CARDIFF UNIVERSITY GREENLAND EXPEDITION '94

Staunings Alps, North East Greenland

(approximately 72°N, 25°W)

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ABSTRACT

Dates: 17/07/94 to 01/09/94

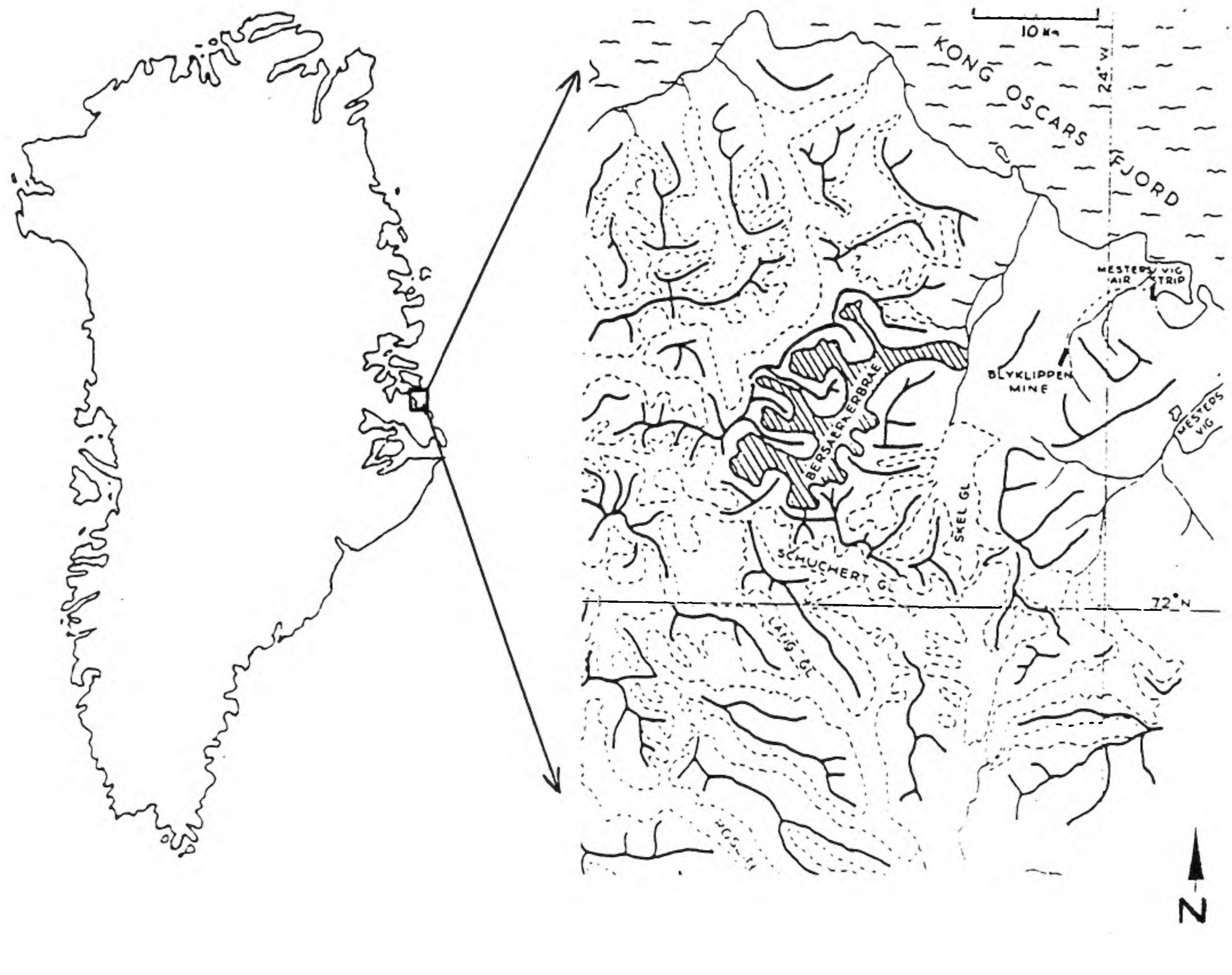
The Cardiff University Greenland Expedition '94 visited the Staunings Alps of North East Greenland (approximately 72°N, 25°W) in order to study geotechnical mechanisms associated with landslides by (a) monitoring temperature and pore water pressure changes in periglacial slopes and (b) collecting samples of 'sensitive clays' deposited near glacial moraines. Atmospheric particulate pollution was also examined in areas surrounding the Bersaerkerbrae glacier. Expedition members attempted to climb S.Face Dunnotar, N.Face Dunottar and Glamis via its Northwest and East Ridges.

Danish Polar Centre Ref. No.	5.125/18-94
MEF Ref	94/26

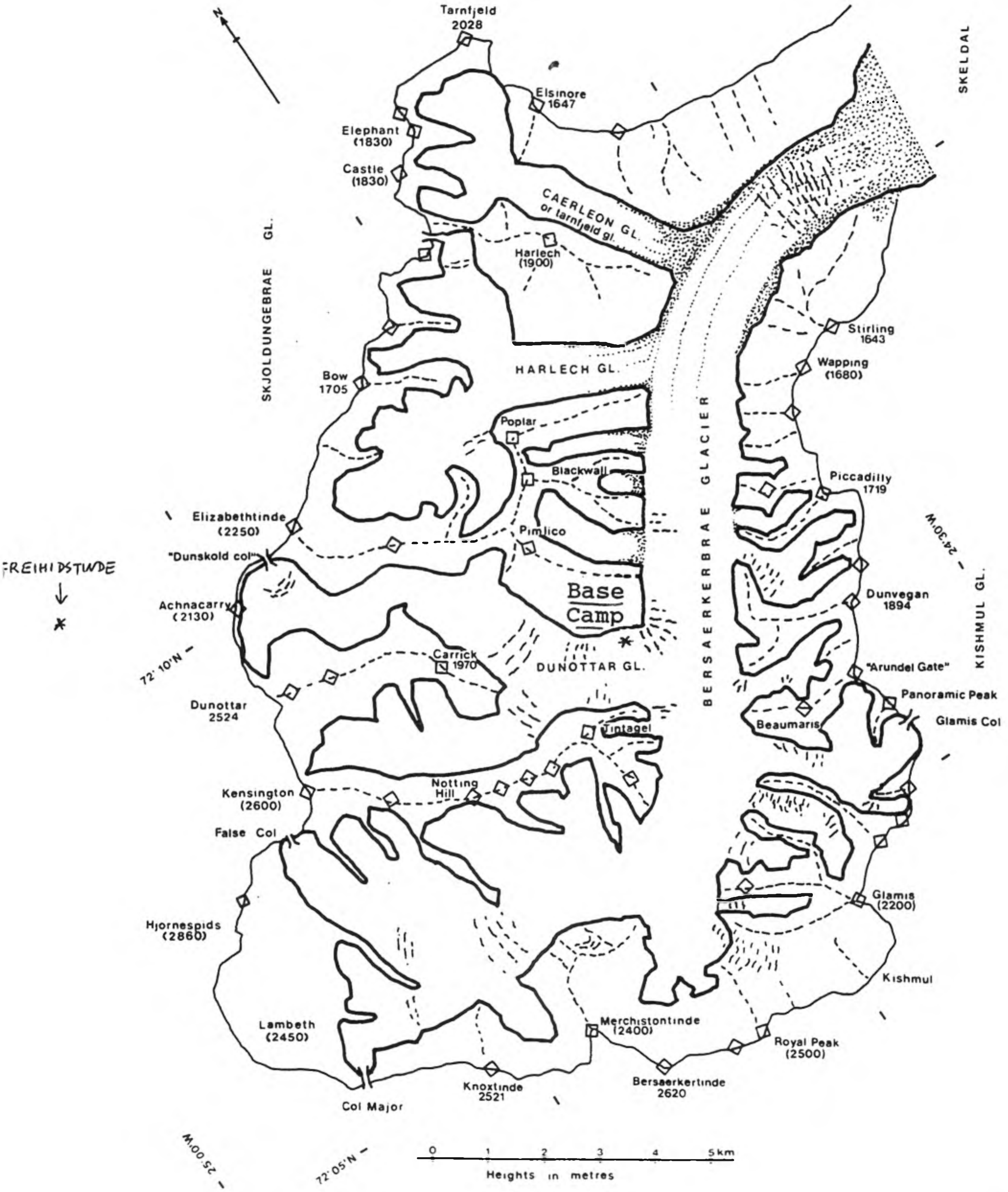
LOCATION OF THE STAUNINGS ALPS

Greenland

The Staunings Alps



MAP OF THE BERSAERKERBRAE GLACIER



SUNEGE 1982

CONTENTS

1.1 INTRODUCTION

The purpose of this report is to provide a summary of the Cardiff University Greenland Expedition to the Staunings Alps of North East Greenland. Within this framework we have tried to provide details of some of the logistical considerations involved in planning an expedition to Greenland. A summary of the scientific research and the teams' mountaineering exploits are also included.

1.1 Expedition Aims:

The expedition had the following aims:

1) to study geotechnical mechanisms associated with landslides by the following methods:
   a) collecting samples of "sensitive clays" deposited near glacial moraines.
   b) monitoring temperature and pore water pressure changes in periglacial slopes

2) to study atmospheric airborne pollution in an arctic environment for comparison with urban data.

3) to attempt to climb a number of new routes on the mountains surrounding the Bersaerkerbrae and the Skoldjungebrae glaciers.

1.2 List of Members

Dr. Gary Timms	Expedition Leader
Mr. Jonathan Rowe	Team leader, Food Officer
Mr. Andrew Roberts	Scientific Officer
Mr. Matthew Roberts	Scientific research, Communications
Mr. David Crease	Communications Officer
Mr. Andrew Woodward	Equipment Officer

1.3 Summary of Events:

Date	
17 July	Depart Heathrow for Keflavik, Iceland
20 July	Depart Iceland for Mesters Vig, Greenland
21 July	Load hauling begins - Mesters Vig to Bersaerkerbrae Glacier
1 August	Basecamp reached
5 August	Science party departs basecamp
15 August	Science party returns to basecamp
24 August	Expedition departs basecamp
29 August	Arrive back at Mesters Vig
1 September	Flight to Akureyri, Iceland
3 September	Depart Iceland for London Heathrow

Chapter 2

ADMINISTRATION AND LOGISTICS

2.1 Permission & Permits

National Park

Permission to enter the National Park must be obtained from the Danish Polar Centre (DPC). A complete set of regulations outlining use and behaviour within the park should be obtained by all expeditions contemplating entering the Park. Permission should be sought before December of the year prior to the year in which the expedition is to take place. A decision is usually made some time between February and June of the year of departure. Our expedition made a formal application in October '93 and received a permit on the 12 July 1994.

Danish Polar Centre (DPC)
Strandgade 100H
DK-1401
Kobenhaven K
Denmark
Tel (+45) 32 88 01 00
Fax (+45) 32 88 01 01
Telex 27 125 DPC DK

Search & Rescue Conditions

The DPC stipulates a rescue assurance of DKK 900,000. An assurance statement form must be obtained from the DPC, which requires the acknowledgement of your insurance company that this amount is made available in the event of any rescue attempts. The form must be returned to the DPC no later than 3 weeks prior to the start of the expedition

Furthermore, it is a requirement that all expeditions carry at least one Personnel Locator Beacon (PLB) and preferably one per working group if the expeditions' objectives cause the team to divide in the field.

The DPC strongly advise that a radio be taken, however they do not insist upon this as a requirement.

Firearms

The hazard of Polar Bear attack is extremely limited but not unheard of! Musk Oxen are a potential hazard for expeditions, although with careful behaviour any incidents can be avoided. As a precautionary note it is strongly recommended that all team members carry emergency flares to discourage any uninvited guests. We obtained small flares in Akureyri, (Iceland) and carried these at all times.

Air drop

The current understanding with respect to air drops within the National Park is that they are not permitted. More up to date information should be sought from the DPC for individual expeditions.

2.2 TRANSPORT

UK London Heathrow) to Iceland (Keflavik)

The booking of flights was left as late as possible to allow for the potential problem of being refused a permit to the National Park in Greenland. With the six members obtaining International Student Identity Cards (ISIC) we were able to purchase the tickets at a reduced price from the University travel agent.

Iceland Internal : Keflavik to Akureyri

The flight to Mesters Vig on the Greenland coast required us to charter a small aircraft from Akureyri, a town in the north of Iceland. For us a direct connection between Keflavik and Akureyri was not possible. To reach Akureyri we needed the use of a local bus transfer from Keflavik to Reykjavik followed by a further flight from Reykjavik to Akureyri. Both our internal Icelandic flights and Greenland flights were arranged with the same company, Flufelag Nordurlands, which meant that the booking procedure and also details such as the internal transfer of luggage were extremely straightforward.

Iceland (Akureyri) to Greenland (Mesters Vig)

This part of the journey represents the most costly component of the entire expedition. We chartered a twin otter to fly us to Mesters Vig on the north east coast of Greenland with refuelling stopover at Constable Point, a research station on the Greenland coast. Journey time was approximately three hours in the twin otter and on the return journey this was reduced to two hours by using a Metro III aircraft.

From the early stages of planning we were fortunate to come into contact with Sigurdur Adalsteinsson of Flugfelag Nordurlands who ensured that our travel arrangements proceeded as efficiently as possible throughout the whole expedition. He can be contacted at:

Flugfelag Nordurlands hf.
Nordlandair Ltd
Akureyri Airport
Box 400
602 Akureyri
Iceland

Tel 354 6 12101
Fax 354 6 12106

2.3 FREIGHT

Freight costs can be extremely prohibitive to expeditions if not arranged with some degree of forethought and planning. The difference in cost between air freight and sea freight can be six -fold.

We decided on a compromise between the two options and opted to use air freight on the outward journey which gave us greater flexibility in finalising food and equipment sponsorship, etc., and for the return journey we relied on sea freight.

When organising freight, the packing and labelling of packages is important not only from an expedition's organisational point of view but more importantly for customs & excise records and checks. An individual identity should be given to each package and a record made of the contents and weight of that package.

