

THE EXONIAN VATNAJOKULL EXPEDITION



(*35): 91(08)
[1992]

Grænalón, Iceland. 1992

shelf (X35):91(08)[1992]

THE EXONIAN
VATNAJÖKULL
EXPEDITION

ICELAND 1992

(Grænalón, South West Vatnajökull)

Final Report



PREFACE

The Exonian Vatnajökull Expedition was organised between November 1991 and June 1992. It took place for 7 weeks during July and August of 1992.

The style of the expedition was small and light. It consisted of 5 members, all 19 years old.

The objectives of the expedition were: To set up a base camp in a remote and seldom visited part of Iceland; to carry out scientific research; and also do some mountaineering and Nordic skiing if the area turned out to be suitable.

The site of the expedition was chosen to be Grænalón, in the south west corner of the Vatnajökull Icecap. This was a remote ice-dammed lake. The nearest access and point of communication was 24km away on foot. This meant the site had never been visited for any period of time before. It was ideal for our scientific objectives. The mountaineering objectives were also well represented. The active volcano of Grimstövn lay 40km away in the centre of the Vatnajökull itself. Oræfajökull, the highest mountain in Iceland, stood 50km to the east.

I would like this opportunity to thank all those that helped in the organisation, funding, and running of this expedition. Without your support none of the achievements would have been possible.

This report has been written firstly as a way of recording the expedition, but also as a way of thanking those who helped us, and hopefully giving them an indication of what we achieved. Finally, it is hoped that other groups wishing to go to Iceland to carry out similar work will find this report useful.

People often ask me why we think we can ask charities and companies to fund our 'expedition' but not their 'holiday'? Well I hope that those who read this report will see the difference between an expedition and a holiday. Expeditions have a clear set of original objectives. To achieve these objectives will inevitably involve hardships, and in parts make life uncomfortable and unpleasant. Being rained into a tiny two man tent, when you haven't washed for 5 weeks; the constant desire for fresh and convenience food; seven days of solidly carrying 75lb loads over a volcanic and glacial landscape; pulling a friend who has gone blind off an Icecap for 36 hours non-stop is certainly not something I would choose to do on a holiday! Having said all that, no-one regrets any of the expedition, because the sense of achievement, and knowledge in your own mental and physical limits gained from such experiences. We also produced original scientific results, which will be published in the relevant Icelandic Journals in the fullness of time.

The total cost of the expedition came to around £3800. This is remarkably low for a 5-man, 7 week arctic expedition. Keeping the budget low was something everyone was continually striving for. Not only does it then cost the individuals less, but if someone gave us money, we could honestly assure them that it was all going on the expedition. The low budget was achieved by using minimum sophistication. We didn't hire a vehicle, two-way radio, or buy excessive amounts of new equipment; and we didn't have 'meals out' (or similar) on the expedition's expenses.

I would like to once again thank all those who helped with this extremely successful expedition.

CONTENTS

Preface.....	2
--------------	---

GENERAL REPORTS:

Logistics & Administrative Report.....	4
Financial Report.....	7
Walk-in Report.....	9

SCIENTIFIC REPORT:

Science leader's Report.....	12
Hydrology Report.....	20
Geological Report.....	33
Mapping Report.....	49
Meteorological Report.....	53

ADVENTUROUS REPORT:

Grimstovn & Kerlinga.....	55
Nibba.....	65

APPENDICES:

Equipment Report.....	67
The Team.....	71
Menus.....	72
Useful Addresses.....	73

LOGISTICS & ADMINISTRATIVE REPORT

PERMISSION

We found that expedition permits were split into "research" and "fieldwork" permits. We applied for a research permit to The Icelandic National Institute. It transpired that we did not need a permit, and never received one.

This turned out alright, only we had to do a lot of explaining to Customs Officials, and to obtain aerial photographs. I recommend to a future expedition, that you push the authorities for a permit, even if you are told that it is not necessary.

A Visa is not required for a British Citizen to travel to Iceland for 7 weeks.

We were advised to get permission from the farmer at Nupssadur to go to Grænalón. He never replied to our letter. The nearest enclosed pastures were 5km west of where we were dropped off by the bus. The land we travelled across was true wilderness, and permission was not necessary (or probably possible).

TRAVEL

Icelandair has a monopoly on flights to Iceland, and they were unable to discount our fares beyond prices we obtained through STA. We flew from London Heathrow to Keyflavik. Bus transfer from Keyflavik to Reykjavik cost 240kr. Once in Reykjavik, we were fortunate enough to stay at a friend's house, and he generously drove us around the city to sort out our equipment.

To a future expedition, I would recommend hostel accommodation. Dick Philips, or Tony Escritt would be able to update you on what is available. I would also recommend hiring a vehicle for a day. While Reykjavik has only 140 000 people, it is spread over many miles.

Our journey to the start of the load carry was by public bus. This departs from the Long Distance Bus Terminal at 0800 daily. The cost of a single ticket was 2300kr. We arrived on the Sula road bridge at 1430. The bus will stop anywhere on request.

FREIGHT

We initially approached MGH Shipping. They were very sluggish in their replies, so eventually we used a small company called Expedition Freight Ltd. They were sympathetic to our needs. The freight was taken to Custodia in London, three weeks before we flew to Iceland. Custodia are handling agents for the Icelandic shipping company - Samskip.

Our freight arrived in plenty of time.

My only complaint is that the initial quote of £190 turned into £353. This was partly due to an under estimation of the volume of equipment we would be shipping, but the error certainly didn't warrant a near doubling of the price.

A future expedition might try approaching Samskip directly.

There are a number of truck companies in Iceland, which will transport road freight. This is much cheaper than taking excess baggage on the buses. It cost us 2500kr to take 300kg out to Nupssadur.

The buses have no formal weight limit, although it would be pushing your luck with more than one large sack and skis. I was informed the bus will take freight, in their own time, at a charge of about 100kr per kilo.

INSURANCE

We tried a number of companies. The only two worth getting quotes from in my view are BMC and West Mercia. We chose West Mercia. It is well worth writing exactly what you want from your insurance, and not using their limited application form.

We were covered for "Camping, Scrambling, Rambling, and General Mountaineering", with special cover to include; "Ski Mountaineering and Off Piste Skiing". We also had a certificate for a single mountain rescue of value up to £15 000. This proved adequate for our needs.

My only complaint is that there was no cover for photographic equipment, or money if not stolen from the person.

MAPS

Nowhere else in the world has as good maps as Britain.

Iceland is covered to a 1:100 000 scale, and to 1:50 000 in certain popular areas. Maps can be obtained in the UK from Stanford's in London, or from Dick Philips (who is cheaper). The 1:100 000 are generally correct, but lack some important detail, and are often old. I recommend a visit to Orkastofun and Landmaelinger on arrival in Reykjavik. We were able to find a new 1:50 000 map of Grænalón at Orkastofun. This was of much improved quality.

If you know one area will be worked in regularly, then I recommend the maps are cut up and laminated in stiff plastic. They are then almost indestructible.

AERIAL PHOTOGRAPHS

I recommend that any trip to Iceland studies aerial photographs of the area it is going to prior to arrival. These are so much more useful than pouring over maps.

In the UK, Tim Masters is the contact for aerial photographs. However, you need a research permit to obtain any.

In Iceland, Orkastofun hold all the photographs. Again, a research permit is needed to obtain photographs, and they can take several weeks to copy. They cost about £12.00 each (1992).

We found photographs of Grænalón invaluable, as maps were of insufficient scale to pin-point our position.

EMERGENCIES

Communications in Iceland seem to rely on radio telephones. For a large party, hiring a mobile phone may be worthwhile, providing a reliable power supply can be obtained. We looked into the possibility of a two way radio, but decided the amount of red tape, training, weight, and cost to be prohibitive.

We did take an Emergency Beacon. This was hired from the Icelandic National Lifesaving Society for 3000kr. It provided us with a safety net if all else failed. There is a view in Iceland, that if you consider yourself competent enough to

venture into the Vatnajokull, you should be able to carry out self-rescue if anything goes wrong.

We were eight hours from a telephone at base-camp, and this was the primary plan should anything go wrong.

FUELS

The import of fuel into Iceland is neither necessary, nor practical. The only unobtainable fuel in Iceland is Meths. There exists an alternative called Rodspirits, but this is expensive. Importing Meths for any use is banned.

We used paraffin left over from a previous large expedition. We found it was very sooty, and we needed to clean the stoves every day. I recommend petrol to a future expedition, but be careful!

TIMINGS

We arrived in Reykjavik at 2330 on the 21st July. We spent the following morning with a friend sorting out equipment, and the afternoon on foot in Reykjavik. Due to Jon's immense help, we were able to leave on the morning of the 23rd July.

A single day in Reykjavik without "local knowledge" is not enough, so I recommend two days, one of which is with a vehicle.

We returned to Reykjavik late on the 3rd September. The 4th was spent doing expedition business, and the 5th on sight seeing. Beware, shops, Museums and Institutes are often closed on Saturdays and Sundays.

We flew out on the 6th September.

Stephen Fisher

FINANCIAL REPORT

As with any expedition, it would not have been possible without the generous support of numerous charities, trusts, and companies. No amount of hard work by any member of the expedition can make it a success, without the financial support.

I would like to express our deepest thanks to all those who contributed to this expedition, both those listed below, and those not listed whose support was equally appreciated.

EXPEDITION INCOME:

Lady Rayner	£ 25.00
The Godington Charitable Trust	£ 250.00
R Page & Sons	£ 25.00
The Cole Foundation	£ 150.00
Wexas International	£ 500.00
Heriz Studios	£ 30.00
The Gino Watkins Memorial Fund	£ 1000.00
Aspley's	£ 10.00
The Devon Cambridge Society	£ 100.00
Anonymous	£ 50.00
The Old Exonain Club	£ 200.00
CoScan Travel Awards	£ 150.00
The Donald Robertson Memorial Fund	£ 60.00
Pembroke College Travel Fund	£ 250.00
The Forde Park Educational Trust	£ 75.00
Claude & Mary Pike Charity	£ 150.00
Sir Gordon Higginson	£ 200.00
John Dinham's Charity	£ 50.00
Personal Contributions	£ 600.00
Post Expedition Equipment Sales	£ 113.60
TOTAL INCOME	£ 3988.60

EXPEDITION EXPENDITURE:

International flights	£ 1257.50	(33%)
Insurance	£ 340.00	(9%)
Sea Freight	£ 353.00	(9%)
Other freight charges	£ 67.00	(2%)
Icelandic Travel	£ 283.00	(8%)
Food	£ 672.00	(18%)
Administration	£ 156.00	(4%)
Equipment	£ 665.00	(17%)
TOTAL EXPENDITURE	£ 3793.50	

The total cost of the expedition per man day was £15.81

The balance in the expedition account will have been used to produce this report, and pay for other post expedition expenses.

We would also like to thank the following, whose help was just as important as financial support, in advising us and helping the expedition run smoothly;

Isca Bags
Jon and Frigi Ikasson
Richard Crabtree
Steve Harris
David Roberts
Dr Martin Sharp
Dr Jane Hart
Helgi Bjornsson
Dick Philips
Tony Escritt

Stephen Fisher

WALK-IN REPORT

The original plan was to walk in on the east side of the river Sula, near Nupssadur, to the snout of the Skeidararjokull. Then, depending on the condition of the glacier, either walk up the side of the glacier to Grænalón, or walk up the watershed to the glacier's west, over Eggjar to the lake.

We studied aerial photographs of Skeidararjokull east of Grænalón, and of its snout, and concluded that it was unviable to walk on the glacier due to heavy crevassing. This may have been a result of the glacier surging last summer (1991). This was all the information we obtained before we set out from Reykjavik.

After a brief ground reconnaissance on the 23rd July, we concluded it would be better to walk up the west side of the river Sula, crossing one glacial outwash river, before reaching the top of the Sandur.

This proved to be the easiest route, although the map of the river course proved to be considerably different from what we actually found. The river marked as flowing west from the SW tip of the Skeidararjokull, was not present for the walk-in, however there was a considerable torrent on the walk-out. The river flowing from the top of the Sandur did not disappear under gravels as was implicated on the map, but left the flanks of Lomagnupur to join Sula near the road bridge.

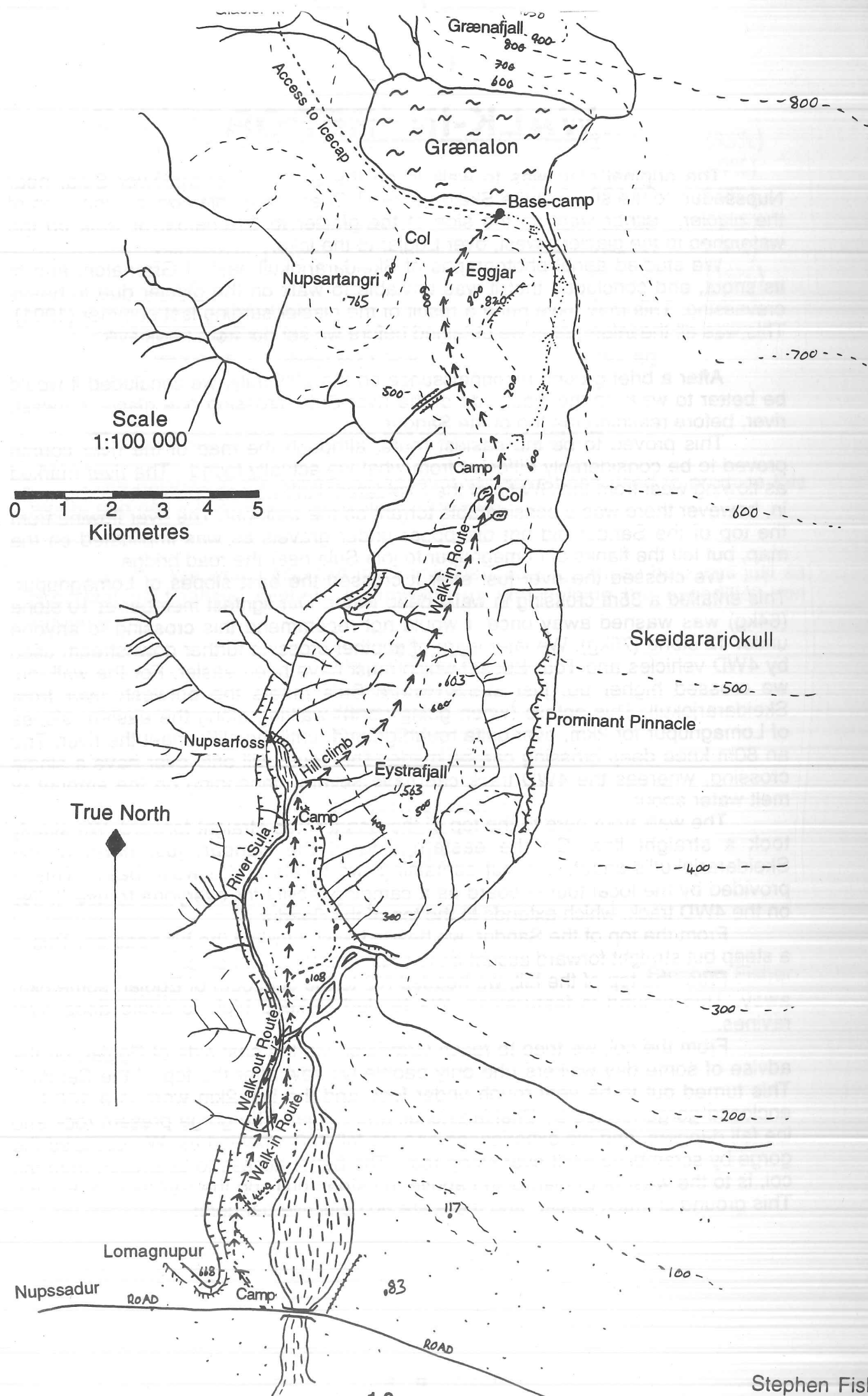
We crossed the river just after it crossed the east slopes of Lomagnupur. This entailed a 35m crossing in waist deep water. Our lightest member at 10 stone (64kg) was washed away once. I would not recommend this crossing to anyone under 12 stone (75kg). We later learn of another crossing further downstream used by 4WD vehicles and Tour Buses, which must have been easier. For the walk-out we crossed higher up, just above where Sula meets the outwash river from Skeidararjokull. This entails (when going north) walking along the eastern slopes of Lomagnupur for 2km, over quite rough ground, until the cliffs meet the river. The an 80m knee deep crossing can be made. This route will only ever have a single crossing, whereas the 4WD track can have several depending on the amount of melt water about.

The walk from here to the top of the Sandur was straight forward. We simply took a straight line. On the eastern side of the Sandur, just north of the Skeidararjokull's snout, is a hut containing two toilets and a wash basin. This is provided by the local tourist board as a camping facility for everyone to use. It lies on the 4WD track, which extends to the top of the Sandur.

From the top of the Sandur, we headed east, tackling the hill head on. This is a steep but straight forward ascent if the route is picked with care.

From the top of the hill, we headed NE to the col south of Eggjar, some 8km away. This ground is featureless. We tended to keep high to avoid deep river ravines.

From the col, we tried to reach Grænalón via the east side of Eggjar, on the advice of some day walkers (the only people we saw after the top of the Sandur). This turned out to be very rough under foot, and the last 2km were in a 100 foot enclosed gorge formed by Skeidararjokull and Eggjar. The gorge present rock and ice fall dangers, and we experienced one ice fall 400m behind us. We escaped the gorge by scrambling west over steep rock. The better access to Grænalón from the col, is to the west of Eggjar, going above the steep gully on the SW flank of Eggjar. This ground is much easier, and there are no objective dangers!



Our equipment was divided into three loads each. Essentially, two were food, fuel and science kit, and one was personal kit, tents, and mountaineering equipment.

The food had been pre-packed into boxes of weight 60-70lb (30kg), but on arrival it was decided to pack the food straight into sacks, for comfort's sake, and not strap the boxes onto empty sacks as originally planned.

The different route also caused a change of plan. Originally a six day walk-in was planned, split up to fit the obstacles of the route. From the road we saw that it was possible to do a five day walk-in, with our new route. We kept to schedule on the first and second days, but at 11 hours long we had to reduce the distance on the third day. Forty hours of rain during the fourth and fifth days also slowed our progress, and eventually it took seven days to set up our base camp at Grænalón, with all our food and equipment.

To any future expedition, I recommend 4WD access to the top of the Sandur. We were unable to do this because we were all too young to hire a vehicle in Iceland (you need to be 20), even if we had been aware such access was possible.

Assuming a load carry starting at the top of the Sandur, follow the route suggested above. Only a very fit party would be able to make Grænalón and back with 70lbs for more than a day or two. I would suggest that the hill climb is carried out before going for the lake, to make the load carrying easier.

The use of 4WD vehicles to eliminate the walk across the Sandur, makes Grænalón an attractive site for small expeditions, as 6 weeks supplies can be carried in in 3 days.

We set up our base-camp at the SE corner of the lake, near two streams draining off the north slopes of Eggjar.

Care must be taken to ensure that any camp is on firm ground, as the gravels, which constitute most of the flat ground in the area, become very boggy, and even submerged, during prolonged rain.

SCIENTIFIC FIELDWORK AND RESEARCH.

SCIENTIFIC LEADER'S REPORT.

CONTENTS.

Introduction: Graenalon.
The development of the research programme.
Permits.
Air photographs.
Scientific equipment.
Arrival in Iceland.
Acknowledgments.
References.

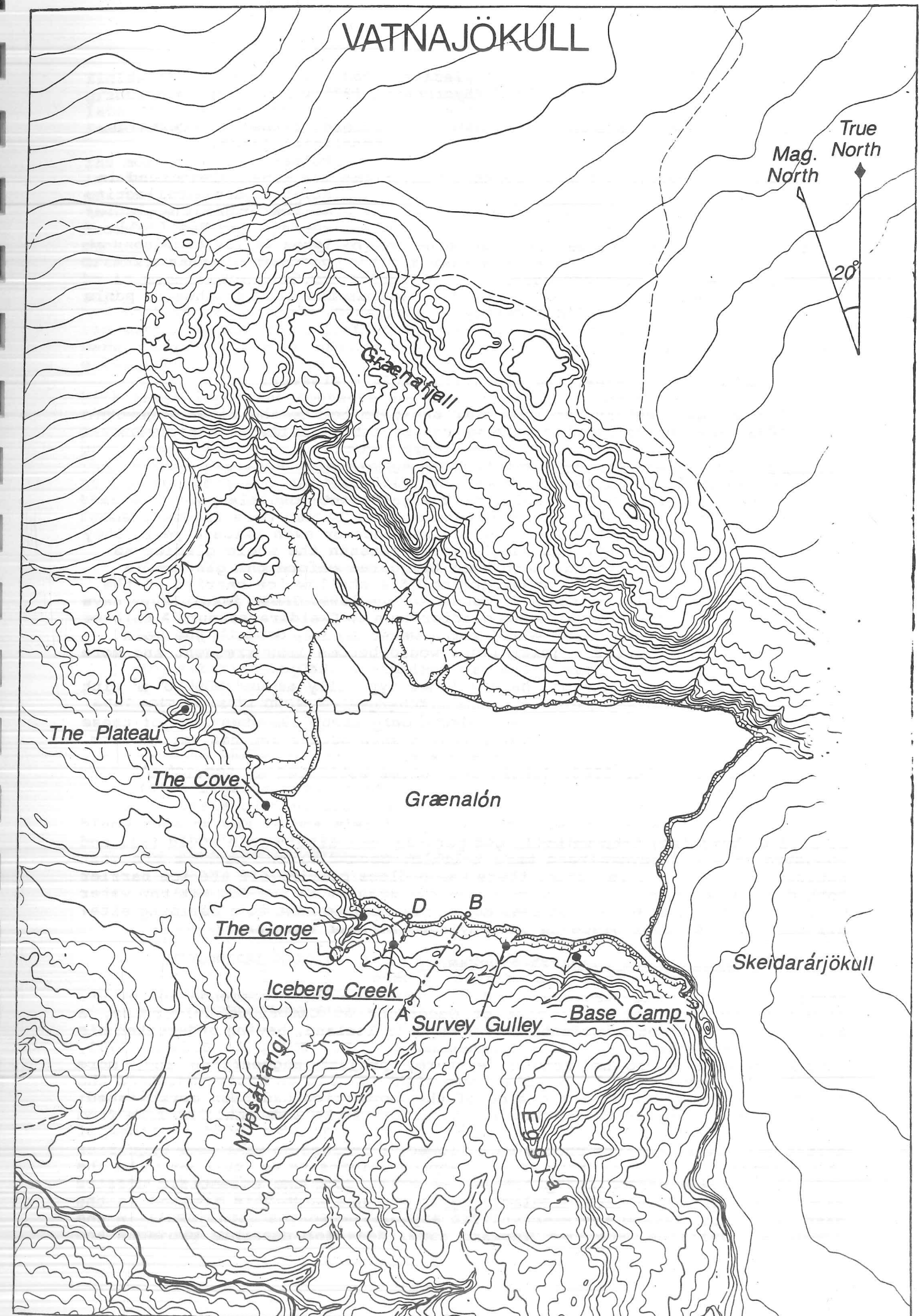
Introduction: Graenalon.

Glacier lakes are a common feature of Icelandic glaciers. Table 1 shows how they can be classified according to their geographical setting (Bjornsson, 1976). Glacier-margin lakes probably account for the majority of glacier lakes in Iceland; almost every southern to eastern outlet glacier of Vatnajökull dams up - permanently or periodically - one or more lakes. These vary in size from only a few hectares up to the size of the largest, Graenalon, which usually varies between 10 and 15 km² in area. These lakes largely form as a result of a glacier advance - in the first instance, small lakes form in gullies and ravines on the glacier margin but if the advance is more lasting, lakes form in tributary valleys; a glacier surge can also dam up a lake quite suddenly.

Most marginal lakes in Iceland are lateral lakes - these have been defined by Bjornsson (1976) as lakes bound by glacier ice on one side and rock on the other. The glacier surface slopes towards the lake which accumulates meltwater from the glacier and runoff from the surrounding rocks. The lake may drain either continuously over a col at the rock barrier or suddenly in a jokulhlaup (that is a mass drainage) beneath the glacier. Graenalon is the largest and most well known lateral lake in Iceland situated in an ice-free tributary valley dammed up by the western margin of Skeidararjökull, a large outlet glacier descending through mountain ranges towards the coast from the southern side of Vatnajökull (Fig.1). Table 2 shows the recorded jokulhlaup history for Graenalon compiled from Bjornsson (1976, 1989) and Thorarinsson (1939).

The highly active nature of Graenalon made it a very exciting environment in which to live and work. As well as these frequent jokulhlaup events, the most recent of which had occurred about two weeks before our arrival at the lake, two other features of the environment gave it a decidedly dynamic nature. Firstly, the weather conditions were highly changeable. We had periods of

Fig. 1 (overleaf). A map of Graenalon, taken from SKEIDARARJÖKULL, ICELAND 1:50,000, Edition 1-DMA, series C761, sheet 2013 II (prepared and published by the Defense Mapping Agency Hydrographic/Topographic Center, Washington, D.C. in cooperation with the Iceland Geodetic Survey; compiled in 1990 from best available sources). The map shows the location of base camp and a number of landscape features which were given names, largely for use in the geological mapping, but also used as reference points to locate the profiles B-A and D-C, also shown on the map.



