our field deployment to Mt Erebus Saddle by two days.

- *Safety and Risk Management processes*

The risk management process was useful.

- *General comments about Scott Base*

The Hillary Field Centre is a well designed, practical, and much welcome improvement for field preparations. The cage system as well as the bench space along with the excellent organisation and coordination of B. McDavitt and J. Burton allowed a number of groups to concurrently prepare and test their science and field equipment indoors. In addition this provided an atmosphere for scientific exchange between groups as well as exchange of practical experience between individuals. The doors to the cages are somewhat too narrow and don't allow equipment to be transferred by trolley. Also, the bench space would benefit from better protection against dust and cold air coming from the garage entrance part, which makes it currently difficult to leave sensitive equipment out on the benches.
Overall, we observe an increase in rules and regulations at Scott Base that seem at times unnecessary, such as increased bureaucratic paperwork (eg. we were required to fill out three separate Event Risk Management & Scott Base Processing forms), posted common sense rules (eg. a sign in the bar that intoxicated or underage persons will not be served alcohol), and the somewhat ridged implementation of regulations (eg. we were told that we would not be allowed to deploy into the field for our third field deployment this season (Mt Erebus Saddle) if the signed Event Risk Management and Scott Base Processing form wasn't received by the Programme Support Manager by 8pm the previous evening). While growing demands and challenges may necessitate Antarctica New Zealand to streamline, we hope that the practical and innovative spirit of the New Zealand programme will be retained.

FIELD TRANSPORT

- *Vehicles*

Fig.1: Linked skidoo traverse

Skidoos

We used two Bombardier skidoos (SWT 10 and 08) for traversing Whitehall Glacier. These skidoos are easier to drive and to start than the older Alpine II models. However, in soft snow the pulling capacity of the Bombardier is less than that of an Alpine II and at steeper slopes, we had to assist pushing the Nansen sledge manually to avoid the skidoo to be drawn down-slope by the weight of the sledge. Also, in soft snow, a second person had to sit on the front skidoo to enhance traction, which was possible once we radar scanned the area for crevasses. In addition, both skidoos showed signs of fatigue with hairline cracks developing in the chassis of the variator. Overall, the skidoos were reliable and performed well. We are grateful for the in depth discussion with Scott Base mechanics T.Griffith-Jones prior to our field deployment on maintenance and safety issues as well as on necessary adjustments for high elevation deployment. The skidoos were well prepared and fitted with spare parts and we received professional and useful advice during field deployment via radio.

- *Aircraft Operations*

DC-3

The field deployment with the DC-3 was highly successful, efficient, and a practical alternative to a potential Hercules field deployment. In preparation for field deployment to a new site, we met with the pilots, discussed satellite images and digital elevation models of the site. The crew provided us with aircraft pallets which we pre-packed and plastic wrapped. Total cargo weight of 5,400-5,800 lb for deep field input combined with the large cargo volume makes the DC-3 a very efficient aircraft for medium size field parties. The landing at this new site was smooth and unproblematic. Three flights accommodated the cargo input of almost 15,000 lb. The loading and unloading of the aircraft was fast and relatively easy even for heavy equipment, such as skidoos or fuel drums, with the built in crane system and ramp. We would like to thank the crew for their professional, practical, and friendly approach and attitude.

Fig.2: DC-3 deployment at Whitehall Glacier

Twin Otter

Fig.3: Twin Otter pick-up at Whitehall Glacier

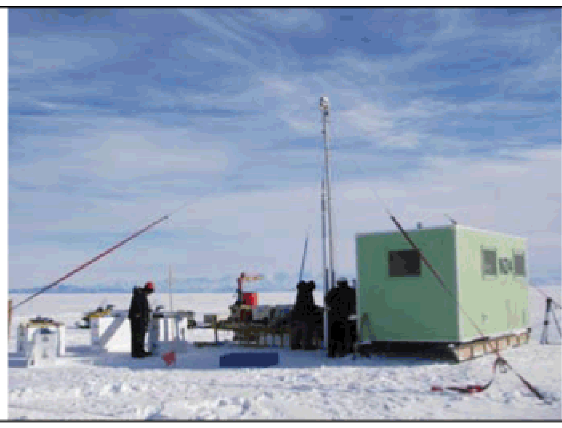
In the second half of our field deployment, the DC-3 was committed with other field programmes. Instead, the Mario Zuchelli Station based Twin Otter proved also highly efficient in picking up ice core boxes, passengers and remaining cargo. The communication with the crew at Mario Zuchelli Station was at times difficult from the field site because of radio problems on our site, and assistance from Scott Base was much appreciated. We are also grateful for the professional and friendly assistance of staff at Mario Zuchelli Station and the Twin Otter crew

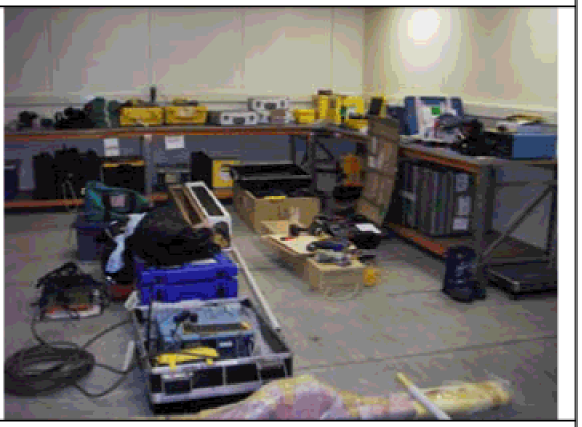
HNO

Field deployment to Mt Erebus Saddle was carried out with HNO. Despite difficult weather conditions, the deployment and pickup of cargo and passengers was very professional, efficient, and safe. A total of eight loads were deployed to the site including six sling loads, which were pre-packed under supervision of the flight crew, R.McPhail and R.Fletcher, prior to the scheduled flight day. All sling loads travelled well and high efficiency of the crew and the SB support crew (B.McDavitt and J.Burton) ensured that all cargo was deployed safely and quickly. The extensive regional and local experience of R.McPhail is invaluable. We are grateful for the exceptional support by HNO.

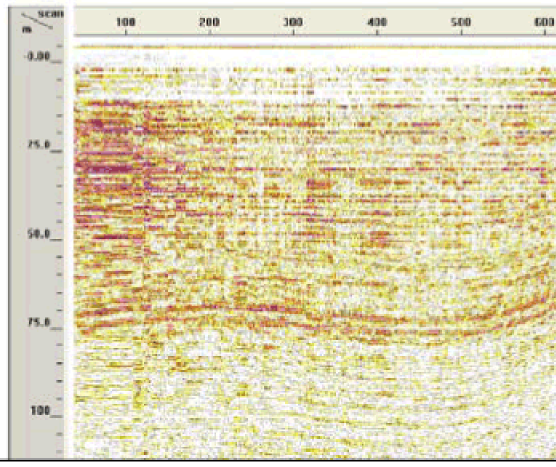
Fig.4: Helicopter deployment at Mt Erebus Saddle

*EVENT DIARY

Date	Main Activities and Location	Other Comments
19 Oct Thu	Bertler, Kipfstuhl, Kingan arrive at SB	
20 Oct Fri	AFT refresher, locate cargo	
21 Oct Sat	Loading of ice core drilling equipment on Huggland sledge, test 3-phase generators	
22 Oct Sun	Transfer ice core drilling equipment to ANDRILL drill site, discuss drill set-up and site safety with A.Pyne and T.Kingan	
23 Oct Mon	Set-up of ice core drilling system and commence drilling to 10m depth, transfer of wannigan to drill site, ice cores are stored in SB science freezer in ice core boxes 300, 301	
24 Oct Tue	Bertler, Kipfstuhl, Kingan complete skidoo licence, continue test drilling, target depth is 20m as water level in ANDRILL hotwater borehole is ~20m from surface.	

	Remaining 10m of core are packed in ice core boxes 302-303 and stored in SB science freezer	
25 Oct Wed	Disassemble drilling system and transfer back to SB; start to pack and weigh field cargo, repacking of drilling system	
26 Oct Thu	Testing of field equipment, such as tents, stoves. SB carpenter finished generator boxes and SB engineer assists in set-up of winch system	
27 Oct Fri	Watson and Robinson arrive at SB, cargo preparation	
28 Oct Sat	AFT and roped skidoo – Nansen sledge travelling training with Robinson and Kirkwood, continue to test equipment and set-up traverse radar and GPS system	
29 Oct Sun	Crevasse rescue training with Robinson and Kirkwood, continue traverse training	
30 Oct Mon	Set-up of radar equipment on Nansen sledge and test radar equipment to skifield using 500 MHz antennae, finish cargo preparation, test radio equipment	
31 Oct Tue	Test radar equipment using 35 MHz antennae on deeper ice, identify and certify hazardous cargo	
01 Nov Wed	Test radar equipment using 10 MHz antennae on deeper ice on Aurora Glacier, meeting with DC-3 pilots to discuss cargo packing requirements	
02 Nov Thu	Pick-up of aircraft pallets, commence prepare individual loads for DC-3 input	
03 Nov Fri	Complete cargo loads, complete testing field equipment	
04 Nov Sat	Transfer cargo loads to ice runway	

05 Nov Sun	Science visit to ANDRILL, SB check-out meeting	
06 Nov Mon	Bertler, Kipfstuhl, Watson, Kingan, Robinson: put-in to Whitehall Glacier with two DC-3 loads; flight time 120mins (one way), total cargo load 11,000 lb Set-up camp, secure cargo *(sunny, cloud-free, wind <5knots)*	
07 Nov Tue	Set-up ground penetrating radar (GPR) equipment and GPS base station, commence radar survey with 35MHz and 500MHz antennae. Survey shows only minor crevasses *(sunny, 10% cloud cover, wind 5-10 knots)*	
08 Nov Wed	Continue GPR survey with 35MHz and 500MHz antennae, weather conditions deteriorate and survey is suspended. Initial data show site will be suitable for drilling. Move to Malta Plateau is not necessary. *(80% low cloud cover, visibility 50-2000m, blowing snow, wind 10-25 knots)*	
09 Nov Thu	Weather conditions remain marginal, field work is restricted to camp area, set-up of snow accumulation stakes, repositioning of HF radio antenna, check and secure cargo *(100% low cloud cover, visibility 50-500m, blowing snow, wind 25-45 knots)*	
10 Nov Fri	Weather conditions improve, dig out cargo and camp equipment, repair snow damage on GPR sledge, blowing snow damages electronic during operation *(40-100% low cloud cover, visibility 200m to unrestricted, blowing snow, wind 10-20 knots)*	
11 Nov Sat	Continue GPR survey using 10MHz antennae, but blowing snow damages electronics, field work is suspended, Bull arrives at SB from Chch, change 60L fuel drum of polar heaven heater *(5-20% cloud cover, unrestricted visibility, blowing snow, wind 10-15 knots)*	
12 Nov Sun	Continue GPR survey using 10MHz antennae, measure snow temperature and snow accumulation, Bull participates full AFT *(5-15% cloud cover, unrestricted visibility, blowing snow, wind 10-20 knots, drop of 2mbar)*	
13 Nov Mon	Continue radar survey using 35MHz antennae, measure snow temperature and snow accumulation, Bull participates full AFT	

	(10% cloud cover, unrestricted visibility, wind 10 knots, no blowing snow, drop of 3mbar)	
14 Nov Tue	Continue radar survey using 35MHz antennae, measure snow temperature and snow accumulation; Bull and Peterson arrive at MZS *(sunny, <10% cloud cover, unrestricted visibility, wind 10 knots, no blowing snow)*	
15 Nov Wed	Complete 35MHz antennae radar survey, measure snow temperature and snow accumulation *(sunny, <5% cloud cover, unrestricted visibility, wind 5-10 knots, no blowing snow)*	
16 Nov Thu	Analyse radar survey results, determine drill site, conduct high resolution radar survey with 200MHz and 35MHz grid in the vicinity of drill site. The radar shows good, horizontal reflectors (image left) and indicates suitable conditions for drilling. *(sunny, <10% cloud cover, unrestricted visibility, wind 10 knots, no blowing snow)*	
17 Nov Fri	Complete all GPR survey work, pack GPR equipment, final assessment on location of drill site *(100% cloud cover, cloud base <3000m, wind 10-15 knots, minor blowing snow)*	
18 Nov Sat	Bull, Peterson, and Marshall arrive at Whitehall Glacier with DC-3, total cargo load in 3400 lb. Marshall carries out environmental audit of the field camp. Watson and Marshall return to SB, total K049 cargo load 2900 lb Set-up capstan, start excavating drilling trench to 1.65m depth, cover trench with drill tent *(sunny, unrestricted visibility, wind <5 knots, bad weather warning from MZS)*	
19 Nov Sun	Built snow shelter for drilling trench as weather conditions deteriorate, continue to excavate drilling trench from within the drill tent to 2.20m depth. During the night, strengthened winds and increased snow drifts cause partial collapse of drill tent and fatigue of tent poles. Repairs are carried out and tent stabilises. *(100% cloud cover, blowing snow, large snow drifts, wind 10-45 knots)*	