Our freight transfers were organised with the help of the following companies:

Air Freight
Angela Lacey
J.E. Bernard & Co. Ltd
Hamard House
Cardiff
Fax. 01222 732491

Sea Freight
MGH Ltd
MGH Transportation Centre
Middleplatt Road
Immingham
South Humberside
DN40 1AH
Tel. 01469 571880
Fax. 01469 571878

2.4 INSURANCE

One of the most important considerations for an expedition entering the National Park is the arrangement of search and rescue cover insurance (see 2.1). Without a signed declaration to cover any rescue attempts permission to enter the National Park will be refused.

A number of options were considered for expedition insurance cover with our final choice being Alexander and Alexander. For any expedition attempting to transport delicate and/or expensive scientific equipment, it is well worth checking the small print of your policy and carefully considering the worst possible scenario and how expensive this might be. We arranged our policy limit for £6000 to cover equipment and stores.

Alexander & Alexander (UK) Limited
Richmond House
College Street
Southampton
Hampshire
SO14 4ZB
Tel. 01703 225616
Fax. 01703 631055

2.5 FOOD & FUEL

When visiting the Staunings Alps an expedition must take all their food with them, since their are no opportunities to buy food after leaving Iceland. Food is very expensive in Iceland, so it is most cost effective to purchase the expedition's food in Britain and freight it out in advance. This requires considerable planning well in advance of the departure of the expedition. Here are some points which must be considered.

Weight

All your food must be carried from the airstrip to your basecamp, so it is vital that rations are kept as light as possible. However it is very difficult to keep rations for one man day down to 1kg. This means that an expedition of 7 weeks, food will weigh excess of 50 kg for each person. This is a lot of food, and should not be underestimated as a major part of load carrying during the walk in to base camp.

Calories

A daily intake of approximately 4000Cal is sufficient for this type of expedition. This is quite difficult to achieve with light weight and dehydrated food.

Variety

It is vital to plan as varied a diet as possible since this will help keep up morale.

A lightweight, high calorie varied diet full of interesting and varied food is a tall order, but it is well worth a great deal of effort. However, some degree of repetition is unavoidable and must be accepted.

Packing

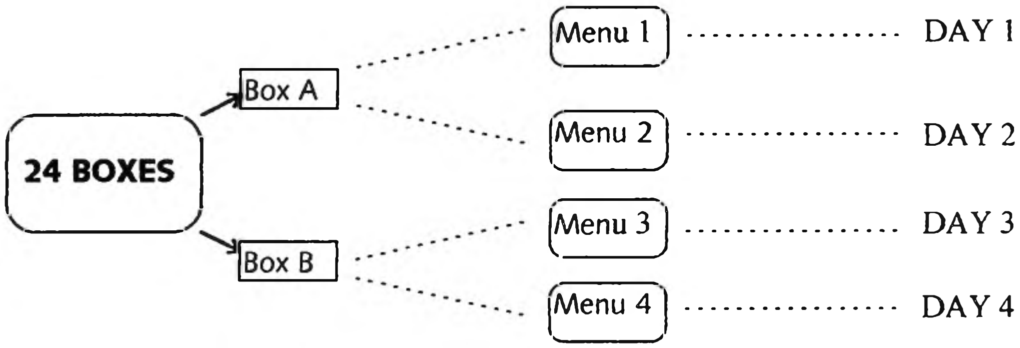
Food must be packed such that it will survive the rough handling it will experience during freight and especially during the walk into base camp. The packages of food must also be easily handled and carried in a rucsac. In the field, they are likely to be left out in the open for weeks, and must therefore be weatherproof, and animal (fox, wolf, etc.) proof. The packaging must be as light as possible. If you lose a box of food on the way to base camp, it is important that you do not lose the whole seven weeks supply of porridge or chocolate. Do not put all your (dried) eggs into one basket.

We packed two days worth of food (complete menus) for all six members into a single box. The food was sealed in a polythene sack, inside a cardboard box. This box was then sealed inside another heavy duty polythene sack. All the corners were reinforced with heavy duty gaffer (carpet) tape. There were 24 boxes in total, each containing two days worth of food and each weighing approximately 16kg.

This type of packing was only just adequate. By the time they reached base camp, several boxes were deteriorating, although all the food survived undamaged. The boxes were a little awkward to carry and had to be strapped to the outside of a rucksack. The packaging, although not ideal for this use, did have the advantage that at the end of the expedition the cardboard and polythene were easily burned which avoided the necessity to carry out large quantities of empty packaging. All burned remains were carried out.

Menus

Each food box contained food for two days. The boxes were divided into two types; Type A, containing menus 1 and 2, and type B, containing menus 3 and 4. There were 12 of each box type. Menus 1 to 4 were all slightly different. By alternating boxes A and B, our menus varied on a four day cycle.



Each box also contained two days supply of toilet roll, matches and other consumables. The portions of each type of food and the total packed in each of the two box types, A and B, are shown in the Tables 21 and 2.2.

Comments on food

- Golden syrup is a great treat on porridge
- Flora margarine excellent for boosting calories
- Dairy milk chocolate is a great snack and morale booster
- Flapjacks make a good alternative to chocolate for a snack
- Beanfeast meals one of the best dehydrated meals that we have experienced for mountaineers because of their light weight and rich flavours.
- Morning porridge oats are the perfect oats for this type of expedition. They only take one minute to cook, and make a superbly smooth porridge.
- Powdered eggs make a surprisingly good scrambled egg (or can be added to chapati dough to make naan type breads) and is a good source of protein.
- Basmati rice is by far the tastiest rice and has the best texture. Such things are important to make a repetitive menu as good as possible. If you are going to take rice, basmati is the one to take.

- Vegetarian pate (from tubes) goes well on biscuits or chapatis for lunch.
- Muesli was a poor alternative for porridge.
- Malt loaf is good for breakfast.
- 25 lighters and many boxes of matches were left unused at the end of the expedition, although this excess may have been useful if matches had been destroyed by water.

Fuel

We estimated for a fuel consumption of approximately 60 litres of aviation kerosene for the whole expedition. This was based upon a generous estimate of one litre per day for the 6 members. It turned out that we had more than enough fuel and had to carry out a certain amount out with us. Aviation kerosene can be arranged with Sigi at Flugfelag Nordurlands when arranging the flight details. Ours was collected during our refuelling stop at Constable Point on the East coast of Greenland. Suitable carrying containers were also supplied.

As the majority of our cooking was to be carried out using 2 MSR XG-K's and a peak 1 Multi fuel stove, we were not overly concerned about the type of fuel being used, knowing their adaptability to various fuels. As a precautionary measure, a filter was taken to be used when filling the smaller fuel bottles from the larger 10 litre containers. We found that the MSR's worked well at times but as rule they needed a considerable amount of attention to maintain this performance. Unexpectedly the Peak stove was rarely cleaned but performed much better. Two 'old' primus stoves were also taken as spares and in use they exhibited the same characteristic problems that were encountered with the MSR's.

At least one spares kit per two stoves is essential for the MSR's however we would strongly recommended one kit per stove. Familiarity with stove maintenance is vital before reaching the field.

BOX A

FOOD	Portion (per person)	Total in box
Porridge	85g	2 x 500g
powdered milk	1/2 pint	2 x 200g tubs
sugar	50g	2 x 300g
malt loaves	1/2 loaf	3 loaves
condensed milk (tins)	1/3 tin	2 tins
digestive biscuits	1/2 packet	3 packets
packet noodles	1 packet	6 packets
tins tuna	1/2 tin	3 tins
margarine	40g	2 x 250g
chocolate bars (mars type)	1 bar	6 bars
flapjacks	2 bars	12 bars
packets shortcake	1/3 packet	2 packets
golden syrup cakes	1/3 cake	2 cakes
mixed fruit and nuts	100g	6 X 100G
bolognese beanfeasts	1/2 packet	2 packets
gravy beanfeasts	1/2 packet	2 packets
chilli beanfeasts	1/2 packet	2 packets
rice	125g	3 x 250g
mugs potato flakes	1/2 mug	3 mugs
tomato / brown sauce	1 sachet	6 sachets
angel whip dessert	1 portion	6 portions
small chocolate bars	1 bar	6 bars
boiled sweets	20 sweets	0.5kg
tea bags	4 mugs	40 bags
coffee	4 mugs	1 x 100g
hot chocolate	2 mugs	2 x 500g
toilet roll	20 sheets per day	1 roll
box matches		2 boxes
pan scrubs		2
lighters		2

Table 2.1 Contents of food box, type A

BOX B

FOOD	Portion (per person)	Total in box
Porridge	85g	2 x 500g
powdered milk	1/2 pint	2 x 200g tubs
sugar	50g	2 x 300g
malt loaves	1/2 loaf	3 loaves
golden syrup		1 tin
muesli	150g	3 x 300g
packet noodles	1 packet	6 packets
flour		1 x 1kg
margarine	40g	2 x 250g
chocolate bars (mars type)	1 bar	6 bars
flapjacks	2 bars	12 bars
chocolate digestive biscuits	1/2 packet	3 packets
ginger cakes	1/3 cake	3 cakes
mixed fruit and nuts	100g	6 X 100g
vegetarian pate		2 tubes
dried eggs	4 eggs	24 eggs
bolognese beanfeasts	1/2 packet	2 packets
gravy beanfeasts	1/2 packet	2 packets
chilli beanfeasts	1/2 packet	2 packets
rice	125g	3 x 250g
pasta	125g	3 x 200g
tomato / brown sauce	1 sachet	6 sachets
custard	1 portion	6 portions
small chocolate bars	1 bar	6 bars
tomato puree		1 tube
lentils	75g	3 x 150g
tea bags	4 mugs	40 bags
coffee	4 mugs	1 x 100g
horlicks	2 mugs	2 x 500g
toilet roll	20 sheets per day	1 roll
box matches		2 boxes
pan scrubs		2
lighters		2

Table 2.2 Contents of food box, type B

2.6 PHOTOGRAPHY

The subject of photography in mountainous and arctic regions has been widely reported in the past. It is our intention to provide only a summary of our expedition camera equipment and the problems that we encountered.

We are indebted to Ian Edwards of Leeds Photovisual and Howard Cheetham (Cardiff University Photographer) who provided much advice on the selection of camera bodies and film.

Summary of Expedition Camera Equipment

SLR-bodies

Nikon FM2

Nikon F-801

Nikon F-401

Konica A-1

Pentax ME Super

Extra Lenses

Nikon 35-135mm

Konica 28mm

Canon 400mm

Compact Cameras

Pentax Zoom 105-R

Camera Film

(totals for all expedition members)

100 rolls Fuji Sensia 100ASA (slide)

30 rolls Fuji Velvia 50ASA (slide) *

30 rolls Ilford FP4 (print)

5 rolls Kodachrome 64 (slide)

5 rolls Fuji Super G 100ASA (print)

**highly recommended*

Accessories

Jessops vacuum "tripod-bag" - highly recommended for use in areas where a flat surface is not available. Relatively inexpensive compared with traditional tripods.

Lens cleaning kit essential on all expeditions if photography is to play an important part.

Camera problems/breakages

In total the expedition suffered breakages/failures of 5 cameras during the course of the expedition (see Table 2.3) In some instances the problem was repairable.

Camera	Problem	Cause/Solution in the field
Nikon FM2	bent shutter blade	camera tipped over whilst loading film / repaired with tweezers.
Nikon F-801	no shutter response - electronic fault	unknown/none
Nikon F-401	no response - electronic fault	unknown/intermittent-eventually worked
Pentax105-R	no shutter response - electronic fault	unknown
Pentax ME Super	damaged lens	possibly knocked during transport / no spare available

Table 2.3 Summary of camera problems/breakages.

2.7 MEDICAL REPORT

First Aid Kit

The expedition needed to be medically independent for all but the most circumstances, and even then medical assistance would be many hours or days away. There was no qualified medics on the team but several members were experienced in mountain first aid (as members of the Bridgend Mountain Rescue Team).

On the following page is a list of contents of the main first aid kit which was left at base camp for the duration of our stay on the glacier. The common mountain injuries which we prepared ourselves to treat included cuts and bruises, fractures and breakages, and infections. The base camp first aid kit was stored in two BDH containers which were durable and weatherproof.

In addition to the first aid kit, we took a copy of Peter Steeles book "Medical handbook for mountaineers" (published by Cordee). This provides clear and concise information and instructions covering the treatment of a wide range of injuries and illnesses. The expedition advisory centre's " Polar Expedition Manual" also has some useful information on medical supplies and the organisation of medical kits.

None of the expedition members suffer from diabetes, epilepsy or any allergy to any of our medications. All members had dental check-ups shortly before departure. Tetanus vaccinations were all up to date.

Medical Problems

Several members suffered from painful knees, presumably as a result of carrying heavy loads over rough ground. Two members had a history of knee problems before the expedition took place. It was generally found that Ibuprofen was not effective at alleviating the pain.

In the cold, dry environment, several members suffered from severe sore throats for much of the time. They would have appreciated throat lozenges or cough medicine, which had not been included in our medical kit.

One member suffered extreme reactions to mosquitoes. Little relief was gained from hydrocortisone cream and a more powerful treatment would have made his life less miserable during the walk in.

Details of the base camp kit are given in Table 2.3.

In addition to the base camp kit, each climbing pair carried at all times a "field kit" containing :

- 2 triangular bandages
- 1 crepe bandage
- assorted safety pins
- assorted plasters
- 2 small dressings
- ibuprofen
- temgesic

Base Camp Medical Kit

BDH 1	BDH 2
3 Crepe Bandages	paracetemol x 100
6 triangular bandages	ibuprofen x100
2 adhesive elastic bandages	temgesic x 30
2 eye dresssings	temazepam x 30
10 gauze squares	
7 absorbent dressings (melolin10cm x 10cm)	cephradine x 1 course
7 absorbent dresssings (melolin 5 x 5 cm)	erythromycin x 2 courses
4 rolls micropore tape	metronidazole x 2 courses
4 dressing bandages	cyproxin x 3 courses
assorted plasters	
20 assorted safety pins	chloramphenicol cream x 3 tubes
	antiseptic cream x 2 tubes
1 finger splint	hydrocortisone x 2 tubes
10 assorted steristrips	
20 alcowipes	immodium x 30
3m tubigrip	lopiramide x 50
5 sutures	senakot x 10
1 forceps	5 hypodermic needles
2 thermometer strips	1 plastic eye bath
2 scissors	1 airway tube
3 packets scalpel blades	3 temporary fillings
3 x 100ml syringes	
5 salvoldil irrigation sachets	
5 saline irrigation sachets	

Table 2.3 Details of expedition base camp medical kit.