SCIENTIFIC FIELDWORK AND RESEARCH.

SCIENTIFIC LEADER'S REPORT.

CONTENTS.

Introduction: Graenalon.
The development of the research programme.
Permits.
Air photographs.
Scientific equipment.
Arrival in Iceland.
Acknowledgments.
References.

Introduction: Graenalon.

Glacier lakes are a common feature of Icelandic glaciers. Table 1 shows how they can be classified according to their geographical setting (Bjornsson, 1976). Glacier-margin lakes probably account for the majority of glacier lakes in Iceland; almost every southern to eastern outlet glacier of Vatnajökull dams up - permanently or periodically - one or more lakes. These vary in size from only a few hectares up to the size of the largest, Graenalon, which usually varies between 10 and 15 km² in area. These lakes largely form as a result of a glacier advance - in the first instance, small lakes form in gullies and ravines on the glacier margin but if the advance is more lasting, lakes form in tributary valleys; a glacier surge can also dam up a lake quite suddenly.

Most marginal lakes in Iceland are lateral lakes - these have been defined by Bjornsson (1976) as lakes bound by glacier ice on one side and rock on the other. The glacier surface slopes towards the lake which accumulates meltwater from the glacier and runoff from the surrounding rocks. The lake may drain either continuously over a col at the rock barrier or suddenly in a jokulhlaup (that is a mass drainage) beneath the glacier. Graenalon is the largest and most well known lateral lake in Iceland situated in an ice-free tributary valley dammed up by the western margin of Skeidararjökull, a large outlet glacier descending through mountain ranges towards the coast from the southern side of Vatnajökull (Fig.1). Table 2 shows the recorded jokulhlaup history for Graenalon compiled from Bjornsson (1976, 1989) and Thorarinsson (1939).

The highly active nature of Graenalon made it a very exciting environment in which to live and work. As well as these frequent jokulhlaup events, the most recent of which had occurred about two weeks before our arrival at the lake, two other features of the environment gave it a decidedly dynamic nature. Firstly, the weather conditions were highly changeable. We had periods of

Fig. 1 (overleaf). A map of Graenalon, taken from SKEIDARARJÖKULL, ICELAND 1:50,000, Edition 1-DMA, series C761, sheet 2013 II (prepared and published by the Defense Mapping Agency Hydrographic/Topographic Center, Washington, D.C. in cooperation with the Iceland Geodetic Survey; compiled in 1990 from best available sources). The map shows the location of base camp and a number of landscape features which were given names, largely for use in the geological mapping, but also used as reference points to locate the profiles B-A and D-C, also shown on the map.

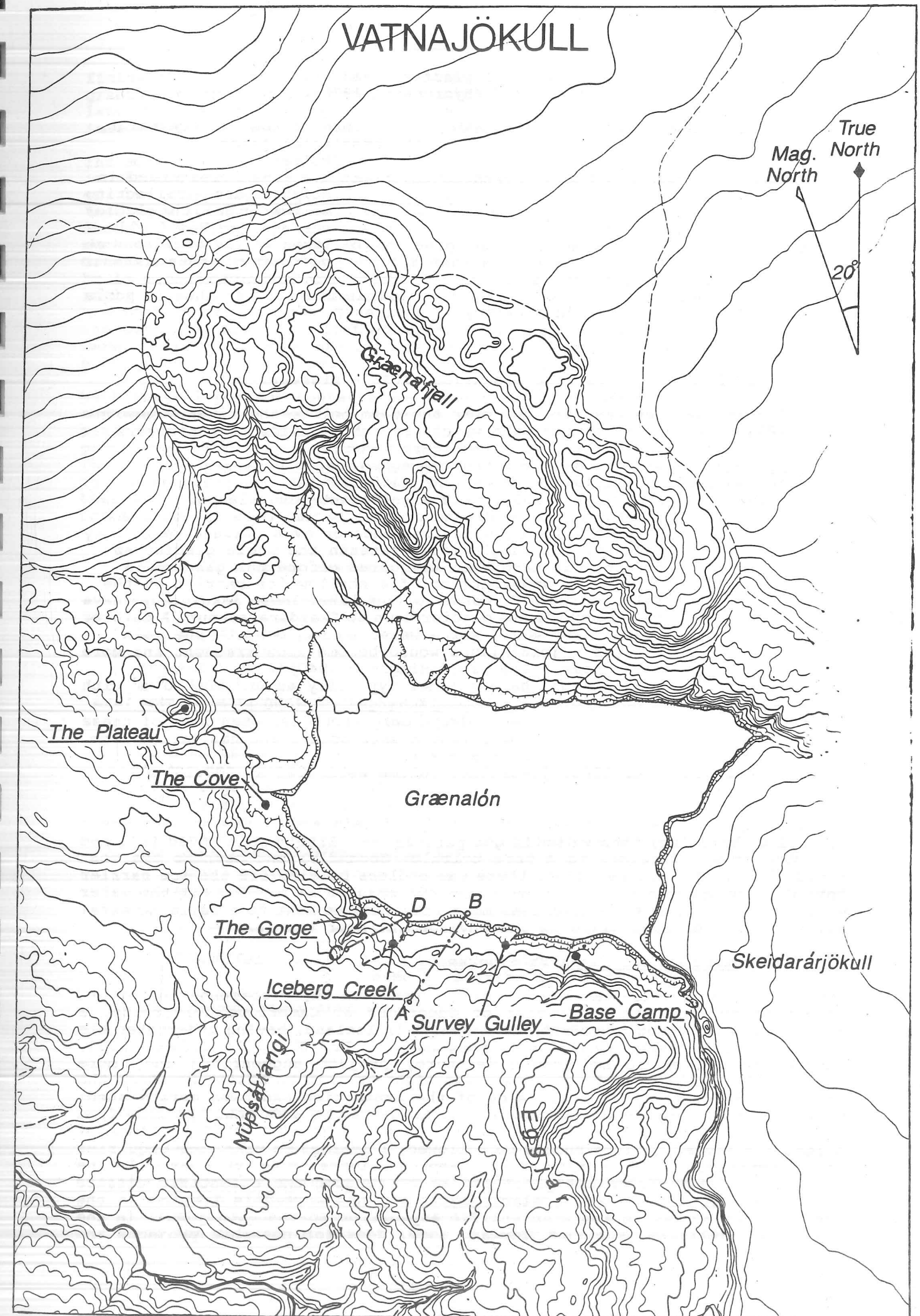


TABLE 1. The classification of glacier lakes
in Iceland (Bjornsson, 1976).

1. GLACIER-MARGIN LAKES (MARGINAL): (a) lateral lakes, eg. Graenalon.
(b) proglacial lakes,
eg. Jokulsarlon.
2. GLACIER-SURFACE LAKES (SUPRAGLACIAL): (a) ice sink holes found in
ablation areas collecting
meltwater from the glacier
surface, eg. Esjufjoll.
(b) lakes in ice cauldrons at
geothermal areas,
eg. Grimsvotn.
3. SUBGLACIAL LAKES: storage of water within the glacier when it pools
in a cavity.

TABLE 2. Jokulhlaups from Graenalon, 1898 - present.

During last century: drained over the 635m col to the river Nupsvotn.
1898: jokulhlaup emptied lake which ran subglacially to the rivers
Sula and Blautakvisl at Skeidararsandur.

1901-1935: lake drained over the col again.

Autumn 1935: jokulhlaup emptied lake ($1500 \cdot 10^6 \text{ m}^3$).

1939, 1943, 1946, 1949, 1951: next significant jokulhlaups.

Since 1951: jokulhlaups from Graenalon have become more frequent and
less voluminous, occurring once or even twice a year. They
have not run subglacially beneath the whole glacier as
before, but have been triggered before the glacier is
floated by undercutting of a shallow ice barrier at the
inlet in the S.E. corner of the lake. These jokulhlaups have
run alongside the glacier down to Skeidararsandur. A thicker
ice barrier would force water to run beneath the main
glacier - jokulhlaups would become less frequent and more
voluminous again, as during the 1940's.

Most recent jokulhlaups: have volumes typically around $200 \cdot 10^6 \text{ m}^3$ with
maximum discharges of $2000 \text{ m}^3/\text{sec}$. The lake
level drops only about 20m when each of these
jokulhlaup events occurs and has varied from
560-580m a.s.l.

August-September 1986: jokulhlaup volume estimated as $500 \cdot 10^6 \text{ m}^3$.

several days when we would get vast amounts of rain and so the streams would
be full to bursting; then we would get periods when little rain would fall and
the streams would revert to a mere trickle. Secondly, and perhaps the most
noticeable of the two features, there was endless calving off the ice barrier
both day and night creating great thunderous crashes as the ice hit the water
which made living at Graenalon seem more like camping next to a building site!
All our research took place in the environment near the lake.

The development of the research programme.

Stephen chose Graenalon as the expedition venue on the recommendation of Dr.
Martin Sharp from the Department of Geography at Cambridge University, a
scientist well versed in scientific research in Iceland, having undertaken his
Ph.D. research there. Following a meeting with Dr. Sharp in October 1991,
Stephen passed on to me some literature, project suggestions and, more
importantly, key names of scientists who might be able to assist me. Once the
foundations for the scientific side of the expedition had been established:
where we were going, what the general character of the area would be like from
a geographical point of view, and suggestions as to what kind of lines of
scientific investigations should be followed, I decided to make some enquiries
at the Department of Geography at Southampton University as this would be the
most obvious and convenient place for me to conduct the scientific affairs
from. I met Dr. Jane Hart, a glaciologist who has worked in Iceland in the
past, including having led a scientific expedition to the Vatnajokull in the
summer of 1991; she, too, put forward some ideas for possible projects and

fieldwork. My most valuable consultant, however, was David Roberts, a post-
graduate student at Southampton. I sought his advice on a regular basis from
late 1991 right through to just before we flew out to Iceland and I am
indebted to him for his perpetual enthusiasm in assisting me throughout.

The most significant development in the research programme, however, arrived
in the post on the 3rd December 1991. In mid November, I had written to one
of Iceland's leading glaciologists, Helgi Bjornsson, from the Science
Institute at the University of Iceland and also of the Iceland Glaciological
Society, stating who we were, where we were going and for how long, and how
much scientific training we had. Helgi has carried out extensive research at
Graenalon in the past, indeed for many such similar ice-dammed lakes, hence
he is probably one of the greatest authorities there is on the subject. His
reply to my letter was therefore a major breakthrough: as well as a copy of
his most recent paper on Graenalon to add to the literature I already had on
the area, he sent me a list of project suggestions on the lake level which
were then to form a skeleton structure for the research programme and
subsequently be developed and undertaken the following summer.

With these important contacts now established from whom I could draw advice
and assistance, I was then able to pool all my ideas and the suggestions
passed on to me in order to put together some kind of framework for a research
programme laying down a series of objectives which we could then work towards.
The initial research objectives are laid out below (Table 3). When compared
to the research and fieldwork actually undertaken (Table 4), it can be seen
that several minor projects were not carried out and others were developed
further.

TABLE 3. Initial research objectives.

1. GLACIAL GEOMORPHOLOGY:

- (a) mapping of glacial moraines and eskers and their dating by
lichenometry.
- (b) establishing crevasse orientations on Skeidararjokull, to interpret
shear stresses.
- (c) the mapping and dating of possible boulder chains emerging from the
lake, signs of earlier floods.

2. LAKE LEVEL STUDIES:

- (a) a regular measure of the altitude of the lake surface on a daily
basis over several weeks.
- (b) the mapping of strand lines in order to estimate former volumes of
the lake and the lake level when jokulhlaups were triggered.
- (c) estimations of the water balance of the lake, input from rivers,
rain, output in jokulhlaups.
- (d) measurement of the lake temperature; several vertical profiles taken
done from a rubber boat.
- (e) estimations of the flow of ice into the lake and the calving rate.

3. GEOLOGICAL MAPPING: the production of a map displaying the rock types seen at surface around the lake.

4. METEOROLOGICAL SURVEY: keeping a daily record of rainfall, humidity, temperature, wind conditions and a general account of the weather.

TABLE 4. Fieldwork and research accomplished.

1. LAKE LEVEL STUDIES:

- (a) a regular measure of the altitude of the lake surface on a daily
basis over several weeks together with a profile from the lake shore
to a benchmark showing lake level below this reference point.
- (b) the mapping of strand lines in order to estimate former volumes of

- the lake and the lake level when jokulhlaups were triggered.
- (c) estimations of the water balance of the lake, input from rivers, rain, output in jokulhlaups.
2. GEOLOGICAL MAPPING: mainly around the south of the lake but an excursion was made to the northern side of the lake.
 3. METEOROLOGICAL SURVEY: an accurate daily record was kept throughout the period in the field.
 4. TOPOGRAPHICAL MAP: a map of the topography of the S.E. corner of the lake was produced to a scale of 1:1400.

My intention was to devote most of our time to the lake level studies, the main part of the programme that was being carried out in conjunction with Helgi Bjornsson. This was a blend of both original projects and a repeat of past projects from which we could draw comparisons and, together with the fact that the ideas had been put forward by Helgi Bjornsson and Martin Sharp who have worked together in the past, this meant that they showed the most potential both in terms of execution in the field and the usefulness of the results on our return. Nearer to departure, I finally made the agonizing decision not to proceed with the lake temperature project. To the best of my knowledge, it had never been done before and it would certainly have made very interesting research, but getting a boat, lifejackets, a puncture repair kit and so on there and back would probably have added an extra two days onto the walk-in and an extra day onto the walk-out which, coupled with the safety aspect, meant that the arguments against far outweighed those for. However, for any future scientific expedition going to Graenalón, I would recommend you seriously consider undertaking this project: it would require thorough planning with much time and care devoted to it, but the results may well be a just reward. Also at this stage, I had found no suitable method for estimating the calving rate from the ice barrier and measurement of the flow of ice into the lake and, as this project seemed beyond our capabilities and equipment, I again decided to leave it out.

Unlike the lake level studies, the glacial geomorphology projects did not show as much promise. Very little work has been done on the ice margins of Skeidararjökull - Stefan Jewtuchowicz concentrated on the east side in 1973 (Geographica Polonica, V.26, pp.115-137); hence just a few ideas were put together with the aim of producing a glacial geomorphological map so as to establish what is, and what has been going on in the area in terms of interactions between processes. As I progressively learnt more of the general character of the terrain around Graenalón, it seemed less and less likely that it was going to be possible to identify some of the features such as past ice fronts at our expedition venue, therefore I held little hope for the validity of these projects. In the event, these projects were left out for a number of reasons: firstly, the glacier foreland to the west of Graenalón (Fig. 1) appeared chaotic with extremely complex moraine ridges that showed no substantial colonization of lichens - the ice from the west has swept across this area in recent times (a photo by Sigurdur Thorarinsson in 1947 shows this ice front to be almost at lake altitude); secondly, Skeidararjökull had a surge in the summer of 1991 and was heavily crevassed, so access onto the ice barrier was virtually impossible; and finally the location of boulder chains due to floods became an irrelevant subject once I had found out about floods and drainage routes from the lake.

The geological mapping was conducted by Stephen and although he obtained very little background on the area prior to departure, the project turned out to be a great success, largely facilitated by there being very little vegetation, hence outcropping was widespread. As most expeditions do, we also recorded the meteorological conditions of our stay on a daily basis; as well as an information source in its own right, the data was collected to compliment the lake level studies. Towards the end of the expedition, we had some time on our hands and so an extra project was introduced to the programme - the production of a topographical contour map of the S.E. corner of the lake where it begins to drain to the south alongside Skeidararjökull.

Permits.

According to Tony Escritt, "Iceland: the traveller's guide", all scientific expeditions visiting Iceland require permission to undertake fieldwork from the Icelandic Council of Science. Two forms of permit are issued: a "RESEARCH PERMIT for expeditions carrying out any research project of an original nature" - this "would normally be expected to appear in a scientific journal"; and an "EDUCATIONAL PERMIT for expeditions carrying out fieldwork as opposed to research work". When I came to deal with this task, I was very confused as to where our research programme would stand in terms of 'research' or 'fieldwork'. I had always considered these terms synonymous with one another and so when I wrote to Helgi in mid November 1991, I asked him to clarify the point and advise me as to which application to follow. In his reply, he told me to apply for a research permit and that I could mention his name in my application.

I at once wrote to the Director of the Icelandic Council of Science, Dr. Axel Bjornsson, stating who we were, where we were going and for how long, what are intended plans were, who our contacts were, and that I wished to apply for a research permit on the recommendation of Helgi Bjornsson. Much to my surprise, I was then sent a standard letter "TO ALL SCIENTISTS, EXPLORERS AND TRAVELLERS IN ICELAND" with two statements being marked as applicable to our expedition:-

- "You do not need a specific research permit and can visit Iceland as normal traveller".
- "Forms for research permit application are enclosed for your information".

'Normal traveller' status, since 1990, refers to school expeditions and non-scientific explorers who "are welcome and can visit Iceland as normal travellers and visit sites of interest". This status seems to be everything that we weren't: we certainly weren't a school expedition or non-scientific explorers and one of our primary aims was to avoid the popular expedition venues and visit a more remote, unspoilt location where we could put our resources and expertise to good use in producing worthwhile scientific work in conjunction with Icelandic scientists.

This was all a little worrying at first, as a research permit or equivalent is required for customs clearance in Reykjavik when collecting your sea freight but I had the standard letter from the Icelandic Council of Science and Helgi's letter amongst other official correspondence; hence we had enough proof that we were a 'bona fide' scientific expedition. In the event, they never asked to see any official scientific documentation on collection of the food, skis and scientific equipment.

Air photographs.

Air photographs are kept by the Iceland Geodetic Survey who also produce all the maps of Iceland. Although acquiring air photographs was not a priority, I wrote to them in early 1992 to try and get hold of some before leaving the U.K., as looking at the photographs under a 3-D viewer would have given me a good idea of the terrain around the lake. The most recent air photographs were from August 1991 and each one covers an area of 8 by 8 kms. Unfortunately, they wouldn't allow me to purchase any from them.....because I didn't have a research permit! On arrival in Iceland though, we managed to pick up two air photographs of Graenalón - they worked out to the rather unusual price of 1292.5, -IKR. each, a heavy increase from the price I was quoted in February of 1989, -IKR. However, with managing to persuade the young woman to actually sell us the photographs, it would have proved difficult to argue the point over the cost of them as well.

Scientific equipment.

During May and June of 1992, I negotiated the loan of some scientific equipment from the Department of Geography at Southampton University. With the help of David Roberts and Dave Anderson, the Department's lab. technician, I was allowed to take the equipment listed below out to Iceland (Table 5a). In addition, we supplied ourselves with some extra items (Table 5b) to compliment the equipment on loan.

The scientific equipment was something I had had to bear in mind throughout the whole preparation stage: my target had been to find a suitable balance between weight or bulk of equipment and number of projects or length of time it would be used for, but in doing so to also keep the weight to an absolute

TABLE 5a. Scientific equipment: loaned from Southampton University Geography Department.

- Tripod/Quickset level.
- 2 30m tapes.
- 4m telescopic graduated marker pole.
- 1 5.5" rainguage (funnel, drainpipe holder, 500ml collecting bottle).
- Spring balance (for measuring rainfall collected).
- Whirling hygrometer (for measuring humidity).

TABLE 5b. Additional scientific equipment.

- Map boards.
- Digital thermometer.
- Compasses.
- Rulers.
- Pencils (including coloured pencils).
- Sample bags.
- 2 calculators (scientific and non-scientific).
- Notebooks/paper (A3, A4, tracing-, graph-).
- Hand lens.

minimum. For example, although the lake temperature project would have been a long project, it would have been totally unrealistic to think about carrying the boat and associated equipment in. As it turned out, a highly suitable balance resulted; for example, much of the levelling equipment (tripod, quickset level, 4m graduated pole and 30m tapes) could be used for many of the projects.

Arrival in Iceland.

Amongst the various tasks I had to do on Wednesday 22nd July 1991 on our way out was to find out some information on benchmarks at Graenalon. If we were going to carry out a regular measure of the altitude of the lake surface we were first going to have to establish some kind of reference point that had been used before for finding the lake level. Unfortunately, on our arrival in Iceland, Helgi was away on a trip along the south coast and I would not see him until early September on our return to Reykjavik. However, I had been in constant touch with him on the phone during the previous week ironing out last-minute problems and queries, and he kindly left me a list of people I could consult about benchmarks with my friend Jon Isaksson, with whom we stayed whilst in Reykjavik. Not surprisingly, a number of these people were also away on holiday at the time and I was finally put onto a Mr. Kristinn Einarsson of the National Energy Authority (Orkustofnun). He provided us with two profiles from lake shore to benchmark points and a copy of a new 1:50,000 map of Graenalon and Skeidararjokull. Since our return, I have again been in correspondence with him and am truly grateful for his valuable assistance and encouragement.

Acknowledgments.

The great success of the scientific fieldwork, which will hopefully shortly culminate in the publication of the lake level studies (HYDROLOGY REPORT) in the Iceland glaciology journal "Jokull", came as an immense relief to me on our return to the U.K. Having the responsibility of the scientific fieldwork was a great privilege and challenge for me and I must thank Stephen for the opportunity. However, being responsible for possibly the most important part of the expedition was initially, so it felt, quite a daunting task. It was important that it went well and I was under a certain amount of pressure to see that it did. However much more preparation I might have done, I could

never have been sure of how it was going to turn out. But, as each day in the field passed by and the various parts of the research programme slowly began to be completed and fall into place, the growing sense of achievement gave me renewed strength to tackle the remaining projects.

I must therefore first of all thank my four expedition companions for their support in keeping the work programme ticking over during all kinds of weather conditions: Stephen for conducting the geological mapping, Walter for assisting him, Rollo for keeping a regular and accurate account of the meteorological conditions, and finally Rupert for all the assistance he gave me in carrying out the lake level studies. I should also take this opportunity in thanking them for the great strength of character and considerable kindness they showed when pulling me off Vatnajokull when I was unfortunately struck with snowblindness.

My grateful thanks also go to Dr. Martin Sharp of the Department of Geography at Cambridge University and Dr. Jane Hart of the Department of Geography at Southampton University for giving me some initial ideas to build upon, but above all I extend my warm thanks to David Roberts (Geography Department, Southampton University), Helgi Bjornsson (Science Institute, University of Iceland) and Kristinn Einarsson (Iceland National Energy Authority) for most rewarding discussions, valuable advice and assistance, and keen involvement and interest in our endeavour.

In addition, I thank the Department of Geography at Southampton University for kindly loaning the expedition the main items of scientific equipment needed but I must finish by thanking my great friend, Jon Isaksson, for providing accommodation, transport and invaluable assistance during our time in Reykjavik. Without his help, our tasks would have been a lot harder and certainly taken a lot longer.

References.

Refer to hydrology report.

Mark Cooper.

HYDROLOGICAL REPORT.

CONTENTS.

Introduction to the projects.
Altitude of the lake surface.
Strand lines.
Water balance of the lake.
Concluding remarks.
Acknowledgments.
References.

Introduction to the projects.

The lake level studies, as noted earlier, covered three main areas:-

- a regular measure of the altitude of the lake surface on a daily basis over several weeks together with a profile from the lake shore to a benchmark showing lake level below this reference point.
- the mapping of strand lines in order to estimate former volumes of the lake and the lake level when jokulhlaups were triggered; work was also carried out on dating the top strand line and studying the old river bed of the Nupsa.
- estimations of the water balance of the lake, input from rivers, rain, output in jokulhlaups.

My aim in carrying out these projects was to continue a succession of work at the lake by obtaining hydrological data for 1992 and subsequently to use it to the best of my ability to create a greater understanding of the hydrological characteristics of Graenalon. As my hydrological and glaciological knowledge is somewhat limited (I am in fact a geology undergraduate at present), the report is more of a preliminary report at this stage. Although some discussion with Icelandic scientists has taken place to date, mostly with Kristinn Einarsson of the National Energy Authority (Orkustofnun), I am still intending to make some more enquiries in Iceland with the view of enhancing the usefulness of my results before publication of the report in the Iceland glaciology journal "Jokull", which I hope will take place in the near future. In particular, this report will be examined by Kristinn Einarsson, Helgi Bjornsson and also, I hope, by Sigurjon Rist, one of Iceland's leading hydrologists, a name that has only really come to my attention recently. This should then realise the full potential of the data for future reference.

Altitude of the lake surface.

In order to carry out a regular measure of the altitude of the lake surface, it was first necessary to establish the altitude of the water level with reference to some kind of benchmark for the day the regular lake altitude survey was to begin. The two measuring profiles provided by Kristinn Einarsson of the National Energy Authority (Orkustofnun) enabled me to do this.

One of the reference profiles provided showed the lake altitudes for the 22nd of September 1973 and 1976 with reference to lake altitudes prior to jokulhlaups in August of each of these years. To quote Rist (1990):on the 20th of April 1951 the reference point for the water level of Graenalon was chosen at a rock outcrop at the south-east corner of the lake. This reference profile was marked with alternating red and yellow marks (probably paint?) on the 14th of July 1970 and was intended for visual inspection from a small aeroplane, from which the water stage could be determined with 1-2m accuracy. We spent a lot of time at the south-east corner of the lake as this was where base camp was located but we never found this particular profile - doubtless nearly two decades of being subject to the elements had had an effect on the red and yellow marks, particularly if they were only paint.