20 Nov Mon	Snow accumulation and wind stress on drilling tent causes significant damage and collapse of the tent; wind barrier (anchored ice core boxes and additional cargo) disintegrates, weather conditions are marginal and deteriorate, all movements are restricted to camp site *(100% cloud cover, blowing snow, large snow drifts, visibility <10m, wind 40-60 knots)*	
21 Nov Tue	Weather conditions remain marginal, all movements are restricted to camp site, polar tents show signs of fatigue with rips in the outside canvas along poles *(100% cloud cover, blowing snow, large snow drifts, visibility <10m, wind 40-75 knots)*	
22 Nov Wed	Weather conditions improve, check camp and cargo, clear snow (net accumulation for the last 48 hours ~40cm snow), commence repairs on polar tents *(100% cloud cover, blowing snow, visibility 200-1000m, wind 10-35 knots)*	
23 Nov Thu	Initial improvement of weather conditions, clean-up of camp and cargo, inspection of drill site. Clearing snow of the collapsed and ripped drill tent, excavate snow that had filled the exposed drill pit, set-up of alternative cover for the drill pit using fragments of the original tent and additional tarpaulins. Enlarge and strengthen snow wall around the drill site (2m high and 1.5m wide). In the evening weather conditions deteriorate, wind increases to ~50 knots). *(20-80% cloud cover, blowing snow, visibility unrestricted, wind 15-30 knots, increasing to ~50 knots in the evening)*	
24 Nov Fri	Further strengthen snow wall, deepen drill pit and commence setting up the drill rig *(80% cloud cover, blowing snow, visibility unrestricted, wind 15-30 knots)*	
25 Nov Sat	Completed set-up of drill rig. Change to nightshift operation. Drilling operation is carried out during night hours, when temperatures are up to 15ºC cooler. Team goes to sleep at 4pm, reconvenes at midnight for breakfast, and commences drilling at 1am, 26 Nov *(100% cloud cover, precipitating snow, visibility <200m, wind 15-20 knots)*	
26 Nov	Commence drilling operation at 1am until 10am,	

Sun	accomplished drilling and processing depth 29.0m *(night time: sunny, <10% cloud cover, calm)*	
27 Nov Mon	Continue drilling shift at midnight, accomplished drilling and processing depth 57.0m. Commence concurrent high resolution snow sampling in multiple snow pits. *(night time: sunny, <10% cloud cover, calm)*	
28 Nov Tue	Continue drilling shift at 11pm, accomplished drilling and processing depth 85.0m. Shift times are commenced earlier, as temperatures in the morning are now rising more rapidly due to the sun now climbing above the eastern mountain range. Temperature in the drilling pit at midnight is -14ºC, dropping to -20ºC at around 4am and rises to -7ºC at around 10am. Continue concurrent high resolution snow sampling in multiple snow pits. *(night time: sunny, no cloud cover, calm)*	
29 Nov Wed	Continue drilling shift at 11pm, accomplished drilling and processing depth 102.82 m. Electronic malfunction of drilling control unit terminates drilling. Attempts to repair the unit fail. Continue concurrent high resolution snow sampling in multiple snow pits. *(night time: sunny, <10% cloud cover, wind ~5-10 knots)*	
30 Nov Thu	Continue high resolution snow sampling in multiple snow pit. Continue to attempt repair of malfunctioning control unit. With assistance of SB staff we correspond with the drilling engineer at the Alfred Wegener Institute in Germany. Change to dayshift operation. *(night time: sunny, 30% cloud cover, wind 10-20 knots)*	
01 Dec Fri	Continue high resolution snow sampling, Twin Otter pick-up for ice core boxes and Peterson to SB. The flight is carried out as cold-deck to ensure integrity of the samples. Inspection of the data loggers shows that core box temperature during the flight remained below the temperature limit of -18ºC *(sunny, 50% cloud cover, wind 5-10 knots)*	
02 Dec Sat	After final attempt, decision was made that drill was not repairable in the field. Continue high resolution snow sampling. In discussion with SB staff pull out for 05 and 06 Dec is scheduled. *(sunny, no cloud cover, wind 10-20 knots)*	
03 Dec, Sun	Dismantling drill, pack cargo, pull down drilling tent. Continue high resolution snow pit sampling. *(sunny with fog in the afternoon, visibility dropping to <20m, wind 10-20 knots, increasing to 40 knots during the night)*	

04 Dec Mon	Commence building loads for four Twin Otter shuttles. Complete high resolution snow pit sampling *(sunny, visibility unrestricted, wind 10-20 knots, increasing to 30 knots during the night)*	
05 Dec Tue	1.Twin Otter shuttle arrives 9am; Kipfstuhl, remaining ice core boxes with snow samples, and ice core drill return to SB. 2. Twin Otter shuttle arrives 4pm; remaining ice core drill and science cargo return to SB. Continue to break-down camp *(sunny, visibility unrestricted, wind <5 knots)*	
06 Dec Wed	3.Twin Otter shuttle arrives at midday; camp and remaining science cargo return to SB. 4.Twin Otter shuttle arrives at 8pm; Bertler, Robinson, Kingan, Bull return with camping equipment to SB, arriving 10pm at Willies Field *(sunny, visibility unrestricted, wind <5 knots)*	
07 Dec Thu	SB electrician and engineer, Lyal Cross assists in helping to identify the problem with the control system. On-line information shows that the second control unit is wired differently from the first. We order new material for a drilling tent substitute for Mt Erebus from NZ Boys arrives at SB from Chch	
08 Dec Fri	Cross identified the problem in the control unit and re-wires the system. Initial tests show the new wiring plan circumvents the problem. Cross orders a new potentiometer Calculate total fuel needs (mogas and diesel). Identify and certify hazardous cargo for helicopter transport to Mt Erebus.	
09 Dec Sat	Set-up of the drilling system and testing of all units show the drill is operational again, pulling together new tents and camping equipment for Mt Erebus Robinson and Bull depart for Chch	
10 Dec Sun	Testing of new drilling tent set-up using scaffolding tubing and large, heavy tarpaulin Cleaning of tarpaulin and adjustment of scaffolding connectors	
11 Dec Mon	Packing eight helicopter loads and preparing 6 sling loads at the helo loading zone ready for pick-up	

12 Dec Tue	Scheduled put-in to Mt Erebus Saddle postponed due to weather condition to Thursday	
13 Dec Wed	No helicopter time available	
14 Dec Thu	Attempt for put-in to Mt Erebus Saddle; however attempt is aborted due to deteriorating weather conditions	
15 Dec Fri	Bertler, Kingan, Kipfstuhl, Boys, Roche, MacKey, successful put-in to Mt Erebus Saddle with eight helicopter loads, the prepared sling loads make the put-in efficient and fast, and all cargo is moved to the site before weather deteriorates again, set-up of camp, securing cargo	
16 Dec Sat	Commence set-up of drilling trench and drill tent. After a trench of initial 1.80m depth is excavated, it is covered with a tent to avoid snow filling over night. A substantial snow wall of ~1m thickness and ~1.80m height is constructed to protect the drilling trench from the predominantly southerly wind flow. *(sunny, visibility unrestricted, wind <5-20 knots)*	
17 Dec Sun	Continue excavation of drilling trench, excavating the processing platform to 2.60m, the core extraction platform to 4.00m, and start excavating ice core storage cave *(sunny, visibility unrestricted, wind <5-20 knots)*	
18 Dec Mon	Complete excavation of drilling trench and ice core storage cave, commence set-up of ice core drilling system *(sunny, visibility unrestricted, occasional low clouds restricting visibility, wind <5-20 knots)*	
19 Dec Tue	Complete set-up of ice core drilling system. Roche and MacKey depart for SB, remaining team switches to night shift and commences drilling at 11pm until 5am. Accomplished drilling and processing depth 20.0m *(sunny, visibility unrestricted, occasional low clouds restricting visibility, wind <5-20 knots)*	

20 Dec Wed	Continue drilling operation from 9pm to 7am. Accomplished drilling and processing depth 60.43m *(low clouds restricting visibility, wind <10-30 knots)*	
21 Dec Thu	Continue drilling operation from 9pm to 7am. Accomplished drilling and processing depth 100.00m *(low clouds restricting visibility, wind <10-20 knots)*	
22 Dec Fri	Continue drilling operation from 9pm to 4am. Accomplished drilling and processing depth 122.00m. Contaminated fuel causes generator failure. The generator is taken apart and cleaned but problem persists. *(sunny, unrestricted visibility, wind <10-20 knots)*	
23 Dec Sat	Arrange with Scott Base for HNO to pick up generator for repair by Scott Base mechanic T.Griffith-Jones. In addition, engineer W.Dean modifies fuel pump to include a filter to prevent further problems due to contaminated fuel. Generator and modified fuel pump are returned to the site by late afternoon. Continue drilling operation from 9pm to 6am. Accomplished drilling and processing depth 150.00m *(low clouds restricting visibility, wind <10-20 knots)*	
24 Dec Sun	Continue drilling operation from 9pm to midnight. Core quality deteriorates and drilling adjustments are necessary. Accomplished drilling and processing depth 155.40m Christmas dinner at 8am in beautiful weather. *(sunny, unrestricted visibility, wind < 5knots)*	
25 Dec Mon	Continue drilling operation from 10pm to 2am. Core quality issues persist, antitorque appears to slip. Accomplished drilling and processing depth 158.90m *(low clouds restricting visibility, wind <10-20 knots)*	
26 Dec Tue	Adjustments and minor repairs on the drilling system do not improve drilling quality. The spinning antitorque causes the drill cable to kink. Drilling operation is terminated. Commence manual drilling of 8 x 2m surface	

	cores for high resolution snow analysis *(low clouds restricting visibility, wind <10-20 knots)*	
27 Dec Wed	Commence dismantling drill, pack cargo, pull down drilling tent *(low clouds restricting visibility, wind <30-40 knots)*	
28 Dec Thu	Complete dismantling drill and pack cargo, prepare helicopter sling loads	
29 Dec Fri	Return to Scott Base, store ice core boxes in Scott Base Science Freezer, start cleaning and drying field equipment	
30 Dec Sat	Clean and dry field equipment, start packing cargo, discuss with Keith DePew, US Science Cargo Officer, shipment of ice core boxes to NZ	
31 Dec Sun	Pack cargo, clean and return field equipment, store empty ice core boxes in container	
01 Jan Mon	Day off	
02 Jan Mon	Arrange ice core boxes in Scott Base Science Freezer to economise room, weigh cargo, identify hazardous cargo	
03 Jan Tue	Palletise cargo, discuss with cargo handler J.Martin handling procedures for the shipment of temperature sensitive material, MAF permits, and requirements for the remaining cargo, find space to store the	
04 Jan Wed	Bertler, Kipfstuhl, Pyne, Boys, Roche, Clendon to Victoria Lower Glacier to set-up GPS on mass balance devices (above) and then move on to Evans Piedmont Glacier to service weather station and download data, measure mass balance devices, and take 100 snow samples. Then return to Victoria Lower Glacier to pick-up GPS equipment and return to Scott Base, Kingan returns to NZ	
05 Jan Thu	Pack snow samples for shipment, pack GPS equipment and palletise, return remaining field equipment, such as generator, fuel, survival gear etc	
06 Jan Fri	Clean out cage in the Hillary Field Centre	
07 Jan Sat	Meeting with US Science Cargo Officer, K.DePew to discuss loading and procedures of ice core shipment, check weather station data and discuss with P.Clendon,	

	Boys returns to NZ	
08 Jan Sun	Down-load temperature data loggers from ice core boxes, clear office space.	
09 Jan Mon	Transport of 4 ice core boxes to MZS for shipment with Italica to Alfred Wegener Institute Bertler, Kipfstuhl return to NZ	

EVENT MAP

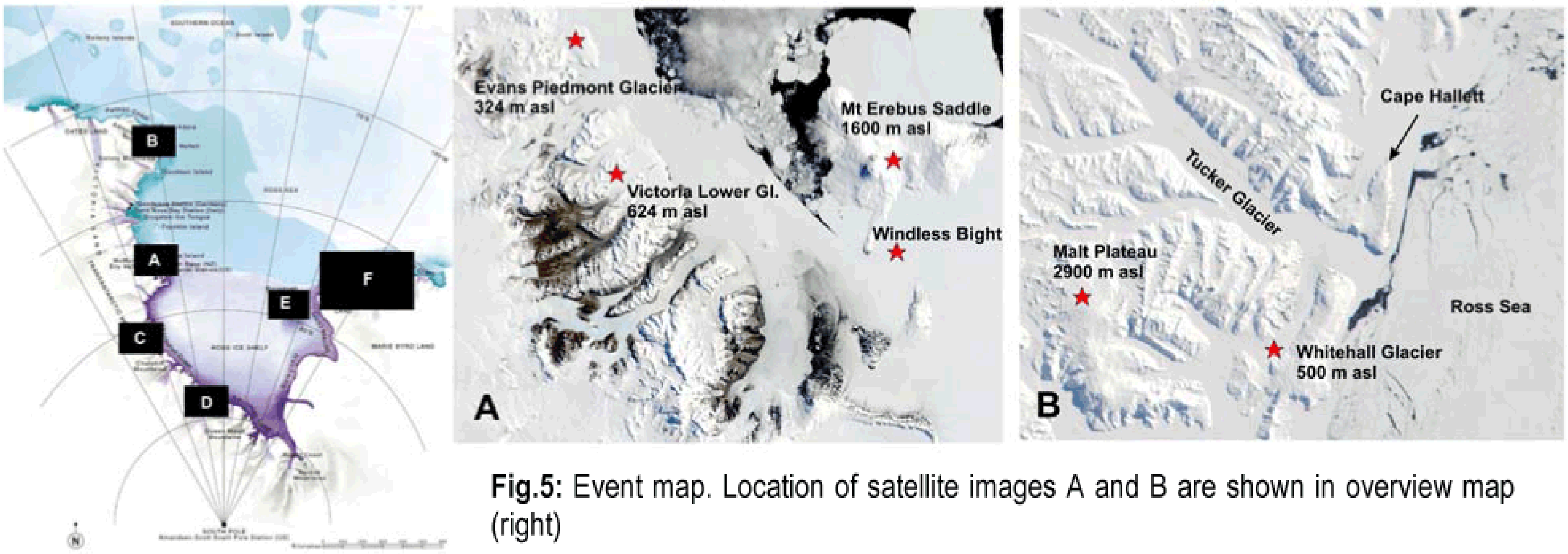


Fig.5: Event map. Location of satellite images A and B are shown in overview map (right)

*WEATHER

During field deployment, a Tinytag Ultra 2 temperature data logger was tied to a pole to record ambient temperature. As these data loggers are not protected from solar insolation, maximum temperatures are vastly exaggerated and provide only a qualitative approximation of ambient temperature trends. Overall, we had variable weather conditions at Whitehall Glacier with strong winds up to ~70 knots and temperatures to -30ºC with blowing and precipitating snow, while weather conditions at Mt Erebus Saddle were surprisingly pleasant with overall calm, sunny conditions.