Chapter 3
MOUNTAINEERING AND EQUIPMENT

3.1 Summary of peaks visited and routes attempted:

Bersaerkertinde	North Face*
Dunottar	North Face
Dunottar	South Face
Glamis	Northwest Ridge
Glamis	East Ridge,
Tintagel	Ice Couloir, North side

**GT and AR made a close up reconnaissance of the north face but did not make a direct attempt to climb it.*

3.2 Route Descriptions

team members attempting route given in brackets

North Face Bersaerkertinde

After much reconnaissance from basecamp and examining snow and rock conditions on peaks surrounding the face, the climbing team reluctantly decided to stand down from an attempt on the north face. A potential line takes the left hand side of the face as shown in fig. 3.1. From the lower rock section the route takes the first large snowfield however from the top of this snowfield the route is not so obvious. A possible route may take a line trending right to a second snowfield and then finishing more directly through the upper rockband to the summit.

Fig 3.1 North Face Bersaerketinde
A potential line to the summit is marked

Dunnotar, North Face (AR, MR, DC, AW)

The route takes the more straightforward line to the summit of Dunnotar. An easy angled snow climb with some avalanche potential. The summit commands spectacular views of the Skjoldungebrae glacier and the magnificent peak of Frihedstinde.

Dunnotar, Pinnacle - South Face (GT, JR)

Attempted new route to the left of the Salford South Face route (1983) and I.M. Marsh South East Face route (1985). The proposed route is shown in fig 3.2. From the bergschrund the route takes a rightward slanting line to the shoulder before trending left to the upper terrace directly below the main face. The upper section of the route follows the obvious crack line to the summit. The lower section provides mostly easy grade climbing (II/III) with the crux (IV/V) being a slanting wet crack at 25m below the shoulder. Careful route finding to the upper terrace is required.

We found ourselves restricted with time and were only able to reach the upper terrace.

Glamis, Northwest ridge (GT, JR, DC)

Our potential route took the line shown in fig. 3.3, following the lower section of ridge before traversing onto the steeper, more technical part of the ridge. At an early point along the ridge we discovered indications of a previous Italian expedition to this area.

The route turned out to be much more technical than we had anticipated and with three of us climbing together and carrying large rucksacks we decided to return to basecamp, after 24hrs on the route.

Glamis , East Ridge (GT, JR, DC)

Approach made via the glacier shown in fig.3.3, with the intention of ascending a slope at the head of the glacier, traversing back along the ridge, and making a final push along the summit ridge. During the walk-in we decided on a more direct approach to reach the ridge, involving 10 hours of Scottish grade I/II climbing. Our ascent led us towards a shattered rock pinnacle on the crest of the ridge. Rock conditions in this area were found to be extremely unstable restricting movement to the summit ridge.

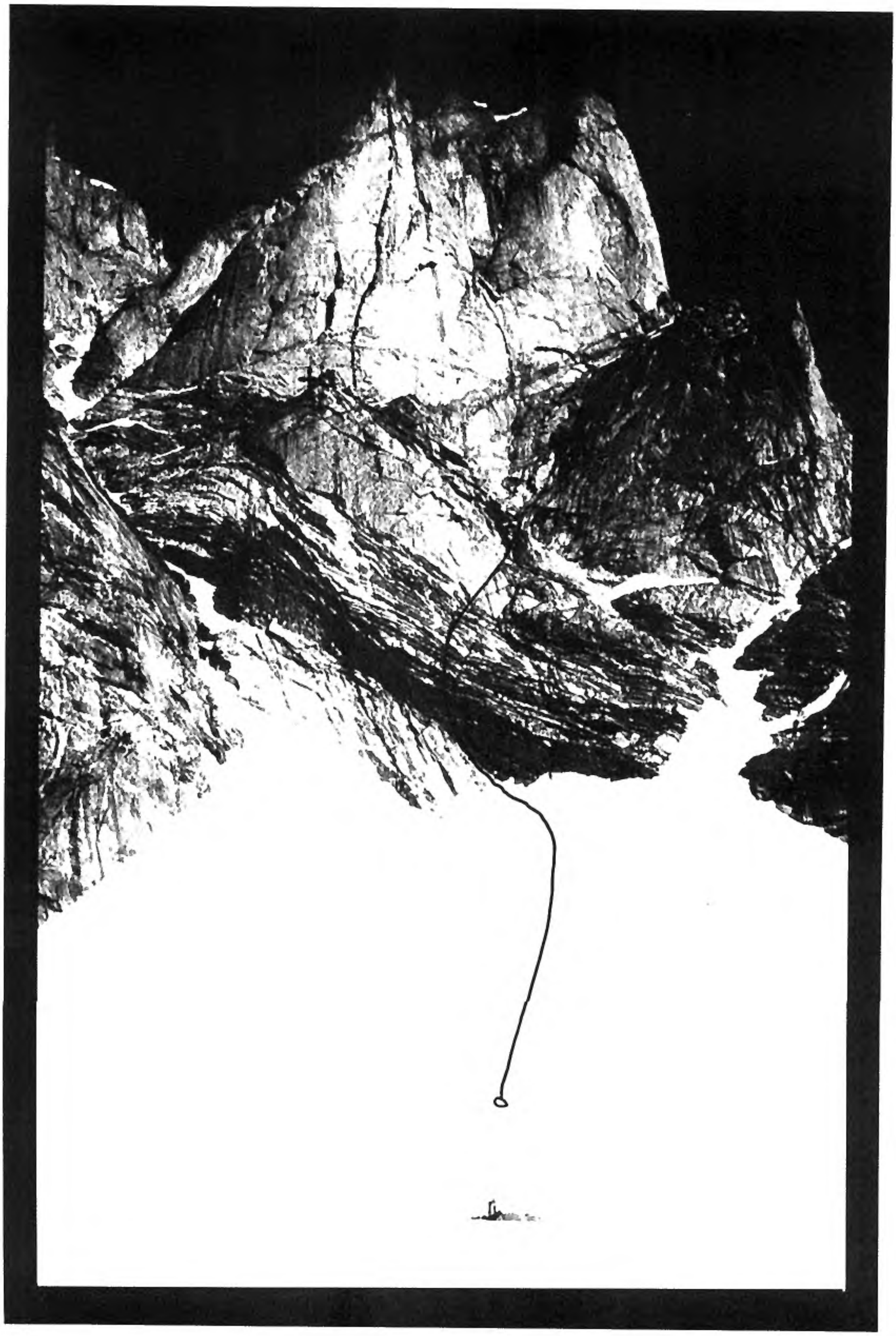


Fig 3.2 South Face Dunnotar Pinnacle
Our intended route takes the line shown. High point marked (+)

Fig 3.3 Glamis
East ridge (skyline) and northwest ridge (centre) are marked. The approach to the East ridge follows the route shown in the bottom left corner.

Tintagel, ice couloir on north side (GT, JR, DC)

Attempts were made on the icefall from the Dunottar glacier with little success. A broken crampon whilst leading on steep ice dampened our morale for a further attempt upon this route.

3.3 Equipment:

This section aims to provide details of the expedition's climbing equipment, clothing and general equipment. It was decided that once we had reached Greenland we would load-haul our equipment rather than take the highly expensive option of hiring a helicopter to ferry the gear to base camp. In hindsight, after taking two weeks to reach base camp, we may consider the option of a helicopter to ferry much of our base camp loads on any future expeditions. However, the long walk in did provide us with a greater sense of 'belonging' to our surroundings.

We have detailed all group and personal equipment in Tables 3.1 - 3.3.

Notes on equipment:

- MSR X-GK stoves melt snow and boil water very quickly but require a considerable amount of maintenance when using Kerosene as a fuel supply.

- RAB down equipment provided ample warmth and comfort. 5 out of the six members used Rab duvets and 4 out of the 6 used Rab sleeping bags. The Rab Andes jacket is highly recommended as an all round base camp jacket.

- Thermarest mats were essential for base camp comfort.

- Thermarest chairs are well worth the expense and extra weight.

- Pulks made it possible to carry much heavier loads per trip up/down the glacier- well worth it.

- Plastic snow shoes disintegrated during heavy load carrying.

- Contact lenses (weekly disposable soft-type) were worn by one member of the expedition. No problems were encountered, however extreme care was taken to ensure a high level of hand cleanliness during the fitting process.

- Ski poles were a great asset during the early part of the expedition when heavy loads were being ferried between camps.

- A suncream of a high factor (~15) was used by most members. Total sunblock was used for lip protection (recommend Piz Brun - expensive but very good)

- Flares were carried by all members of the expedition in the likelihood of a musk oxen attack. At no time were they needed.

The expedition would like to express it's thanks to the following for their help with our equipment:

Kay Schofield and Richard Johnson at S & MC (Rab clothing).
Chefaro Ltd - Jungle Formula mosquito spray.
Taunton Leisure Swansea.
Andrew Gillett for use of ice climbing equipment.
Armstrong & Millington Opticians of Chepstow for supplying all members with sunglasses.

Item	Details	Notes
Group		
Ropes	6 x 9mm (50m)	
	25m tubular abseil tape	
Leader Racks	set of rocks on wire (sizes 1-6)	
	large rocks on rope (sizes 7-9)	
	Hex's on rope (sizes 1-6)	
	set of friends	
	6 quick draws	
	6 x 4ft slings	
	6 x 8ft slings	
	10 assorted rock pegs	
	10 assorted ice screws	
Individual		
	Harness	
	fig of 8	
	belay device	
	prussik loops	
	ascendeurs (x2)	Troll expedition with handle
	helmet	
	crampons	
	ice axes	a) walking type for science members
		b) 2x technical axes for climbing members
	whistle	
	knife	
Miscellaneous		
	1 Spare ice axe	
	1 spare pair crampons	
	crampon maintenance kit	

Table 3.1 Details of climbing equipment (group and personal)

Item	Notes
Down Jacket	most used RAB Andes
Goretex Jacket	
Goretex Salopettes	
Fleece Salopettes	
Fleece smock or jacket	
2 thermal vests	
1 Pair thermal tights	
1 Pair cotton trousers	
1 pair of shorts	
1 sweatshirt	
1 light cotton shirt	
Plastic mountaineering boots	4 Asolo + 2 Koflach
Lightweight trekking boots	
Dachstein gloves or equivalent	
Waterproof overglove	
Fleece balaclava	
several pairs thick socks	
several pairs underwear	

Table 3.2 Details of expedition clothing.

Item	Details
Tents	1 x Vango Odyssey 300
	2 x Wild Country Quasar
Stoves	2 x MSR X-GK (including maintenance kit x2)
	1 x Peak 1 multi fuel
	1 x Primus
Fuel	Kerosene (60 litres in 10 litre containers)
	Optimus priming gel (6 tubes)
	4 x 1 litre sigg fuel bottles
	2 x plastic funnels
Cooking	6 x 1.5 litre billy cans (Trangia)
	2 ladles
	2 wooden spoons
	4 pan grips
Eating utensils	8 plastic bowls
	8 plastic mugs
	6 sets of cutlery
Sleeping	2 x RAB premier 900g down bags
	1 x RAB premier 1100g down bag
	1 x RAB standard 1000g bag
	2 x Quallofil type
Personal	head torch
	washing kit
	glacier glasses
	book(s)
Greenland Travel	6 x plastic pulks
	6 pairs of snow shoes
Miscellaneous	1 Roll heavy duty gaffer tape
	sewing kit
	5m paracord
	leatherman pocket tool kit
	6 x packets mini flares (6 cartridges per packet)
Specialist	Sea Marshall personal locator beacon
	First aid kit - base camp + personal
	Cameras including accessories

Table 3.3 Details of general expedition equipment.

Chapter 4
EXPEDITION DIARY

Selected extracts from the personal diary of team member, Andrew Roberts.

Sunday 17th July

Left Heathrow at around 9.30pm after a cramped minibus journey and arrived in Keflavik to low cloud and drizzle at 12pm. Resigned to sleeping in airport terminal though met with much local rejection and finally stayed in local campsite.

Monday 18th

Travelled by bus to Rejkjavik across landscape of barren lava flows. Lumped vast amounts of kit across from bus station to airport before waiting 5hrs for internal flight to Akureyri. Arrived in Akureyri to snow-capped mountains and fjords. Stored gear in aircraft hanger and plastered on jungle formula; mosquitoes getting everywhere already!

Tuesday 19th

Walked into town and had coffee and waffles. Signed postcards for sponsors.

Wednesday 20th

Left Akureyri at 9am on twinotter. Arrived at Constable Point in Southeast Greenland 2.5hrs later for kerosene. Fall in temperature very evident. Shared 45 min flight to Mesters Vig with two Norwegian chaps on a canoeing expedition. Icebergs and interesting sedimentary formations in mountains below made for an unforgettable flight. After an uneven landing arrive to find that fjords are frozen, what a bumper! Sirius Patrol very good and drive us 6km up the valley with all our gear, probably saving us a couple of days. First muskox sighting. Began hauling kit to abandoned mining hut further up the valley. Finished for the day at about 10.30pm wishing it was day 10 when I know I'll be fitter!

Thursday 21st

Started on trek up to Gefionpass overlooking Skeldal River, which took 3hrs. Saw first glimpse of Staunings Alps. Started back up the col at 7pm and arrived back at 1am. Neck aches, shoulders ache, hips ache, legs not too bad, blisters forming. It's 2am and just off to bed, sun is just coming over the ridge to the east and lighting up the valley.

Friday 22nd

Up at 11.30 to breakfast of porridge, condensed milk and malt loaf. Left at 2.30pm on first load. Norwegian's popped up for dinner; fjord is still frozen.
Bed at 3am in brilliant sunshine.