The second reference profile, which was intended for more precise measurements

and hence the one which was of use to me, showed the lake altitude for 1951 but was not from the same place as the ones from 1973 and 1976. This profile was surveyed by Sigurjon Rist on the 2nd of September 1951 and marked with a line of cairns. To quote Rist (1990) again: I put a benchmark (steel bolt) in the old bed of river Nupsa. It was at that time (ie. 2nd September, 1951) 37m above the water level of Graenalon. The benchmark is at the lowest point of the pass (or saddle) between Nupsartangi and Eggjar. When the glacier was larger, river Nupsa flowed there towards the south. According to the chief surveyor of the Iceland National Energy Authority, Gunnar Thorbergsson, who has for decades been in charge of maintaining large parts of the principal triangulation points in Iceland, this benchmark has never been incorporated into the triangulation network, nor has it been measured with proper instruments in relation to a known datum height, but nevertheless if we couldn't determine the lake altitude above sea level, we could compare the lake altitude for 1992 with that of 1951 in relation to the steel bolt benchmark. In fact, this is probably a more useful line of approach anyway. Although Sigurjon Rist did, however, approximate the height of the steel bolt benchmark as 640m a.s.l., it is only an approximation, taken from the old 1:100,000 map, and so therefore should perhaps best be avoided.

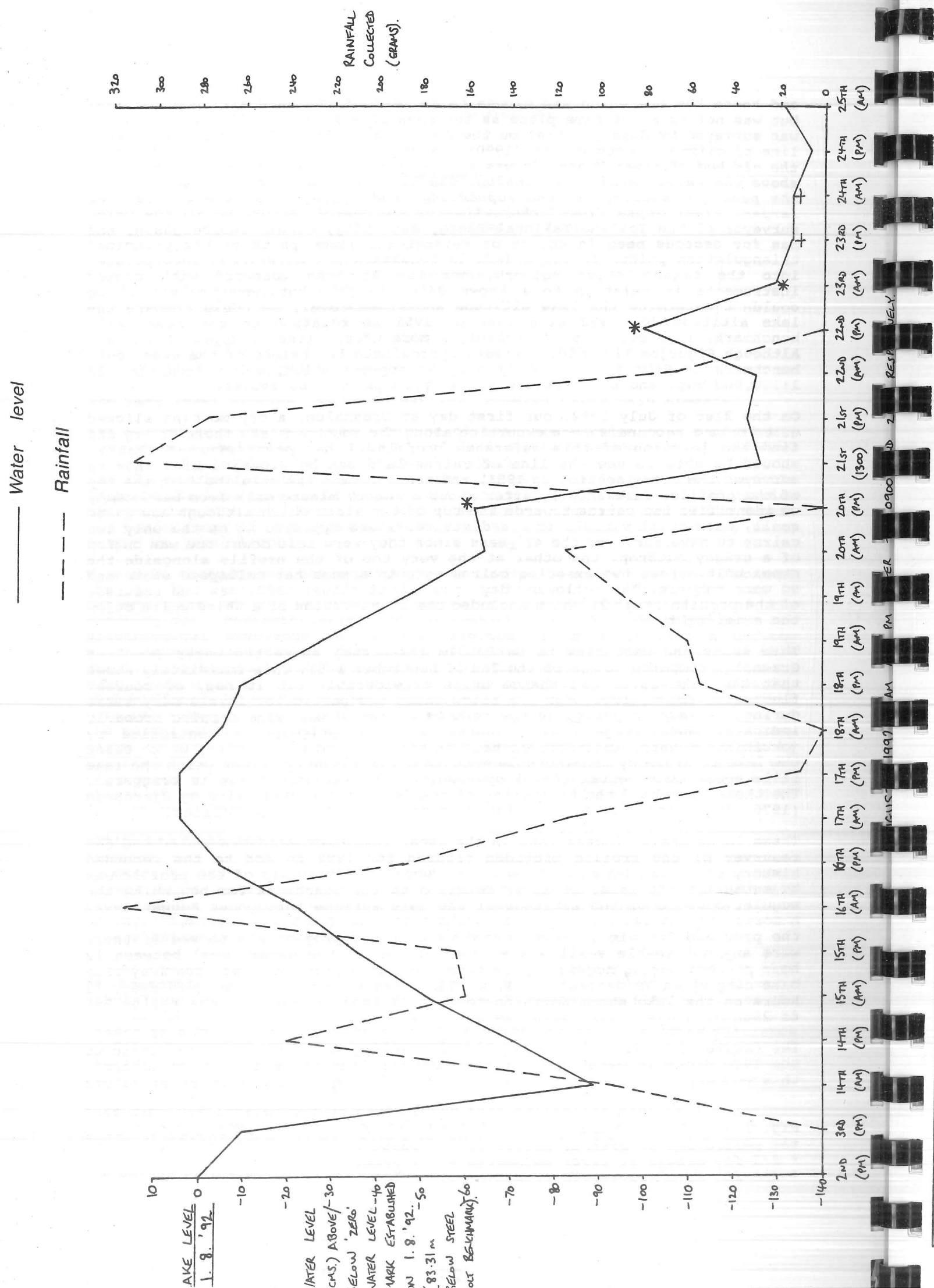
On the 31st of July 1992, our first day at Graenalon, a dry morning allowed us to make a reconnaissance excursion along the southern lake shore to try and find the location of this reference profile. I had been informed that we should be able to see the line of cairns laid out by Sigurjon Rist when he surveyed the cross section in 1951, and hence locate the steel bolt at the top of the profile. Sure enough, after about a twenty minute walk from base camp, we identified two cairns towards the top of the slope which although now quite small, were still visible from a distance. These appeared to be the only two cairns to have survived the 42 years since they were laid down: one was on top of a craggy outcrop, the other at the very top of the profile alongside the steel bolt. These two existing cairns were in a somewhat collapsed state and so were rebuilt. The following day, the 1st of August 1992, saw the resurvey of the profile (Fig. 2) which included the construction of a third cairn below the existing two.

This shows the benchmark to be 83.31m (+/-0.44m) above the water level of Graenalon compared to 37m on the 2nd of September 1951. This immediately shows that the lake level can change quite considerably but it has, of course, fluctuated above, inbetween and below these two particular levels many times during the last 41 years, as the results of the strand line mapping probably indicate. Such large scale fluctuations are principally controlled by jokulhlaup events, interactions between the lake and ice barrier, which cause the lake to drain by considerable amounts quite abruptly, after which the lake fills again to a certain level upon which the next jokulhlaup is triggered. The theories behind the triggering of jokulhlaups are dealt with by Bjornsson (1976, 1989) and seem to be related to the size of the ice barrier.

These large scale fluctuations in the water level are well documented and the resurvey of the profile provided figures for 1992 to add to the recorded history of annual lake level readings. But the primary aim of the profile was to establish the water level in relation to the benchmark for beginning the regular measure of the altitude of the lake surface throughout August 1992. A series of regular readings over a short time period has never been taken in the past and the aim of this second part of the project was to see if there were any noticeable small scale fluctuations in the water level between 12 hour periods during August. Apart from a 10 day period, when we were away from base camp up on Vatnajokull, lake surface measurements were recorded every 12 hours on the lake shore north-north-east of base camp during the period 2nd to 25th of August 1992 inclusive (Fig. 3).

The results of this survey are quite interesting: at first I was surprised to see 19cm drops in water level - assuming the lake to be say 10 km² in area, this corresponds to a volume loss of 1.8 . 10⁶ m³, quite a considerable volume

Fig. 3 (overleaf). A graph of the water level of Graenalon and rainfall during the period 2nd to 25th of August 1992 inclusive.
* 2/3 ft. breakers: error estimated as +/-10cm.
+ 1/2 ft. breakers: error estimated as +/-5cm.

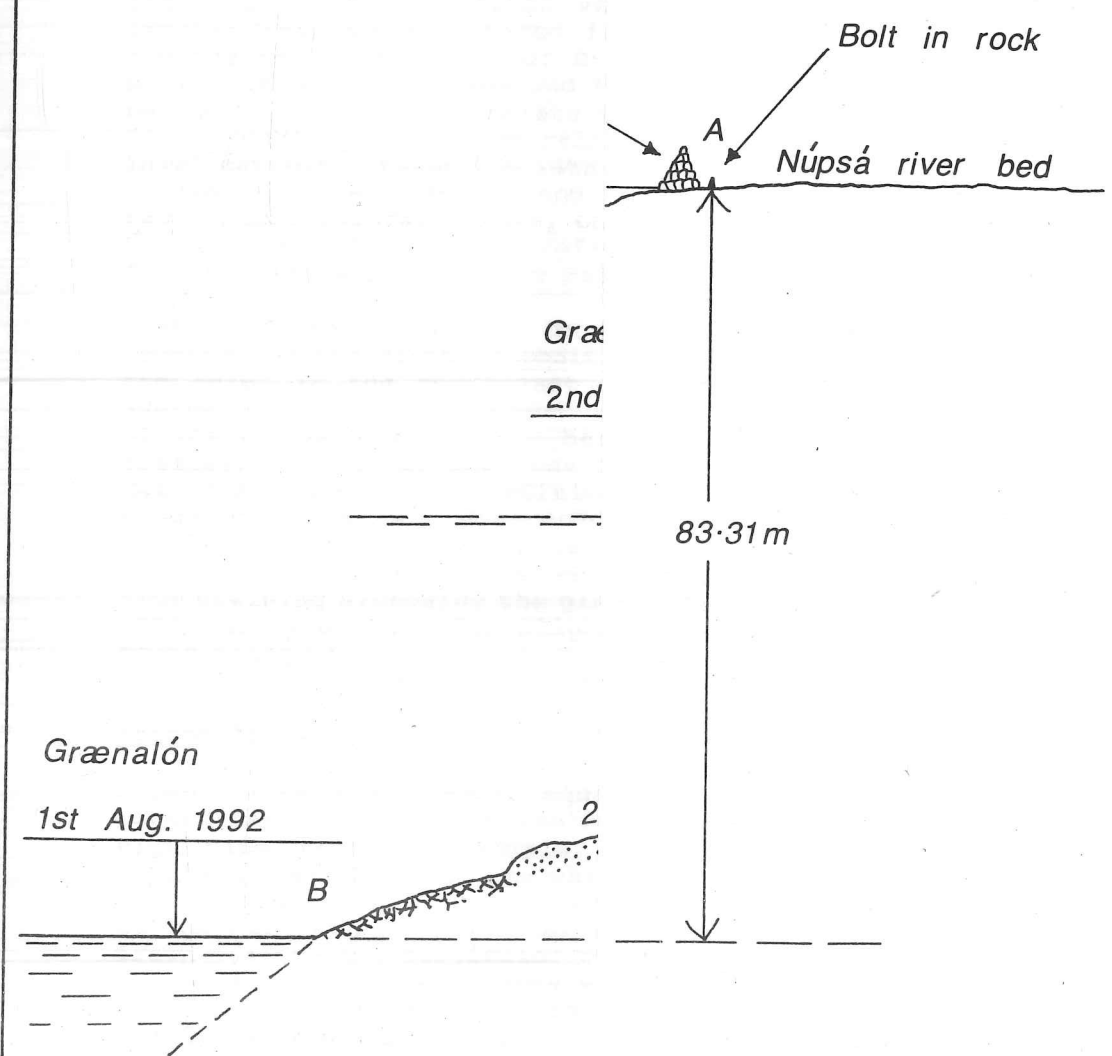


EXONIAN VATNA

Profile B-A

GRAENALÓN

Fig. 2. Cross section of the Direction of cross section



EXONIAN VATNAJÖKULL EXPEDITION

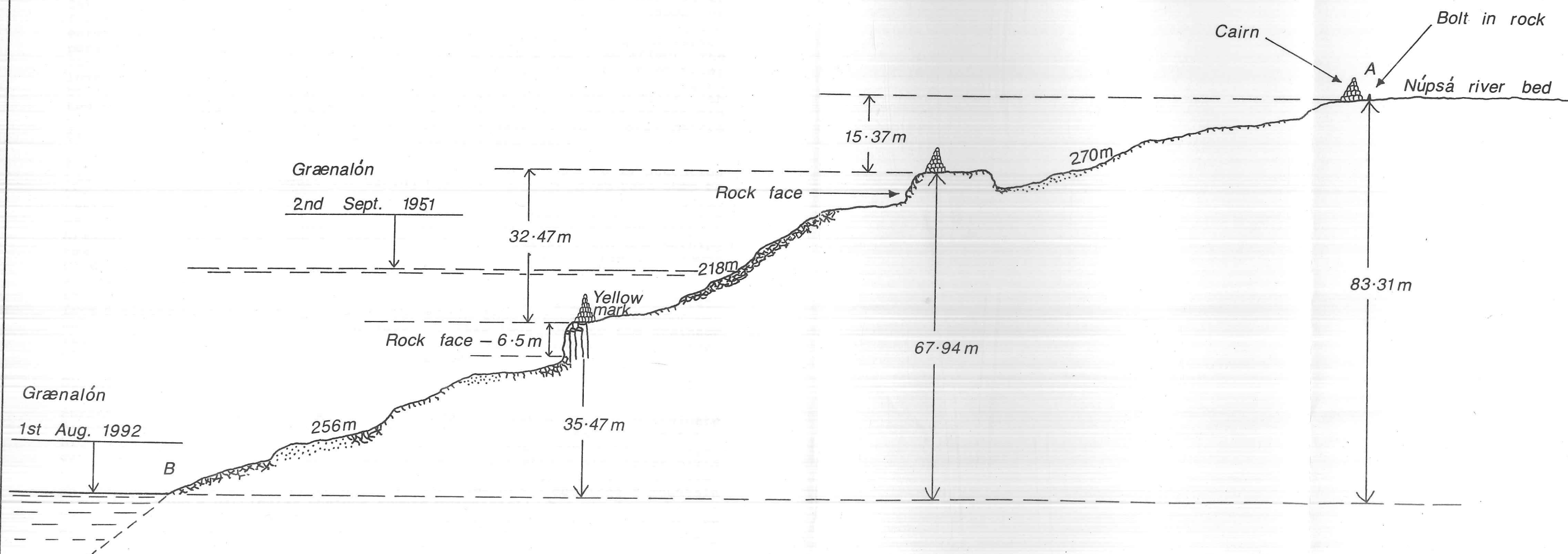
GRAENALÓN

1.8.'92 M. Cooper

Profile B-A

Fig. 2. Cross section of the bank of Grænalón 50m west of Núpsá river bed.

Direction of cross section is 033° (true) measured from the benchmark (steel bolt).



of water to drain from the lake in a 12 hour period; but then later on in August, between 2100 hours on the 20th and 1300 hours on the 21st, a huge drop in the water level of 64cm occurred in just 16 hours - this would correspond to a volume loss of $6.4 \cdot 10^6 \text{ m}^3$, an almost unbelievable amount of water to drain from the lake during this very short period. The rises in water level seemed to be more uniform, generally between 9 and 19cm. Considering the amount of rain we had on certain occasions, these figures are highly believable!

These small scale fluctuations in the water level are likely to be controlled by diurnal variations in the inputs and outputs to the lake water balance system, including rainfall, ablation rates from the surrounding glaciers and behaviour of the ice barrier. Being a new discovery, I intend to leave the full interpretation of these small scale fluctuations open to discussion with the more experienced Icelandic glaciologists and hydrologists, but two possible controls are worth discussing at this stage. Firstly, the water level of Graenalón can almost certainly be related to rainfall - a quick glance around the lake highlights just how many streams there actually are entering the lake as runoff from the surrounding rocks, far more than have ever been noted on any map of the lake. This is chiefly due to the fact that in periods of dry weather, many streams do not actually exist - it is only following periods of intense rain that many of the streams spring into real existence. Graenalón has a very small catchment area, certainly no larger than the area of the lake itself, which, coupled with the steep slopes down to the lake shore, mean that it takes very little time for the effect of periods of intense rain to be noticed in the change in lake level. Fig. 3 shows the fluctuating water level of Graenalón together with the rainfall during the survey period. The rises and falls in the rainfall pattern during the survey period can be seen to relate to the water level with a lag time effect. The first double peak in the rainfall pattern relates to the increase of water level between the 14th and 17th of August; then as the rainfall begins to cease between the 16th and 18th, the lake level again gradually falls with two further rainfall peaks, one between the 18th and 20th, the other between the 20th and 22nd, only reflecting slight increases in lake level before falling away again with no rain between the 22nd and 25th.

A second possible control on minor water level changes came to my attention towards the end of the expedition. During the last week we moved base camp to the inlet in the south-east corner of the lake where it drains alongside Skeidararjökull to the south. We had heard frequent immense crashes of columns of ice coming off the ice barrier at this location throughout our stay at Graenalón but never seen any of these gigantic ice falls. Then, one morning near the end of the expedition, columns of ice equating in size to a tower block of flats came down across the inlet only about 150m from the tents. Within minutes, the water levels on either side of this temporary dam were several metres apart, the water on the lake side seemingly being held back from draining alongside the glacier to the south. This frequent phenomenon may well partly account for slight increases in lake level due to the drainage route being temporarily blocked and then sudden slight decreases in lake level when the temporary ice dam is finally breached.

Strand lines.

Strand lines are lines of equal height around the lake shore which indicate former lake levels, much the same as lines of seaweed on a beach indicate the high tide mark for example. From a distance, these were extremely eye-catching, particularly one which seemed to be the top strand line which could be visually traced at what seemed to be the same height around the whole lake. On the northern lake slopes, this top strand line stood out like a mountain track following a particular contour around Graenafjall, but was less obvious on the southern lake slopes where it was only prominent to the west of the steel bolt benchmark. In order to map a strand line profile, it was necessary to find a suitable slope on which a large number of prominent strand lines existed. The more strand lines present, the closer the profile would be to representing all former lake levels; the more prominent the strand lines are, the less chance there is in mapping terraces which appear like strand lines but which are, in fact, formed by slope processes. However, on close inspection, even on what appeared to be the most striking succession of strand lines on the southern lake slopes, the strand lines were not so easy to

identify.

Fig. 5 (below) shows how I defined the strand lines for the purpose of the project. This was done by examining the more prominent ones which tended to be located lower down the profile, probably due to the fact that the lake reaches such levels more often. The higher up the profile, the less recognisable they become as solifluction and other such slope processes come into play, and in places they required a traverse of the slope to check if they were in fact strand lines and not just minor slumps and the like. The project involved mapping the most obvious strand lines (Fig. 4) - with such frequent water level fluctuations at Graenalón, there are likely to be many more levels to which the water has been than the 21 strand lines I mapped on the profile, but the majority of these have never left a permanent trace of their levels on the slopes. The reasons behind this probably lie in subsequent rises in lake level which destroy earlier strand lines by wave action and so forth. This was noticeable around the lake shore in August as the lake altitude was continually fluctuating inbetween 4cm above and 137cm below the established lake altitude for the 1st of August 1992, and hence, together with the strong winds producing high energy wave action for some quite considerable periods of time, there was no evidence of a definite strand line for the general lake altitude for August.

FIG. 5.

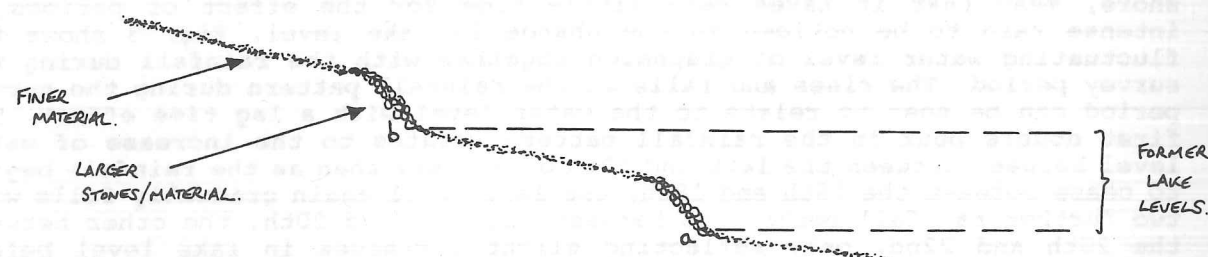


Fig. 4 shows the heights of each of 21 identified strand lines above the lake level on the 18th of August 1992 for a profile on the southern lake slopes. The height of the top strand line (u) above the lake level on this day was 84.57m (+/-0.62m) which represents the highest level that the lake has ever attained. The benchmark, which is located just below the watershed at the col between Nupsartangi and Eggjar, was 83.36m (+/-0.45m) above the water level on this day, and since this figure is almost within a metre of the altitude of the top strand line, these altitude figures must relate to the times when the lake drained over the col by the river Nupsa to the south. The lake level on the 2nd of September 1951, 37m below the benchmark, would probably correspond to strand lines m or n. The lake level prior to the July 1992 jokulhlaup (refer to water balance) is probably in the region of strand lines d to f.

Lichenometrical dating of the top strand line:-

This part of the project involved dating the top strand line by lichenometry, a method normally applied to dating glacial moraines in order to establish the position of past ice fronts. The widely accepted concept is that following ice retreat, the newly exposed ground will slowly begin to become colonised by lichens; within a general region with the same microclimate, lichen growth is a function of time elapsed since colonisation, hence an estimate of substrate age can therefore be made, the diameter of the largest thalli being proportional to the age of the surface in question. In my short lichenometrical study of the top strand line, I assumed the concept for glacial ice to be applicable to water for the lake: when the water level fell from the top strand line, colonisation occurred shortly after the surface was exposed and has continued ever since; this enables the date that the lake was last to the level of the top strand line to be estimated.

On a stretch of the top strand line running about 1-1.5km to the north-west of the benchmark, five plots of 25m in length and 4m in width were set up, each about 200m apart along the strand line. Each plot was examined for the five largest lichens of species *Rhizocarpon geographicum*, a green yellow

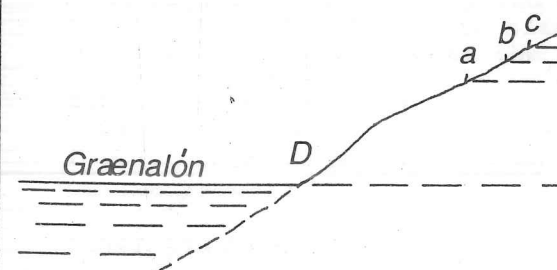
EXONIAN VATNA

Profile D - C

GRAENALÓN

Fig. 4. Cross section of
Direction of cross section
lake shore (D) 60m nor

level (m)



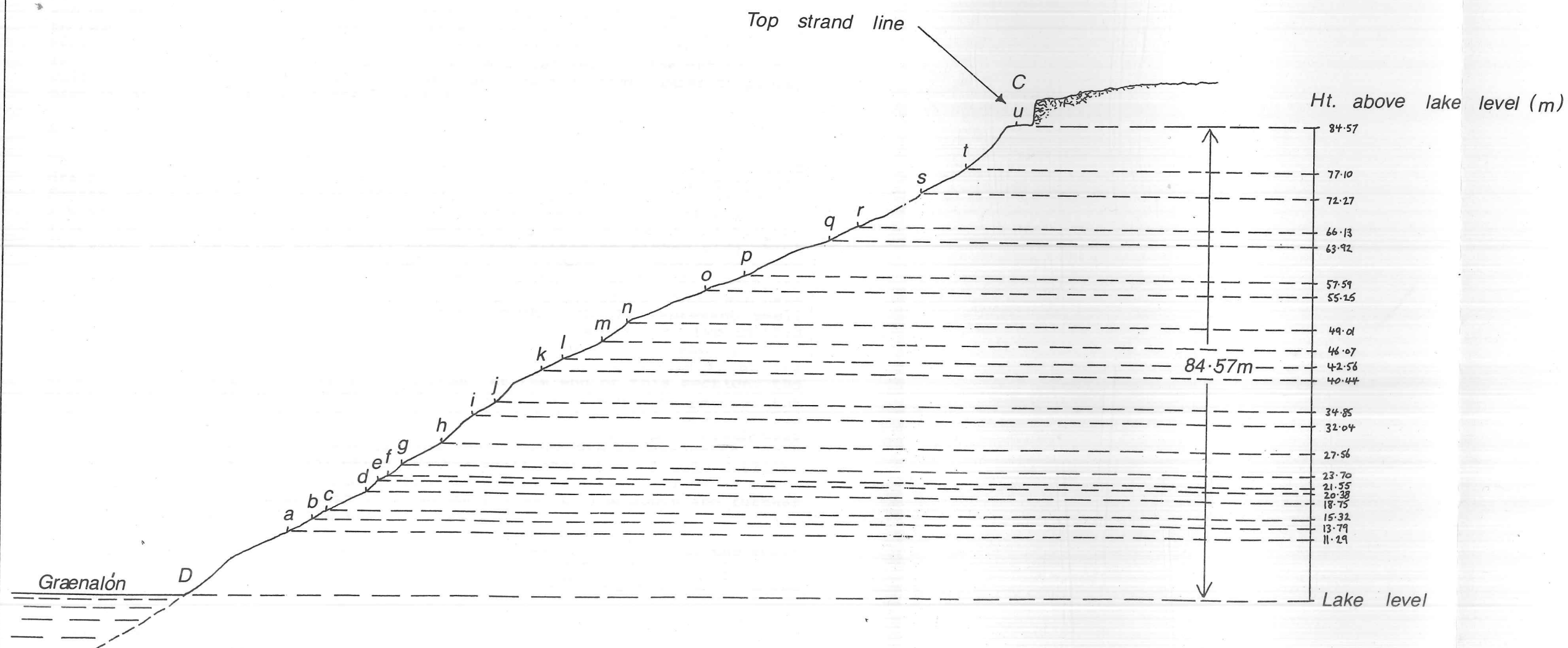
EXONIAN VATNAJÖKULL EXPEDITION

GRAENALÓN

18. 8. '92 M. Cooper

Profile D - C

Fig. 4. Cross section of the bank of Grænalón showing strand lines (a → u).
Direction of cross section is 242° (true) measured from a point on the lake shore (D) 60m north-west of where Iceberg Creek enters the lake.



crustose lichen abundant in many Arctic alpine environments, widely used in lichenometrical studies. Only lichens with distinct thallus margins were chosen - those ranging in shape from slightly elliptical to circular were measured. Complex thalli and those in wet, poorly drained sites were ignored. For each of the five largest lichens, the maximum diameter to the nearest mm was recorded; an average was then taken to obtain the plot mean.