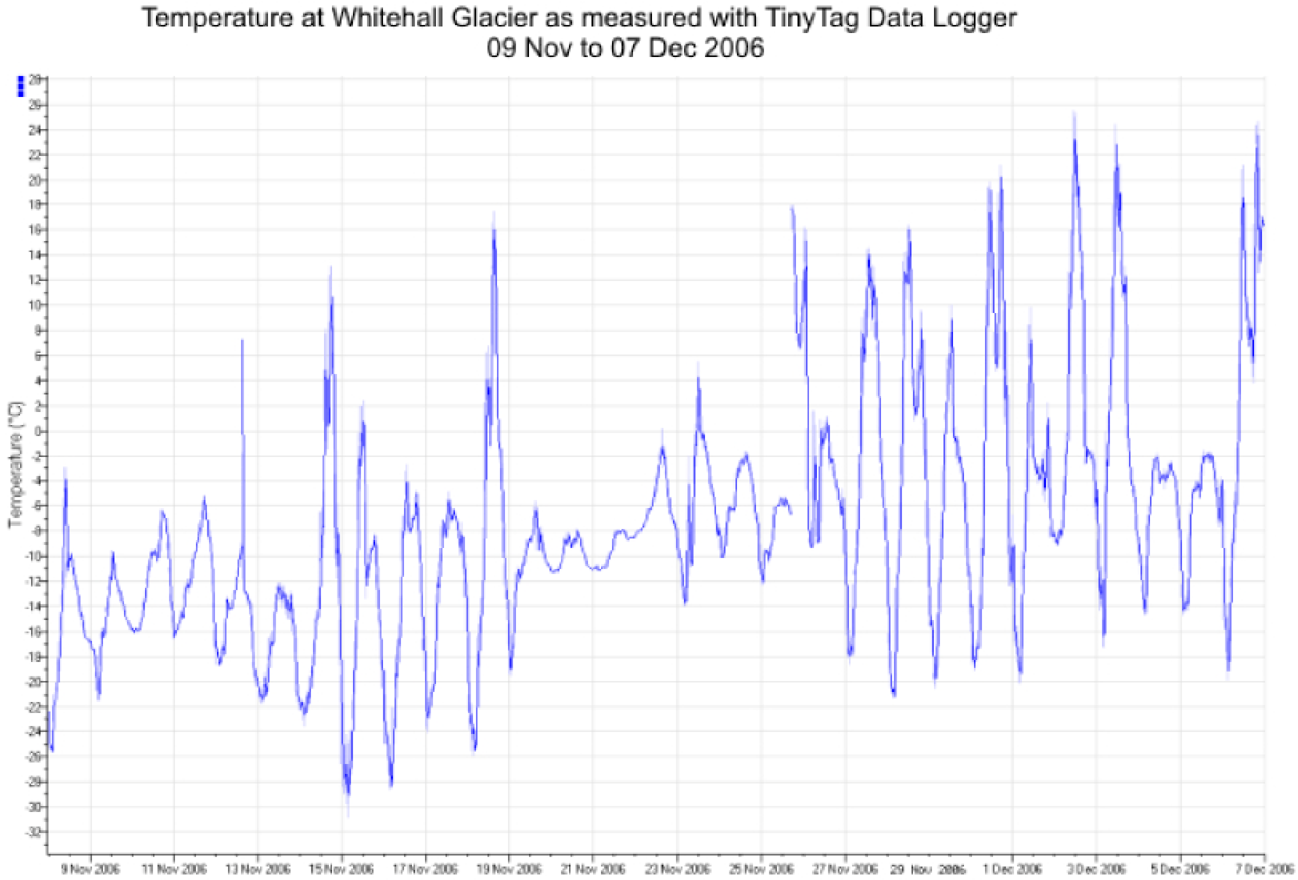


Fig. 6: Temperature at Whitehall Glacier as measured with TinyTag Data Logger

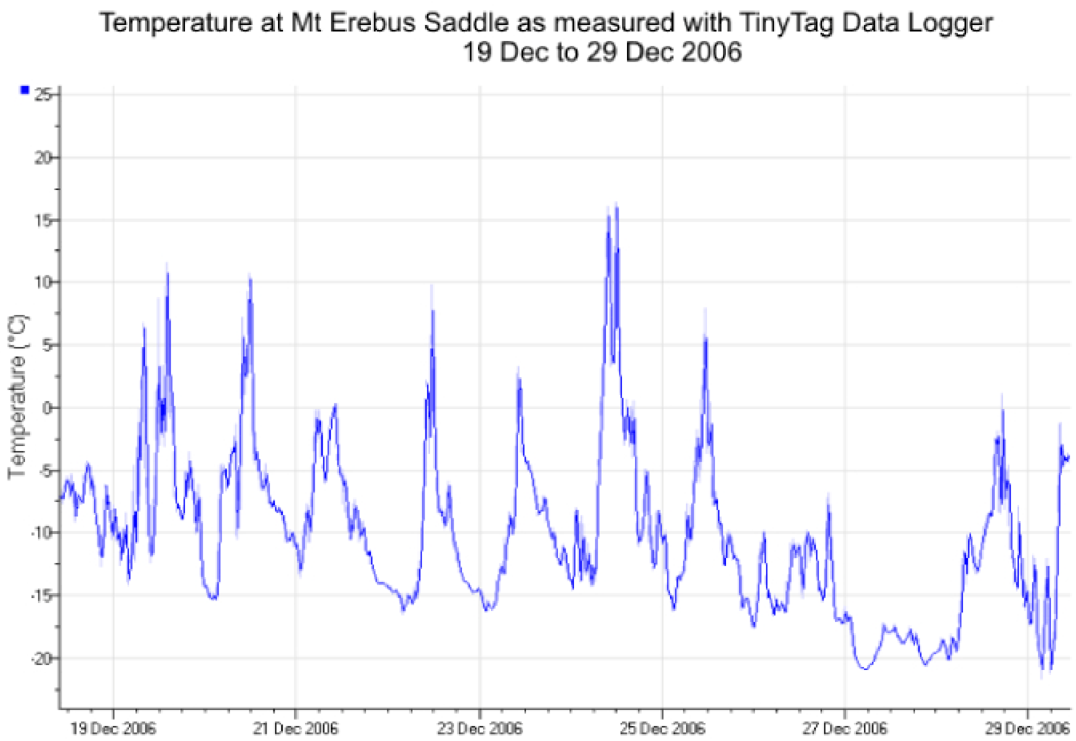


Fig. 7: Temperature at Mt Erebus Saddle as measured with TinyTag Data Logger

*ACCIDENTS, INCIDENTS OR HAZARDS

N.A.

FIELD EQUIPMENT

- *Quality, suitability and performance of field clothing*

ECW Jackets: The new ECW jackets performed extremely well. They are comfortable, warm, relatively light weight, and shed snow extremely well. The design and black colour was also well perceived. The two-layer system is very practical and allows the jacket to be used in cold and temperate conditions alike. The hood doesn't perform in high winds as it is not ridged enough. In addition the neck is cut too narrow and the sippers can't be closed over a neck gaiter. The sippers on arms and wrists are too narrow and don't allow for fleece or lather gloves to go underneath. Furthermore, the sippers on the outside pockets are to the side and not to the top. This makes it difficult to check that nothing falls out, while items are taken out of the pockets. In addition, the pockets don't allow to carry for example a radio, which is too large to fit, and will fall out in the current pockets.

Fig.8: D.Peterson in a snow storm at Whitehall Glacier

Windproof Trousers: The new Cactus windproof trousers are practical, shed snow extremely well, provide good freedom of movement, and are very durable. All members of the group wore almost exclusively these trousers from October to January, regardless of weather conditions or work tasks. Despite the heavy use, they showed no sign of fatigue. Only during the coldest of days (~30ºC) during skidoo traversing in high winds were the trousers somewhat too cold. The only complaints some group members have is, that the full length sippers catch in the material as the seam is not stiffened enough. D.Robinson had a more durable version of this trouser. However, the material was less efficient in shedding snow and hence got wet at times. For this reason, we would recommend the simpler version. Together with the new ECW jackets, this combination offers an excellent and weather proof outer shell.

Down-Jacket: Some members of our group brought their personal down jackets. These proved particularly useful when working in cold, wind sheltered conditions, such as in the drilling trench, where the ECW jackets are too bulky to work on samples or cores. This type of jacket is currently offered by Antarctica New Zealand to Search and Rescue staff and we would like to suggest that they are also optional for science groups.

- *Performance and design of field equipment such as tents, technical climbing equipment, kitchen gear, primus boxes, sleep kits and sledges*

Polar Tents: As we were moving to a remote site, we requested high grade polar tents. When we tested the provided tents, we found that older tents or had been re-classified as higher grade tents over the previous winter. No other high grade tents were available when we left for Whitehall Glacier. In the windy conditions of the site, all tents showed signs of fatigue and required repairs during and after the storms. Due to previous experience at Mt Erebus Saddle, we requested highest grade polar tents and were given two of the one planet tents and one higher grade polar tent. In contrast to previous years, the weather at Mt Erebus Saddle was relatively calm and pleasant and the tents endured the conditions well.

Fig.9: Tent repairs during windy conditions at Whitehall Glacier

Polar Heaven Tent: the new polar heaven greatly improved working and living conditions in the field through significantly higher insulation, stability, and functional doors. The new floor however, is extremely slippery with snow and poses a significant risk, in particular during set-up of the tent. We used old carpet from Scott Base (see Fig.10) which not only provided a safe surface, but also provided further insulation and improved ground stability over time. The new oven heaters for the polar heaven are a good addition, however they are somewhat large and bulky to transport. Instead, we used the VUW heater, which is smaller and lighter. After some very cold nights, water in the diesel fuel froze in the hose and stopped the fuel flow to the oven. Placing the hose frequently (every few days) in a hot water bath prevents the ice built-up and improves efficiency.

Fig.10: Carpet in the new, well insulated polar heaven

Gas stoves: as in previous years, the two flame gas stove performed excellently and was much appreciated by the group. To ensure safe operation, it is important to keep the gas hose from freezing as this causes the butan to freeze, causing significant flaring.

Sleeping bags: We used a combined system of a synthetic outer and a down inner. The combination provided excellent thermal conditions. However, the synthetic outer layer required frequent drying or else significant ice built-up occurred and subsequent melt. During the two major storms all our sleeping bags became wet because of the lack of drying for more than 4 days.

Nansen Sledge: For mapping glacier flow structures and the glacier-bedrock interface a 'GSSI SIR 10 A and GSSI SIR 20A are used. A 35MHz antennae-pair (Radarteam AB-SE-40), a 100MHz antennae-pair, and a single 400MHz antenna are pulled by the Nansen Sledge, which carries the control units, generator, and solar panels. The sledge was in condition and performed extremely well in both soft snow and rough terrain.

Fig. 11: Nansen Sledge set-up

Plastic Sledge: We used a plastic sledge for excavating the drilling trench and for moving heavy items in the field (eg. fuel drums and drilling equipment). The sledge was very durable and performed well.

Fig. 12: Plastic sledge carrying snow out of the drilling trench

- *20 person day ration box system*

The variety and quality of food in the new bags is good and sufficient. Freeze-dry food back up for 14day additional supply is a good alternative for taking full new bags. It saves room and weight. Maybe this could replace all freeze-dry in general food bags, since freeze-dry is expensive, not much liked, and causes digestive problems for some people.

- *Condition and performance of 'wannigans'*

N.A.

- *Performance and use of generators, spill kits, alternative energy systems*

At Mt Erebus Saddle, contaminated fuel from rusty 209L drums caused both generators to malfunction. While fuel filters were exchanged an hoses etc cleaned (Fig.13a), the problem persisted and one generator was returned to Scott Base for repair. To prevent further problems, Scott Base engineers and mechanic (W.Dean and T.Griffith-Jones) modified a fuel pump system adding a filter (Fig.13b) that solved the problem during our field deployment. We appreciated the extremely flexible and quick response of Scott Base to pick-up, repair, and deliver the generator back into the field on the same day.