Saturday 23rd

Decide to have a rest day. I must say John looks as pale as a very pale thing, apparently Woodward feels the same. Who said flies aren't an intelligent life form they are hovering the hole I've dug before I've even squatted. 10pm and Gary has the 3 bob bits, shouldn't really laugh but he is wandering around with a very concerned look on his face

Monday 25th

Great night on Gefionpass. Approx. 2ft of snow between pass and ridge overlooking river means we can test out pulks and snow shoes. Decide to go with a lot of kit and succeeded in falling over within first 100 yards after snapping snow shoe; Skeldal river looks brown, fast flowing and a bit nippy. As now continued to melt in heat of the day Mat fell into a stream. Gary and I went back to get final load at 9pm. Arrived back at 11.50pm. Left knee is in agony. Bed at 1am

Tuesday 26th

1.5km of rocky descent to river. Strapped up knee but it hurts a great deal - took a couple of pain killers. Lagged behind everybody at start of day as knee refused to respond. Made back up to the top as easier going. Though at end of 2nd descent remain at bottom to cook dinner - hope the situation has improved tomorrow. Put up tents and it rains.

Wednesday 27th

Oh what a joy it's river crossing day. It rained all night and its still coming down. Mountains to the south have had a powdering of snow. It took 11 trips in all to cross the river. Difficult to find footing sometimes and it wasn't a good idea to risk deeper channels.

Thursday 28th

Rest day!! Think I'll amputate my knee with my penknife later on. Had a shave and feel 100% better. Mat's thermarest went down in the night and coupled with Woodward's snoring all went towards a pretty miserable nights sleep. Finished the Liar today, Fine book, suspect I'll read it again!! Started "The Van" and had read half by dinner time.

Friday 29th

Up at 12pm. walked a bloody long way with heavy rucksack (again) to edge of glacier and another dump. Hard going under foot and they desperately need a footpath here. I think my knee will be spending a week in Stoke Mandeville when I get back. Good view back over Kong Oscars Fjord and ice is now breaking up. Made 3 round trips today, just boring and hard going after 1st trip. Made it back to camp at 2.30am for dinner of beanfeast and pasta, so I guess its now Saturday. Bed at 4.30am.

Saturday 30th

Spent the whole day ferrying more loads with extremely painful knee and had to miss final load. Nothing I do seems to stop it from hurting. No room for tents at this stage and bivi for the night.

Saturday 31st

It rained all night, which it seems was very eventful. Gary fell asleep with bivi open and consequently got a little wet, Matt had a panic attack inside his sleeping bag and John's bivi (or is it teabag) leaked. After a brew decided to take essentials and 3 days food and establish basecamp. Walking on glacier very easy though distances are very deceptive. Streams are copper sulphate coloured and quite beautiful. Visibility got very bad and when down to 10m, and found ourselves in crevasse field. After 6hrs walking John and Dai recce camp.

Monday 1st August

Mist cleared up and awoke to a fabulous view in bright sunshine. Looking down the valley mountains are visible on the far side of Kong Oscar Fjord probably about 30km away. Can finally see the big north face and it looks daunting, still over 6km away and certainly not looking 1mile high. Just heard 1st minor avalanche on peaks opposite camp which reverberated around the whole valley

Tuesday 2nd

Rest day at basecamp. Starts to get cold about 8pm when sun goes behind west ridge and down jackets are a must.

Wednesday 3rd

Up at 10am, stayed in basecamp whilst others went back down glacier to fetch food and rest of personal kit. Took the guys 12hrs. Dai fell down a crevasse though nothing too serious.

Thursday 4th

Rest day

Friday 5th

Begin walk back to Blyklippen, (concerned about knee), to commence Mat's GPS project and other science projects on Skeldal River. 11hrs later (at 1am) after a pleasant stroll, arrive back at mining hut. Steams are now dried up and mossed over and mosquitoes seem more at home. Finally bed at 3am

Saturday 6th

Up at 1pm another welcome rest day, there isn't an area of my body that doesn't ache! Think I'll hobble around the hut all day, do some washing and learn how to use Mat's GPS. Went for a walk late in the afternoon and saw an arctic hare. Hillsides also teeming with birds nests and hard to pick a route without disturbing too many of them.

Sunday 7th

Mat has gone to Mesters Vig - Woodward and myself walk back to Skeldal with GPS rover unit and 6 days food; walk takes 5hrs.

Monday 8th

Glacial rock flour sampling on Skeldal River. Felt very giddy all day which I have attributed to mozzie bites of which I have bloody thousands. Finished Roald Dahls autobiography and started the autobiography of Richard Feynman.

Tuesday 9th

Mat arrived back in the afternoon and we crossed over the river to help him across.

Wednesday 10th

Took some more meltwater samples and Mat collected fuel from dump at head of glacier.

Thursday 11th

Mat has 3 more days at the river to complete GPS project. Woodward and myself take four days food and head for the fjord where there is a beach. Arrive after 6hrs walking.

Friday 12th

Awoken early by some large geese outside my bivi bag. The tranquillity of this place is amazing. I can see about 40 miles up and down the fjord where the water is so still and deep blue, with the occasional iceberg. There isn't a breath of wind and all I can hear is the geese over the other side of the fjord. The sun is now lower in the sky and we were treated to the most stunning sunset in the evening.

Saturday 13th

After 7hr walk arrive back at Skeldal to meet up with Mat. Saw 7 muskox on the way. River was very fast flowing and not pleasant to cross.

Sunday 14th

Rest day before long haul back up the glacier with remainder of fuel and food. Brilliant sunny day and not a cloud in the sky.

Monday 15th

After running repairs to Mat's rucksack, set off for basecamp at around 3pm. Reached food dump after 3hrs and loaded pulks. After 4hrs reach crevasse field and with snow melting rapidly. Couldn't find snow bridges we used on the outward journey. Roped up and soon found ourselves falling in up to our waists as snow was still soft from the days sun. Got into a bit of a mess and others watching from basecamp with binoculars come to give us a hand! Good to see them again.

Tuesday 16th

Now have to break ice on pond in morning for water. Modelling for promotional photos all day but managed to get in a bit of climbing in the ice fields.

Wednesday 17th

John and Gary leave in the evening to secure some new routes whilst the rest of use set off to attempt North Face of Dunottar. Set off at 12pm.

Thursday 18th

After 7hrs trek arrive at bivi site. Glacier on route heavily crevassed and hard going and after arrival plan to sleep through sunlight and make attempt late this evening. Mat feeling very groggy and after 400m starts vomiting and decides to stay at bivi site whilst other 3 carry on.

Friday 19th

Ascent relatively easy going and as we gain height the views over Kong Oscar Fjord become breathtaking. 5hrs later reach summit in deep powdery snow. Take in view at summit for a good couple of hours - could even see as far as ice cap inland. Return about 10am to find Mat no better. He is missing Michelle, Dai is missing Sam and all I'm missing is a good pint of bitter and a plate of fish and chips which speaks volumes about the state of my love life. Return to basecamp.

Saturday 20th

After dinner at 1.30am moon actually appears over ridge to the east; first time in 5 weeks!

Sunday 21st

Tent was covered in a thick frost this morning, winter slowly arriving

Monday 22nd

Filter snow all day for pollution studies

Tuesday 23rd

Pack up basecamp and break up remaining food boxes! Burn rubbish and take out non degradable stuff.

Wednesday 24th

Leave basecamp. Started on glacier at 11.30am with heavy rucksacks and pulks. Felt bloody miserable all day and after arrival at Skeldal at 11pm didn't really want to face trip back up to glacier for remaining kit and used up my expletives quota for the day. Mosquitoes are back as well.

Thursday 25th

Ferried loads across river and John directed me to a patch of quicksand which gained mass approval. Make 3 trips up and down hill, feeling very good and much fitter - no problems with knees now

Friday 26th

More load carrying

Saturday 27th

More load carrying

Sunday 28th

Final run from Blyklippen to Washburn Hut, even jogging with Gary at one point as fitness is much improved. Once at hut I try at adapt gas canister to a lamp, laughter turns to concern as canister receives blows from various blunt instruments. We did have light though we weren't too sure how safe it was to sit in the same room as the arrangement, which rather defeated the object!

Monday 29th

Bit blowy outside. John walks in with bomb dressing on his chin (some kind of infection!), not sure whether it's the complaint or the dressing which is making him talk stupid. Arrive at Mesters Vig to see Norwegian canoeists again. Danish military chaps agree to come and collect our stuff and offer us two nights accommodation. Hut had a proper toilet and a shower. Sat up with the Norwegians until 2am recollecting experiences.

Tuesday 30th

Norwegians are early risers and catch us on the hop. Mat makes the most lumpy porridge of the trip so far. Wander over to abandoned mining village after breakfast - looks like the people left only yesterday. Polar bear spotted not too far off coast.

Wednesday 31st

1st hangover in about 7 weeks after drinking last night with Sirius patrol. Plane due to arrive later this evening. Shared a plane back with some Norwegian geologists and saw the most amazing sunset yet.

Thursday 1st September

Had burger and chips for lunch which was eaten at a fair old rate of knots. Went swimming and developed nice scum layer on the surface. Had salmon for dinner which went down a treat.

Friday 2nd

Up at 10am to hit restaurant again. Bought a copy of Newsweek and caught up on world affairs; pretty dull few weeks it would seem. Went to sleep dazzled by the northern lights. Exceedingly hard to describe, but the whole sky danced with green and red, pretty unforgettable experience.

Saturday 3rd

Check in at 10.30am for flight south with only us onboard. Fond farewell from pilot after landing at Keflavik. I certainly intend to return one day.

Chapter 5
SCIENCE REPORT

The Cardiff University Greenland Expedition '94 presented the six members of the team with an unmissable opportunity not only to explore this beautiful, remote polar region, but also to collect highly original scientific data.

In response to feedback from fellow researchers at Cardiff School of Engineering who had research interests within this polar region, three projects emerged as being potentially suitable.

As with other areas of the trip, careful preparation and planning were required at an early stage to ensure minimal operational difficulties. Every eventuality, ranging from suitable sites of study to equipment failure, was dealt with at this stage. The precision of detail at this level of the preparations required flexibility of thought and alerted us to every possibility, from whether the selected projects were viable to where possible problems might arise, and even as to exactly what we hoped to achieve from each project brief. Working in such a remote area where resources are limited it was important that the projects were procedurally and technically simple, so as to avoid unnecessary complications. Trial runs of each project were completed prior to departure (greatly assisting their field operation), and should be considered an essential part of the planning for any expedition where fieldwork is to be undertaken.

Once in the field it was important to maintain a professional attitude towards work and towards getting results, and despite low morale on occasions, the thought that so many people other than ourselves had invested a great deal of their time, effort, and money in the success of our operation pulled us through. Prior preparation was shown to have been largely successful, as the majority of problems that we encountered occurred in the more technically advanced areas of work. Despite accounting for every operational hiccup, the use of sensitive equipment in one project itself increased the chances of operational breakdown and it was disappointing not to have obtained results in this area after the long months of such careful preparation. In this respect it was prudent not to have attached too much significance to one project alone and to have had the results of the others as a back-up if anything went amiss.

Once back home the writing up of results has been a long process given the long term nature of the 2 remaining research projects. Despite significant findings in the area of glaciomarine sediments, frustratingly samples of filtered snow collected to form part of a pollution study are still the subject of on going analysis and cannot be reported upon here.

Andrew Roberts
Scientific Officer

Project 1

Role of amorphous material in initial glaciomarine sedimentation and consideration of early diagenesis as a consequence of land emergence

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Abstract

For a period of 10 years between 1972 and 1984 a large amount of geochemical research focused on the nature and role of amorphous phases present in sensitive glaciomarine clays. In recent years the validity of these findings have been questioned; the argument centring around the accuracy of the analytical techniques employed, and more specifically their ability to selectively remove amorphous phases.

TEM analyses of recent glacial sediment from northern East Greenland along with sensitive clays from Canada and Norway have found particle coatings of Fe and Al. An "amorphous model" is proposed in which it considers that both glacial grinding and chemical weathering are mechanisms which strongly influence sediment behaviour, through the generation of amorphous material.

One of the major differences between Scandinavian and Canadian sensitive glaciomarine clays is that high strengths in the range 50-80kN/m^2 are common in eastern Canada but are not found in Scandinavia. Preconsolidation is influential at many locations but large differences exist in the degree of cementation. The amorphous model proposes that a primary control on cementation is the duration of exposure to freshwater leaching. Differences of up to 2,000 years in the deglaciation chronology are suggested as having a strong influence on the timing of land emergence and the commencement of leaching. A mechanism for the cementation process involving chemical weathering within the clay mass is discussed.

Introduction

Sensitivity of a soil is defined as the ratio of undisturbed and remoulded strengths. Highly sensitive soils are found in Scandinavia, eastern Canada, Alaska, the northern part of the former Soviet Union and in selected parts of the Southern Hemisphere, such as New Zealand. Sensitive glaciomarine clays in Scandinavia and eastern Canada typically exhibit undisturbed strengths of 15-80kN/m2, when remoulded at the same moisture content they transform to a slurry with a strength of less than 0.5 kN/m2. The development of high sensitivity behaviour is recognised as being a post-depositional process.

Excessive settlement is a property of sensitive clays but their most spectacular characteristic is their susceptibility to slope failure. An initial landslide is often followed by retrogression and gravitational remoulding which transforms the clay to a viscous slurry. Major slope failures have driven the research effort in this field. One of the most destructive landslides was at St. Jean Vianney, Quebec, in 1971 (La Rochelle, 1974); during the failure 7 million m3 of clay liquefied, 40 homes were destroyed and 31 persons lost their lives. The more recent landslide at Rissa, Norway, is perhaps better known (Gregersen, 1981); during this event in 1978, 5-6 million m3 of clay carried away 12 homes, there were no fatalities.

Glaciomarine clays were formed 9,000-12,000 years ago as the Devensian ice sheets retreated. One of the first and most scientifically satisfying explanations of the post-depositional processes which can impose sensitivity onto glaciomarine clay sediments was proposed by Rosenqvist (1953,1977). Rosenqvist's theory of sensitivity envisaged that illite and other fine grained particles were sedimented into marine and brackish waters that existed at ice margins towards the end of the Pleistocene. A salt concentration of 35 grammes/litre suppressed the negative charge on the clay minerals, particles moved into close proximity and the positive edge charge caused flocculation. Under these conditions the silt and the clay-sized particles would settle together to form a flocculated, high void ratio sediment. The structure of the sediment was that of an open cardhouse which has sufficient integrity to withstand overburden pressures without collapse. This structure provides for the maintenance of the undisturbed strength and constant water content while other changes which decrease the remoulded strength are occurring. Removal of the ice load caused the land mass to gradually rise; the restoration of isostatic equilibrium caused the marine waters in which the sediments had been deposited to retreat and the deposits to be lifted to elevations in excess of 200 metres above present day sea level. As the new groundwater regime was established, the flow of freshwater through the sediments gradually reduced the salt content from 35 to < 1 grammes per litre.