From this data, the strand line mean can be calculated (the average of the five plot means) and applied to the only growth curve to have ever been published for Iceland (Gordon and Sharp, 1983). The growth rate for the aggregated species Rhizocarpon geographicum was derived for the proglacial area of Breidamerkurjökull which lies 55km to the east-south-east of Graenalon. The relationship between maximum lichen size (y) to substrate age (x) is suggested to be linear and is described by the equation:-

$$y = -3.1836 + 0.6728x$$

A lag time of five years was suggested before there is any visible evidence of colonisation. The results of my study estimated about 45 years since the lake was last at col altitude, in other words in 1947. Taking into account likely varying environmental conditions between the sample sites (aspect and size of boulders in particular) which also affect lichen size and hence the estimate of the substrate age, this estimate corresponds quite closely to the recorded lake level history - the lake certainly drained over the col in 1935 and probably during the 1940s too. In undertaking the study, I was not trying to read too deeply into the concepts, assumptions and problems inherent in the techniques involved, but simply to obtain an approximate date for the water level at col altitude from the basic lichenometrical method. The estimate may well have been a little more precise had I studied a greater number of plots, particularly some on the northern lake slopes.

Lake drainage over the col:-

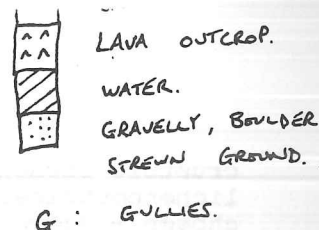
When the lake level was to the altitude of the top strand line, the lake drained to the south by the river Nupsa over the col between Nupsartangi and Eggjar (refer to Fig. 6). About 170m to the south-south-west of the benchmark, a prominent cutting between two lava outcrops can be found (A). This is most likely part of the drainage channel from the lake when it was at col height. Its width here is 22.6m with small blocky lava cliffs on either side about 3.5-4m high. As you follow the channel to the south-west, it begins to widen and turns sharply towards the south where it widens greatly (B). Here its banks, about 4m high on either side, comprise gravel and larger rocks and have numerous dry gullies entering the channel which probably represent small streams after periods of rain. The channel appears to split into two in this section with a rocky "island" inbetween but in times of drainage from the lake, water would probably have covered this "island" completely; at its widest point here it measures 97.8m across. At the end of this section, the channel was full of water up to a bedrock neck from where this part of the channel was draining (C). From here, where the channel now only measures 34m across, the water from the "island" section drains to the south-south-west down a large stream channel across bare rock. About 85m to the south, this stream forms a large pool (D) where another small stream, obviously draining from Eggjar, joins it from the east. From here on, the stream is seen to begin to lose height and grow in size as it winds its way to the south and further streams join it from both the east and west.

As for the sections of the channel already described, the channel to the south looked a lot deeper and larger than would be expected for the size of stream flowing through it, indicating that this is almost certainly the old river bed of the Nupsa.

Water balance of the lake.

The aim of this project was to obtain some rough estimates of some of the major inputs and outputs to the lake water balance system. With the equipment available, the measurable inputs were rainfall (ie. runoff from the surrounding slopes) and glacial rivers, and the measurable outputs were jokulhlaups. Other inputs and outputs include runoff from supraglacial streams on the ice barrier, evaporation from the lake surface, melting of beached and

FIG. 6. Sketch in plan view of the old river bed of the Núpsá at the col between Núpsártangi and Eggjar. (14.8.92. am and 17.8.92. am)

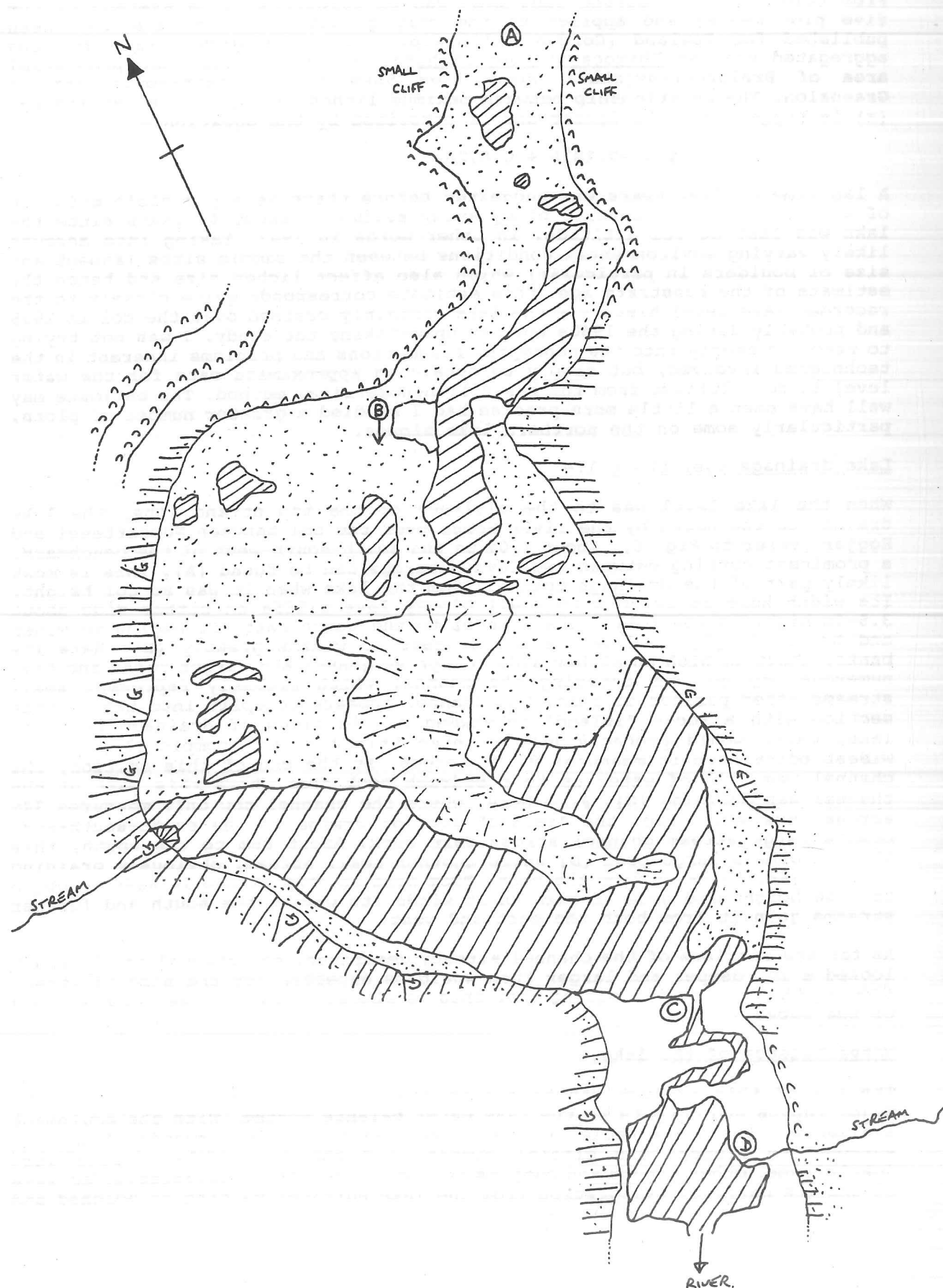


LAVA OUTCROP.

WATER.

GRAVELLY, BOULDER STREWED GROUND.

G : GULLIES.



floating icebergs, and discharge from the drainage route in the south-east corner of the lake where the lake drains to the south alongside Skeidararjokull. Such is the complexity of the water balance system that it is so very difficult to come up with some meaningful figures to complete a water balance equation: some of the variables are almost immeasurable and those that are possible to quantify can often only be afforded very rough estimates. I will therefore seek a more complete interpretation of my results through discussion with the more experienced at a later date. The following inputs and outputs were studied:-

Rainfall input:-

The rainfall input to the system has already been partly dealt with in terms of its relation to the lake level (refer to altitude of the lake surface). Here, a study of two runoff streams from the southern lake slopes will be discussed; the study involved taking hourly depth and velocity measurements during a 24 hour period and then depth measurements every 12 hours during the period 14th to 25th of August inclusive. The two streams, known as stream A and stream B (Figs. 7a and 7b), were the first two streams encountered on walking west from base camp, stream A being the first. For each stream, a 4m section was marked out and a particular point marked where depth readings were to be measured. For both the 24 hour and daily surveys, depth was recorded at this point to the nearest mm; also for the 24 hour survey, ten times were recorded for a small object to float down the 4m section.

The aim of the 24 hour stream survey (1600 hours, 14.8.92. to 1500 hours, 15.8.92.) was to obtain a range of depth and velocity readings from which a graph could be drawn (refer to Figs. 8a and 8b which also include lowflow conditions velocity readings taken on 25.8.92.); this enables velocities to be read from the graphs for given depths taken during the 12 hourly survey, and hence together with the cross sectional area figures (Figs. 7a and 7b), it can be possible to draw up discharge graphs for each stream for the period 14th to 25th of August - this is something I intend to do in the near future with some additional expertise, but to give some idea of the magnitude of inputs from such runoff streams at this stage, the discharge on the 17th of August 1992 was 0.027 m³/sec. and 0.018 m³/sec. for streams A and B respectively.

Glacial river input:-

A brief excursion to the northern lake allowed a little time to study the most northern of the two glacial meltwater rivers from the glacier to the west of Graenalon. A brave attempt by Rupert to survey a cross section of the river gave us a reasonable estimate of the cross sectional area (Fig. 7c). A 24 hour survey of the river, involving taking hourly depth readings at a marker and velocity readings over a 15m section of the river, surprisingly showed little change during the survey period: for example, the depth varied only between 0.12m and 0.16m and this could well be due to the water washing against the pole making the measurements difficult to determine, particularly when taken in the dark. As a result of the negligible changes during the survey period, it is probably only worth giving an estimate here of the likely discharge from this glacial river, particularly in view of the fact that the cross section is not wholly accurate. An estimate of the discharge from this river on the 27th of August 1992 is 5.13 m³/sec.

July 1992 jokulhlaup:-

On our walk in to Graenalon we had met some Icelanders returning from a day walk to the lake who informed us of a jokulhlaup about two weeks previous. On approaching the lake for the first time alongside Skeidararjokull, beached icebergs along the drainage route to the south provided the first evidence of this; on arrival at Graenalon, icebergs up to the size of small houses had been beached on the lake shore, a definite indicator of a recent jokulhlaup. This fortunately gave us the opportunity to measure the height above the lake level of some of the highest beached icebergs so as to get some idea of the lake level prior to this jokulhlaup in early July. Four icebergs were levelled up to giving heights of 15.52m (+/-0.1m), 12.40m (+/-0.08m), 13.76m (+/-0.08m), and 14.27m (+/-0.08m) above the lake level. Bearing in mind that these icebergs would have had the greater proportion of their volume sitting below

17. 8. 92. DEPTH AT MARKER = 0.05 m.
CROSS SECTIONAL AREA \approx 0.0736 m²

FIG. 7a.

CROSS SECTION OF
STREAM A.

17. 8. 92. DEPTH AT MARKER = 0.04 m.
CROSS SECTIONAL AREA \approx 0.0476 m²

FIG. 7b.

CROSS SECTION OF
STREAM B.

27. 8. 92. DEPTH AT MARKER = 0.14 m.
CROSS SECTIONAL AREA \approx 4.475 m²

FIG. 7c.

CROSS SECTION OF
NORTHERN GLACIAL MELT WATER RIVER.

ESTIMATED
DEPTHS.

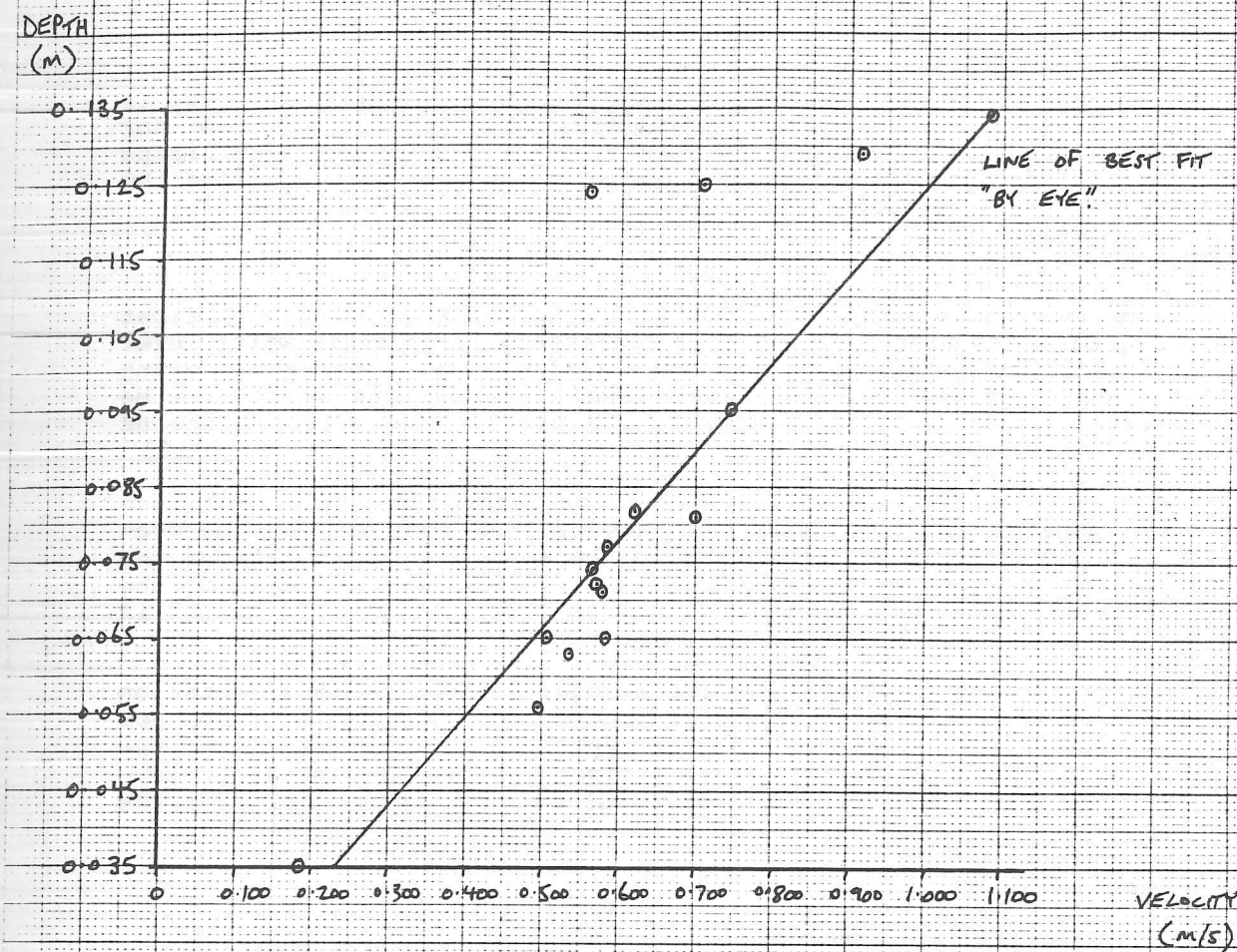


FIG. 8a. DEPTH - VELOCITY GRAPH FOR STREAM A.

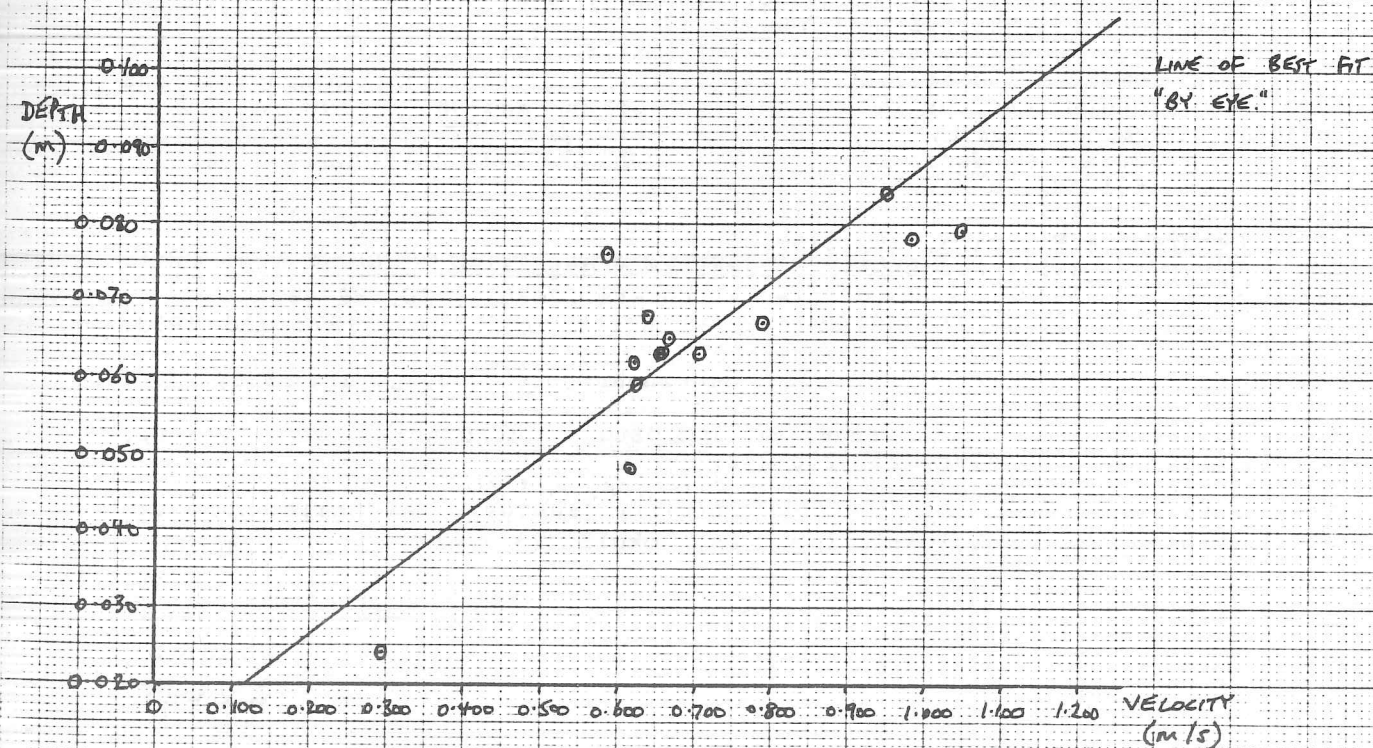


FIG. 8b. DEPTH - VELOCITY GRAPH FOR STREAM B.

the water level, it seems likely that the lake level before the jokulhlaup in early July was in the region of 20m higher than the general altitude for August, a fluctuation figure very similar to that for other jokulhlaups occurring in recent times. The total volume of water that drained from the lake in this jokulhlaup in early July 1992 is estimated as 200.10^6 m^3 .

Concluding remarks.

A profile has been given showing lake altitude below a benchmark first established by Sigurjon Rist in 1951. This represents large scale water level fluctuations. A regular measure of the lake altitude was undertaken during August and identified small scale water level fluctuations which can be related to rainfall and possibly temporary ice dams at the inlet in the SE corner of the lake, where it drains to the south alongside Skeidararjokull.

Strand lines have been mapped onto a second profile: the top strand line corresponds to the water level when the lake drained over the col between Nupsartangi and Eggjar by the river Nupsa to the south. A description of the old river bed of the Nupsa has also been given. Lichenometrical dating of the top strand line suggests the water level to have last been at this height in 1947.

Although this section of the hydrology still requires further interpretation and discussion, some estimates of inputs and outputs to the lake water balance system have been made: discharge from a typical runoff stream from the surrounding rocks - 0.018 to $0.027 \text{ m}^3/\text{sec.}$; discharge from a glacial river - $5.13 \text{ m}^3/\text{sec.}$; and an estimate of the volume of water that drained from the lake in the July 1992 jokulhlaup - 200.10^6 m^3 .

Acknowledgments.

Refer to scientific leader's report.

References.

- Bjornsson, Helgi. 1976: Marginal and Supraglacial lakes in Iceland. *Jokull*, 26, 40-51.
- Bjornsson, Helgi. 1989: The volume of Graenalón and changes in the size and frequency of jokulhlaups. *Jokull*, 39, 90-95.
- Collins, Anna. (Geography undergraduate, Southampton University, 1992) Lichenometrical dissertation on the glacial history of Kviarjokull and Holarjokull (various references inc. Gordon and Sharp, 1983).
- Defense Mapping Agency Hydrographic/Topographic Center, Washington, D.C./Iceland Geodetic Survey. 1990: SKEIDARARJOKULL, ICELAND 1:50,000, Edition 1-DMA, series C761, sheet 2013 II.
- Jewtuchowicz, Stefan. 1973: The present-day marginal zone of Skeidararjokull. *Geographia Polonica*, 26, 115-137.
- Rist, Sigurjon. 1951: MISCELLANEA. Burst from Graenalón. *Jokull*, 1, p.14.
- Rist, Sigurjon. 1970: Annals of glacial bursts. *Jokull*, 20, 88-89.
- Rist, Sigurjon. 1973: Annals of glacial bursts for 1971, 1972 and 1973. *Jokull*, 23, 55-60.
- Rist, Sigurjon. 1990: Water is needed. *Menningarsjodur*, Reykjavik, 1990, 248p.
- Thorarinsson, Sigurdur. 1939: The ice dammed lakes of Iceland, with particular reference to their value as indicators of glacier oscillations. *Geografiska Annaler*, 21, 216-242.
- Thorarinsson, Sigurdur, Saemundsson, Kristjan, and Richard S. Williams, JR. 1973: ERTS-1 Image of Vatnajokull: Analysis of Glaciological, Structural, and Volcanic features. *Jokull*, 23, 7-17.

Mark Cooper.

GEOLOGICAL REPORT

CONTENTS

Introduction to the project
General description of the area
Descriptions of the common units
Field slip notes
Special projects
The Northern lake
Conclusions

INTRODUCTION TO THE PROJECT

In undertaking this project, I was not trying to read deeply into the processes and conditions in which the units were laid down. I undertook the project after my first year at Cambridge University (studying Geology, Physics & Chemistry); and I felt in-depth analysis would be more than my limited geological training could reliably cope with. I have instead concentrated on producing an accurate description of the sequences in the area. In my conclusions, I suggest what I consider to be the most likely genesis, however, I would prefer such conclusions to be left to more experienced, and informed Geologists.

A limitation of the geological mapping project, was the base maps used. The Landmælingar Islands 1:100 000 map of Grænalón was hopelessly inaccurate when blown up to 1:25 000, despite being recently revised. The mapping project was saved by a 1:50 000 map just compiled from Satellite imagery by Orkustofun. We obtained this map a day before we left for the field, so were unable to make any photocopies. The field slip is consequentially of the same scale.

I was able to obtain very little background on the area prior to departure. I do not regard this as a bad thing, as there is less chance of me; 'seeing what I want to see'. I was able to obtain more background on my return from the 1:250 000 Geological map of the area, and from the Natural History Museum in Reykjavik.

At the time of writing this report, I have not consulted any more experienced Geologists about the project. This is something I hope to do in the near future.

All bearing are True. Magnetic variation was taken to be 20° west.

GENERAL DESCRIPTION OF THE AREA

Grænalón is situated at $64^\circ 10' \text{N}$, tucked into the southwest corner of the Vatnajökull Icecap. The topography is rolling mountains to the south of the lake, while to the north of the lake, the terrain is steeper and more heavily ravined. The area is surrounded to the west, north and east by the Icecap. The lake itself was low at the time that I was there (see Hydrology Report), and this led to increased exposures.

The area had little vegetation, and there was consequentially extensive outcropping. There was much greater outcropping lower down (closer to the lake), than on the ridges. The rest of the ground was covered in rock fragments. These rock fragments were predominantly locally derived, however, west of base camp there were fragments of obsidian widely distributed, which came from the glacier to the west of Grænalón.