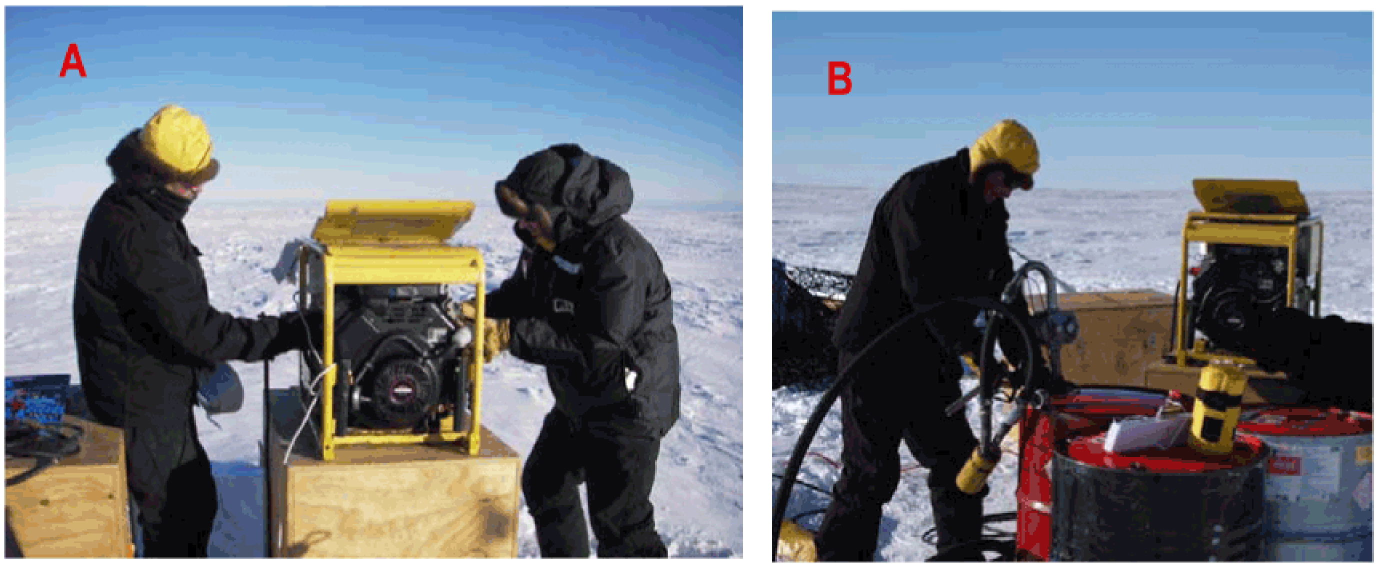


Fig.13: A) Attempting to repair contaminated generator in cold, windy conditions at Mt Erebus Saddle. B) fuelling the generator with the new fuel pump fitted with a filter

- *Other comments*

Throughout the season, Scott Base staff were exceptionally supportive, helpful, and innovative in solving problems or accommodating special requirements of our programme. We are particularly grateful to B.McDavitt, J.Burton, R.Kirkwood, S.Trotter, A.Roche, N.Cross, P.Clendon, L.Cross, W.Dean, T.Griffith-Jones, G.MacKey, and J.Martin.

RADIO COMMUNICATIONS

- *Suitability and effectiveness of the radio equipment*

Fig. 14: HF-radio antenna set-up

Radio communication from Whitehall Glacier was difficult. The instruction for the provided HF radio antenna suggested that the antenna should be deployed 70 feet above ground. In most field settings this is unpractical. We deployed the antenna approximately 4m above ground, tied to double flag poles. Overall, reception at Whitehall Glacier was of good quality. However, transmission from Whitehall Glacier was often difficult to read for both, Scott Base and Mario Zuchelli Station. In addition, the provided battery of the radio was un-chargeable in negative temperatures. We rewired the radio to one of our batteries. The provided satellite phone was a good and practical alternative, in particular when relaying detailed information on flight schedules etc. At Mt Erebus Saddle we used VHF radio. Despite the high gain antenna, reception and transmission often was marginal. The satellite phone was again a practical alternative when radio communication was particularly difficult.

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

The timing of the radio schedule was well handled and practical. With our team shifting between day and night shifts, we had to change the radio schedule to allow for resting times at appropriate times. We appreciate the flexibility of communication officers to accommodate this.

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

The communication officers were efficient, reliable and friendly. Their efforts are much appreciated.

- *Other comments*

The performance of batteries for both HF and VHF is at times unsatisfactory. To better distinguish between well performing and marginal batteries, they should be tested after storage in the Scott Base Science Freezer to replicate the higher strain of field conditions. In addition, the solar panel for charging VHF batteries would be improved if it could be secured in windy but sunny conditions.

SCOTT BASE AND ARRIVAL HEIGHTS FACILITIES

Facility	Use
Hatherton Geoscience Laboratory	
Q-Hut study carousels	
Scott Base Wet Laboratory	
Scott Base Summer Laboratory	
Arrival Heights Laboratory	
TAE Hut	
Library	

- *Additional equipment taken to Scott Base*

N.A.

- *Other comments*

N.A.

COMPUTER FACILITIES

- *Assistance the science technicians gave with computer / IT issues*

N.A.

- *Issues concerning public computer facilities in the Hatherton Laboratory*

N.A.

REFUGE AND RESEARCH HUTS

Refuge/research hut name	
Overall condition	
Scale and condition of provisions	
Suitability of location	
Unnecessary equipment or rubbish/debris in the area	

MOVEMENT OF TEMPERATURE SENSITIVE SCIENCE CARGO

We collected a total of 56 ice core boxes of ice cores (total of 260m) and snow samples (total of 1000 samples). 4 boxes were sent to Mario Zuchelli Station to be shipped with the Italica to the Alfred Wegener Institute in Germany. The remaining 52 boxes were stored at the Scott Base Science Freezer and then shipped in a reefer container on the American Tern to Christchurch and on to Wellington. The reefer container was accompanied by an empty reefer container as back up. Twelve temperature data logger were packed randomly in boxes of the shipment. In Fig.15 the temperature history of ice core box no 350 is shown. The boxes were stored in the field in an ice cave that was excavated off the main drilling trench at sufficient depth to ensure stable temperatures below -18ºC at all times. The boxes were flown either by Twin Otter (Whitehall Glacier) or Helicopter (Mt Erebus Saddle, Figure below) to Scott Base and shifted immediately by B.McDavitt and J.Burton into the Science Freezer. Their careful and speedy handling of the samples is much appreciated. The samples were then packed on the day of ship loading into the provided reefer and transported on the American Tern to Christchurch. The samples were cleared by MAF in Wellington, but briefly hold by MAF in Christchurch due to confusion whether the MAF issued permit was correct. MAF then approved its permit, and P.Woodgate shipped the reefer container by train to Wellington. As recorded by the data logger, the samples were stored and transported under excellent conditions. In the field, sample storage in an ice cave proved to be an efficient and safe storage option despite relatively high ambient temperatures at the site. The Scott Base Science Freezer exhibits very stable thermal characteristics. The testing and monitoring efforts by L. Cross are much appreciated as well as the arrangement of a back-up reefer container at Scott Base. During transport in the reefer container the samples remained below -25ºC. Overall, the storage and shipment of our samples to New Zealand was highly successful. We also would like to thank P.Woodgate for his careful, reliable, and speedy handling of the samples. A point of general concern is that the system failed to identify during shipping the sample container from the back-up container. Good progress has been made in initial discussion with Antarctic Support Manager, Iain Miller, on how to further improve the tracking and monitoring system during transport.

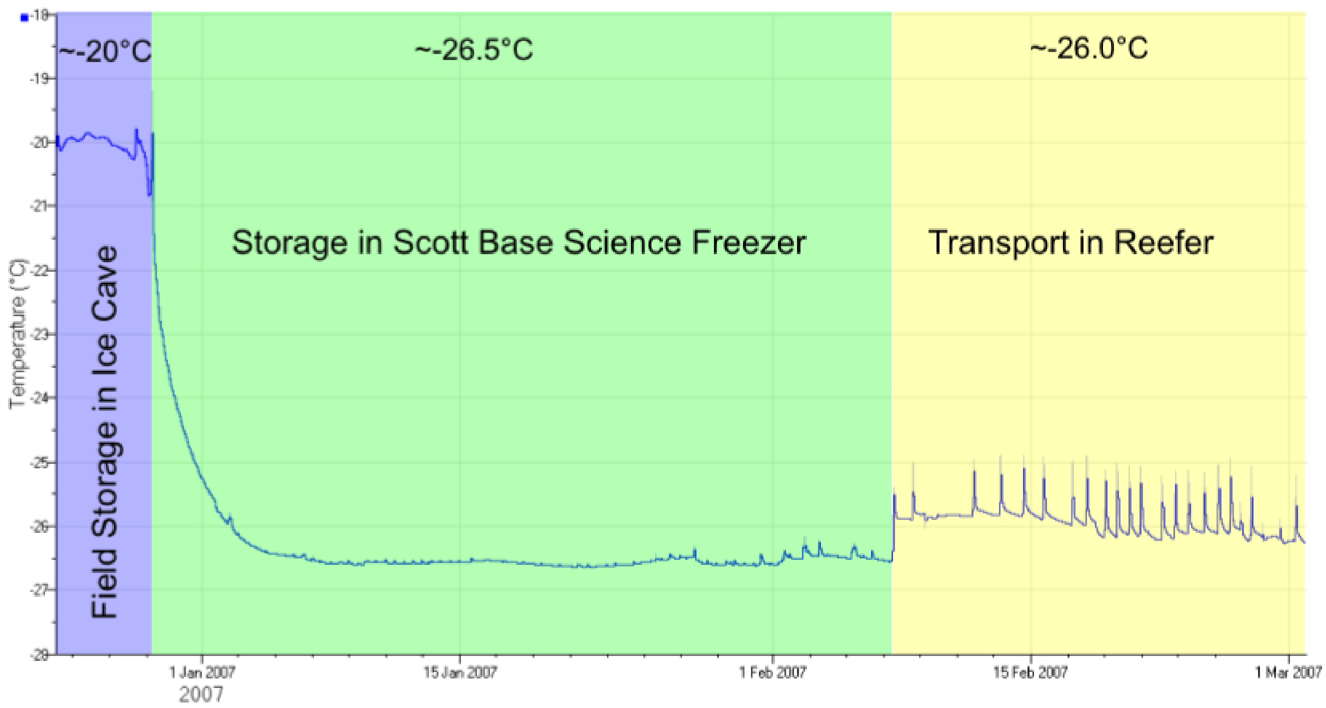


Fig.15: Temperature history of ice core box 350 from Mt Erebus Saddle to Wellington.

*ENVIRONMENTAL IMPACT

***Sites Visited** (please fill in a box for each site visited)

Site name	Windless Bight
Site location (coordinates/description including whether it is in the Dry Valleys ASMA or an ASPA)	77º53' 19.85" S, 167º05'20.66" E
Dates occupied	22 Oct to 24 Oct 2006
Total days (or hours) at site	4 days
Maximum number of people at site (your event)	3
Total person-days (or person-hours) at site	12 person-days
Main activity undertaken	Ice core drilling
Cumulative impacts observed	None
Helo landing site if not established AND marked	N.A.

Site name	Whitehall Glacier
Site location (coordinates/description including whether it is in the Dry Valleys ASMA or an ASPA)	72º 54.773' S, 169 º 5.100 E, 400m asl
Dates occupied	06 Nov to 06 Dec 2006
Total days (or hours) at site	32
Maximum number of people at site (your event)	11
Total person-days (or person-hours) at site	174
Main activity undertaken	Site survey and ice core drilling
Cumulative impacts observed	Less than minor
Helo landing site if not established AND marked	N.A.

Site name	Mt Erebus Saddle
Site location (coordinates/description including whether it is in the Dry Valleys ASMA or an ASPA)	77º 30.90' S, 167 º 40.559 E, 1600m asl
Dates occupied	15 Dec to 29 Dec 2006
Total days (or hours) at site	15
Maximum number of people at site (your event)	6
Total person-days (or person-hours) at site	70
Main activity undertaken	Ice core drilling
Cumulative impacts observed	Less than minor
Helo landing site if not established AND marked	N.A.

Site name	Evans Piedmont Glacier
Site location (coordinates/description including whether it is in the Dry Valleys ASMA or an ASPA)	76º 43.53' S, 162 º 35.29 E, 310m asl
Dates occupied	04 Jan 2007
Total days (or hours) at site	4
Maximum number of people at site (your event)	7
Total person-days (or person-hours) at site	28
Main activity undertaken	Maintenance of automatic weather station
Cumulative impacts observed	Less than minor
Helo landing site if not established AND marked	N.A.

Site name	Victoria Lower Glacier
Site location (coordinates/description including whether it is in the Dry Valleys ASMA or an ASPA)	77º 19.81' S, 162 º 31.93 E, 630m asl
Dates occupied	
Total days (or hours) at site	2 hours
Maximum number of people at site (your event)	7
Total person-days (or person-hours) at site	14 person-hours
Main activity undertaken	Mass balance measurement
Cumulative impacts observed	Less than minor
Helo landing site if not established AND marked	

Chemicals

Chemical name	*Site of use*	*Quantity used*	*Purpose*
N.A.			

Geological Material

Location (coordinates if available)	*Specimen type*	*Quantity (kg)*
WHG (72º54.773'S, 169º5.100E)	Snow and ice	2600 lb
MES (77º30.900' S, 167º40.559E)	Snow and ice	2600 lb
EPG (76º43.53'S, 162º35.29E)	Snow	70 lb

Equipment installed/left in field

Type of equipment/marker installed	*Location*	*Number of items left in field*	*(Dimension in metres: H, W, L)*	*Estimated retrieval date*
N.A.				