In its leached state:

- the clay exists at moisture contents in excess of the liquid limit, that is, if the clay was remoulded it would be a liquid;

- the interparticle forces are no longer those of attraction, and if the cardhouse structure was caused to collapse the particles would repel and move away from each other.

Whilst there is no doubt that all sensitive glaciomarine clays have been subjected to leaching and that the clay minerals responded to the change in the chemical environment in the manner envisaged by Rosenqvist, there are additional factors which can influence the development of sensitivity (see Torrance 1983).

Speculation on the contribution and role of amorphous compounds in sensitive soils has led to numerous detailed geochemical studies (Loiselle *et al.* 1971; McKyes *et al.* 1974; Hendershot and Carson 1978; Yong *et al.* 1979 a,b; Locat *et al.* 1984), which confirmed their common occurrence and that the three major phases were silica, iron and aluminium. The investigations used "selective" dissolution techniques and analysis of the extracted chemicals. The quantity of amorphous material detected varied from <1% to >25% and appeared to be a function of the dissolution technique employed.

Dissolution techniques cannot be truly selective and the affect on other mineral phases is difficult to quantity. The use of these methods is further complicated by the fact that the distinction between amorphous and crystalline materials is not clear cut. Whilst it is possible to define amorphous phases as materials that lack long-range order and hence preclude identification by XRD, soils may also possess pseudo-amorphous and poorly crystalline materials either as discrete particles or as surface coatings on crystalline-core particles. To avoid the problems associated with dissolution techniques a direct quantitative study of particle coatings on glacial sediments using EDAX analysis and TEM is undertaken.

Sensitive clays are Quaternary materials and as such need to be more specifically related to quaternary processes. The analysis of recent glacial sediments from northern East Greenland along with sensitive clays from Quebec and Norway has made a significant contribution to our understanding of amorphous materials in these sediments. This article addresses the question of the role of amorphous material and within this framework it is postulated that subsequent changes in the geotechnical properties arise from the changing properties and quantity of amorphous materials in response to fresh water leaching; a mechanism for post-depositional cementation within the clay mass is discussed.

Materials and Methods

The samples used in this investigation include a Champlain sea clay from Quebec, eastern Canada, a sensitive clay from Norway, along with recent glacial sediment from northern East Greenland. The Champlain clay from St. Thecle originated from a depth of 13.6m where it formed part of a block sample which had been sealed in paraffin wax at its natural moisture content. The Norwegian clay was taken from a depth of 13m at Overhalla in mid-Norway and was also sealed to prevent moisture loss.

With its Arctic climate and extensive areas of glaciation Greenland could reasonably be considered to closely simulate conditions which existed towards the end of the last Ice Age in eastern Canada and Scandinavia and provides an ideal modern analogue in the study of these problematic clays.

Samples of glacial rock flour were taken in the Staunings Alps region of northern East Greenland. Here the inland ice impinges on the western side of the fold belt and splits into several large valley glaciers. Elsewhere the land is mainly ice free today due to the fact that cyclonic centres, which move northwards along the coast of East Greenland deposit the major part of the precipitation south of Scorsby Sund (70^{o} 15' latitude) (Hjort,1979). Sediment samples were taken from the Skeldal River (72^{o} 15' latitude); at this location meltwater from the Skelbae glacier was the main source of suspended sediment. Meltwater from other several other smaller hanging glaciers to the west also feed into the river, with a further input coming from melting snow on surrounding slopes. Like most glacial meltwater the river carried a high sediment load, the water being very turbid and brown in colour. A volume of water was drawn through a 0.4um millipore filter with a syringe attachment, until the filter took on a noticeable brown discoloration. Sediment laden filters were maintained in their wet state by sealing in plastic bags.

The study of particle coatings involves analysis using a Philips 301 transmission microscope fitted with an EDAX 711 energy-dispersive analyser. This quantitative assessment was carried out on quartz grains and provides an absolute measurement of elemental phases present.

Each sediment sample was ultrasonically dispersed in distilled water and mounted on 3mm carbon-coated gold grids. Gold grids have been found to be the most suitable as they contribute only a weak Ma peak to the X-ray spectrum which does not interfere with any of the X-ray lines of elements present in silicate minerals (Pooley,1977;Bentley *et al.*,1980). A drop of the suspension was transferred to the support grid using a pipette; the samples were left to evaporate, leaving the particles adhering to the carbon film. To prevent the simultaneous collection of X-ray spectra from different mineral particles care is taken at this early stage to ensure particles prepared in this manner for examination are adequately spaced. All single particle analyses were performed at an accelerating voltage of 60kV, such high voltages ensure adequate excitation of heavier elements whilst obtaining optimum peak to background rates (Pooley,1977). The X-ray counts for the various elements are processed using an Edax 707a multi-channel analyser. Counts are converted to oxide mass percentage data using conversion factors obtained through the analysis of mineral standards. Elements analysed for included the following: Na, Mg, Al, Si, K, Ca and Fe; results obtained do not include water of crystallisation. Approximately 20 readings were taken on a number of quartz particles within each sample; readings were contoured to give an indication of their surface distribution.

Test Results

Role of amorphous material

The presence of Fe and Al compounds is in agreement with earlier material characterisation studies using chemical dissolution methods which confirm Fe, Al and Si as being the most dominant phases.

Their presence as particle coatings supports evidence derived from SEM studies (Yuk-Lin Li,1985;Yong *et al.*,1992) and from the enhancement of X-ray peaks intensities (Yong & Sethi,1977;Hendershot & Carson,1978;Yong *et al.*,1979) following the removal of amorphous material. However most significant to the present study is the realisation that these materials exist on mineral grains recently deposited.

Recent evidence from environmental scanning electron microscopy (ESEM) and low vacuum SEM of these clays in their wet state, has shown the presence of a large proportion of material that is unresolvable by these techniques. These particles are at the lower end of the colloidal subdivision and smaller; one way in which such materials can be formed is by the breaking down of coarser particles into colloidal dimensions. It is not unreasonable to assume, given the relatively small amount of chemical weathering in these recent sediments, that glacial grinding is a credible mechanism for its formation. Although it is thought that typical ice pressures which exist within valley glaciers are in the region of 1.5MPa (Iversen,1990); the collection of such data from field studies is hampered by the inaccessibility of the subglacial environment and relatively few studies have been made. Given a hard rock surface and a contact force distributed over a small surface area Iversen (personal comm.) envisages stresses in the region of 50-100MPa.

Most inorganic colloids are crystalline though as grain size decreases so does the apparent perfection of crystallinity, and probably no sharp boundary exists between imperfectly crystallised minerals and amorphous materials (Mason & Moore,1982). However one defines the lower limit of crystallinity, what is certain is that particles at the lower end of the colloidal size range and below, will have collective properties including high specific surface area and high ion-exchange capacities, which in response to changes in the geochemical environment are capable of influencing initial sediment microstructure. For the purpose of the current investigation the term "amorphous" is used to describe that material which is found to be unresolvable by SEM techniques.

The present study has not set out to show the existence of amorphous silica. Given that silica is the most abundant material in terrestrial rocks and it readily goes into colloidal solution, coupled with the available geochemical evidence, it is likely is that amorphous silica is intimately associated with both Fe and Al, possibly playing host to both through isomorphous substitution.

Although the precise role of amorphous coatings in initial structural development is a matter of conjecture, its early presence as a bonding material will unquestionably reflect in the stability of basic fabric units and ultimately the integrity of the initial soil structure. An increased understanding of the physiochemistry of such a material, specifically its rigidity, water bearing capacity and response to salinity variations is needed. The problem of collapse of sensitive clays is really a structural problem, what holds it together and what causes it to collapse; initially a simple non-plastic contact bond is most likely to give an incompressible structure. The high water content of the glaciomarine sample must be provided by an open structure and in the absence of significant amounts of phyllosilicate minerals such an open porous arrangement is evidence of cross-particle links sufficiently strong to resist initial consolidation.

Amorphous Model

Evidence from the present study along with that of previous investigations and the widely observed properties of sensitive clays has led to the formulation of an "amorphous model" to reasonably explain aspects of their behaviour.

1. Glacial grinding is responsible for the generation of amorphous complexes of Si, Al and Fe that coat sedimenting particles.

2. These complexes in the presence of water develop hydroxylated surfaces. Their surface charge is determined by electrolyte concentration and pH. The point at which the surface is unchanged is known as the zero point of change (ZPC) (Yong et al.,1992). Within mildly alkaline glacial waters these complexes will be above their ZPC and hydroxylated surface layers will develop a net negative charge. Initially contribution of amorphous silica is greatest (mass ratio (MR) is low- where MR = mass of Fe/ mass of Fe + Al + Si), which further increases the negative charge density; water bearing capacity is at a maximum.

3. In the glaciomarine environment amorphous material responds to large change in electrolyte concentration. Complexes adsorb cations and assist particle flocculation.

4. Particles aggregate and intra-aggregate links are sufficiently strong to resist consolidation resulting in open-porous arrangement and high water content.

5. Sediments are uplifted by isostatic rebound

6. Leaching removes Na^+ ions lowering the LL (liquid limit) and leaving sediments sensitive to disturbance, due to repulsion between negatively charged amorphous complexes (low to medium sensitivity).

7. Oxidation of susceptible minerals proceeds in alkaline pore waters releasing polycations of Fe and Al. Increase in MR by isomorphous substitution further lowers LL and PI (plasticity index) is at its lowest point (very high sensitivity). Sediments are more susceptible to disturbance.

The current study has shown an increased of both Fe and Al in sensitive clays, from recent glaciomarine sediments. In a synthesised mixture of amorphous silica and iron in an illitic soil, a critical low value of LL and corresponding PI, was found to result from an initial increase in iron content (Yong *et al.*,1992).The weathering of susceptible minerals is a post-depositional process; it can affect the clay mass deep beneath the modern ground surface. The release of amorphous materials must be driven by environmental changes during the post-depositional period; the dominant post-depositional process is freshwater leaching.

Chemical weathering is a recognised phenomenon in sensitive clays. It produces a stiff, desensitised crust that is generally 2-5 metres thick. It is also recognised that the weathering process liberates amorphous compounds which contribute markedly to the mechanical properties of the weathered crust. A more contentious issue is whether a degree of chemical weathering can take place within the deeper mass of clay beneath crust. The chemical environment of the sensitive clays changes gradually as the leaching process proceeds and the marine pore fluids are replaced by freshwater. Bjerrum (1967) and Moum (1967) have suggested that the replacement of marine pore fluids by freshwater causes a change in the pH and oxidation capacity. Oxidation proceeds more rapidly the more alkaline the solution (Mason & Moore,1982) and numerous studies have shown the pore waters in sensitive clays to be alkaline (Torrance & Pirnat,1984;1984;Lessard & Mitchell,1985). It is possible that these changes to the pore water environment promote chemical weathering of particularly unstable minerals and cause the release of amorphous compounds. Some support for the proposal that environmental changes resulting from freshwater leaching process drive the cementing process is given by Shainberg (1973). He pointed out that little weathering of aluminosilicates can occur until the salinity of the pore water has been reduced to low values. Following a quantitative mineralogical study of sensitive clay from nine sites in eastern Canada, Locat *et al.* (1984) showed that the primary mineral phase hornblende, existed as a source of amorphous iron, even in the clay sized fraction. Elsewhere in eastern Canada, mica, amphiboles and chlorite were shown to be the most likely source of the iron oxides (Torrance *et al.* 1986). Loughnan (1969) describes the decomposition of hornblende as a rapid process that liberates iron, aluminium and manganese oxides. The amorphous nature of these compounds suggests that they are present in an hydrated oxide form; it has long been recognised that amorphous hydrated ferric oxide is particularly common in natural clays (Mackenzie 1957).

8. As weathering proceeds the Fe content (MR) increases further. The plasticity of intra-aggregate amorphous complex increases, leading to increased remoulded strength and reduction in sensitivity.

Hendershot and Carson (1978) found a marked decrease in sediment plasticity, in proportion to the amount of Fe chemically extracted and in a study of a Norwegian clay from Emmerstad (Yuk-Lin Li,1985) finds no relationship between the low amorphous content in this clay and sensitivity. Conversely Champlain Sea clay from Canada show decreased sensitivities in response to higher amorphous contents (Yong *et al.*,1979a). It is possible that when amorphous content is below a certain critical level the sensitivity is independent of the amorphous content.

9. Simultaneously released amorphous Fe complexes precipitate as inter-aggregate cementation between fabric units, increasing the degree of structuration. With time the undisturbed strength increases. The contribution of Fe to remoulded strength is greater than its influence on undisturbed strength, therefore with increasing sediment diagenesis an inverse relationship is established between amorphous material content and sensitivity.

Analysis of particle coatings has shown a correlation between undisturbed strength and Fe content. In the clay from St. Hyacinthe where Fe content has increased to the same levels as Al, the undisturbed strength in this sediment is 30% higher than the clay from Norway where Fe content still lags behind Al. Most significantly where undisturbed strength is highest at 75kPa in the clay from St. Thecle, Fe content is also the highest in the samples analysed.

In the discussion centring around a potential source of cementing agents in Canadian clays Sangrey (1972b) recognised a particular suite of minerals, the most unstable of these being amphiboles and pyroxenes. Sangrey (1972) proposed that as a consequence of the post-depositional conditions that prevailed these minerals would rapidly breakdown to form chlorites, vermiculite and potential cementing compounds such as hydrous and anhydrous oxides of aluminium, iron and manganese. Later studies have also suggested that these phases in amorphous forms are responsible for cementation in Canadian clays (Yong *et al.* 1979b, Quigley 1980).