The geology of the area consists of two major units. A sedimentary unit, which I called Unit 1; and basaltic Lava Flows. There was also considerable intrusive activity in the area. There are several faults which trend SW-NE, and vary in displacement. Less commonly, mineral precipitation has occurred, and there are recent glacial rocks on the sequence. Much of the area is covered by out-wash, and lake deposits.

DESCRIPTION OF THE COMMON UNITS

UNIT 1:-

The sedimentary unit, which I called Unit 1, had me confused for a long time, and even now I am wary of advocating a classification for it. It tended to vary from place to place, but the distinctive feature was the medium to fine grained supporting matrix. Firstly I will give a general description of a 'standard' outcrop, and then go on to describe the differences which occurred.

General Description of a Typical Outcrop:

Structure:

Unit 1 has no original structure, but there is a mild secondary structure near base-camp, consisting of occasional partings trending approximately 060°. The surface weathers a light brown, which is usually prevalent throughout the unit.

Texture:

The Unit is commonly a breccia, with 10% clasts. The clast occurrence can vary from 0% to 50%. The clasts vary from just larger than the matrix (1mm diameter) to 400mm diameter. The mode is about 50mm. The larger clasts only occur in low concentrations. There is little sorting generally, but individual outcrops can be well sorted uni- or bi-modally. The clasts tend to have reasonable sphericity, however they are often fractured into many pieces. Their roundness varies from almost none to total, depending on the outcrop, and the area.

The texture of the clasts is very fine. Some of the larger clasts have chilled margins. Clasts sometimes contain pore-space of 1 or 2mm diameter.

The matrix is the distinguishing feature of Unit 1. It is a medium to fine grained sand. The grains show little sphericity, and even less roundness. They appear to interlock, rather like an igneous rock of similar texture.. It is possible to see cleavage surfaces on the grains under the hand lens. The degree of sorting varies with the area and the outcrop, from high to low.

The fabric of Unit 1 depends on the occurrence of the clasts. When they are not present the Unit appears homogeneous. When clasts do occur, the matrix tends to be less homogeneous. The matrix appears to be very well packed, although I cannot reliably say this without a thin section. The Unit is slightly porous, although the major flow of water through the rock is in the secondary structure.

Composition:

I cannot determine the mineralogy of the clasts. However they are some dark mafic minerals. The matrix composition is also beyond my expertise. The matrix is commonly one third dark mafic minerals, one third off white crystals, and one third crystals which appear light brown. This colour may be their true colour, or more likely, be due to a surface staining.

LAVA FLOWS:-

Structure:

This unit comprises of many individual flows laid down on top of each other. The flows were generally horizontal and of uniform thickness, although in places they were often seen to flow into hollows, or leaves pools on their tops. A typical flow thickness was 3 or 4m, but they could extend to 10m, or down to 1m. Lavas sometimes formed regular polyhedral jointing within the flow. On the Lavas on Eggjar, SE of the lake, the Flows displayed no jointing, and were homogeneous. The jointed polyhedra vary in diameter from 1m to 20cm, and from fairly irregular shapes to almost perfect hexagons.

Texture:

Lava Flows were a grey colour. The majority of the lava was fine grained crystalline, and the crystals were just distinguishable with the hand lens. The Flows also contained varying degrees of pore space. This varied from flow to flow, and from place to place. Flows tended to have the greatest percentage of pore space at their top, whereas the middle would be least porous, and the base only slightly more porous than the middle. Pore space could vary from almost none, up to 30% (values for the middle of the flow). The jointed lavas tended to be less vesicular than the unjointed lavas, which had the greatest percentage of pore-space.

The Lavas occasionally had white phenocrysts. These could make up 10% of the rock, or not be present at all. They were up to 3mm in diameter, but commonly 2mm. They had cleavage surfaces, but I was unable to distinguish any relationship between them, due to their size.

The tops of the Flows proved texturally interesting. Flows tended to exhibit one or more of the following:

The pore space would increase dramatically,

The Flow would become a brick red colour,

The top would become broken up, and infilled with Unit 1,

The top would take on a "whipped cream" textural appearance,

Occasionally, there would be a blackened layer on the Flow boundary. This most often occurred when a flow was in contact with Unit 1.

Composition:

Due to the fine grained nature of the Lava, I was unable to determine its mineralogy. However, I don't think I am being unreasonable to suggest that it is a basaltic Lava, in view of its appearance, and background knowledge. The white phenocrysts are probably plagioclase feldspar.

SOLIFLUCTION:-

Solifluction beds occur between Lava Flows on the north slopes of Eggjar, and amongst Unit 1 in the Northern Lake area. The Eggjar solifluction beds were 40cm to 1m thick, and horizontal. These beds were reasonably well sorted, and consisted of rounded clasts up to 10cm in diameter. The beds were clast supported. The clasts were all basalts, similar to the Lava Flows.

The Northern Lake Solifluction deposits were very different. They were not traceable over any distance, but visibly wedged in and out, becoming several metres thick. They were also much less well sorted. They consisted of blocks up to 1m in diameter. The blocks were of basaltic appearance. I didn't spend sufficient time in this area to say anything more detailed.

INTRUSIONS:-

Intrusive activity varies considerably within the area. Intrusions could be from 5cm to 3m wide, and could be seen to wedge out, or be traced over many hundreds of metres. Typically they were darker than the Lavas. They were fine grained, and without any phenocrysts. Jointing was present normal to the trend of the intrusion. The central region of the larger intrusions was often slightly vesicular (10%).

Intrusions were extremely useful to trace faults, and measure they displacement, as faulting must have taken place after intrusive activity. They was also cross cutting relationships which seem to suggest, that all the intrusive activity took place at roughly the same time.

YELLOW CLAY DEPOSIT:-

The composition, and reason for this deposit still eludes me. The deposit occurred in several places within Unit 1:

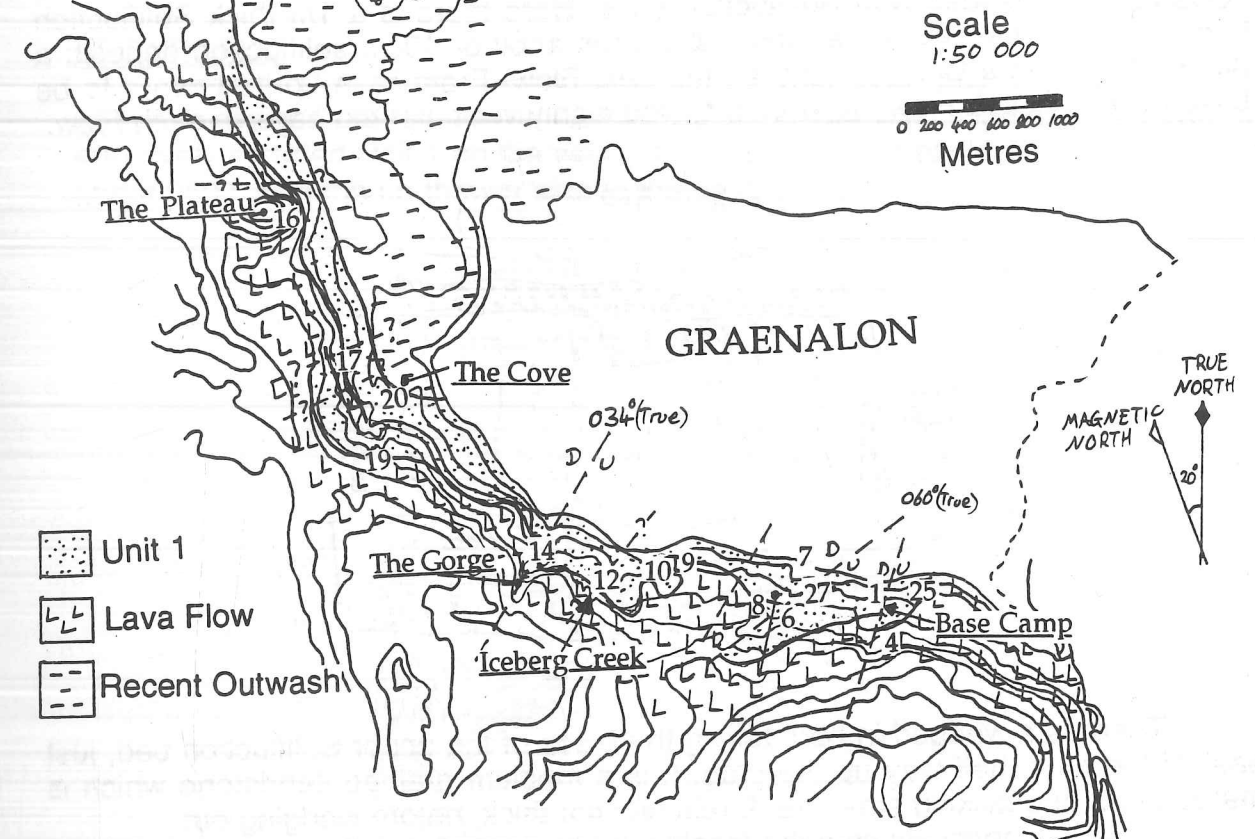
1 - Around large clasts in Survey Gully; the fractures in the clasts, and the surrounding Unit 1 have the deposit. It looks almost like a weathering product.

2 - In the tectonically induced cracks in Unit 1. There is often a film of this deposit, up to 1cm thick. Occasionally it occurs with a white mineral precipitate, like that found in Survey Gully.

3 - In Location 6, the deposit occurs next to an intrusion in Unit 1. The deposit is up to 20cm thick, and has eroded faster than the surroundings to form a small gully. It can be seen from this gully that some minor movement has occurred along the line of the intrusion.

The deposit is a clay like, mud-grade rock. It is creamy yellow. It shows no structure, and is homogeneous. It can be easily scraped up with a knife blade. Its composition is unknown, however, from the localities in which it occurred, I would suggest that it is some kind of alteration product of Unit 1's matrix, possibly deposited by hydrothermal leaching.

GEOLOGICAL FIELD SLIP SOUTH



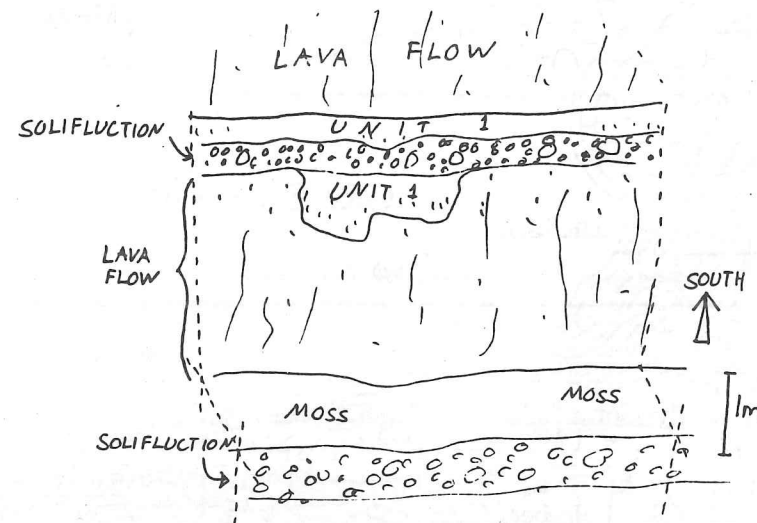
FIELD SLIP NOTES

LOCATION 1:

Unit 1 - Occasional clasts up to 1m, but more commonly 5-10cm. 10% clasts. No bedding. Tendency to form surfaces dip approx. 20° north. Occasional fractures trending 060°.

LOCATION 4:

Lava Flows - The Flows were 2-3m thick. The top metre is 50% pore-space, while the bottom is 20% pore-space. The pores can be up to 10mm diameter. The flows are interbedded with Solifluction beds. Here there is a 1m thick Solifluction bed on Unit 1; followed by a Lava Flow; then another 40cm solifluction deposit; a 30cm of clast free Unit 1; and then the next Flow. From here up it appears to be Lava Flow, on Lava Flow, separated by red highly vesicular top parts to each Flow.



There is a wedged in bed, taking the place of the upper Solifluction bed, just east of the fault, half way up the crag. It is a medium grained sandstone which is maroon red, and lacking structure. It reaches 4m thick, before wedging out.

A FAULT definitely cuts the locality. It lies down the valley, and beds do not correlate across it. There is also a vertical cliff of Unit 1 on the up thrown side. There has been about 25m vertical displacement; any strike-slip component was not measurable. The fault trend was 040°.

LOCATION 6

Here there is a 3m deep gully, about 80m long, and 1.5m wide. Fairly straight, trending 310°. It occurs in Unit 1. In the base of the gully is the Yellow Clay Deposit, and an intrusion. The Yellow Clay must be the reason for the gully has been eroded out. The Unit 1 on the sides of the gully, has a 10cm bed containing more, and larger clasts, whereas Unit 1 here normally has no clasts. This bed can be seen on both sides of the gully, and the beds do not match, indicating that there has been a slight movement on the intrusion. The intrusion can be traced north for 100m.

LOCATION 7

See Special Projects - Survey Gully

LOCATION 8

Recent Glacial Deposit - This lies on the Unit 1/Lava contact, behind a highly polished outcrop of Lava. It contains clasts of up to 10cm diameter, of both Unit 1 and Basalts. It is 35% clasts. The matrix is a grey-black mud.

LOCATION 9

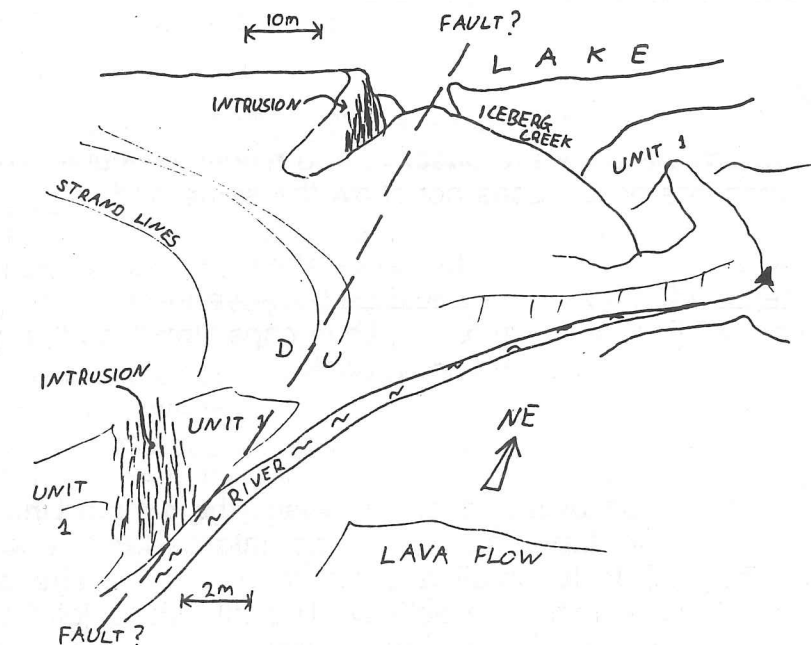
The Lava here is less vesicular, and vertically jointed polyhedra occur.

LOCATION 10

This is the furthest east that Unit 1 is found to overlie a Lava Flow.

LOCATION 12

Iceberg Creek has an intrusion on its west side only. Higher up the hill, above Iceberg Creek, there is jointed Lava on the east side of the river, with massively intruded Unit 1 on the west side. This could be explained by a fault, trend about 050°, with the up-thrown side to the east.

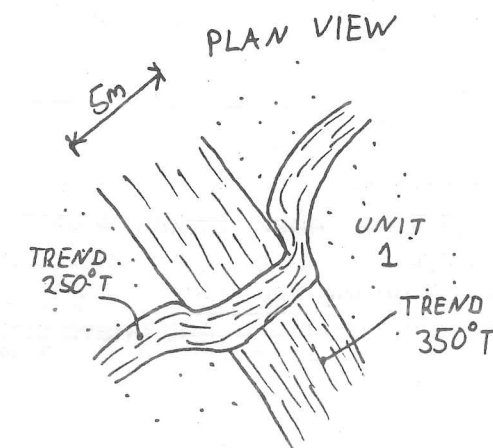


LOCATION 14

There are excellent exposures of Unit 1 low down here. There are also several major intrusions on the west bank. The Unit 1/Lava contact is clearly visible on both sides of the Gorge, and these contacts are at different heights, suggesting a fault, trend 035°, and up-thrown on the east side by about 20m.

The Gorge is several hundred metres long. At the top end, the Lavas appear in 'waves', of wavelength 20m. There is also a layer on the edge of the Flows, which has the appearance of tar, but is as hard as the rest of the Flow.

On the east side of the Gorge, at about 600m altitude, is a spectacular cross-cutting relationship. A 5m wide intrusion must have been cut by a smaller intrusion, while the larger one was still slightly fluid. The small intrusion has been 'washed' 50cm downstream. The smaller intrusion has also been offset by slight movement along the larger intrusion.



LOCATION 16

This knoll is formed entirely from hexagonally jointed Lavas. The outcrops provide spectacular cuts through the swirling lines formed by the jointing. The jointing is predominantly vertical. On the southern cliffs, the pillars are eroded normally, to leave there cross-sections visible. Just north of the main knoll are highly porous Lavas, horizontally interbedded with fine Unit 1 deposits.

Looking more generally at the area from the Icecap, there appears to be another similar feature a couple of kilometres to the northwest of The Plateau. The Plateau does have the appearance of some kind of central complex. Perhaps it was the main pipe bringing the Lavas which formed the landscape.

LOCATION 17

Bedding appears in Unit 1 here, as 30cm beds of fine sand and breccias. The clasts in the breccia beds are basaltic, and highly vesicular. The stream gully in which the exposures occur, does not show the same beds on both sides of the gully.

A couple of small gullies in the area show this same lack of correlation between sedimentary features. This could be because the beds are very localised, or there could be faulting. In Location 17; Lava caps Unit 1 on the north bank, but no such contact can be found on the south bank.

LOCATION 19

In this whole region of the lake, there isn't the simple Unit 1 under Lava relationship. Unit 1 and Lava appear to be interbedded, and not uniform. Unfortunately 1:50 000 is too small a scale to map this. The area is further complicated by extensive extrusive activity. The intrusions joint similarly to the Lavas, and when they are not obviously cross-cutting, they are difficult to distinguish from Lava Flows. Observations of contacts for signs of baking is needed.

LOCATION 20

On the north wall of The Cove, just past the meeting of the two rivers are pillow lavas. They are dark grey and porous, typically of diameter about 70cm. They are surrounded by a black mud grade deposit, exhibiting compositional banding. A further 4m up the sequence, clasts are present.

LOCATION 23

Two outcrops of pillar basalts form the buttresses of a 40m deep corrie. The back of the corrie contains a medium grained black sandstone, containing rounded clasts of basalts and Unit 1 up to 4cm in diameter. This looks similar to the recent glacial deposits from Location 8.

LOCATION 25

Unit 1 has consistently been below the Lava, until it suddenly disappears, and never reappears all the way east, around and down the side of the glacier. The abruptness of the disappearance of Unit 1, makes me suspect faulting, but the fault cannot be traced back up the hill, where the exposures are good. It could be the same fault that appears in Location 4, and I have just wrongly judged the trend.

LOCATION 27

This is an excellent example of a fault-intrusion relationship.

A very prominent intrusion can be traced over 500m. It is 150cm wide, and trend 328°. The middle 40cm are vesicular, with 30% pore space. The intrusion is offset 125cm by a fault, trend 060°. The existence and displacement of the fault is confirmed by to splinter intrusions to the NE. Both intrusions and the fault are almost straight, while the ground is far from flat. Hence these features are vertical, so only the strike-slip component of the fault can be deduced from this relationship.

The fault can be traced north for many hundreds of metres until the Lava Flow contact. Here it is seen to cause a major step in the contact. There must be about 60m vertical movement on the fault.