Waste management

Location	*Approximate quantity*	*Disposal methods i.e. tidecracked, returned to SB etc*
WHG (72º54.773'S, 169º5.100E)		Solids – returned to SB Liquids – disposed in the field
MES (77º30.900' S, 167º40.559E)		All returned to SB
EPG (76º43.53'S, 162º35.29E)		All returned to SB

Spills and incidents

Location (coordinates if possible)	*Type*	*Quantity (if applicable)*	*Response/Clean up*
WHG (72º54.773'S, 169º5.100E)	Minor fuel spillage (mogas)	1 L	Contaminated snow was removed and returned to SB for disposal

***Differences from original Preliminary Environmental Evaluation (PEE)**

ANTARCTIC SPECIALLY PROTECTED AND MANAGED AREAS

Note that all event leaders who hold permits for entry to an ASPA need to complete a Visit Report for each ASPA entered. Please download this form from our 'Returning to New Zealand' web page or contact Miranda Huston, the Environmental Advisor.

- *New ASPA or ASMA designation to be considered:*

HISTORIC SITES

Historic site name	
General observations on site condition	

- *Other comments*

ANTARCTIC GEOGRAPHIC PLACE NAMES

Location of Feature	
Type of Feature	
Proposed Name	

DESCRIPTION OF REMOTE, RARELY USED FIELD SITES

IMMEDIATE SCIENCE REPORT

K049: NZ ITASE
ANTARCTICA NEW ZEALAND 2006/07

Event Personnel:

Dr Nancy Bertler	Antarctic Research Centre, Victoria University of Wellington & GNS Science
Dr. Sepp Kipfstuhl	Alfred Wegener Institute, Germany
Dr. Dean Peterson	Antarctica New Zealand
Mr Alex Pyne	Antarctic Research Centre, Victoria University of Wellington
Mr Glen Kingan	Webster Drilling and Exploration Limited
Mr Matt Watson	ScanTec Limited
Mr Davie Robinson	GNS Science
Ms Julia Bull	Antarctic Research Centre, Victoria University of Wellington
Mr Rod Boys	School of Geography, Environment, and Earth Sciences, Victoria University of Wellington

1 Scientific Programme

a. Context of the research

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 1.8ºC and 6.4ºC by 2100 (IPCC, 2007). 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 & Jones, 2003).

While meteorological records from instrumental and remote sensing data display the large intercontinental climate variability, they series are insufficient to infer trends or to understand the forcing, which renders prediction difficult (Jones et al., 1999; Mann & 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 humans, a new focus of ice core work is now moving towards 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 (Bertler et al., 2004a; Bertler et al., 2004b; Bertler & 54 others, 2005; Bertler et al., 2005a; Bertler et al., 2005b; Patterson et al., 2005). 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.

b. Objectives

The 2006/07 field season comprised objectives at Whitehall Glacier (WHG), Mt Erebus Saddle (MES), Windless Bight (WB), Victoria Lower Glacier (VLG), and Evans Piedmont Glacier (EPG). Malta Plateau was an alternative site to Whitehall Glacier. However, we found excellent conditions for ice core drilling at WHG and therefore did not visit Malta Plateau.

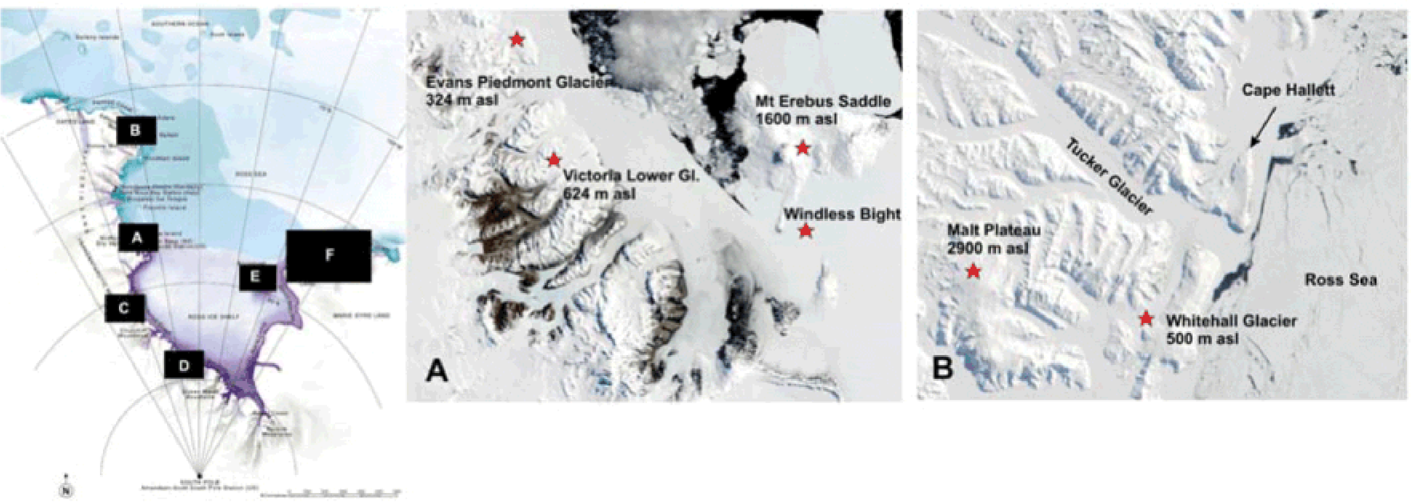


Fig. 1: Overview map of the Ross Sea region showing the location of the satellite images A and B. A) Locations of sites in the McMurdo Sound region, B) Location of sites in the Cape Hallett region. Satellite images are derived from MODIS

Test Drilling at Windless Bight

To test our drilling equipment before deploying to Whitehall Glacier, we conducted a test drill at Windless Bight (Fig.2). This is a convenient location, as it is close to Scott Base and in the vicinity to the ANDRILL drill. The shakedown went well, none of the equipment suffered from the transport. The recovered 20m firn core will contribute to a PhD thesis quantifying dust input into the McMurdo Sound and hereby contributing to the ANDRILL science effort.

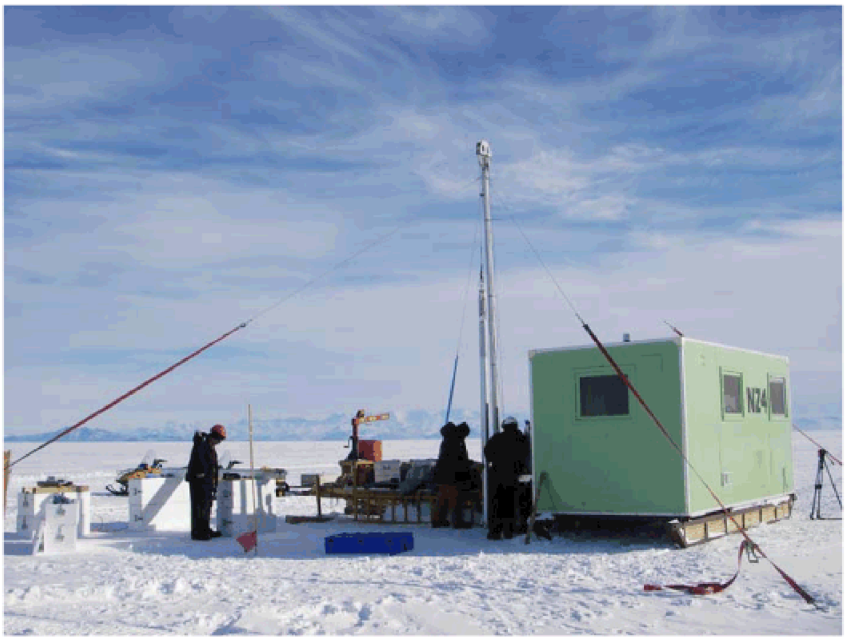


Fig.2: Drilling at Windless Bight

Ice core drilling at Whitehall Glacier (WHG) and Mt Erebus Saddle (MES)

The scientific goal of the NZ ice core programme is to improve our understanding of the major Southern Hemisphere climate drivers causing high frequency climate variability. These are in particular the El Niño Southern Oscillation (ENSO), the Antarctic Oscillation, and the Antarctic Circumpolar Wave, as well as drivers and feedback mechanisms causing abrupt climate change. These climate drivers operate on relatively short time scales (sub-decadal) but also potentially respond to longer term forcing (centennial to millennial). It is therefore important to obtain high resolution (sub-annual) records that can reliably capture the high frequency variability of these drivers from sites that are particularly sensitive to their influence, and at the same time providing a long enough record to investigate superimposed longer-term trends. ITASE focuses on the last 200 years and where possible longer.

We have identified key locations at low elevation, coastal sites that are particularly climate sensitive, as they capture tropospheric climate variability and in general have a higher snow accumulation rate than sites from the Antarctic interior. This makes these sites ideal when investigating abrupt climate change. For this reason, the International Partnership of Ice Coring Sciences (IPICS) has identified an array of 2000-year long records from especially coastal sites as one of four priorities for ice core research in the next 20 years. Currently only NZ and Australia have worked on coastal sites.

For this field season our objective was to recover two intermediate depth ice cores from WHG and MES.

WHG is a small, East Antarctic Ice Sheet independent ice mass with an ice divide at 500 above sea level, just 12km of the coast. Due to its coastal, low elevation characteristics it is ideal for our NZ ITASE objective. In addition to this, an ideal site should satisfy the following: a) consistent annual precipitation (even if seasonal), b) limited summer melt c) limited wind erosion or snow accumulation through wind drift, d) a long enough record (for our purposes at least 200 years but preferably ≥ 2000 years), and e) undisturbed ice flow and smooth bedrock topography.

MES has an extremely high accumulation rates, exceeding by one order of magnitude the regional average. The drill site is located at an ice divide at 1600 above sea level, just 20km of the coast.

Site survey at Whitehall Glacier

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 (8 MHz, 35 MHz, 200MHz, and 500MHz) 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 Sledge, 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 WHG camp.

Traverses totaling approximately 80km have been surveyed with GPR. The measurements show that the glacier thickness exceeds 550m. Excellent isochrone reflections are visible in the top part of the profile, 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. At MES a site survey was conducted during the 2003/04 field season.

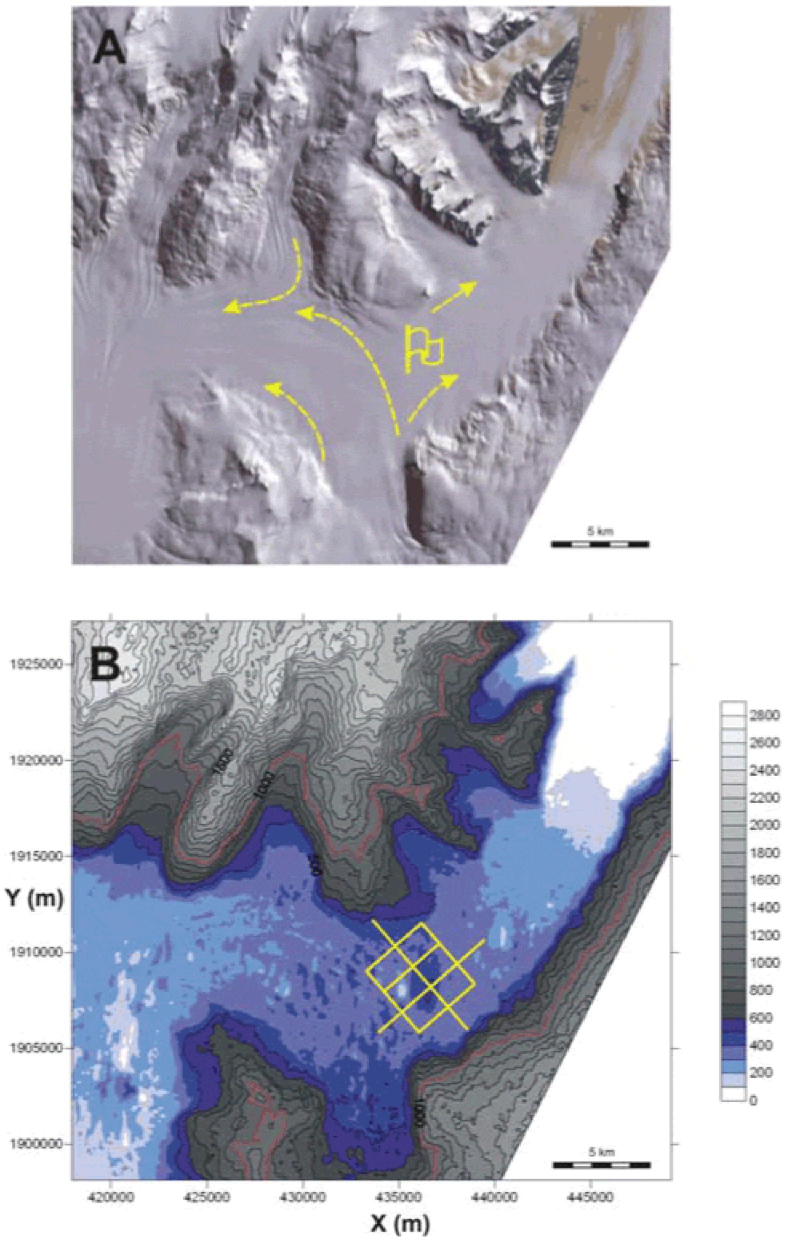


Fig. 3 A) ASTER satellite image of Whitehall Glacier and vicinity. See Figure 1 for overview. Image from January 2005. Yellow flag indicates approximate location of proposed drilling site. Yellow arrows indicate approximate major flow lines. **B)** Digital elevation model. X/Y/Z grid in UTM 58 map units. Yellow grid indicate proposed ground penetrating radar survey lines (differential, 8, 35, 200, and 400 MHz)

High resolution snow pit sampling at Whitehall Glacier and Evans Piedmont Glacier

At WHG one 4m, one 2m, and two 1m deep snow sequences were sampled at the drilling site to allow high resolution snow analyses. 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.6). This is necessary as the top 4m are usually of very low density, providing little material to run high resolution analyses.