Evidence in support of a strong degree of structuration is provided by both geochemical and physical studies. Canadian studies have examined the effect of selective extraction of amorphous constituents on geotechnical properties. The study by Loiselle *et al.* (1971) involved milder treatment and the removal of <1% amorphous material; even removal of such small quantities of material had a pronounced effect on the undisturbed properties. Loiselle *et al.* (1971) leached quantities of iron out of samples using EDTA solution and observed marked reductions in undisturbed strength, decreases in apparent preconsolidation pressure and increases in deformation at maximum shear stress. A chemical and mineralogical study of the Toulnustouc River clay identified aluminium and iron hydroxides as the only potential cementing agents present (Quigley 1968).
Few studies of amorphous materials in Scandinavian clays have been performed, probably because the amorphous material was believed to act as a cementing agent, and the engineering characteristics of Scandinavian clays do not reflect cementation in the microstructure to the same degree as Canadian clays. The presence of amorphous material has been detected in Norwegian clays using EDTA solution (Moum 1967; Kenney et al 1967; Loken 1970) and analyses showed the extract to be iron and aluminium compounds.
Although some of the dissolution studies undertaken to-date can be criticised for the use of particularly aggressive reagents, the studies which used mild reagents do indicate that iron and aluminium oxides have a cementing role in Canadian sensitive clays. There is a body of opinion that regards the alumino-silicates as being the parent material for these

oxides. However, it has also been suggested that the iron identified by the dissolution studies is particulate magnetite which is co-sedimented at the time of deposition (Torrance per comm). Whether one or both of these origins is correct is less important than the processes which either liberate the iron and aluminium oxides from their parent minerals and/or cause the redistribution of the iron from the magnetite.

Of the large amount of published soil test data on cemented clays (Sangrey 1972a, Lefebvre and La Rochelle 1974, Yong et al 1979a, Silvestri et al.1989, Quigley et al 1983), some of the earliest is provided by Conlon (1966) in his investigation of clay from Toulnustouc River, Quebec. The cemented nature of this clay was immediately apparent, it would "ring" when struck with a hammer. Strength tests showing initial peak strength at very low strains were interpreted as reflecting the maximum bond strength of the cement. Beyond this initial peak a progressive breakdown of the cementation bonds seemed to occur with increasing strains. During compression tests the clay would withstand the load and then fail suddenly with a rapid reduction in void ratio.

Soil-water potential studies have provided an important understanding in the stability and integrity of microfabric units. In the study of a clay from Emmerstad, Norway (Yuk-Lin Li,1985), the water content at any given soil-water potential was found to be higher for undisturbed samples than for remoulded ones. This can be substantiated by the fact that soil fabric units are stiffly connected by "bridge-bonds", in between which pore water may be retained. For the remoulded sample in which the "bridge-bonds " are destroyed by remoulding, the water is drained from the voids. This degree of unit fabric bonding is also evidenced by the difference in water content between desorption and absorption; for undisturbed samples of varying sensitivity the differential water content response is more pronounced in those samples with higher sensitivities, indicative of a more well-aggregated sample. For remoulded samples with similar sensitivities the response is similar though less pronounced. This suggests that remoulding does not fully destroy the soil fabric units, but only the "bridge-bond" between them. Moreover it is apparent that soil-water potential and soil sensitivity are linearly related in terms of water content.

In a comparative test, undisturbed shear strengths of clays from Saint-Maurice in the Champlain basin were found, by fall-cone testing, to be double those of clays with similar water contents and dry densities from Emmerstad, Norway, at around 60KN (Yuk-Lin Li,1985). For the clay from Saint-Maurice a sudden dramatic fall in volume during the desorption process is indicative of structure collapse, when compared to the gradual variation shown by the Emmerstad clay in a simultaneous test. This structure collapse of the Champlain Sea sample is mirrored by a dramatic fall in water content in response to desorption, further highlighting the contrast between bond strength of the two clays.

This result highlights the contrast between the strongly bonded Canadian clays and the weakly bonded nature of a clay from Norway which is easily broken down at low strain. One of the major differences between Scandinavian and Canadian sensitive clays highlighted is that high strengths in the range 50 to 80 kN/m2 are common in eastern Canada but are not found in Scandinavia. Cementation of the clay microstructure is considered to be an important factor in causing these strength differences. In his review paper, Torrance (1983) stated that, " The amount of cementation varies greatly in Leda clays (of eastern Canada), whereas the Scandinavian quick (sensitive) clays are generally considered to be uncemented. One of the still unanswered questions is why this variation exists".

Typically, Scandinavian sensitive clays have undisturbed strengths in the range 15 to 25 kN/m2. Clays with similar strength values are commonplace in eastern Canada. However, a difference between the deposits in the two countries is that in eastern Canada high strength clays (50 to 80 kN/m2) are also common, whilst in Scandinavia high strength clays are not found. It would be quite wrong to give the impression that high strength Canadian clays are solely a function of cementation. Strengthening of clays by preconsolidation due to former overburden during their geological history is a very common phenomenon in eastern Canada. Whilst many strong clays can be related to geological events and preconsolidation there is convincing soil test data that indicates that the high strength of some Canadian clays is due to cementation of the clay microstructure.

Deglaciation and exposure to leaching

If chemical weathering and cement production are caused by changes to the chemical environment of the pore fluids which accompanies the leaching process, then the factors controlling the rate of cement production would be mineralogy, particularly the content of iron and aluminium bearing minerals which are susceptible to chemical decomposition, permeability, hydraulic gradient, and the magnitude of the changes effected in pH and Eh. Exposure to leaching would be an important factor controlling the duration of the cementing process.

Exposure to leaching is a function of the timing of land emergence and this is governed by deglaciation chronology and topographic relief. Following the initial pioneering work of Gerard De Geer (Lundqvist, 1985), the modern revised clay-varve chronological scale enables the accurate dating of deglaciation. Radiocarbon dating, along with marine and other glacial deposit mapping has been used to date the deglaciation of Scandinavia and eastern Canada. Details of the deglaciation of Scandinavia are provided by Lundqvist (1988) and Andersen (1987) and are reproduced in *Figure 2*. A more detailed history of the deglaciation of south-eastern Norway is proposed by Sorensen (1983). Here the city of Oslo was found to lie between the two prominent Aker and Ski moraine ridges, dated at 9,000 years before present (BP) and 10,000 years BP respectively by radiocarbon dating. The Canadian deglaciation has been studied by many researchers (Prest 1973, Dyke and Prest 1987, Gadd 1988). Lines of ice recession for eastern Canada after Dyke and Prest (1987) are shown in *Figure 3*.

A comparison of the data shows that there are significant differences in the timing of the deglaciation of parts of Scandinavia and eastern Canada. For example, approximately 10,000 years (BP) Oslo was deglaciated; approximately 12,000 years BP Montreal was deglaciated.

Topographic relief is another important consideration. The elevation of the glaciomarine sedimentary basins would vary along each ice recession contour; sediments at higher elevations would emerge from the marine environment before sediments at lower elevations. However, the differences in elevations of the glaciomarine sedimentary basins along a contour would be small in the context of the total amount of isostatic rebound.

So whilst acknowledging that topographic relief within the sedimentary basins had some controlling influence, it is considered that deglaciation chronology had primary control over the emergence of these marine sediments.

Discussion

An hypothesis has been developed which proposes that the occurrence of high strength (50-80 kN/m2) sensitive glaciomarine clays in eastern Canada and their absence in Scandinavia is related to a difference in their respective exposure to post-depositional processes which promote cementation of the clay fabric. Within this proposal, it is recognised that the degree of cementation in Canadian clays varies widely and that weak as well as high strength clays are commonplace.

The key factor in the proposed hypothesis is that liberation of cementing compounds is triggered by environmental changes which accompany freshwater leaching. In the upper 2-5 m of exposed sensitive clay, chemical weathering and cement production are recognised phenomena but there is not overwhelming evidence that similar processes operate deep within the clay mass. Compounds which represent the end-products of chemical decomposition have been identified in geochemical studies but because of the perceived inadequacies of the analytical techniques used in the past some scepticism remains about the validity of this research as evidence of cementation and chemical weathering.

The degree of cementation exhibited by sensitive clays is a function of both the rate and the duration of the cementing process. In the proposed hypothesis the rate of cementation is influenced by such factors as mineralogy, permeability, hydraulic gradient and climate. These and other factors will vary locally within a sequence as well as regionally, and their variation goes some way to explaining the large differences in the degree of cementation in Canadian clays. In the same way, it could be argued that the lack of cementation in Scandinavian clays is related to variations in these same factors. This argument requires one or more of the factors to be quite different from their Canadian counterparts. For example, a lack of cementation in Scandinavian clays would be understandable if they contained no minerals which were potential parent material for cementing compounds, or, if their permeability's were markedly less than their Canadian counterparts. More significantly, this argument would require a lack of natural variation in mineralogy and permeability of Scandinavian clays.

Many factors influence the local variation in the degree of cementation in sensitive glaciomarine clays but a dominant regional factor must be the duration over which the post-depositional processes have been active. Where significant differences in the timing of land emergence exist between parts of Scandinavia and eastern Canada, this must have a primary influence over the degree of cementation exhibited by sensitive glaciomarine clays of the two countries.

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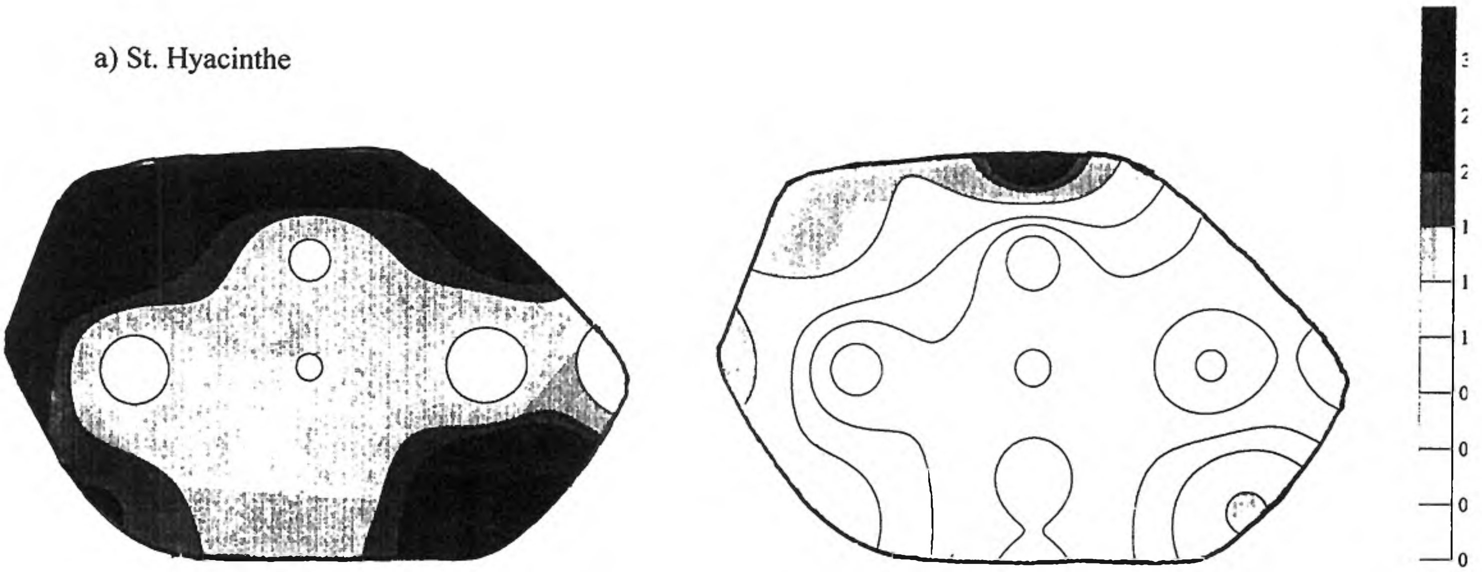
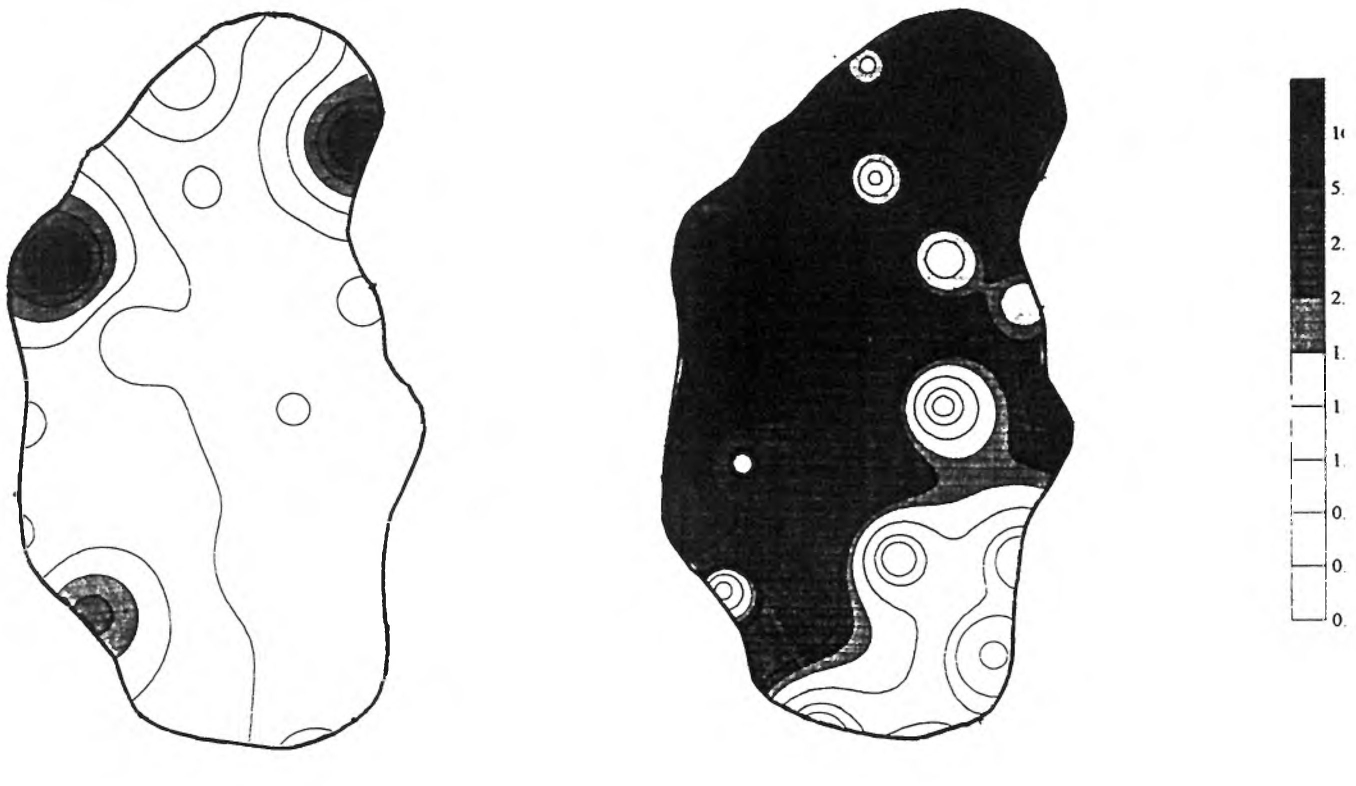
Figure 1. EDAX analysis of quartz grains showing distribution of
(i) Al and (ii) Fe