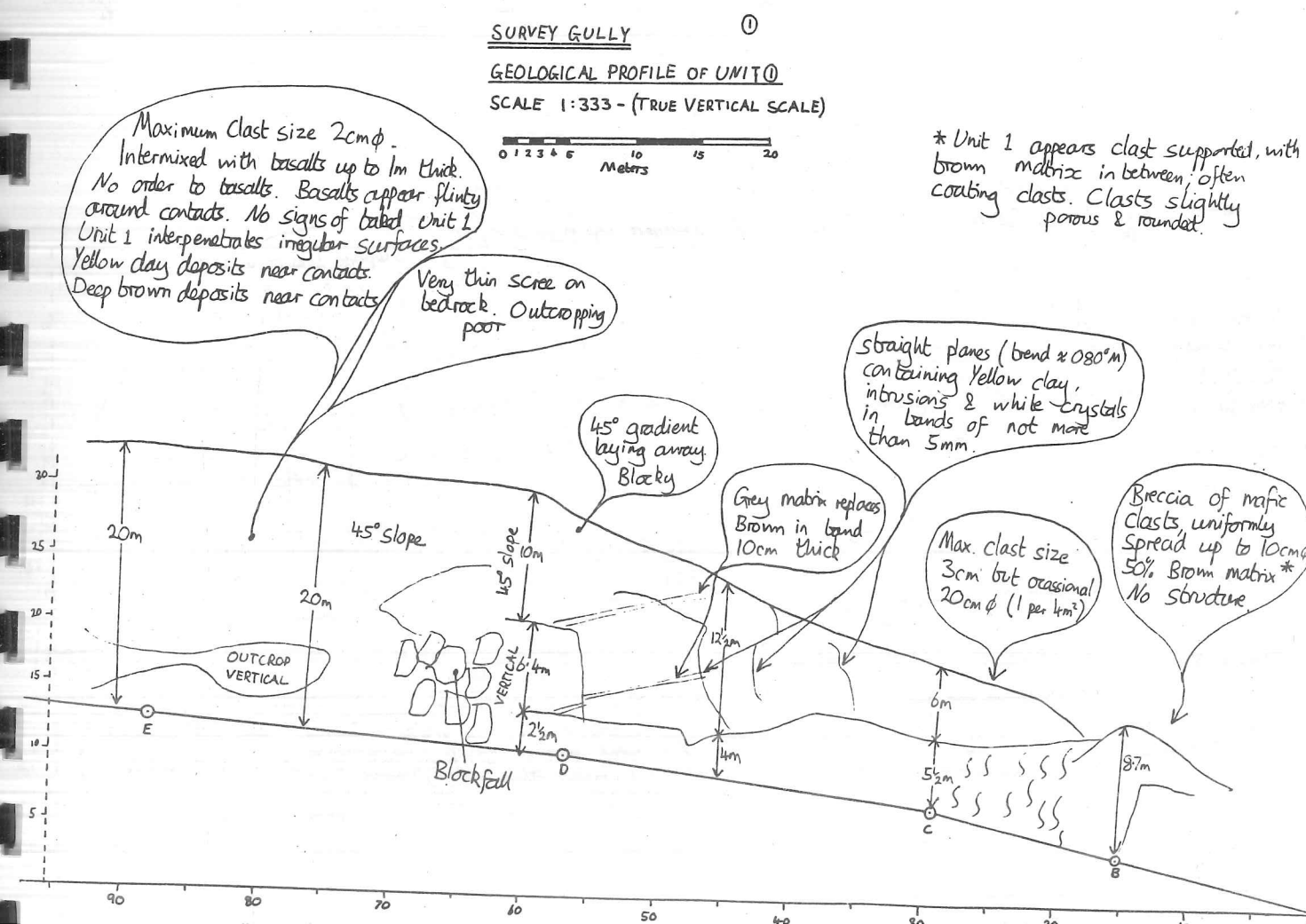
SPECIAL PROJECTS

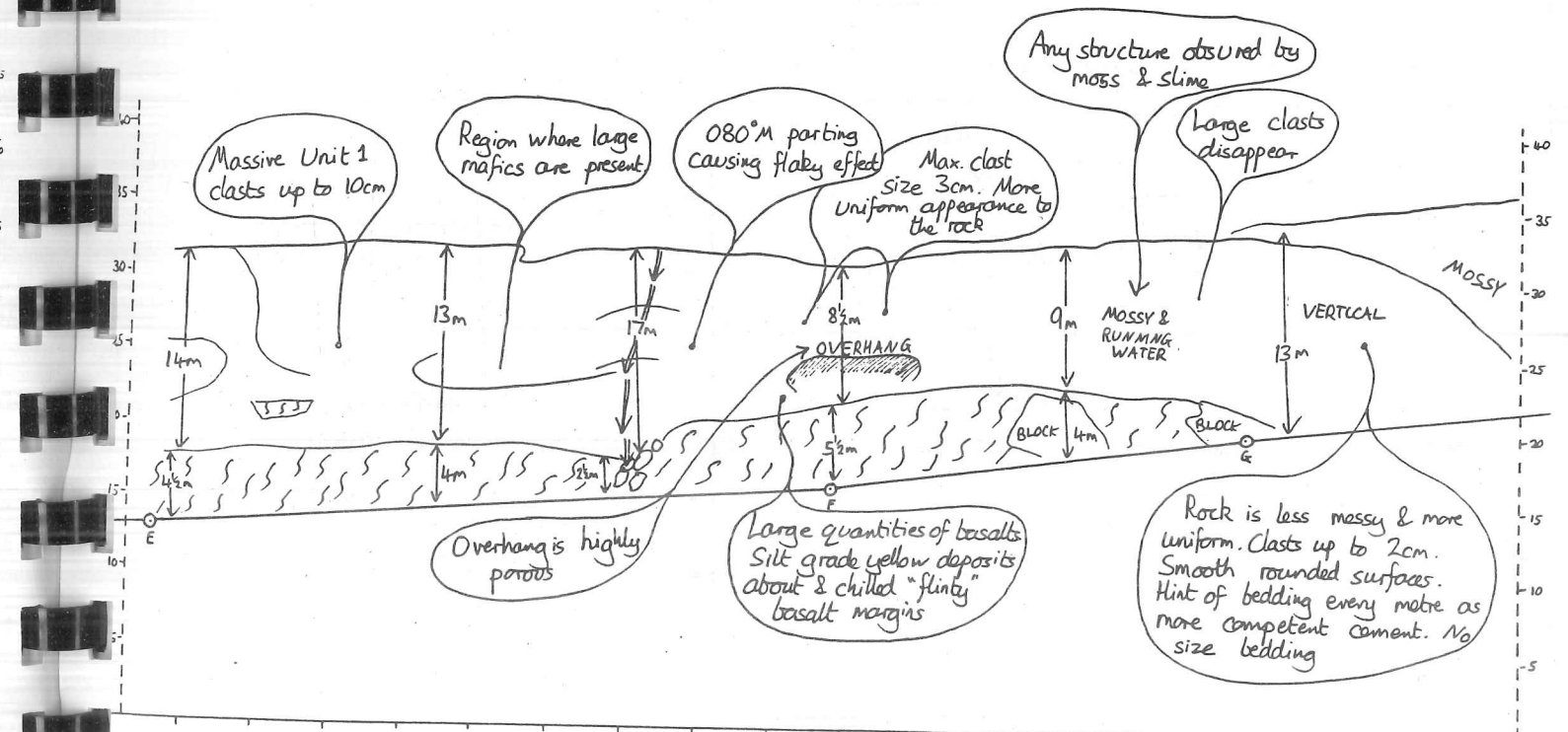
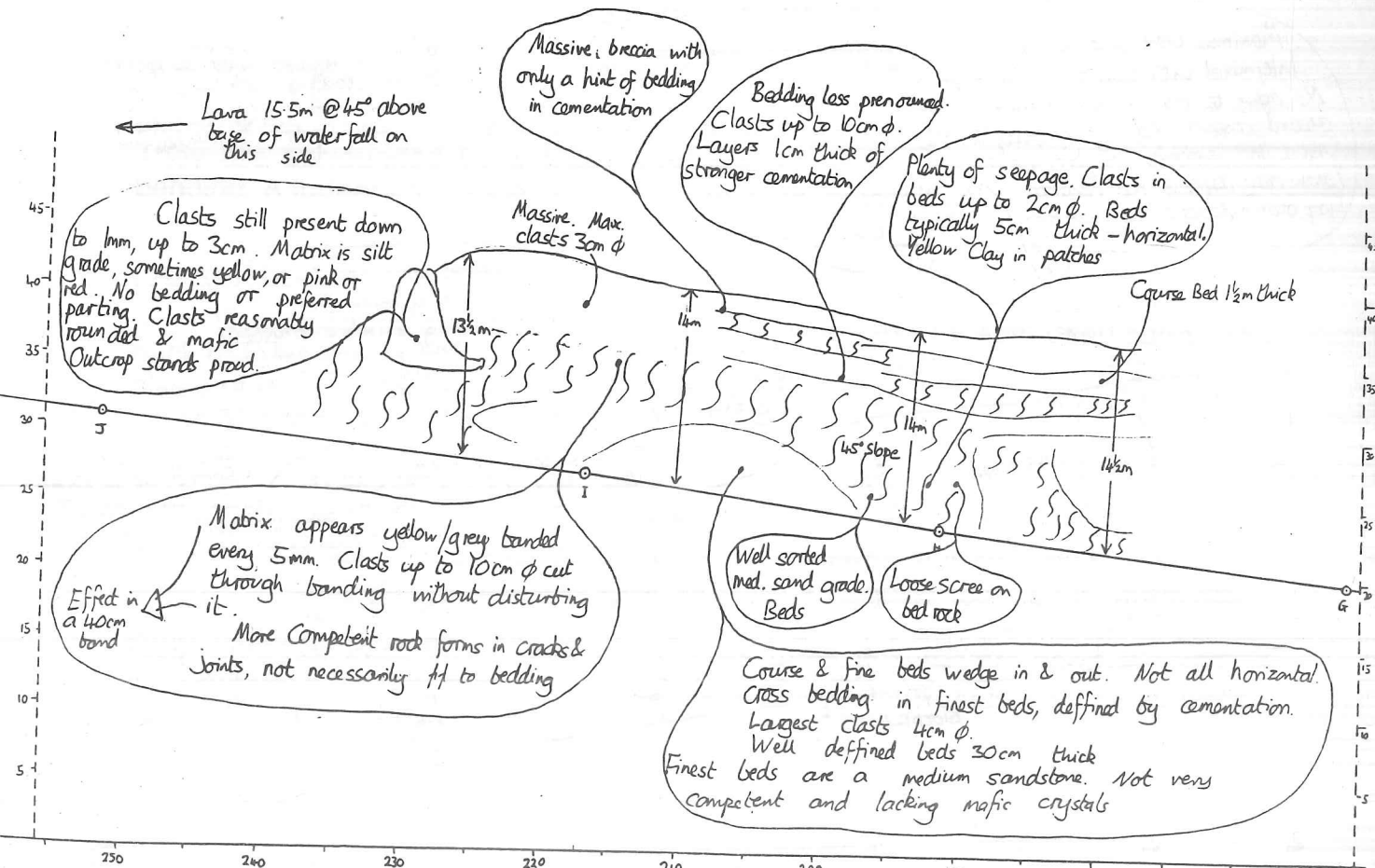
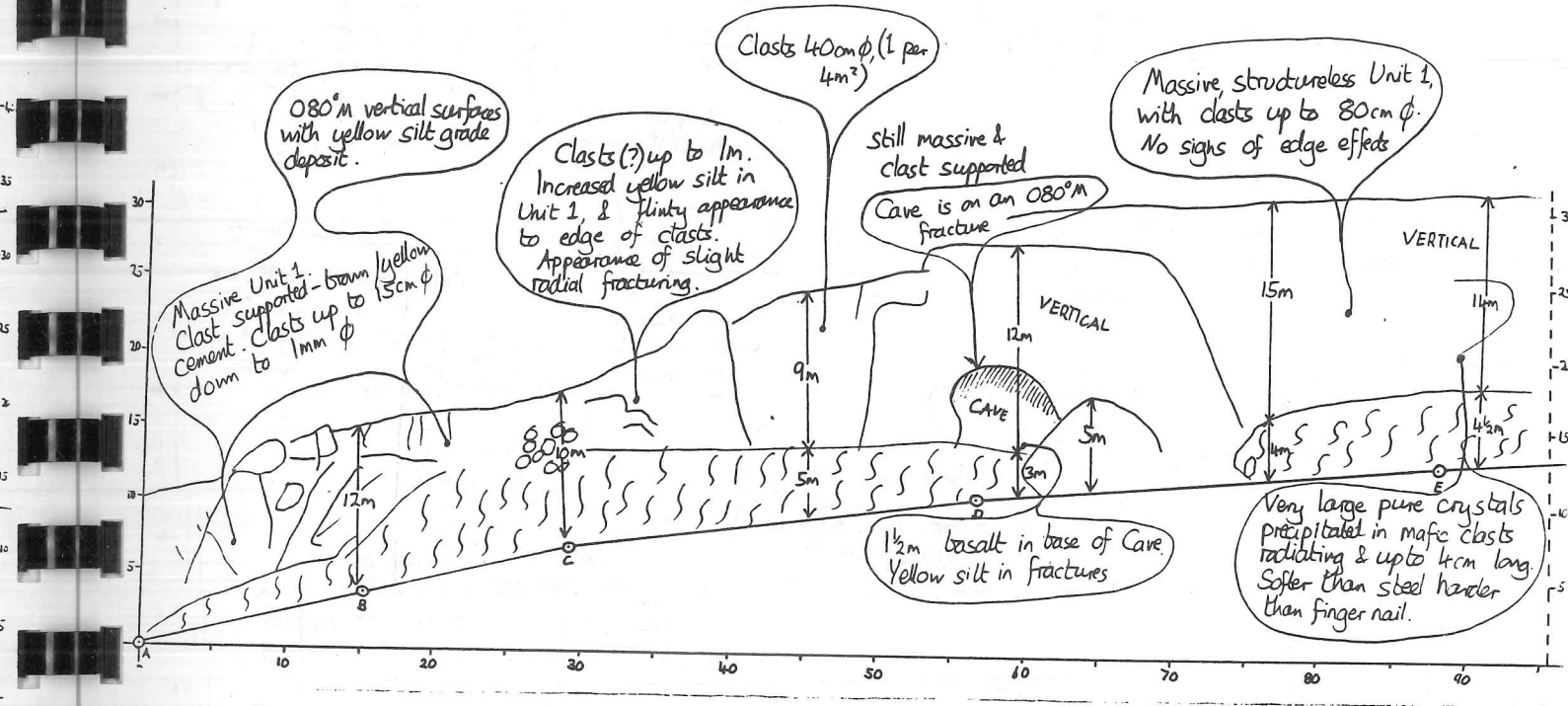
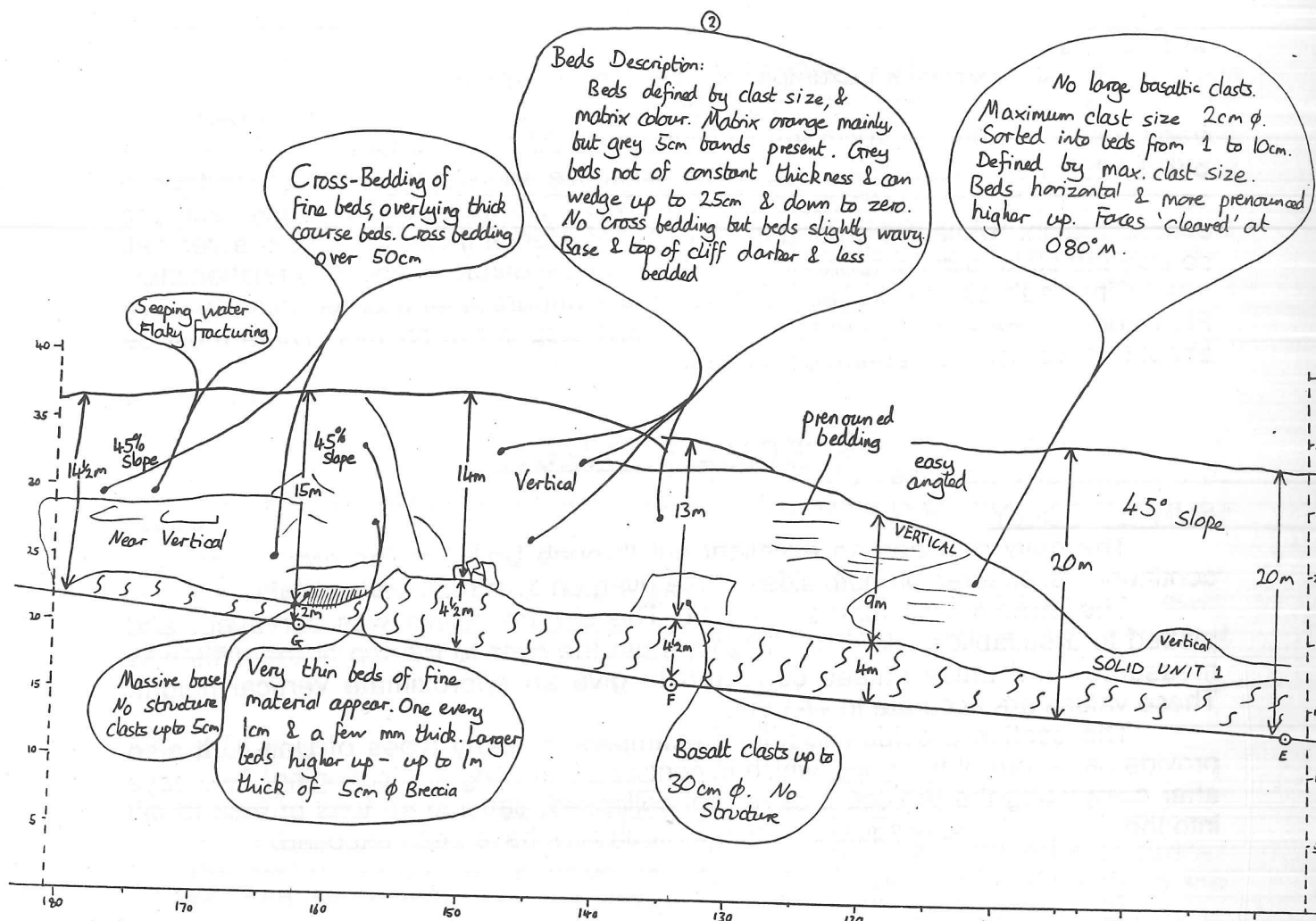
SURVEY GULLY

The gully provides an excellent cut through Unit 1 in the area. There are continuous exposures on both sides of the river, on 10m near vertical cliffs.

The stream was almost straight. The stream profile was surveyed, and plotted to a suitable scale. The distance from the river to the top of the cliffs was measured, and these values corrected to give an approximate vertical height. These values are accurate to ± 1.5 m.

The section provides excellent examples of many types of Unit 1. It also provides a record of the gully, which is continually eroding and changing. Two days after completing the project, a cave roof collapsed, causing 40 tons of rock to fall into the river, and many square metres of fresh rock have been exposed.

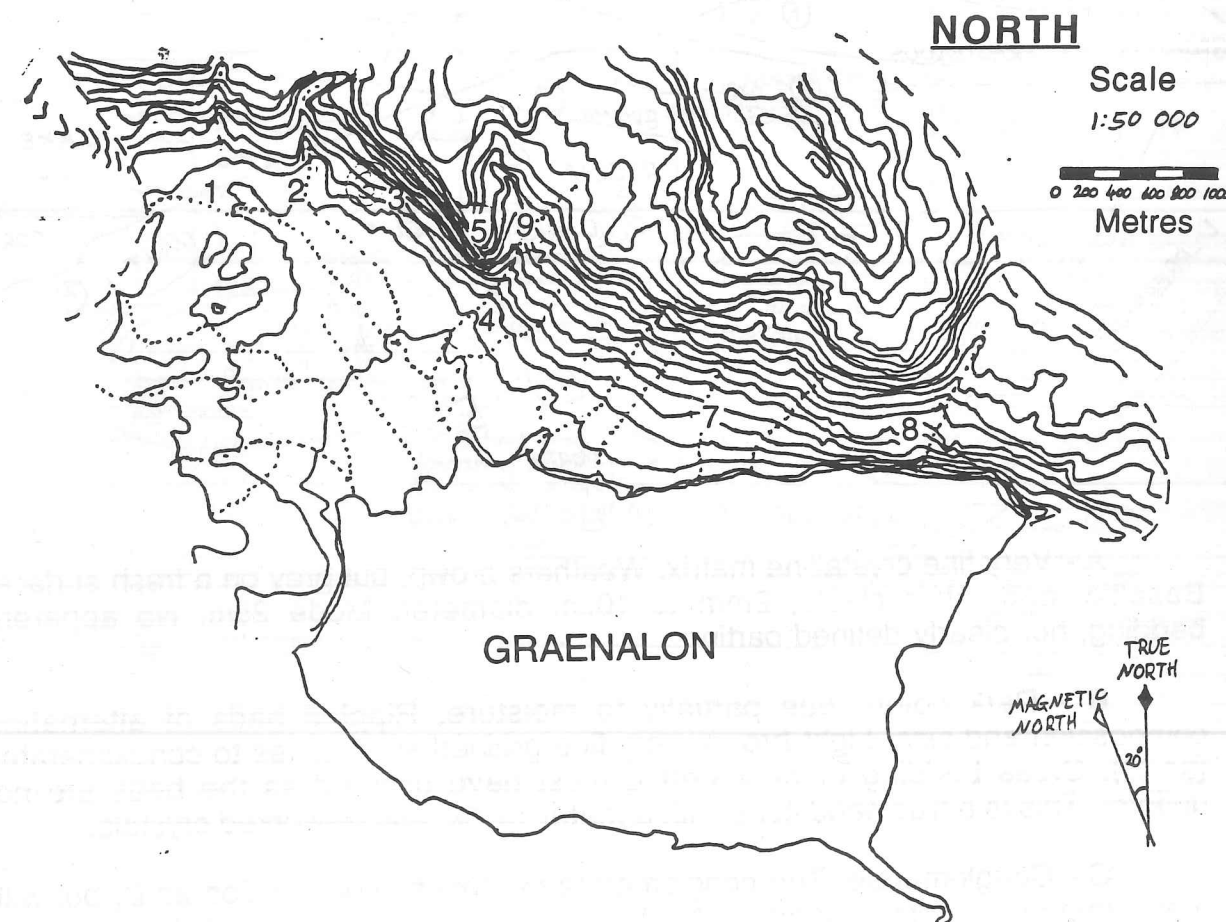




THE NORTHERN LAKE

We spent only one day making a flying visit to the Northern Lake area. The area had many spectacular ravines, providing perfect exposures. I'm sure we only saw a fraction of the interesting features in the area, and it would have been well worth spending more time here.

GEOLOGICAL FIELD SLIP



LOCATION 1

This was standard Unit 1, with occasional basaltic clasts, up to 5cm diameter.

LOCATION 2

A large waterfall has created outcrops 25m high. Hexagonally jointed basalts form 50 % of the out crops, arranged in no preferred orientation. Vertical intrusions 1m wide run through the area. Unit 1 appears between the igneous rocks. There is also a black mud rock in places.

LOCATION 3

These crags were observed from a distance. They appear to be Unit 1, which has bedding defined by bands of greater competence. The SE edge of the ridge is capped by hexagonally jointed igneous rocks. The joints are within 30° of vertical. The capping rocks are about 50m thick.

LOCATION 4

Here a rock capped waterfall is formed by a Lava Flow overlying a black course grained sandstone unit. There is bedding defined by beds of small clastic material, and more competent matrix. This deposit lies on Unit 1, which here contains 10% rounded clasts, up to 5cm in diameter, which are evenly spread throughout the matrix.

LOCATION 7

All round this side of the Lake, there doesn't seem to be the simple relationships found in the Southern Lake area. Unit 1 and Lavas both occur, as well as occasional Solifluction and black sandstone deposits.

From Location 8, we ascended Grænafjall. We walked off the mixed Lava/Unit 1 sequences of the lower slopes, and into Unit 1 alone. This persisted all the way to the summit (which was capped by 10m of Lava). Here Unit 1 clasts were typically vesicular, up to 20cm diameter, and formed 10% of the Unit.

We descended Grænafjall to the SW. Unit 1 was the only rock present, until we reached Location 9.

LOCATION 9

There are 60m deep gorges here, which provide a perfect slice through the local sequences. They show black course sandstone beds, with considerable cross bedding, (similar to sub-aqueous deposits now revealed on the nearby out-wash plain, due to the low lake level). Unit 1 conglomerates and breccias were present, with varying clast sizes, and sometimes the clasts appear to be graded. Large boulders lie in the sequence in places, of diameter up to 150cm. Towards the top of the gorge's cliffs, lavas and intrusions appear.

Unfortunately access to the gorge floor is not possible without an abseil. The area is especially recommended for further study, despite the difficulties of access.

CONCLUSIONS

My conclusions for the formation of the area come mainly from a model in the Natural History Museum in Reykjavik. It seems to describe the sequences observed, although it is very simplified. As I have very little experience in hypothesizing the formation of sequences, I would like to leave this to a more experienced Geologist. I could put forward many hypothesis for many parts of the lake, but I don't think they are necessary.

On the 1:250 000 Geological map, it describes the area as:

" Basic & Intermediate extrusive rocks, with intercalated sediments. Upper Pliocene & Lower Pleistocene, 0.7 to 3.1 my."

From the Museum I managed to identify many of the rocks, with a high degree of certainty.

The basalts found containing white phenocrysts, are called "Poleit". The white phenocrysts being Plagioclase.

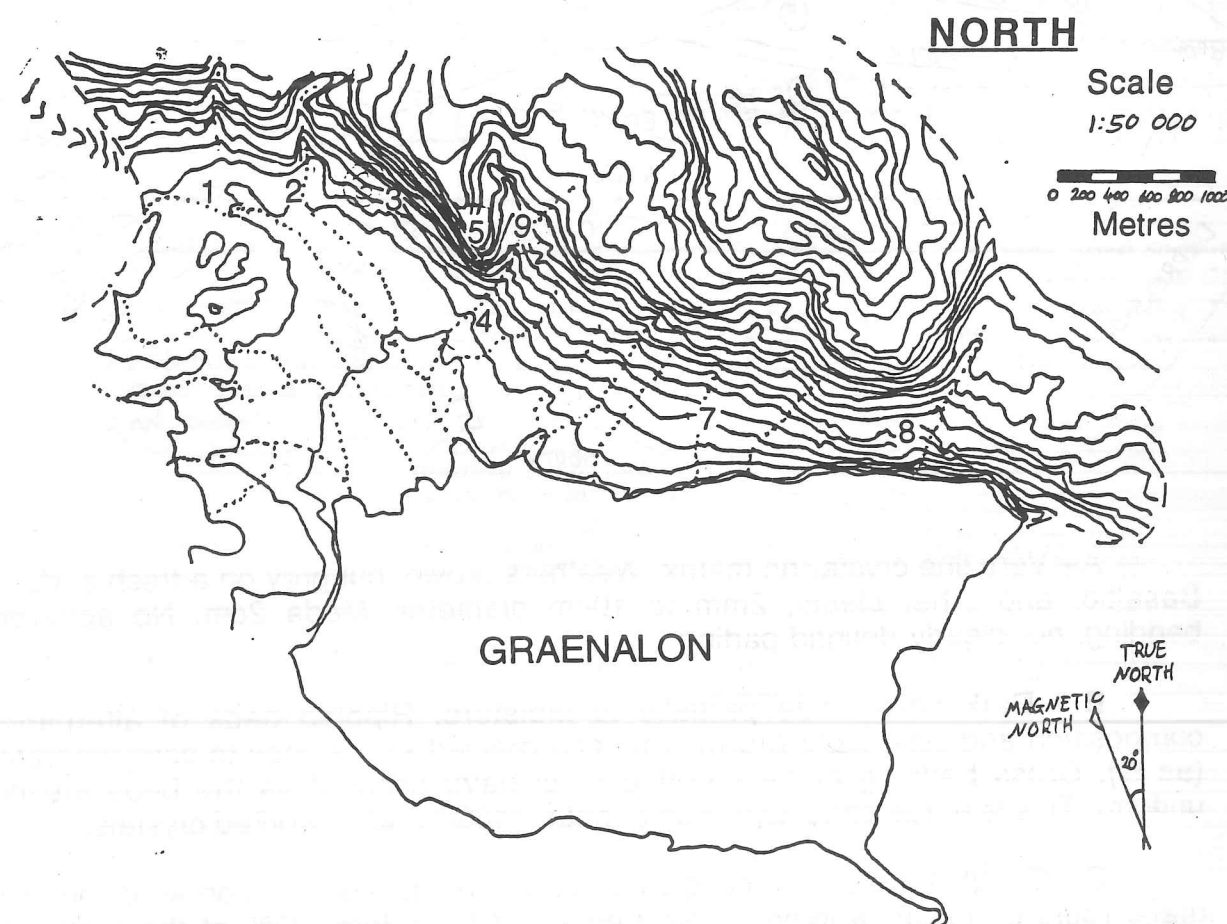
The white mineral found in Survey Gully is Aragonite, and a sample does fizz under weak acid.

Unit 1 covered several rock types, and perhaps a future study could map these separately.

THE NORTHERN LAKE

We spent only one day making a flying visit to the Northern Lake area. The area had many spectacular ravines, providing perfect exposures. I'm sure we only saw a fraction of the interesting features in the area, and it would have been well worth spending more time here.

GEOLOGICAL FIELD SLIP



LOCATION 1

This was standard Unit 1, with occasional basaltic clasts, up to 5cm diameter.

LOCATION 2

A large waterfall has created outcrops 25m high. Hexagonally jointed basalts form 50 % of the out crops, arranged in no preferred orientation. Vertical intrusions 1m wide run through the area. Unit 1 appears between the igneous rocks. There is also a black mud rock in places.

LOCATION 3

These crags were observed from a distance. They appear to be Unit 1, which has bedding defined by bands of greater competence. The SE edge of the ridge is capped by hexagonally jointed igneous rocks. The joints are within 30° of vertical. The capping rocks are about 50m thick.

LOCATION 4

Here a rock capped waterfall is formed by a Lava Flow overlying a black course grained sandstone unit. There is bedding defined by beds of small clastic material, and more competent matrix. This deposit lies on Unit 1, which here contains 10% rounded clasts, up to 5cm in diameter, which are evenly spread throughout the matrix.