Fig.4: Snow sampling at WHG

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. In addition, snow density and temperature was also measured.
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 analyses. Annual layers did not show any sign of inclination or erosion and no melt layers were found. This is particularly surprising, considering the coastal and low elevation (400m asl) setting of this site.
In addition snow samples were also collected from EPG to extend the proxy record for collation with automatic weather station data from this site.

Automatic weather station maintenance and data retrieval
In 2004/05 we deployed an automatic weather station on EPG. The data permit the calculation of transfer functions between ice core proxies and meteorological parameters, such as temperature, precipitation, meso-scale atmospheric circulation pattern, katabatic winds, and seasonality of snow accumulation. In addition a new snow accumulation sensor and high precision snow temperature probes allow us to monitor snow accumulation rates, the potential influence of snow loss through sublimation, wind erosion or melt, and the quality of preservation of the meteorological signal in the snow. Furthermore, the data allow us to estimate the uncertainty of re-analysis data (NCEP/NCAR and ERA-40 data) in the region.

At EPG additionally one 1m snow sequence was sampled excavated to measure density and temperature of the snow pack and to study snow crystal structure and their geographical variability.

Fig.5: Automatic weather station at EPG

Submergence Velocity Measurements at Victoria Lower and Evans Piedmont Glacier

The response time of a glacier to changes in accumulation or ablation is dependent on the size and thickness of the ice mass. In general, the response time of cold-based glaciers is positively correlated with the size of its ice mass, leading to long response times in Antarctica. For glaciers in the McMurdo Dry Valleys, with lengths on average of 5-10km and flow rates of 1 to 3 m/a, the response times are thought to range from 1,500a to 15,000a (Chinn, 1987; Chinn, 1998). Consequently, annual variations in surface elevation may only reflect changes in loss rates. As a result surface measurements of mass balance are difficult to interpret in terms of long-term mass balance (Hamilton & Whillans, 2000). This is especially the case in places like the McMurdo Dry Valleys where mass loss is thought to be predominately due to sublimation at ice cliffs and glacier surface caused by wind and solar radiation (Chinn, 1987; Chinn, 1998). For Victoria Lower Glacier (VLG), two mass balance measurements are available in the literature for 1983 and 1991 based on ice cliff characteristics and the motion of the glacier snout (Chinn, 1998). The measurements indicate that VLG was advancing 1.24m/a into Victoria Valley during this time period. However, the small number of observations (2) and the cliff's sensitivity to sublimation (contemporary surface ablation) result in a high uncertainty of longer term mass balance. To determine the longer-term mass balance of the glaciers, unaffected by annual surface variations, three 'coffee-can' or 'submergence velocity' devices (Hamilton et al., 1998; Hamilton & Whillans, 2000) were deployed at Victoria Lower Glacier in 1999/2000 and two at Evans Piedmont Glacier in 2004/05. These are annually re-measured to monitor mass balance changes.

Fig.6: Submergence Velocity Measurements at VLG

Snow Accumulation at Mt Erebus Saddle

The topography of Mt Erebus Saddle promotes strong winds leading to significant compaction of the surface snow (~0.45 gcm^{-3}). Furthermore, average snow accumulation lies in the range of 72 – 150 cm yr^{-1} water equivalent (Fig.XX). This is more than one order of magnitude higher than the regional average (Bromwich, 1988; Bromwich et al., 1998; Bertler et al., 2004a; Bertler et al., 2004b) and provides ideal characteristics for a high resolution ice core gas record. To measure the accumulation rate at the drill site we deployed three snow stakes, which we hope will endure the high wind velocities and snow accumulation.

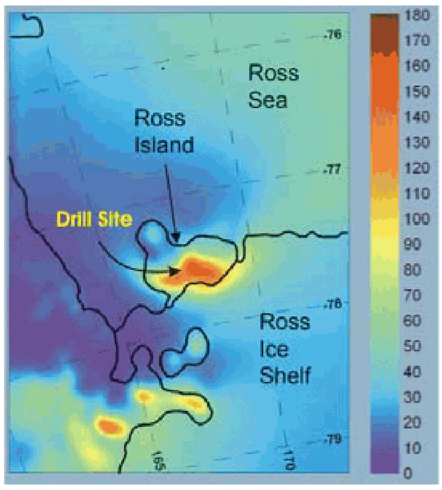


Fig.7: Snow accumulation (cm) in the Southern McMurdo Sound region (after Bromwich)

c. Methodology

Ice core drilling at Whitehall Glacier (WHG) and Mt Erebus Saddle (MES)

At WHG and MES 100m and 160m deep ice cores of excellent core quality were recovered using the ice core drill of the German Alfred Wegener Institute. Above the firn-ice transition clean suits, facial masks, and thin polyethylene gloves are used by the core processing crew to avoid contamination during core handling. Below the firn-ice transition, after gas bubble close off, the inner section of the core is protected from contamination, and more comfortable, warmer clothing can be worn.

Fig.8: Drilling operation at WHG

Once the core is extruded from the core barrel the piece is fitted to the previous run and the recovery is measured and logged. The core is then cut into 1m long sequences. Before the pieces are sawed, a 2mm hole is drilled at the meter mark and the core temperature is measured. This measurement has to be done within 5min of core recovery, as ambient temperatures in the drilling tent can influence core temperature. Therefore, temperature is only measured if the core could be processed within 5min. The temperature is a direct measurement of glacier temperature and reflects in the upper 10m seasonal temperature fluctuations, at around 10m, average annual temperature, and below 15m the signal is a memory of major past temperature fluctuations.

The 1m sections are then weight to calculate density and determine the depth of bubble close-off and firn/ice transition. The densification depends on annual temperature and snow accumulation. Warmer temperatures and higher snow accumulation lead to rapid densification. This is important, as it determines the age difference between the gas trapped in the bubbles and the ambient ice. The faster the bubble close-off is reached, the smaller the age difference and the smaller the dating error. While both sites reach in comparison to other sites bubble close-off very rapidly, the extraordinary setting of MES, makes it a site of special interest. Due to the prevailing high wind speeds snow density at the surface is much higher than at other ice core sites. This in combination with extremely high snow accumulation, and warm annual temperature, the gas bubble close-off is reached at the depth, that is likely unprecedented

Fig.9: Core processing at MES

even in the high accumulation areas of Greenland. For this reason the gas record of this ice core could potentially provide the best dated, highest resolution CO_2 and methane record yet available.

Fig.10: Ice core storage in the field in ice caves cut from the drilling trench

Once these initial measurements on the core are conducted, the core is then packed into well insulating ice core boxes. Cuttings are used to cement the cores into the box for stability and to maintain core temperature, as the cuttings are recovered from the same depth as the core. Furthermore, small chips were used to study gas bubble properties, such as porosity, gas bubble size and geometry. This is especially interesting close to bedrock, as bubble geometry provides clues as to whether the ice is moving or is frozen to bedrock. The boxes are then stored in underground ice caves at temperatures below -20C before transport back to the Scott Base Science freezer.
In addition, a total of six snow sequences were sampled (5 at WHG and 1 at EPG) with 1cm resolution for analysis on snow chemistry, isotopic composition, dust content and mineralogy. The snow sampling surface was cleaned with a pre-cleaned plastic spade, and subsequently with a sterile scalpel, at least 20cm horizontally into the snow to prevent sampling of contaminated snow. All tools, sampling equipment, and bottles were rinsed and soaked with ultra pure 18MΩ Millipore® water and dried in a class 100 clean room facility prior to fieldwork. A scalpel was used to collect 1cm thick samples. Sample were collected into sterile Nasco whirl-paks®. Tyvek® clean suits and dust free polyethylene gloves prevent contamination from sampling procedure.

The following parameters will be measured on the obtained ice cores and snow samples:

Major Cations, Anions, and Methylsulfonate

Major ion concentrations are measured for cations (Na, K, Mg, Ca, NH_3) using a Dionex™ Ion Chromatograph with Dionex CS12 column and 20 mM methanesulfonic acid eluent. Anion concentrations (Cl, NO_3, SO_4) are measured with a Dionex AS11 column, 6.0 mM NaOH eluent. For both measurements a 0.25 mL sample loop is used. Methylsulfonate (MS) content is measured using a Dionex AS11 column with 0.1 mM NaOH eluent and a 1.60 mL sample loop

Trace Elements and Cations

Samples are analysed for trace elements and cations (Al, Ca, Cu, Fe, K, Mg, Mn, Na, P, S, Si, Sr, and Zn) using a Perkin-Elmer Optima 3000 XL axial inductively coupled plasma optical emission spectroscopy with a CETAC ultrasonic nebuliser (ICP-OES-USN at UMaine) and a Finnigan Thermo inductively coupled plasma mass spectrometer (ICP-MS at VUW) for all other trace elements and selected isotopic ratios.

Oxygen and Hydrogen Isotope Ratio

Oxygen isotope ratios are measured using a CO_2 dual-inlet system coupled to a Micromass Isoprime mass spectrometer at GNS Science. The sample is measured in the presence of a standard CO_2 gas. Sample duplicates and standard measurements showed a precision of ±0.08‰. Samples are analysed for stable hydrogen isotope radios δD via Cr reduction with a continuous Helium flow Eurovector elemental analyser coupled to a Micromass Isoprime mass spectrometer. Sample duplicates and standard measurements showed a precision of ±0.6‰.

Gas analysis in ice core bubbles

The gas extraction is carried out using an ice core gas extraction device. The obtained gas sampled will be measured on the two mass spectrometers Micromass ($^{13}CH_4$) and Mat252 ($^{13}CO_2$) at NIWA. Concentrations of CO_2, CH_4 and N_2O will be measured by gas chromatography at NIWA.

Dust concentration and mineralogy

500cm^3 volume of snow/ice is filtered through Whatman quantative 2.5µm ashless filter paper. The filter is burnt in a Vulcan A-550 furnace at 500°C for 24 hours. The residue is weight with a AG204 Mettler Toledo analytical balance, and reweighed after 24hours to check for moisture absorbance during cooling. Mineralogy is determined by mounting the dust samples in glycerol gelatine for examination under an optical particles found in the dust are analysed in a JEOL 733 Electron Microprobe at VUW.

^{32}Si

Cosmogenic ^{32}Si has a half-life of about 140yr. Dr. Morgenstern at GNS has developed an improved method for radiometric detection of natural ^{32}Si, and measures natural ^{32}Si by accelerator mass spectrometry (AMS). With AMS the necessary sample size is reduced by a factor of ca. 1000 to 1kg.

Tritium

A radiometric detection method (TR = 0.03-0.04, Bq/kg = 0.004-0.005) is used to measure tritium concentration. This is achieved by combining a high degree of electrolytic enrichment with a low-level liquid scintillation spectrometer.

Dating the ice core

To ensure a good chronology, a multi-proxy dating technique will be applied. The annual snow accumulation at those low elevation sites is expected to be at least 10cm water equivalent affording annual layer count ice core dating techniques using seasonal signals of the isotope and chemistry records. Furthermore, volcanic time markers in the sulphate records will be used to tie the counted ages to known volcanic eruptions found in Antarctica. Additionally, two new world-leading methods developed by Dr. Morgenstern at IGNS using high resolution tritium and ^{32}Si will be used as independent age benchmarks. The high resolution gas bubble record will provide further age control through wiggle-matching with the extremely high resolution gas record from Mt Erebus Saddle (2004/05 season).

Automatic Weather Station at Evans Piedmont Glacier

During the 2004/05 field season an automatic weather station (AWS) has been established near the ice coring site. The AWS records several parameters to help characterise the meteorology and snow accumulation regime of the area (Fig.11).