(i) (ii)

a) St. Hyacinthe

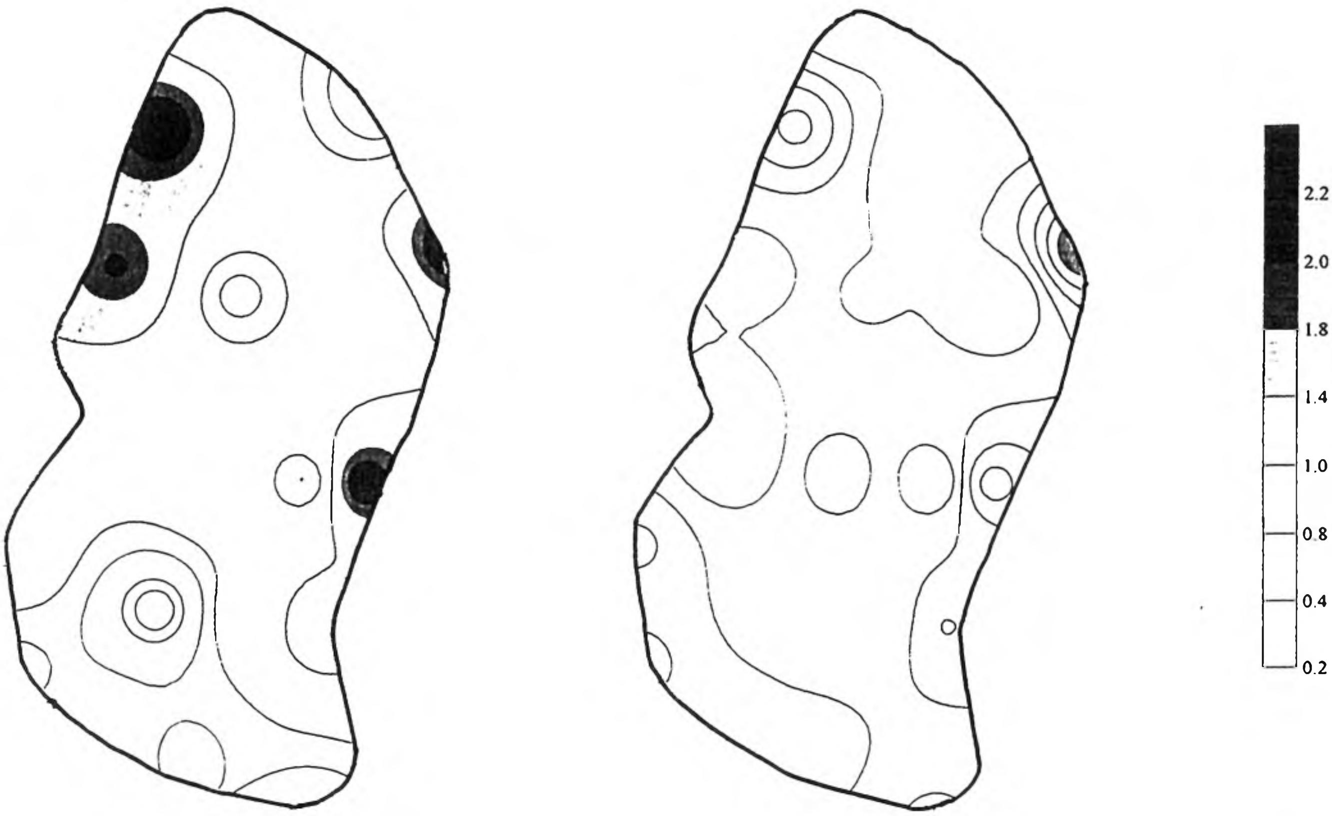


b) St Thecle

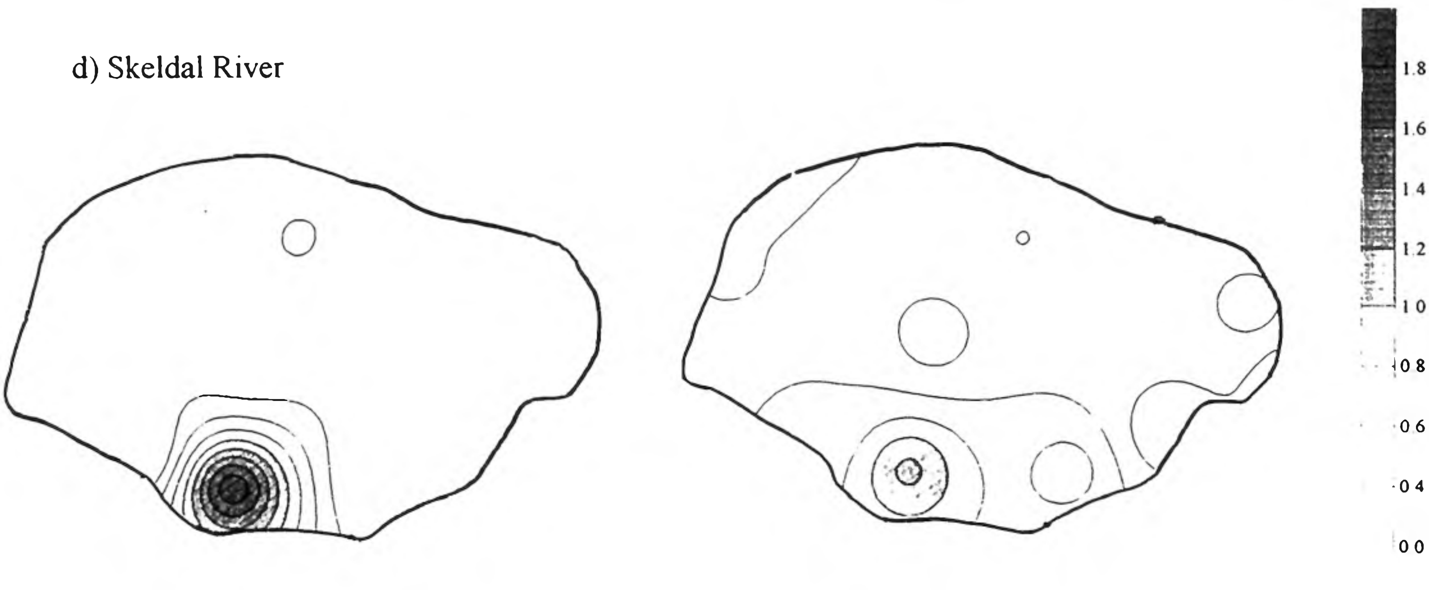


(i) (ii)

c) Overhalla



d) Skeldal River



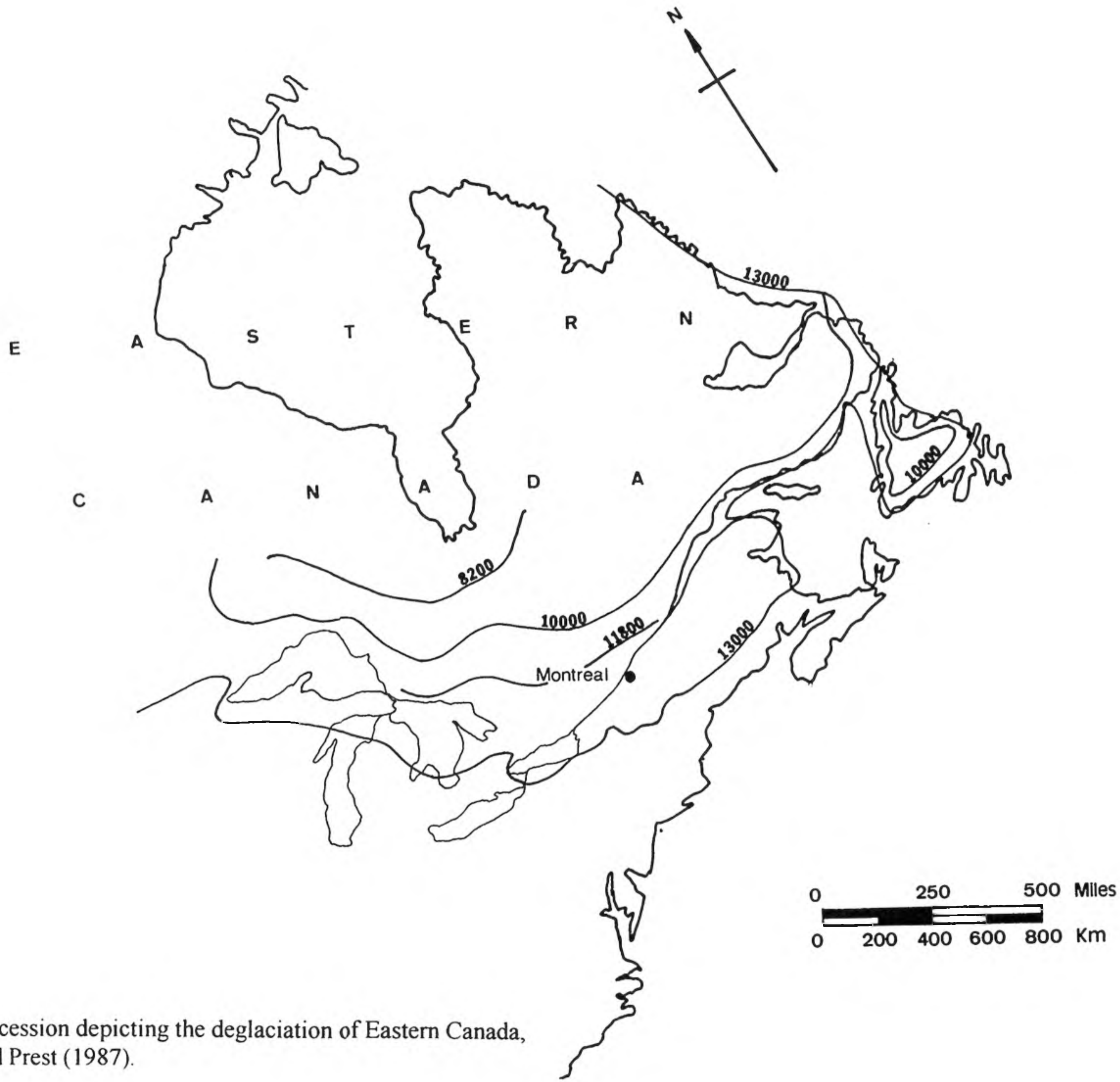


Figure 2. Lines of ice recession depicting the deglaciation of Eastern Canada, after Dyke and Prest (1987).

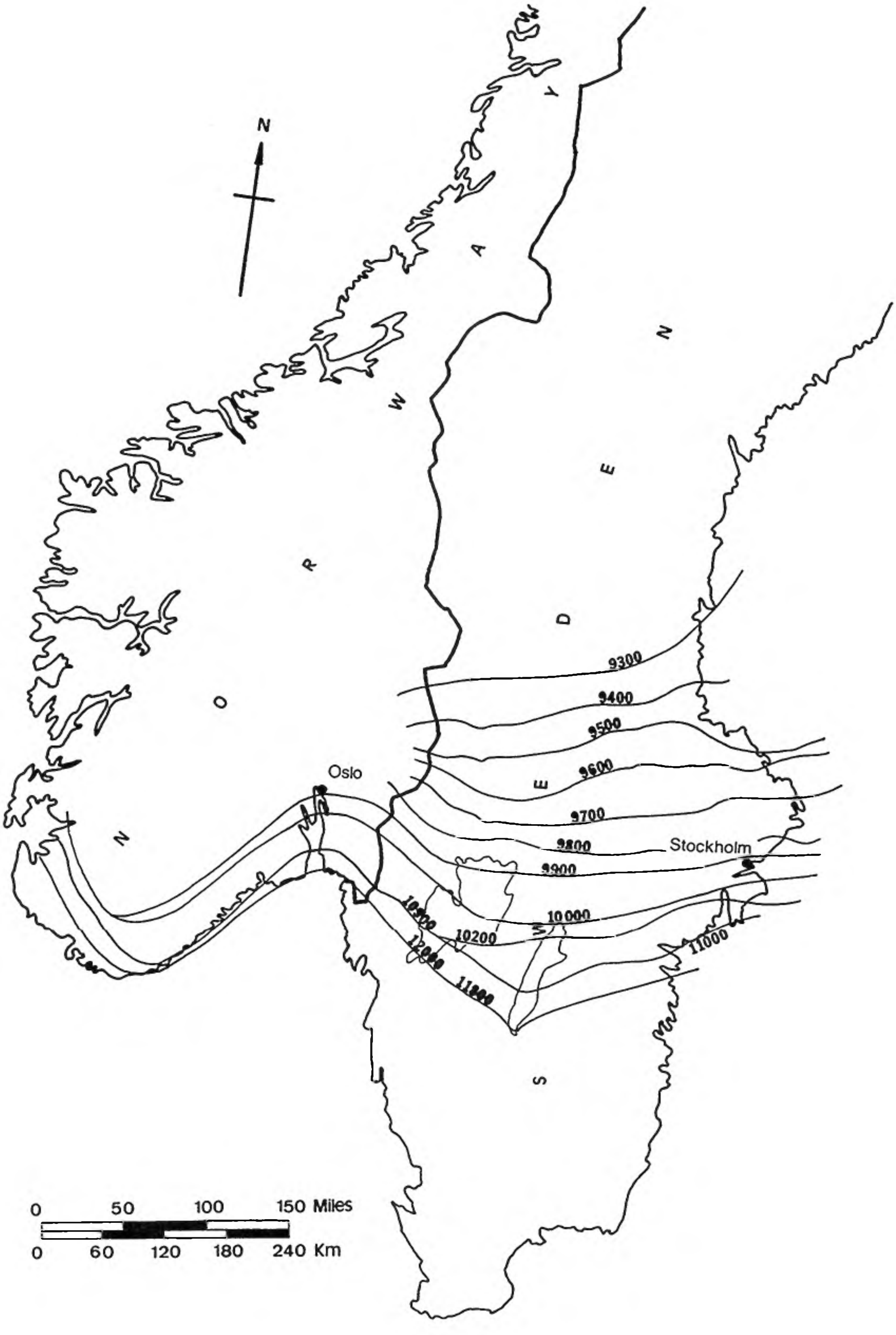


Figure 3. Lines of ice recession depicting the deglaciation of Southern Scandinavia, after Lundqvist (1986).