LOCATION 7

All round this side of the Lake, there doesn't seem to be the simple relationships found in the Southern Lake area. Unit 1 and Lavas both occur, as well as occasional Solifluction and black sandstone deposits.

From Location 8, we ascended Grænafjall. We walked off the mixed Lava/Unit 1 sequences of the lower slopes, and into Unit 1 alone. This persisted all the way to the summit (which was capped by 10m of Lava). Here Unit 1 clasts were typically vesicular, up to 20cm diameter, and formed 10% of the Unit.

We descended Grænafjall to the SW. Unit 1 was the only rock present, until we reached Location 9.

LOCATION 9

There are 60m deep gorges here, which provide a perfect slice through the local sequences. They show black course sandstone beds, with considerable cross bedding, (similar to sub-aqueous deposits now revealed on the nearby out-wash plain, due to the low lake level). Unit 1 conglomerates and breccias were present, with varying clast sizes, and sometimes the clasts appear to be graded. Large boulders lie in the sequence in places, of diameter up to 150cm. Towards the top of the gorge's cliffs, lavas and intrusions appear.

Unfortunately access to the gorge floor is not possible without an abseil. The area is especially recommended for further study, despite the difficulties of access.

CONCLUSIONS

My conclusions for the formation of the area come mainly from a model in the Natural History Museum in Reykjavik. It seems to describe the sequences observed, although it is very simplified. As I have very little experience in hypothesizing the formation of sequences, I would like to leave this to a more experienced Geologist. I could put forward many hypothesis for many parts of the lake, but I don't think they are necessary.

On the 1:250 000 Geological map, it describes the area as:

" Basic & Intermediate extrusive rocks, with intercalated sediments. Upper Pliocene & Lower Pleistocene, 0.7 to 3.1 my."

From the Museum I managed to identify many of the rocks, with a high degree of certainty.

The basalts found containing white phenocrysts, are called "Poleit". The white phenocrysts being Plagioclase.

The white mineral found in Survey Gully is Aragonite, and a sample does fizz under weak acid.

Unit 1 covered several rock types, and perhaps a future study could map these separately.

The homogeneous yellow sandstone type of Unit 1 is a "Tuffucious Hyaloclastite".

The rest of Unit 1 can either be classed as "Hyaloclastic Breccia" or "Hyaloclastic Conglomerate".

The recent glacial deposits were probably laid down during the last Glacial. The last Glacial started 80 000 years ago, reaching its maximum extent 12 000 years ago. At that time, Vatnajökull ice covered most of the island, reaching as far as Reykjavik. The Glacial was brought to a halt 10 000 years ago by a warming.

The obsidian fragments found on the ground came from the glacial moraines of the western Grænalón glacier. These must have come from the region of Palsfjall, and Giervort. These are both obsidian outcrops. The obsidian is said to be rhyolitic. Nibba is marked as acidic volcanic; and the Lava Flow in the valley to the west is marked as post-glacial, and basic.

The model for the formation of the area fits very well. It assumes the area to be mainly under ice at the time of formation.

Initially a rising pipe of hot magma would melt the base of the ice, forming a lake, into which pillow lavas would be extruded. There would then have been a period of little activity, during which time sediments would be deposited. Then renewed igneous activity would extrude more lavas. Lakes would form in the ice, so that sub-aqueous sediments would be deposited along with the lavas. These would contain basic clasts, eroded from the nearby lavas. As the sequence builds up, intrusions would force their way through the rocks from the central pipe.

In the model in the Museum, it suggests that Hyaloclastic Breccias are laid down nearer the central igneous source, while Tuffucious Hyaloclastites are laid down further away.

This model ties in very well with my observations. There are pillow lavas found near the bottom of the sequence, (Location 20). Then follows hyaloclastic breccias (Location 24), and Tuffucious Hyaloclastites (Location 7); followed by extrusive lavas. The predominantly vertical intrusive activity also seems to fit the model. There are even a couple of places which could have been the Central Igneous Vent (Location 16).

Following the deposition, there then followed a time of crustal stress, when faulting was induced in a SW-NE direction, and causing vertical faults of predominantly dip-slip movement.

Stephen Fisher.

MAPPING REPORT

OVERVIEW

We aimed to map the ground in the immediate area of the SE corner of the lake. This map can be used in combination with past ice positions, and lake levels to determine when, if ever, the lake was draining over the rock barrier in this corner of the lake. This mapping is only possible due to the low lake level in August 1992.

The ground was either bed-rock, or Solifluction deposits. The bed-rock was glacially polished. The lake lay in the NE of the area, and its drainage river was running down the east edge of the map. On the other side of the river stood 50m vertical ice cliffs. These were collapsing at a rate of two major falls a day. To be caught in the path of a fall would have been fatal. Consequentially we spent as little time as possible close to the river banks. This means that useful information may have been missed out in this part of the map.

MAPPING PROCEDURE

It took a couple of days to work out an accurate mapping procedure. No one had any experience of mapping before. We were further handicapped by our equipment. We have a Quick Set Level, a tripod, a 4m graduated pole, and two 30m tape measures.

STAGE ONE:

Having decided on the area we were to map, we divided it into two sections. In each section, we established a series of Control Stations. These were placed so as to be at approximately the same level (in the southern area this was not possible). They were also placed so as to give as wide a spread of angles between them as was possible. The positions of these stations were all established relative to each other by triangulation.

The scale was defined by establishing a base line along as flat a surface as possible, and plotting the two end points which are a known distance apart.

Hence, we set up a framework of points around the mapping area, as accurately as we were able to.

STAGE TWO

We established several "Cairn Ladders". We defined the lake level on the ---- August as our 0m Bench Mark. Using the Level, we established a series of cairns at 2.5m vertical intervals. These cairns were in a straight line. The highest and lowest cairn's positions were established. The distance between each cairn was also measured, hence the Cairn Ladder could be plotted on the map.

In the Southern area, the procedure was slightly different due to the ground not being as uniform. We established height cairns near every "Location" (see STAGE THREE), so the height of the Level at each Location could be found.

The homogeneous yellow sandstone type of Unit 1 is a "Tuffucious Hyaloclastite".

The rest of Unit 1 can either be classed as "Hyaloclastic Breccia" or "Hyaloclastic Conglomerate".

The recent glacial deposits were probably laid down during the last Glacial. The last Glacial started 80 000 years ago, reaching its maximum extent 12 000 years ago. At that time, Vatnajökull ice covered most of the island, reaching as far as Reykjavik. The Glacial was brought to a halt 10 000 years ago by a warming.

The obsidian fragments found on the ground came from the glacial moraines of the western Grænalón glacier. These must have come from the region of Palsfjall, and Giervort. These are both obsidian outcrops. The obsidian is said to be rhyolitic. Nibba is marked as acidic volcanic; and the Lava Flow in the valley to the west is marked as post-glacial, and basic.

The model for the formation of the area fits very well. It assumes the area to be mainly under ice at the time of formation.

Initially a rising pipe of hot magma would melt the base of the ice, forming a lake, into which pillow lavas would be extruded. There would then have been a period of little activity, during which time sediments would be deposited. Then renewed igneous activity would extrude more lavas. Lakes would form in the ice, so that sub-aqueous sediments would be deposited along with the lavas. These would contain basic clasts, eroded from the nearby lavas. As the sequence builds up, intrusions would force their way through the rocks from the central pipe.

In the model in the Museum, it suggests that Hyaloclastic Breccias are laid down nearer the central igneous source, while Tuffucious Hyaloclastites are laid down further away.

This model ties in very well with my observations. There are pillow lavas found near the bottom of the sequence, (Location 20). Then follows hyaloclastic breccias (Location 24), and Tuffucious Hyaloclastites (Location 7); followed by extrusive lavas. The predominantly vertical intrusive activity also seems to fit the model. There are even a couple of places which could have been the Central Igneous Vent (Location 16).

Following the deposition, there then followed a time of crustal stress, when faulting was induced in a SW-NE direction, and causing vertical faults of predominantly dip-slip movement.

Stephen Fisher.

MAPPING REPORT

OVERVIEW

We aimed to map the ground in the immediate area of the SE corner of the lake. This map can be used in combination with past ice positions, and lake levels to determine when, if ever, the lake was draining over the rock barrier in this corner of the lake. This mapping is only possible due to the low lake level in August 1992.

The ground was either bed-rock, or Solifluction deposits. The bed-rock was glacially polished. The lake lay in the NE of the area, and its drainage river was running down the east edge of the map. On the other side of the river stood 50m vertical ice cliffs. These were collapsing at a rate of two major falls a day. To be caught in the path of a fall would have been fatal. Consequentially we spent as little time as possible close to the river banks. This means that useful information may have been missed out in this part of the map.

MAPPING PROCEDURE

It took a couple of days to work out an accurate mapping procedure. No one had any experience of mapping before. We were further handicapped by our equipment. We have a Quick Set Level, a tripod, a 4m graduated pole, and two 30m tape measures.

STAGE ONE:

Having decided on the area we were to map, we divided it into two sections. In each section, we established a series of Control Stations. These were placed so as to be at approximately the same level (in the southern area this was not possible). They were also placed so as to give as wide a spread of angles between them as was possible. The positions of these stations were all established relative to each other by triangulation.

The scale was defined by establishing a base line along as flat a surface as possible, and plotting the two end points which are a known distance apart.

Hence, we set up a framework of points around the mapping area, as accurately as we were able to.

STAGE TWO

We established several "Cairn Ladders". We defined the lake level on the ---- August as our 0m Bench Mark. Using the Level, we established a series of cairns at 2.5m vertical intervals. These cairns were in a straight line. The highest and lowest cairn's positions were established. The distance between each cairn was also measured, hence the Cairn Ladder could be plotted on the map.

In the Southern area, the procedure was slightly different due to the ground not being as uniform. We established height cairns near every "Location" (see STAGE THREE), so the height of the Level at each Location could be found.

STAGE THREE

We established Locations throughout the area. These were supposed to form a series of known positions, so that no part of the map was more than 40m away from any location. The positions of these Locations were found by taking three relative angles at the Control Stations. Once the positions were established, each cairn was visited in turn. The Level was set up, and a sighting taken on to a cairn of known height. Hence the height of the Level was determined. Then using the 4m pole, two contours could be located. When a position of a contour was discovered, the angle from that point to another known position was noted, along with the distance from the Location to the position in question. This form of dead-reckoning was performed from each Location, and hence the position of each contour could be established.

This technique was also used to establish the position of other features, such as spot heights, the ice margin, pond positions, and rivers.

ERROR ANALYSIS

The Level was capable of measuring angles to an accuracy of $\pm 1^\circ$, providing all the points in question were in a plane. This was not always possible, especially in the southern area, and then the position of a cairn had to be judged as much as measured. This could have led to an error of $\pm 3^\circ$.

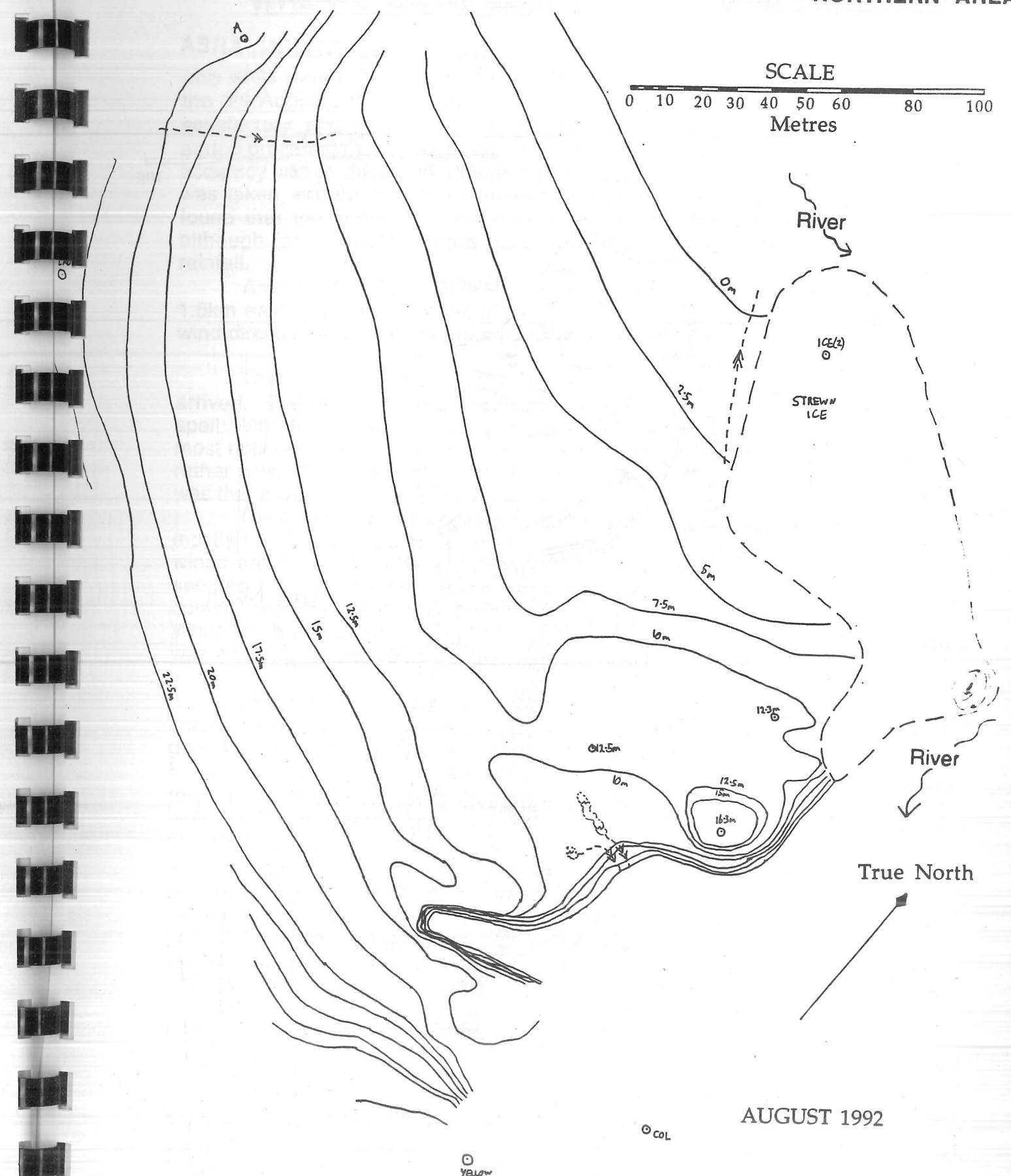
I estimate the accuracy of the position of "End" with respect to "A", eg the maximum possible distortion on the map to be within 9m. In reality, dead reckoning from "Yellow" to "End" produced an error of 3m.

When positioning a Location, the error triangles were typically only a couple of metres across. If they were any greater than 5m across, then the readings were repeated. The dead-reckoning from the cairns was measured to the nearest metre. The angles were also accurate to $\pm 1^\circ$. This was more than enough accuracy, as errors in levelling rendered increased accuracy useless.

The main source of error, appeared to be the ability to use the Level to establish heights accurately. By cross checking several Cairn Ladders, we realise there was an error of ± 3 cm vertically on every sighting. As Cairn Ladders often require 10 sightings, this led to a major source of error. However on most of the ground below the 15m contour, a ± 30 cm vertical error would produce a 2m error circle, and on the steeper ground above the 15m contour, the error radius would only be 0.5m. Hence the contours are positioned to a reasonable degree of accuracy. The lower contours being the more accurate than the higher ones, and the accuracy depending considerably on the steepness of the ground. For example, on the cliffs in the Southern area, the contours are accurate to less than 1m (horizontally), while on the flat SW part on the Southern area, the contours may only be accurate to 10m (horizontally).

SOUTH EASTERN GRAENALON LAKE-ICE MARGIN SURVEY

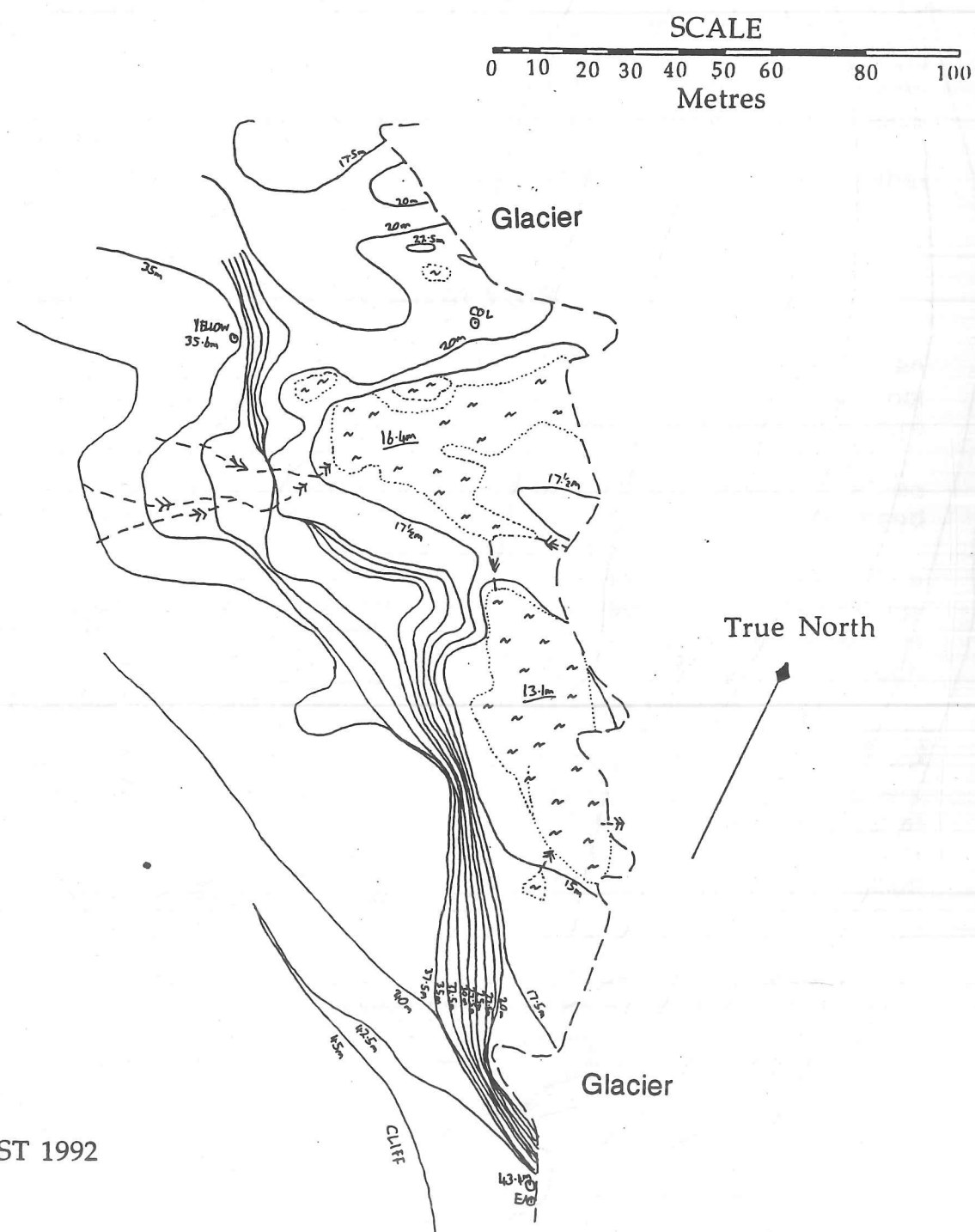
NORTHERN AREA



AUGUST 1992

SOUTH EAST GRAENALON LAKE-ICE MARGIN SURVEY

SOUTHERN AREA



Stephen Fisher

METEOROLOGICAL REPORT

The Meteorological survey was not a continuous project, rather were taken only while were in base camp, from a fixed point. For the first four days (31st July to the 3rd August), the readings were taken every 24 hours. This however was unsatisfactory, and from the 13th August to the 25th, readings were every 12hrs. An added precaution was taken from the 16th August regarding the spring balance. Its accuracy was in doubt, so a measurement of the depth of the rainfall in the gauge was taken, we could then determine the margin of error, back in England. It was found that the spring balance gave weights on a more-or-less arbitrary basis, although larger weights were generally accurate due to the larger amount of rainfall.

An added variation was that from the 29th to 31st of August was moved 1.5km east to the edge of the glacier. This would not effect rainfall readings, but wind direction and temperature may have varied.

The general weather pattern was in a general decline from the day we arrived. The temperature dropped from 10.5°C to 2°C with the occasional warm spell. With this change came ever increasing cloud cover, and stronger winds. The most noticeable element of the weather - the rain - did not seem to follow a course, rather when it rained, it did so for as long as it liked! The only common constraint was that it was for never less than 50 hours!

The reason for this I believed - at the time - to be the changing seasons, but mostly I felt it was local conditions, effected by the glacier and the sea. The strong winds are believed to be katabatic/anabatic - and the changes in its direction seemed to bear this out. The mists and low cloud I believed to be cold fronts coming over the coast, condensing, and moving up the glacier aided by the wind. While these processes may have been happening, we found a much larger system was effecting Iceland. This weather was not local.

On the 4th September we visited the Meteorological Station in Reykjavik and examined their charts covering the time of our visit. We found that the first week of good weather was due to a High Pressure ridge which extended north from Europe. This gave way to a Greenland high pressure system, which was generally responsible for the rest of the 'stable' weather. From the 6th August, this dominant high pressure became a ridge extending down from Greenland and remained until 9th of that month. However Low Pressures tracking west to the south of Iceland brought cloud and rain - the first front crossed the Vatnajokull at 1300hrs, and they kept coming. From hence on the general pattern was a series of low pressures moving from Greenland and Newfoundland crossing Iceland, bringing clouds and rain. Occasionally occluded fronts or warm fronts prevented the rain, saving us from the worst down pores. It seemed that the entire Northern Atlantic was under one anti-cyclone of one sort or another. England was under Low pressure for much of the summer. Indeed nowhere seemed to be having the good summer we had all expected of Arctic summers of recent years.

The rain was not our only enemy. From the 20th August, the wind picked up dramatically, coming down the ice, (an easterly direction) in the evenings, while in the mornings, it seemed to come up the valleys (from the south of base camp). Apparently classic katabatic/anabatic winds it is evident that the 'squashing' of the isobars by the low pressures caused the 50/60 knot winds (on the 23rd and 28th August).

Base camp Met. Observations:

Date	Temp (°C)	Rainfall (gms)	Humidity (%)	Wind Direction/Strength
31:7:92	10.5	0	75	SE light
1:8:92	9.3	10	54	SW light
2:8:92	9.5	0	76	SW light
3:8:92	6.7	0	76	E very light
13:8:92	9.0	45	76	W light
14:8 am	7.2	50	65	W light
pm		240	31	W light
15:8 am	7.8	160	64	Calm
pm	5.5	165	86	Calm
16:8 am	7.1	315	86	Calm
pm	5.1	180	85	Calm
17:8 am	9.9	115	86	E strong
pm	6.1	10	76	E strong
18:8 am	6.3	0	67	Calm
pm	4.6	55	66	E strong
19:8 am	9.8	60	86	E light
pm	5.4	90	86	E light
20:8 am	8.7	115	67	E strong
pm	3.3	0	79	E very strong
21:8 am	5.5	310	93	SE strong
pm	5.0	275	86	SE light & gusty
22:8 am	3.8	65	73	E strong & gusty
pm	4.7	0	73	S very strong
23:8 am	7.9	0	63	E strong & gusty
pm	5.3	0	87	E strong
24:8 am	6.5	0	61	E strong
pm	6.2	0	80	E strong
25:8 am	6.4	0	87	E strong
29:8 pm	3.7	0	42	N strong & gusty
30:8 am	11.4	0	60	N strong
pm	2.0	0	72	N strong
31:8 am	8.2	0	60	N strong & gusty

Rollo Home

ADVENTUROUS REPORT

4th - 13th August

Grimstovn & Kerlinga

Our plan was a 4 to 5 day trip on the icecap. To see Grimstovn with its huge hollow - steam pouring out of the ice in great plumes - and then to continue down the eastern edge of the Vatnajokull to the British Schools Exploring Society's base camp and say hello to a teacher from the school we all went to last year; and then to ski back to Graenalon at an easy pace.

As is so often the case on expeditions, our plans got changed.

Two days before we left, Steve, Rupert, and I took all of the skis, sleds and 9 days of food to the snout of the glacier on the east shore of the lake. We had planned to go all the way to the snow line by climbing up to the top on the ridge extending from Graenafjall to the ice. Unfortunately our way was blocked by a very wide and very fast glacial outwash river and as we had no safty gear for walking on ice we had to leave it at the bottom of the ice. Having the food here meant that we would be able to get onto the ice faster when we left and it could be loaded directly into the plastic sleds.