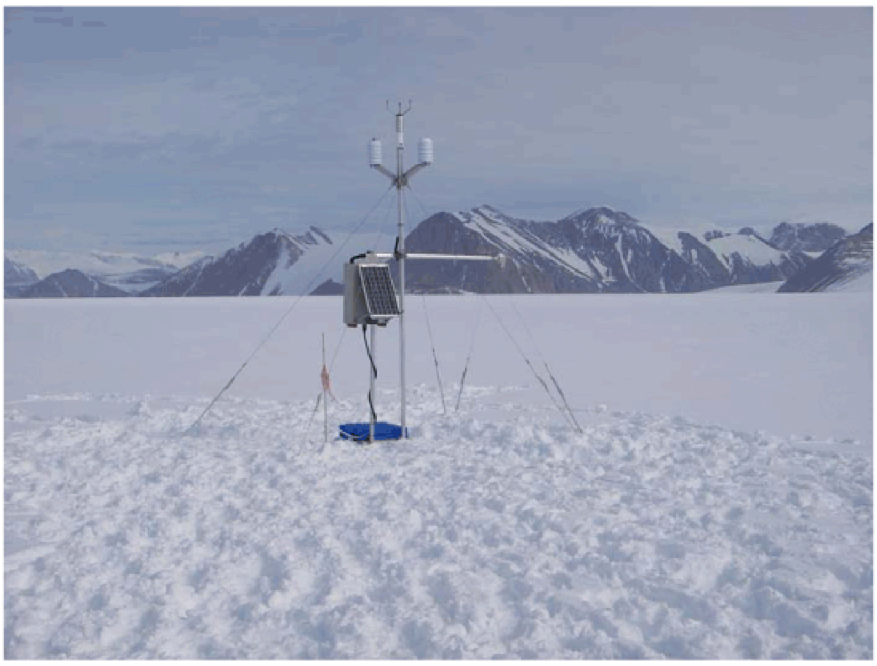


Fig.11: Automatic weather station after the system was dug out and placed a few meters to the south of the original site

Parameters measured as of 15 November 2004 are:

- Air Temperature at 2.5 height
- Snow accumulation, and air temperature at 1.5 m height
- Dew point temperature at 2.5 m height
- Solar radiation (incoming) at 2.5 m height
- Snow temperatures (thermistor resistance) from 0.135 to 2.085 m depth in at 13.5 cm intervals

To these were added as of 01 December 2005

- Barometric pressure
- Wind speed (ultrasonic)
- Wind direction (ultrasonic)

Ground Penetrating Radar

For mapping glacier flow structures and the glacier-bedrock interface a 'GSSI SIR 10 A and GSSI SIR 20A were used with a maximum time window of 10,000 ns. A 35MHz antennae-pair (Radarteam AB-SE-40), a 200MHz antennae-pair, and a single 500MHz antenna are pulled by a Nansen Sledge, which carries the control units, generator, and solar panels. A Trimble 5700 differential, kinematic GPS, provides absolute positioning of the GPR data and allows survey of the glacier surface topography. GPR and GPS measurements are taken in kinematic mode, every 5-15 seconds ≈ 10-30m.

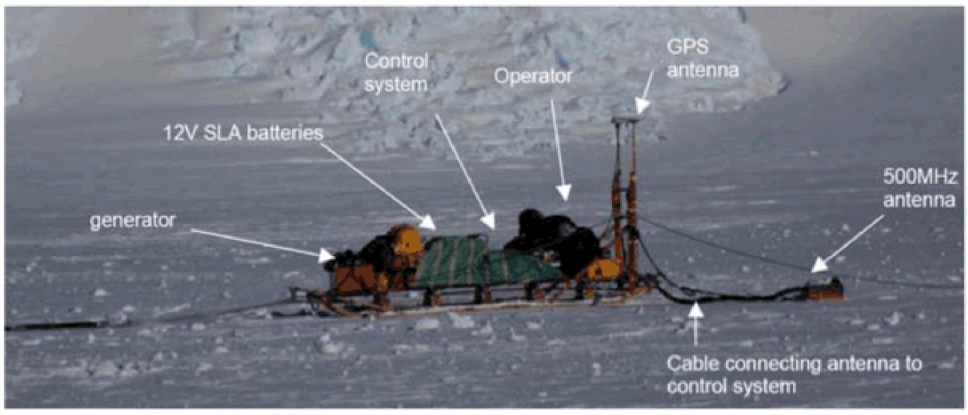


Fig. 12: Photo showing Nansen sledge carrying GPR and crevasse rescue equipment (from Watson, 2007)

Submergence Velocity Measurements at Victoria Lower and Evans Piedmont Glacier
During the 1999/2000 season three submergence velocity devices (Hamilton & Whillans, 2000) for mass balance measurements in the McMurdo Dry Valleys were installed. During the 2004/2005 season two submergence velocity devices have also been installed at EPG. 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.
High precision GPS measurements are used to determine absolute position of the tracking point during subsequent years. Trimble 5700 base station and rover unit were used to measure the absolute position of the tracking point of the mass balance devices. At Victoria Lower Glacier, the base station was deployed on a rocky platform at Staeffler Ridge <3km away from all mass balance sites. The proximity of the base station to the rover allowed the tracking points to be measured with a horizontal precision of <1mm and a vertical precision of <5mm. At Evans Piedmont Glacier base station data from the Cape Roberts permanent GPS/GLONASS and tide gauge observatory will be used. All GPS measurements are post-processed using precise orbits, which are published on-line at "http://igscb.jpl.nasa.gov/components/prods_cb.html". These data are corrected using GIPSY-OASIS II software and provide precise point positions by taking into account satellite orbit, Earth orientation, and clock solution from NASA Jet Propulsion Laboratory's independent analysis of globally distributed GPS receivers.

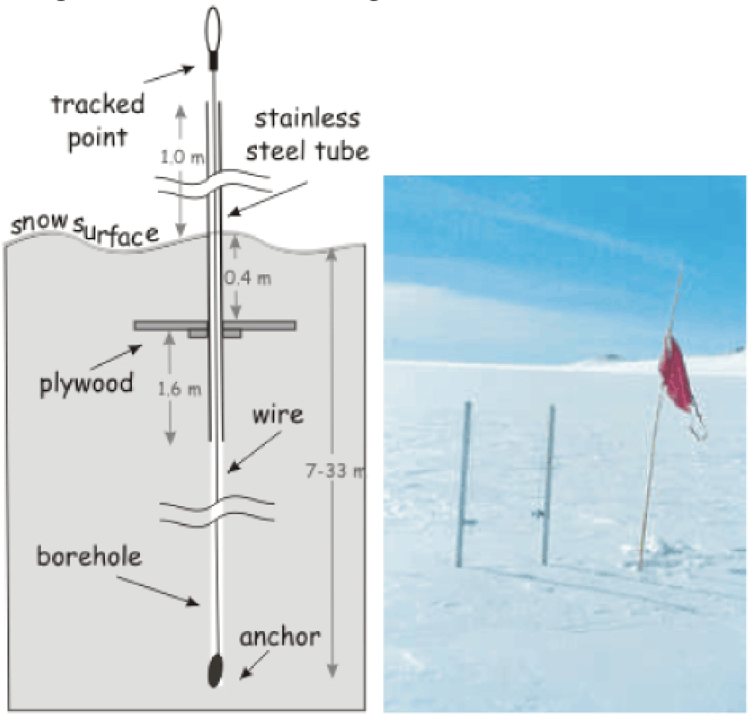


Fig.13 Cartoon of the 'coffee can' submergence mass balance device (modified after Hamilton and Whillans 2000)and picture of coffee can device deployed at Victoria Lower Glacier.

The rate of thickness change H, can then be calculated using (Hamilton et al., 1998):

$$\dot{H} = \frac{\dot{b}_m}{\rho} + \dot{z} + \vec{\alpha} \bullet \vec{u}$$

where:

H	= rate of thickness change (myr^{-1})
b_m	= accumulation rate ($Mgm^{-2}yr^{-1}$)
ρ	= density at marker depth to account for densification processes (Mgm^{-3})
z	= vertical component of ice velocity (upward is positive, myr^{-1})
α	= surface slope (radians)
u	= horizontal velocity (myr^{-1} with azimuth)

Snow Accumulation at Mt Erebus Saddle

To accommodate high accumulation rates of about 2m snow/year, 6m snow stakes that are anchored 2m into the ground were deployed. The three snow stakes, made of epoxy/carbon fibre, have been chosen for their flexibility to withstand high wind velocities in excess of 100knts.

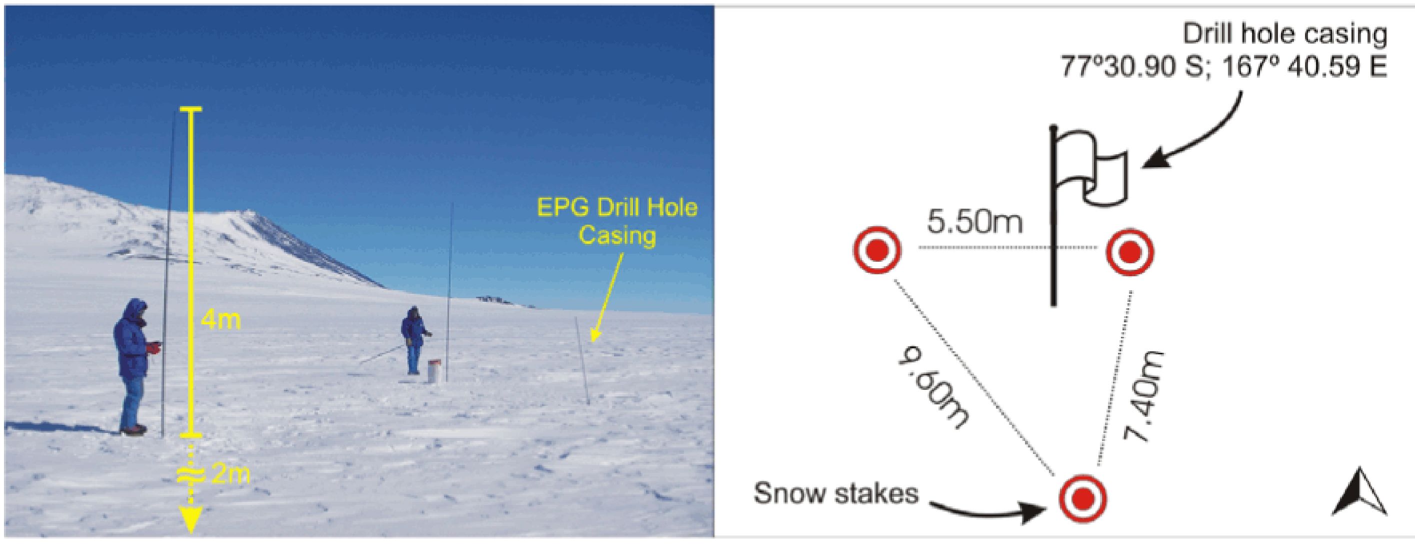
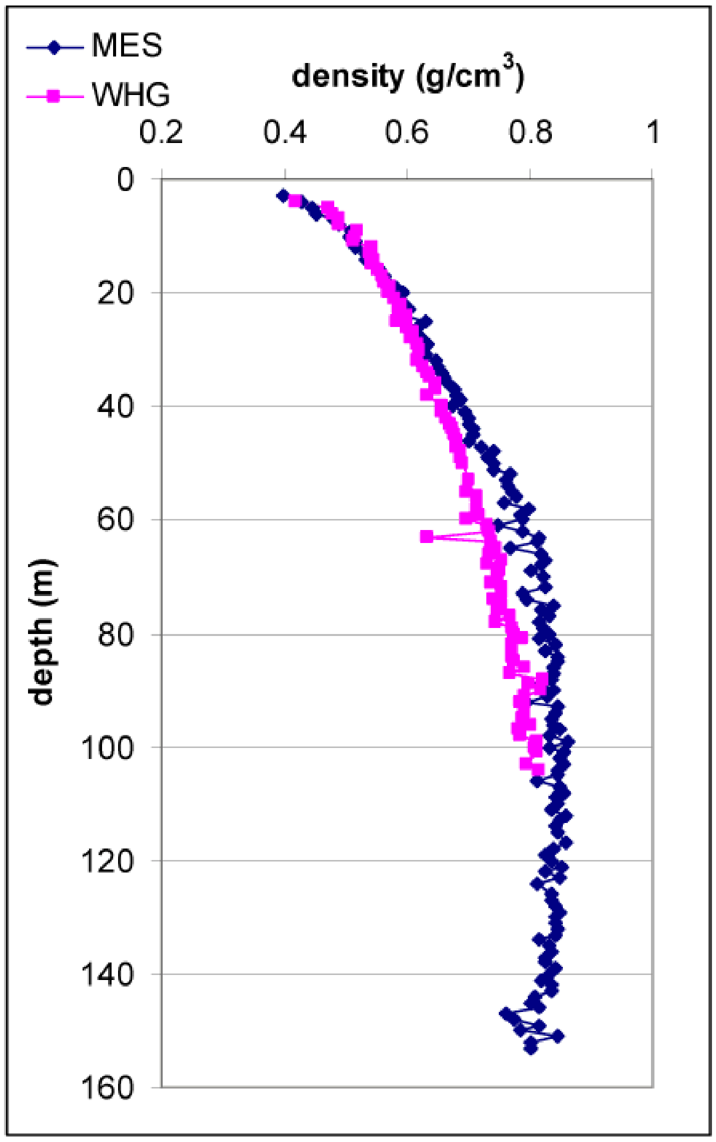


Fig.14: Three snow stakes placed in the vicinity of the 2004/05 drill hole casing at Mt Erebus Saddle

d. Results and discussions

Firn-Ice Transition at MES and WHG



Density measurements on the recovered cores show the depth of bubble close off is reached at MES at about 60m depth while at WHG the firn- ice transition lies below the recovered 100m depth. This underpins the unique characteristics of the MES core. Currently, only the Australian Law Dome ice core has an similar shallow bubble close off depth. Once the annual snow accumulation for the site as been calculated, we can determine whether MES is also as rapid or potentially even faster than at Law Dome, providing the opportunity to measure an extremely high resolution greenhouse gas record.

Fig.15: Density measurements on MES (blue) and WHG (pink) ice cores.

Automatic Weather Station Data from EPG

The weather station continuously recorded data since our last visit on 01 December 2005 until 04 Jan 2007, when we visited the station to download the data and for maintenance work. The recorded data for pressure, solar irradiation, air temperature, snow temperature, dew point, and snow accumulation are shown in below (Fig.16).