PROJECT 2

MONITORING THE VARIATION OF SOIL PORE WATER PRESSURE WITH TEMPERATURE IN THAWING SLOPES

Seasonal thawing of ice-rich frozen ground leads to rapid rates of mass movement in the permafrost zone. Future climatic warming, associated with enhanced active-layer thaw, is likely to have a major impact on high latitude slope stability where currently the ground does not thaw sufficiently to cause major down slope movements. Periglacial slopes formed in non-cohesive soils are characterised by annual thaw-induced active layer displacements (known as gelifluction) in which saturated flow is the dominant mechanism. Where slopes are formed in cohesive clays, however it has been argued that thawing is more likely to trigger shallow planar landslides with the plane of failure lying immediately above the permafrost layer.

An important factor in the initiation of landslides in such regions is the development of pore pressures in the soil. As the soil forming the slope warms up the surface, the frozen layer migrates downward and the pressure of the water in the soil pores (the "pore water pressure") increases. the result of this is a decrease in the shear strength of the soil resulting in large down slope movements and in the extreme failure of the soil and, thus, a landslide.

A probe developed within the School of Engineering monitors temporal variation in both temperature and pore water pressure. It consists of a pressure transducer in a steel housing with a porous membrane allowing for the penetration of water; temperature sensors are also located in the same steel casing.

During the expedition the probe was inserted in to an appropriate slope on the Skeldal Delta. The probe was augered to a depth of 85cm in a sandy clay soil and readings automatically recorded for the duration of the trip. Unfortunately the probe failed to provide the necessary data set required. Although this failure was originally attributed to damage of the pressure transducer, it became evident that this was not the case. It was the view of the team that the design of the equipment was fundamentally flawed; housed in the current steel casing the transducer was not sensitive to minute changes in pore water pressure.

Upon return recommendations were made to the researchers actively involved in this project which led ultimately to the design of a new product which is currently undergoing field trials in the Canadian Arctic region. It was hoped that the results obtained will provide an important data set, which together with the results from laboratory studies, will help to define mechanisms in periglacial slopes and lead to the quantitative predictions of slope stability in permafrost zones.

for more details contact:
Dr C. Harris, Department of Earth Sciences, University of Wales College of Cardiff
Dr M.C.R. Davies, School of Engineering, University of Wales College of Cardiff

PROJECT 3

EXAMINATION OF ATMOSPHERIC AIRBORNE PARTICULATE MATERIAL TRAPPED IN THE SNOW

Until about the 1960's pollutants were generally regarded as problematic when in the immediate vicinity of emission sources or in urban areas. The subsequent realisation that all air pollutants emitted by point and distributed sources are transported, dispersed, or concentrated by meteorological and topographical conditions has highlighted the fact that pollution problems can and have become global in extent.

The Arctic region occupies an essential position in the atmospheric circulation system that dominates the northern hemisphere. It is assumed that atmospheric dust particles become trapped in the snow during snowfall. During the expedition samples of recent snow from the head of the Bersaerkerbrae glacier were collected, melted and filtered onto 0.4um millipore filters; any particulate material becoming deposited on the filter paper.

Use is being made of analytical transmission electron microscopy in order to examine the mineralogical and elemental composition of the atmospheric dust. The results are forming part of a long term project which hopes to provide information on the general level of background airborne particulates worldwide for comparison with urban data.

for more details contact:
Prof. F. Pooley, Department Materials & Minerals, School of Engineering, University of Wales College of Cardiff.

SPONSORSHIP AND ACKNOWLEDGEMENTS

Sponsorship

It is probably safe to say that almost all expeditions, especially those that are primarily scientific based, rely upon the generous donations of sponsors in all forms whether they be large corporations underwriting the whole expedition or a local sponsor who just wants to help a local concern. To all those sponsors we owe a debt of thanks. I would like to thank the following:

Sponsorship has been provided via donations of money and donations 'in kind'.

Charitable Trusts/ Corporate Sponsors

Albert Reckitt Charitable Trust
BMC
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Gino Watkins Memorial Fund
Mount Everest Foundation
Nigel Vinson
Royal Geographical Society
Scouloudi Foundation (previously Twenty Seven Foundation)
The Captain Scott Society
Rev DJ Streeter Charitable Settlememt
The Royal Society of St George
Duke of Edinburgh Trust No. 2
Foundation For Sport & The Arts

Corporate Sponsorship

Barclays Bank, Cardiff
Giovanni Restaurant
Brynawel Garden Centre
Armstrong & Millington Opticians

Personal Donations

Ian Ford (Greenland Club member)
Peter Adams (Greenland Club member)

Food Sponsorship

We would like to thank the following for their generous donations which kept the team well fed and in good spirits:

Bachelors Foods	for Beanfeast dehydrated meals
Cadbury Ltd	for Dairy Milk & Galaxy chocolate bars
Cookie Coach Company	for flapjacks
Framptons Ltd	for dried eggs
Granovita UK Ltd	for Vegetarian Pate
McVities	for biscuit snacks
Morning Foods Ltd	for porridge oats
Tate & Lyle	for sugar & golden syrup
Tescos Supermarket	voucher
Tilda Rice Ltd	for Basmati rice
Van den Bergh Foods Ltd	for Flora margarine

Many thanks also to the following for offers which were not taken up:

Healthy life biscuits

Kraft General Foods

Thanks to the following for their help with food sponsorship:

Alison Dermont

Richard Collin

P Allison

Colin Ritton

John Grieveson

Kate McCarthy

Wendy Cox

Equipment Sponsorship

Chefaro Proprieties Ltd	for Jungle Juice Mosquito repellent
Sea Marshall	for Personal Locator Beacon
Simpla Plastics	for packing boxes & wrapping material
RAB Down Clothing	
Taunton Leisure, Swansea	

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Dr. Lynne Moore
Pam Harries
Prof. Brian Richardson
Debra Evans
Tom Saunders
Mike Peckham
Phil Bartlett
Greenland Club
Lorraine Craig
Mike Banks
Leslie Gunter, Al Rouse Library

EXPEDITION BROCHURE

THE TEAM

Dr. Gary Timms (27),
a research associate in the School of Engineering, has considerable mountaineering experience, including an ascent of Mt. McKinley in Alaska, 1993. He is an active member of the Bridgend Mountain Rescue Team.

Jonathan Rowe (24),
a postgraduate student in the Department of Physiology, and an experienced mountaineer, knows the Staunings Alps from an expedition he led there in 1990. He is a former member of the Dartmoor Mountain Rescue Group.

Andrew Gillett (28),
is a Cardiff Law Graduate and practising solicitor. He led the successful expedition to Alaska in 1993, where he climbed Mt. McKinley with Dr. Timms. He is also a member of the Bridgend Mountain Rescue Team.

David Crease (27)
has been a member of the Bridgend Mountain Rescue Team for ten years and a rescue party leader for the past five years. He is an experienced radio operator and first-aider.

Matthew Roberts (31)
is a Project Officer for the Lliw Valley Countryside Access Project. He has mountaineering experience in the French Alps and Kenya and is a member of the Bridgend Mountain Rescue Team.

James Rowe (23)
is a final year medical student and will be a qualified doctor by the time the expedition leaves for Greenland. He was a member of the aforementioned expedition to Greenland 1990.

THE BUDGET

Transport to Iceland	1700
Chartered flight to Greenland	6800
Freight Charges	500
Insurance	1000
Food and Equipment	1100
Administration	900
Contingency	1200
TOTAL	**£13,200**

EACH MEMBER of the expedition will personally contribute £1000 to the cost of the expedition. The additional £7200 is to be raised from grant awarding organisations and by securing sponsorship, both financial and in kind. We believe that the objectives of this expedition are worthy of your support, and in order for the expedition to succeed, the expedition needs your help.

The expedition is expected to receive considerable publicity in the media as well as the University Press, and we believe that your organisation will benefit from it's association with the University. The expedition will be followed by a series of public lectures and articles, and the publication of an expedition report in which all sponsors will be acknowledged. In addition, we may be able to offer sponsors a unique opportunity for publicity by providing you with pictures of your product or logo in the spectacular arctic and mountain scenery of the Staunings Alps.

If you would like to know more about the expedition, or what we may be able to offer you in return for your sponsorship, please contact us at the following address:

Cardiff University Greenland Expedition '94
Division of Materials and Minerals
University of Wales College of Cardiff
PO Box 925, Cardiff CF2 1YF
Tel: (0222) 874000 ext 5761 Fax: (0222) 874292

Cardiff University

1994 GREENLAND EXPEDITION

CARDIFF

Greenland Expedition '94

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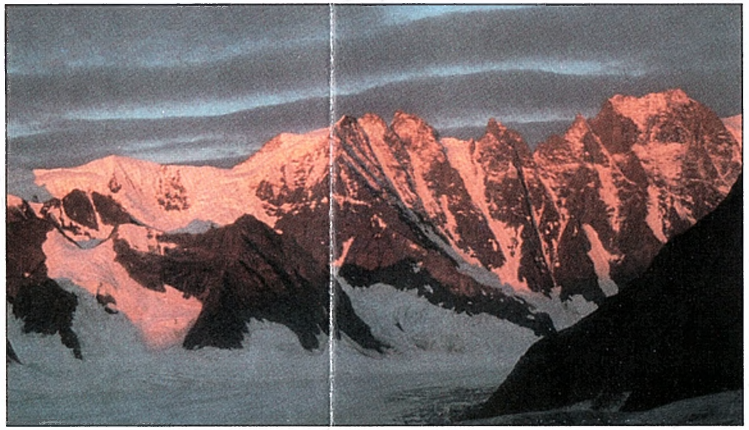
Dr. Brian Smith, MA DSc FRSC CChem
University Principal

Chris Bonington CBE
Mountaineer

THE SIX MEMBERS of the Cardiff University Greenland Expedition '94 will fly to the remote Staunings Alps of North East Greenland in July 1994. The principle objectives of the six week expedition are to explore and make first ascents of a number of routes and summits, including the formidable, unclimbed North Face of the Bersaerkertinde. Following in the great tradition of British exploration the team will also conduct scientific experiments to measure atmospheric pollution in an arctic environment and collect data to further the understanding of the behaviour of glacial materials.

ARCTIC GREENLAND is one of the few regions of the world which has resisted man's attempts to exploit the world's natural resources. This challenging environment has attracted some of the greatest explorers including Wally Herbert and Chris Bonington, a patron of the expedition.

THE STAUNINGS ALPS lie some 350 miles north of the Arctic Circle on the east coast of Greenland. The inaccessibility of these parts prevents frequent visits and consequently, many of the mountains are still unclimbed. Many new routes await the attentions of the adventurous mountaineer.



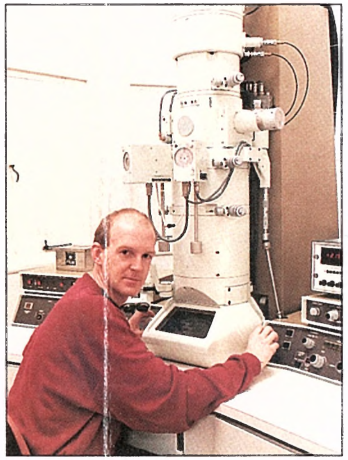
ON ARRIVAL in Greenland it will take approximately six days to trek in to the Bersaerkerbrae glacier in the heart of the Staunings Alps where Base Camp will be established.

THE EXPEDITION has three scientific aims:-

- In order to investigate airborne particulate pollution, we will collect samples of snow, which will be microfiltered in the field. The filtrates, consisting of airborne particulates which have been trapped in the snowfall, will be analysed by electron microscopy back in Britain. The information will be an important addition to the current knowledge of global airborne particulate pollution.

- We will use a probe developed in the University to measure changes in temperature and pore water pressure in periglacial slopes during thawing and freezing. This data will be invaluable to the research group currently developing methods of predicting slope stability in arctic regions.

- Clays formed 10-15,000 years ago in the glacial environment that existed at the end of the last Ice Age, are highly prone to flowsliding. There is a need to examine these clay-sized particles from close to their site of origin to give a proper understanding of their properties. Samples of these "sensitive" clays will be collected and returned to Cardiff University for analysis.



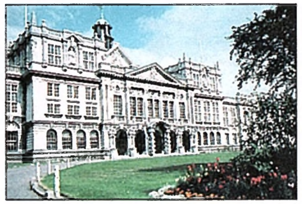
CARDIFF'S UNIVERSITY is one of Britain's major centres of higher education, with a history of service and achievement dating back more than a century.

Staff and students combine to total some 15,000 people, representing a large, vibrant and valued academic community within the city.

Cardiff's broad span of academic provision, capital city status and other attractions assist in attracting students from throughout Britain and from more than 60 overseas countries. Students at Cardiff study a wide range of subjects in the physical and human sciences, humanities and social sciences.

The University makes strenuous efforts to ensure that its expertise and facilities are available to and used by industrial and commercial partners, government bodies and other organisations.

There is a commercial / industrial office dedicated to assisting business and industry work with relevant departments and researchers. Research and consultancy involves work with hundreds of companies from small and local to the large and international.



FINANCIAL STATEMENT

Expenditure

	£
Travel to London	150
Travel to Iceland	1200
Travel in Iceland	500
Iceland Expenses	150
Travel to Greenland	6000
Freight Costs	1400
Insurance	1100
Administration	400
Food	500
Equipment	500
Miscellaneous	200
Final Report	200
TOTAL	12300

Income

Sponsorship and grants	6000
Personal Contributions (6 x £1050)	6300
TOTAL	12300