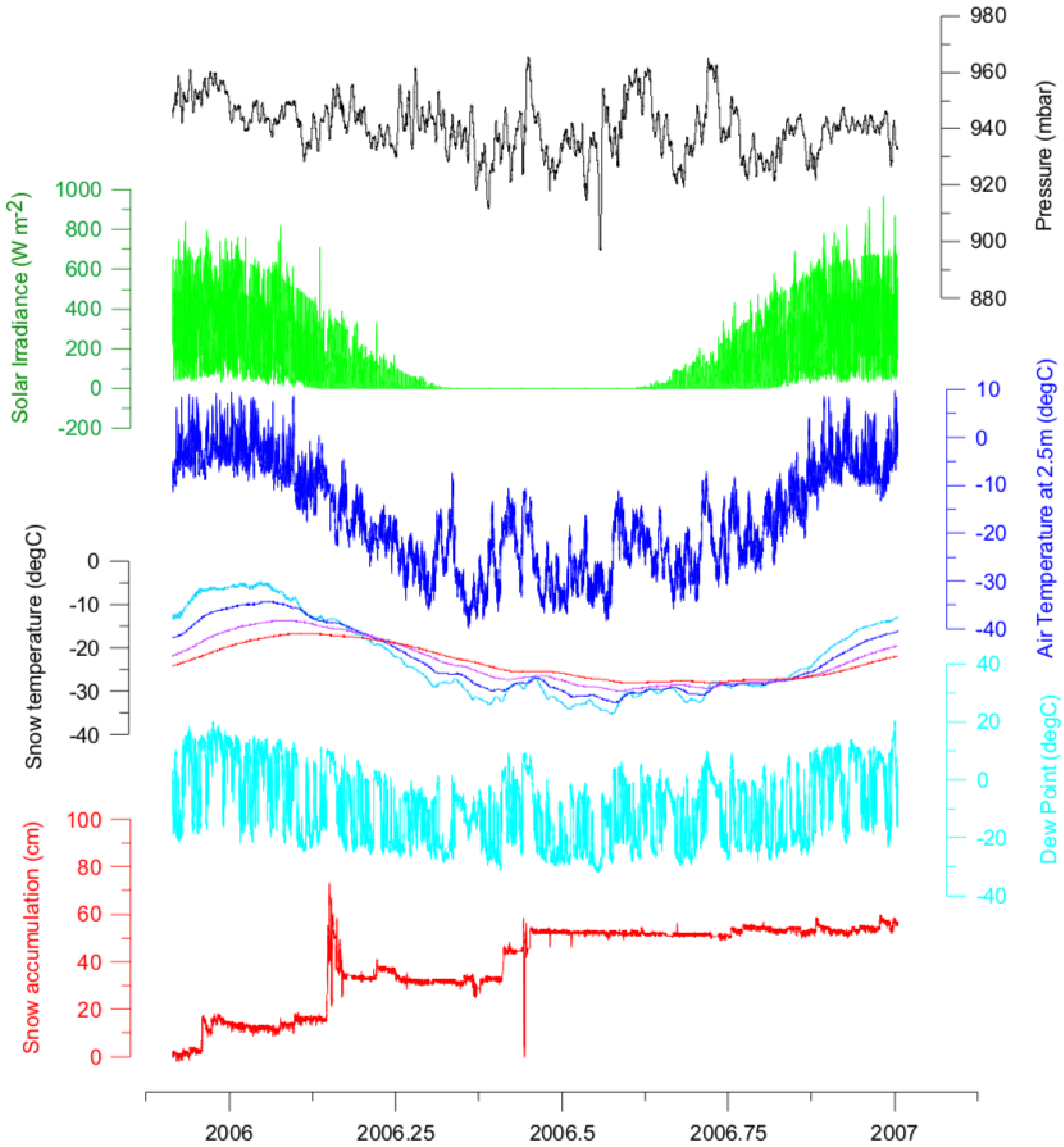


Fig.16: EPG automatic weather station data for 01 Dec 2005 to 04 Jan 2007

As shown in Fig.16 temperature tracks overall solar irradiance. However, from May until early October abrupt temperature increases of up to 20K occurred. Some of these temperature excursions are accompanied by changes in barometric pressure suggesting that these warm events could be katabatic outflow from the McKay Glacier portal. Temperatures in the snow pack measured concurrently at 16 depth horizons from 0.135m (light blue) to 2.085m (red) show the decreasing influence of air temperature variability with depth. The snow temperatures have yet to be corrected for their change in depth, which increased by 60cm as shown in the snow accumulation graph below. The snow accumulation record shows that most of the precipitation occurred during six events of 5 to 10cm snow accumulation. The data show also that are no prolonged time periods of snow loss, except in the first 2-5 days after the snow precipitation event which is partly due to snow compaction. After this time period the snow surface remains stable. Overall, the data confirm EPG as an excellent ice core site. The snow pit data and submergence velocity measurements from EPG and VLG have yet to be processed.

e. How this research fits in with future work being planned

Our preceding research – Holocene Climate History from Coastal Ice – has identified the value of the specific characteristics of ice core records from coastal, low altitude sites (Bertler et al., 2004a; Bertler et al., 2004b; Bertler & 54 others, 2005; Bertler et al., 2005a; Bertler et al., 2005b; Mayewski et al., 2005; Patterson et al., 2005; Bertler et al., 2006a; Bertler et al., 2006b) and showed how tropical phenomena, such as ENSO have a significant influence on the Ross Sea Region. In contrast to Antarctica's interior, which is influenced by temperature inversion and climatic cooling of the stratosphere, the coastal sites are dominated by cyclonic activity, and hence by the climate of the lower troposphere (King & Turner, 1997). As a result, coastal sites are especially climate sensitive and show potential to archive local, rapid climate change events that are subdued or lost in the 'global' inland ice core records, such as Vostok. It is those rapid climate change events that are of greatest concern to human civilisation in the near future. The NZ ITASE programme contains five objectives that are scientifically inter-linked to the following programmes.

1. ITASE-Objective

The main objective of ITASE is to determine the spatial climate variability across Antarctica over the last 200 years, and where possible further back in time. The focus of the New Zealand ITASE group (this proposal) is to provide information from the climate sensitive, low altitude, coastal sites (Fig.8). This will capture the climate signature of the troposphere, which represents a regional account on the Ross Sea climate. Our preceding research showed that while the direct ENSO influence warms the eastern Ross Sea (oceanic forcing), the indirect ENSO influence dominated in the western Ross Sea, leading to the observed cooling in McMurdo Sound Region (atmospheric forcing) (Bertler et al., 2004a; Bertler et al., 2005b). The comparison with data from other ITASE-nations will allow us to date relative phasing and signal migration velocities of these climate drivers across Antarctica.

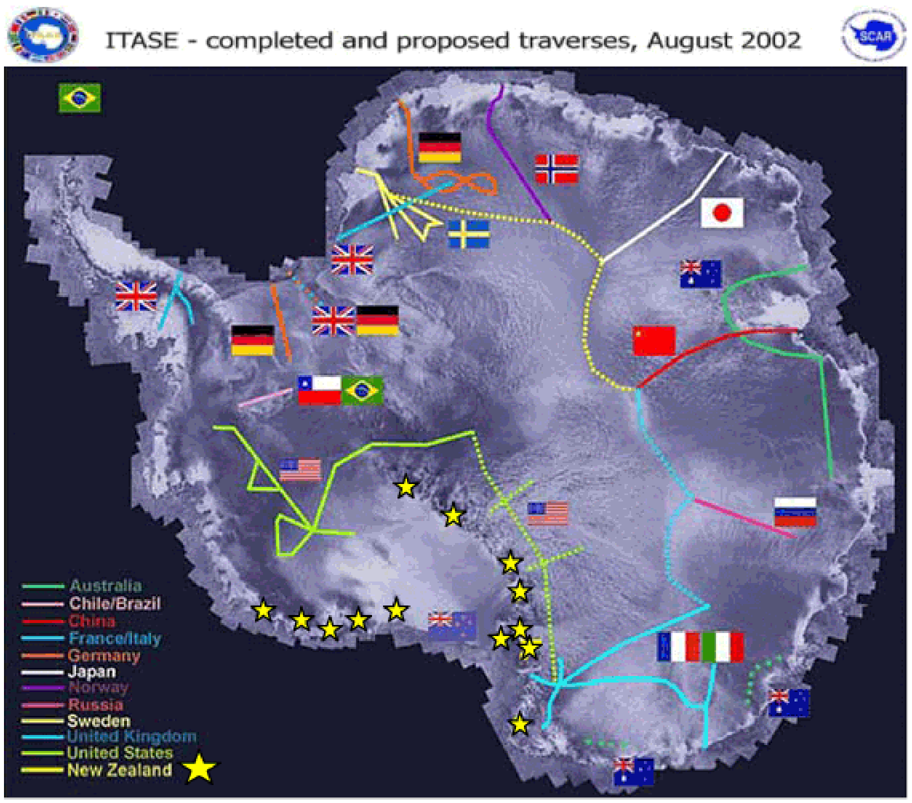


Fig.17: Overview of NZ ITASE proposed drilling sites (stars)

Furthermore, the gas record will allow us to determine the role of CO_2 and in rapid climate change events and the CO_2 and methane source/sink fluxes of the Ross Sea. The isotopic fractionation of biogenic (terrestrial) material is –with the exception of C4 plants – enriched in the lighter ^{13}C isotopes and carries therefore a different signature than ocean derived carbon, which shows no such enrichment (Indermühle et al., 1999; Sigman & Boyle, 2000). For this reason the change of isotopic ratio in CO_2 and CH_4 can be used to determine the change in sources of GHG concentration through time. This is particular important to determine the role of the oceans versus the atmosphere in rapid climate change (White, 1993; Stocker, 1998; Broecker, 2000; Schrag, 2000; Stocker, 2002; Broecker, 2003; Ferretti et al., 2005) and has the potential to detect influences of early human activities in the late Holocene (Ruddimann, 2003).

In conjunction with the US-ITASE traverse of our collaboration partners altitude and continentality gradients across the Trans Antarctic Mountains (TAM) can be established. Temperature and humidity gradients across the TAM are amongst the most extreme on the continent and exceed the latitudinal gradients by more than one order of magnitude. The correlation between the US-ITASE polar plateau traverse (Fig.8) and our data will allow determining the climatic influence of the mountain range and also the position of the Antarctic Vortex, the geographical boundary of tropospheric and stratospheric influence. The results of the NZ ITASE programme contributes directly to science aims of the International Partnership of Ice Coring Sciences (IPICS) and Antarctica in the Global Climate System (AGCS).

2. Latitudinal Gradient Project Objective

Our project is expected to contribute an important data set to the Latitudinal Gradient Project, as it provides a history of temperature, humidity, sea ice cover, precipitation source, atmospheric circulation, and ocean productivity along the Victoria Coast for the last 1000 to 10,000 years depending on the site. This will help to determine whether 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. 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 & Denton, 2000; Steig et al., 2000). Coastal ice core records are very sensitive to the change from an ice shelf environment to seasonally open water, which manifests itself in a shift in the chemical signature of snow and aerosol precipitation (Legrand & Mayewski, 1997). By dating the occurrence of the characteristic chemistry shift in the proposed ice cores locations (Fig.8), average retreat velocity can be calculated and its dependency on air temperature tested. This will also add to our knowledge on the current Ross Ice Shelf stability.

3. ANDRILL Objective

Proposed ice core locations no. 2 and 3 (Evans Piedmont and Mt. Erebus) are in the immediate 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. This will provide the unique opportunity to compare contemporary on- and off-shore records.

4. Longer-Term Mass Balance Objective

During the 1999/2000 season mass balance measurement devices (submerge velocity method (Hamilton et al., 1998; Hamilton & Whillans, 2000)) have been deployed at Victoria Lower Glacier and at Evans Piedmont Glacier during 2004/05. The measurements at Victoria Lower Glacier 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 Sound Region.

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. A joint programme between IGNS, University of Maine, and 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).

f. Contributions from visiting foreign scientists

Dr. Sepp Kipfstuhl from the Alfred Wegener Institute in Germany accompanied us into the field as part of our collaboration with AWI. Dr. Kipfstuhl provided valuable expertise in glaciology and ice core drilling and obtained samples in particular from MES for computer tomography analysis to study crystal and gas bubble characteristics in firn and ice. In addition, the AWI intermediate depth ice core drilling system was used to recover all three cores.

2 Publications

Publications since the 2005/06 Antarctic field season include:

Alloway, B.V., Lowe, D.J., Barrell, D.J.A., Newnham, R.M., Almond, P.C., Augustinus, P.C., Bertler, N.A.N., Carter, L., Litchfield, N.J., McGlone, M.S., Shulmeister, J., Vandergoes, M.J., Williams, P.W., & Members, a.N.-I. ***2007***. Towards a climate event stratigraphy for New Zealand over the past 30,000 years. Journal of Quaternary Science, 22(1), 9-35.

Bertler, N.A.N., Naish, T.R., Mayewski, P.A., & Barrett, P.J. ***2006***. Opposing oceanic and atmospheric ENSO influences on the Ross Sea Region, Antarctica. Advances in Geoscience, 6, 83-86, SRef-ID:1680-7359/adgeo/2006-1686-1683.

Bertler, N.A.N., Naish, T.R., Oerter, H., Kipfstuhl, S., Barrett, P.J., Mayewski, P.A., & Kreutz, K.J. ***2006.*** The effects of joint ENSO-Antarctic Oscillation forcing on the McMurdo Dry Valleys, Antarctica. Antarctic Science, 18(4), 507-514.

Witherow, R.A., Lyons, W.B., Bertler, N.A.N., Welch, K.A., Mayewski, P.A., Sneed, S.B., Nylen, T., Handley, M.J., & Fountain, A. ***2006.*** The aeolian flux of calcium, chloride and nitrate to the McMurdo Dry Valleys landscape: evidence from snow pit analysis. Antarctic Science, 18

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