Day 1

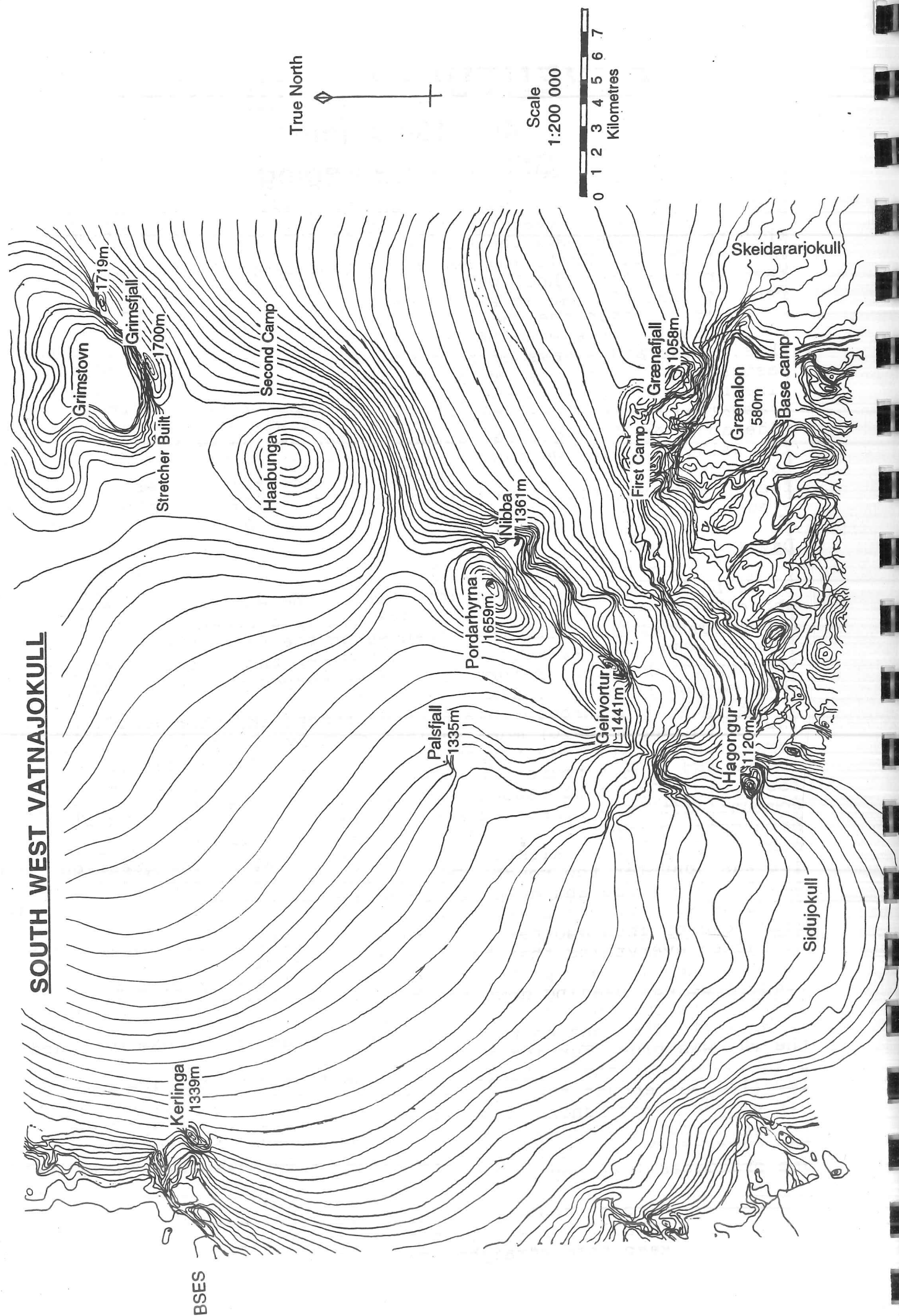
We broke camp at 10:15am and started the walk along the lake shore to the glacier. The lake, drained by a recent jokullhuph by about 20m had left icebergs stranded on the beach where they stood like huge sculptures melting at last after their long journey from the top of the glacier forming strange shapes that sent your imagination running wild.

We walked on through this strange throng and then away from the lake into the heaps of moraine laid down by the glacier and then carved into knife edge topped heaps by the outwash rivers.

Two and a half hours after leaving base camp, we arrived at the food dump. There we loaded our sleds with tents, fuel, and other communal kit like first aid kit and emergency beacon, and donned harnesses, crampons, ice axes, and rope. Once we had gone just a few hundred yards, we realised that sleds were out of the question - the ice was just far too rough. The ice surface was a maze of ditches about 2 feet wide and deep cut by meltwater streams. These resulted in us walking up one a few steps and then having to climb up its side to drop into another. This made sleds absolutely imposible so we packed everything that had been in the sleds into our rucksacs and then carried on up the ice to the end of a spur of a moraine ridge that was heading down to the snout of the glacier. We ate lunch there surrounded by dirt cones.

We left after one hour at 3pm. The sun was up, it was warm and the sky was blue. Turning around we could see Graenalon and Oraefajokull in the distance. Within half an hour the ice had levelled out enough for us to repack our sleds and pull the heavy bit of our loads behind us which was much easier. At 4pm we arrived at our campsite - a snow patch tucked in between heaps of moraine by the edge of the icecap. We droppped all of our kit, put on our skis and practiced for about 2 hours.

"Cross- country skiing is not very easy at all! For going up hill you have to keep them straight, parallel, about 6



inches apart. Take big steps, push with your arms at the right time. And glide with each step. Going down hill you have to stay on! Stopping is very hard, so is turning. Ah well."

We were complete beginners: except Steve who had spent a lot of time on skis in Spitzbergen with BSES in 1990.

We came back, had supper and headed to bed at 7:30, Rollo and I in the Quasar while the others bivied for the night on the moraine.

Day 2

We got up at 2:30 am. Not just because we enjoy doing things like that but because we thought that travelling would be easier if the sleds were running over the hard icy snow that the icecap was covered in at night. This was to be a transition day. It was -6°C and we had breakfast very quickly. Steve and Rollo had to go back down to base camp to pick up the maps. In the excitement and confusion of packing up we had managed to forget just about the only thing we couldn't do without. They also brought up a day's food.

While they were doing this Mark, Rupert, and I were to learn to ski. It was extremely icy and the three of us quickly decided that we would be better off travelling by day. But we struggled on in the belief that if we could ski on this sheet of ice then anything would be easy.

We stopped for lunch at 6:30am and between 8 and 9am the snow improved a lot. By the time Steve and Rollo returned at 11am we had it pretty well figured out.

As we were now going to travel by day, we had to get back to normal time and so didn't have supper until 3pm. Went to bed at 6pm and had a long sleep.

Day 3

Woken up by alarm at 6am. It was -1°C . We packed up and left at 8:30am. Today we would be going up hill all day, climbing 700m in 20km.

The first hour of the day was through lots of dips and humps which I had a lot of trouble with. Whenever I took a step forward, my ski shot out backwards, often leaving me on the ground. Eventually it smoothed out and the going was much easier. We had been skiing unroped for a couple of hours before we saw some big gaping crevasses fairly close by and so we all roped up.

"Skiing on a rope is not the sort of thing you suggest someone should do for a laugh. If you go too slowly, you get pulled by the person in front. If you go too fast you ski over the rope, and when you try to free yourself, you fall over - and pull the person behind. If one person falls, you all stop and wait."

Then we got to a steep downhill. As we couldn't go downhill with any kind of control yet, and there was an enormous crevasse at the bottom we carefully inched our way down, each falling over several times. It took half an hour to go 200m! There at the bottom we crossed a 10ft snow bridge across a crevasse, and went up the hill. Almost immediately we found ourselves in a maze of crevasses. To get through, we had to follow each crevasse until it was narrow enough to cross or there was a snow bridge.

The great thing about skis is that your weight is spread over so much area that you can stand on snow covering a crevasse which is not supported and not plunge through like you do on foot. It was quite disconcerting some of the time because it wasn't always possible to know if you were standing on anything at all! In fact, once when I fell over, Rollo came to help me and stuck his ski pole in the snow - as you do - and it went straight through showing that under 8 inches of snow there was nothing.

We had lunch at 1:45pm and then continued upwards. At about 3pm the cloud came down and we were in a complete whiteout. I don't know how much visibility there was as there was no horizon; it could have been 20ft, 200ft, 1000ft. There's no knowing.

We were skiing on a bearing all this time and with no landmarks it was impossible to know exactly where we were. Using contour lines on the map we could determine roughly where we were, and we seemed to be on course. Then it started to snow. The snow settled on the ground and promptly stuck to our skis balling them up. We continued walking with our skis acting as snowshoes for a while. But with 4 inches of snow stuck to the bottom of the skis it was like walking in very heavy iceskates. We stopped within 20 minutes and camped. It was very odd to stop in the middle of nowhere to camp. No landmark in sight, just white.

Rupert pitched his Quasar quickly, but the big tent took more work. We dug a hole 2 feet deep, cutting it out as snow blocks which we used to build a wall around the hole so that when we pitched the tent in the hole it was effectively surrounded by a 5 foot wall. It took a long time but was well worth it as it was completely sheltered and could have withstood a blizzard. We melted snow for water to drink, cooked and went to bed at about 10pm. It was -1° C in the tent.

Day 4&5

We got up late in the morning at 8:30am. It was -6° C in the tent. Outside the sky was deep blue and the sun was shining brightly. We were in the right place as well, which was a relief. We left at 11am and the skiing was easy - as long as you kept going. To stop meant that your skis would ball up on the fresh snow.

Mark found his vision was rather cloudy that morning which was rather concerning but we could do nothing and it didn't seem to be a problem. We skied to Grimstovn but found that Mark was lagging behind. His right eye was now hurting a lot and he had to keep it closed. At noon we put an eye patch on it which seemed to be a help. Mark hadn't worn any sunglasses the day before.

We got to the summit of Grimstovn at 1pm and had lunch. The cloud had come down again, but through the gaps we could get a few glimpses down into the hollow. We couldn't see any steam vents, or hot lakes, or anything - rather disappointing really. But the rock

of the summit itself was warm, and small fountains of steam could be seen escaping from under rocks. Grimstovn is on one of the faults of the Mid Atlantic Rift.

We left at 2pm and started skiing down to BSES. Mark's eyes were bothering him badly now and at 3pm we stopped. It was obvious that we had to get him to a doctor as soon as possible. It seemed like it was probably snowblindness but we couldn't be sure (because it was worse in one eye than the other) and couldn't take any chances with his eyes. We knew that there was a doctor at or near the BSES base camp which seemed to be only 5 or 6 hours away, downhill. As Mark had to stop regularly to rest his eyes, we decided it would be faster to pull him in a sled.

SF - "1500-1600 Built stretcher. I knew what we had to do, but could we manage? Massive apprehension of what the future holds."

We made a stretcher/ sled by lashing two plastic sleds to his skis and padding with thermarests. Then we put him in a sleeping bag and bivi bag and tied him in. By 4pm we were ready to go. Steve started pulling Mark behind him. The cloud was down but we could still see the sun which made keeping a straight course easier. An hour later, the sun was hidden and we were in a complete white out.

SF - "Very dangerous skiing fast into 2 feet of visibility, what if there was a hole?"

I skied at the front by Steve for a while, and the feeling was very wierd. With the sky exactly the same colour as the ground and no marks on the ground it was impossible to tell them apart. Soon I was imagining small dips and hills but they were never there. Eventually I didn't even know up from down. One more thing to increase my nervousness was the noises the snow made. Seemingly at random it would let out a thud - the sound that snow makes as it breaks or cracks - and it would drop by half an inch or so as I skied over it, convincing me that I was about to plummet into a crevasse. We decided it must be the snow layers shifting under our weight.

SF - "All the time thinking: Is this wise? What if someone becomes exhausted, or we meet a crevass field, or some else becomes injured?"

After 3/4 hour, I retreated to the back of the team where my eyes could cling to the images of the people and tracks in front of me.

At 6:30pm, we stopped and set up the stoves to melt snow for water. We also raided the food bags, helping ourselves to a lunch and some dates and custard.

We then continued on as before, crossing tracks made by 4 wheel drive vehicles that were going slightly a different way to us. At 8pm we decided to follow them anyway as they would be going off the ice to a roadhead (BSES were at a roadhead) and they would avoid any crevasse fields. I took over pulling the sled for about half an hour and then Steve joined me and we both pulled for about an hour before stopping for a rest and to melt more snow for drinking water. Water was a bad problem and we were very worried about dehydration. It took a long time to melt the snow, and once done it tasted very very strongly of paraffin. Mark was in a lot of pain by this time and could see nothing.

We left at 10pm with Rollo and Rupert pulling Mark. Within 20 minutes, Rollo's ski binding broke so I took his place while he mended it. Rupert and I pulled for 2 hours on through the nothingness and were very glad of the tracks to follow.

12:10am. "The cloud cleared at about 11 and we just saw a landmark and got a fix. We think we're 12km from the edge of the ice and 15km from BSES. We're following truck tracks in the hope that they won't cross crevasses. We're melting snow now and we've ravaged most of the food bags for lunches, desserts, Mars bars and biscuits. The snow is crustier now which means everything is gliding better but also skis slip a lot. Its bitterly cold but the wind has stopped. We can even see stars"

SF - *"Can we really go on in this? We must get off the Ice cap in the morning, to reduced the risk of crevasses, and slush pools."*

At 2am we saw Kerlinga, the mountain near BSES, and turned off the track towards it. Rollo and I were pulling Mark, but as it was downhill and icy, I carried on alone as two people would have been impossible. Soon I was gliding and as the hill got steeper I got faster and faster. Then I made a big mistake: I tried to stop. I fell off. Mark, of course on his sled, kept going and ran straight into the back of me. After about 5 minutes of untangling my legs, skis, rucksac, ski poles, arms, and Mark's sled - I stood up. Steven stopped by me and offered to take Mark. I happily agreed. I tried again, In about 10 seconds I fell again and the first thing to break the icy crust on the snow was my nose. I decided to walk the rest of the way down the hill.

At the bottom, I put my skis back on and we carried on towards Kerlinga.

3am. "The sun seems to be coming up. We can see the mountain near BSES. On the map it is 8km downhill. It looks closer and very flat to it. Its -5° C, I'm sweaty and freezing. We're melting more water. My lips are swollen and my mouth dry"

At 4am we decided that it was the wrong mountain because there was a snow ridge connecting it to another peak. We were in fact 15km north of Kerlinga. So we turned and started skiing.

At 5am, Steve decided that it had been the right one after all and the snow ridge was a cloud, so we turned back again.

SF - *"We're heading the right way now. I led Mark onto the Ice, so I'll pull him off. But at 0630, exhausted I had to give Mark to Walter."*

At 6:30, I took Mark back from Steve and continued on the flat and then down the hill to the edge of the ice. We reached Kerlinga at 8am, very relieved to be on dry solid land again. We thought it was all over. There we found a meltwater pool with clean water in it. A true oasis.

We walked down off the ice and set up a tent down on the moraine. We were still 4km from BSES and rather than lead Mark (who couldn't see anything) over moraine, Steve and Rollo set off for the camp leaving Rupert and me with Mark. We had supper and went to bed at about 10am.

We left the others at 0900 by the edge of the Ice. We were heading for BSES Base-camp, which was 3km away, over a ridge. As we set off the cloud came down. We were following a drove of footprints. They could only belong to BSES. After an hour the cloud lifted, and we saw we were heading in the wrong direction. So we sat down and ate in despair.

It took us until 11.30am to get to the area where BSES were, and shore enough, we saw people. What do we say? We didn't want to sound alarmist, but we were trying to get medical advise fast, and we had been on the go for 24 hours. We learnt to our dismay that their Base-camp was 10km down the valley, they were all heading the other way on a load carry. So Rollo and I headed off. We ate our remaining food at 12.30pm.

After an hour or so walking there was no sign of the camp. The valley was full of hillocks and piles of Lava. Had we missed it? We new it must be by a river, so we walked over to the main river. It wasn't there! We'd both run out of water long ago. It was also hot and bright in this lava desert. Where was the camp? Perhaps they're just over that next rise? After 10 minutes of hobbling due to extremely soar feet, I reach it - nothing. The next thing I remember was Rollo kicking me; "Get up! Get up! We've got to find them!" I'd been asleep for over half an hour, lying on the ground, with my ruck sack still on. It was 3.00pm. Our position was more serious than Mark's now. We were both exhausted, dehydrated, and we knew it. Think logically. First priority - water. After 20 minutes we found some. It was stagnant, but we still filtered it and drank. Next priority - Find someone else. No sooner than we had decided which way to walk, we saw two people coming towards us. Our luck had changed at last.

It took us a further hour to reach BSES. We hadn't gone far enough. It was amazing we managed to find the energy, but when you are talking to someone else, you can forget hunger, thirst, soars etc... We reached BSES at 4.30pm. We had been on the go for 30 hours.

BSES were wonderful. They were so sure Mark had snow-blindness that we were totally convinced ourselves. 'He'll get better on his own accord', they said, and we thankfully believed them. We both crashed out at 8.30pm, after we felt we had done enough explaining and socialising.

We were concerned about the others still. But they will just be worrying, and they will have to keep worrying until tomorrow when we will go back to them.

Day 6

We were kindly given extra food by BSES, and driven back up the valley the following morning. We were only 3km from the others. Excitedly, we walked back.

We woke up about 20 hours later at 7am and waited until 9 to have breakfast.

8:20am. "No one has come back yet. Its been nearly 24 hours and we are getting very worried. We pulled Mark for 16 hours to get here and just spent 22 hours in bed. Why hasn't anyone come?"

I spent the morning reading "Touching the Void" by Joe Simpson (a climbing disaster story) which didn't really help! At noon, Rupert and I walked back to the foot of Kerlinga where we had left everything we didn't need when we came down and picked up all the food etc., leaving only skis and sleds. At 1:20pm, we left Mark with the emergency beacon and a watch with an alarm that could ring in 12 hours time. When it rang, he was to set the beacon off. We left a note with him saying where we had gone. We were off to look for Steve and Rollo.

We set off in the direction they had pointed the morning before - they had the only map and our compasses wouldn't work due to magnetic rocks. The landscape was bare, desolate, and very lonely. Along the shore of the lake we saw some fresh footprints mixed with the old footprints of BSES travelling to what turned out to be their Glaciology camp, very close to where we were camped. There seemed to be two sets and going in both directions. We decided that it wasn't worth turning around and that we should keep going up to the top of the ridge and look back on the camp to see if anyone was there.

We arrived at camp just after 2.00pm. Only Mark was there! Where were the others? We read an alarming note by Walter written in serious language. We'd missed them by 30 minutes! But then we had a stroke of luck, I saw two figures silhouetted on the skyline. We both jumped up and down waving survival bags, but they didn't see us, and disappeared over the top.

We kept going up the ridge following the track made by BSES and soon we could see down the other side where we saw a food dump where the base camp was supposed to be. We continued up until we could see the camp and there was someone there waving a survival bag at us!

What should we do now? Eat - It's always a good plan. So we sat down and had lunch, and thought what we should do next.

So, relieved we returned to the camp to find Steve and Rollo in the tent having lunch with Mark whose vision had improved enough to walk.

SF - "Had lunch... ..then Rupert and Walter returned. Altogether at last. Relief." We sat in the tent for an hour telling our various tales.

After hearing all this, we reorganised the food bags and left 4 at the camp (so that when we returned to Graenalon we would have enough to sit out a period of bad weather) with all of our ice gear and took one with us down to the BSES food dump, hoping to see the BSES nurse as she was passing that evening to start her adventure phase on the ice. We arrived at the same time as she did. We camped, ate, and enjoyed feeling safe again.

Day 7

This was to be a recovery day as Steve and Rollo had not had nearly as much rest as us. We didn't get up until 10am, when it was a beautiful sunny day. I had a long awaited wash, and once breakfasted we set off for the BSES camp so that Mark could see a doctor and we could pay a social call. It was 10 km (6.5 miles) each way and took 2.5 hours with a lunch break half way. Their camp was at the other end of the valley we were in and so the walk was an easy one, down the valley between huge hills of moraine piled up as steep as possible, hundreds of feet high. The valley floor was covered in lava boulders varying in size from eggs to statues as big as houses with sharp spikes sticking out in all directions. Once we got there we discovered that the whole expedition except the doctor, Ian Ashwell (the chief leader) and a couple of YEs, had gone on their adventure phase the day before. The doctor checked Mark's eyes, we had a chat, and they very kindly gave us some more food to tide us over. The Mid Atlantic Rift was evidently only 5km away and very spectaclier and well worth a visit so we started towards it. Soon we realised that if we went there we would be walking 30km (19miles) in the afternoon of our rest day. So we turned around and went back to our camp.

Day 8

We decided to give Mark's eyes one more day of rest before exposing them on the ice again and so we had a leisurely day. We got up at 11am and left at 1:30. We crossed the glacial river we were camped by (only 100 yards) so that we wouldn't be crossing it when it was higher and immediately had lunch. Then we walked to the ice, picked up our food and skis and sleds and walked on a bit before camping at the foot of Kerlinga so that we could start skiing straight away in the morning.

Day 9

We got up early, at 5:30am - it was cold, grey, and damp with only about 1km visibility. We left at 8 and started to ski up the dry glacier (ie. no snow on the ice) towards the snowline. It was difficult but even so, in two hours we had covered 7km (4.5 miles) and we were on the snow. We were skiing in a straight line all day. Only one point of interest lay between us and Graenalon - that was Palsfjall, a peak of obsidian (volcanic glass) in the middle of the icecap.

We had lunch at 1, the sun had come out now and it was hot! Shorts would have been ideal! The sky was deep blue, the sun was very strong and reflected off every crystal of snow so that as far as you could see solid light was shining at you and glistening, with

ADVENTUROUS REPORT

Ascent of Nibba - (26th August)

dips and crests like the sea.

One hour later we arrived at Palsfjall. From a distance it looked like a small rock outcrop in the middle of the ice. Once we arrived we saw it rising 50m above the ice, sunk 40m into a well in the ice 60m wide around it with sheer vertical walls. The rock itself wasn't the black shiny obsidian we had seen scattered around base camp but had recrystallised into an orange rock with small white bubbles in it. At the summit however, there was a mysterious pile of shining black jewels. We stayed at the summit enjoying the panorama around us. We could see our tracks stretching 10km into the distance in a straight line in the middle of nothing. We then continued on our way. 45 minutes later we heard an engine. Looking around us we couldn't see anything for a long time until we finally saw a small airplane. It circled Palsfjall, buzzed us and flew on. About 5 miles north of us we saw what looked like a camp but we assumed was a rock outcrop. We found out later that it was BSES.

At 6pm, we saw Graenalon. Instead of its normal muddy brown colour it was deep blue and inviting. We then had a 400m descent to our camp in the moraine.

After negotiating several steep and therefore very tricky slopes, we reached the camp we had used 8 days before. It was 9pm and we stopped.

Day 10

We left at about 10 and walked back down the ice, along the lake shore and back to camp. We were surprised to see the lake had dropped by nearly a metre. We set up camp and ate lots from our treats bag while it rained outside. It rained for the next 4 days.

Walter Borough

The Original plan for the second of our adventurous trips onto the Icecap was to ski to and climb the mountain called Oræfajokull, which is the highest mountain on the Icecap, and in Iceland. This however turned out not to be viable because of a combination of factors. These included having a week of heavy rain, confining us to our tents, and so cutting down our time in the field. Our original planned access route to the mountain was across the Skeidararjokull, adjacent to the lake, but the glacier had recently surged, and heavy crevassing made crossing it impossible. The only access to the mountain would have been around the glacier on the Icecap, which would have added another 2 days each way, making the venture impractical in the time we had available. For these reasons, we decided to do a peak called Nibba, which was within about 8km from our first camp on the Icecap.

On Tuesday 25th August, we walked from our base-camp at Grænalon up to our first camp on the ice, just above the snow-line. We found the ground conditions have changed quite a lot, since we were last there 2 weeks before. The snow-line had receded a great deal and new crevasses had opened up. Our skis and sledges were still where we had left them. The same could not be said about a food bag, which had been left at the glacier's edge, for this had been attached by some type of animal, with all that was remaining being the tins and Healthylife Biscuits. We had enough food however, so this was not too great a set back. After setting up camp on the snow in the moraines, and having dinner, we went to bed ready for the peak the next day.

The following morning I was awoken by Walter at 7.03 and proceeded to cook breakfast. The morning was in total contrast to the day before. There was total blue sky, a very strong wind, and the air was cold. After fiddling with the stove to get it working, porridge and brews were made, and we were ready to set off for our target - Nibba. We packed light sacks, with skis and poles strapped on the outside, as the snow was too hard to ski up-hill, and it was easier to walk. The walk up to Nibba was into a fierce head-wind, and it took 2 hours to cover the 8km from our camp, with very spectacular views over the lake, and surrounding area. As we neared the mountain, we realised it was not a single peak. The main peak and ridge was connected to the Icecap, but an isolated pillar of rock formed the highest summit. This was connected to the main peak by a col that was at 3/4 height. We were going to do a small snow gully on the main peak until we saw that this was not possible, as the back of the gully was a vertical rock wall. We decided to try the large gully that split the main peak from the pillar. We dumped our skis just before a crevass field, roped up, and walked around to the bottom of the gully, which turned out to be half snow - half scree, and flanked by 200ft rock walls. The gully was not as hard as it looked from a distance, being fairly soft snow at about 45°-50°. It would be a Scottish grade I if graded.

The col took about 20mins to reach, being about 600 feet higher than the start of the route. We saw this was as far as we could go, because both sides of the col were rock walls, and we only had ice climbing equipment. With rock climbing equipment, both sides could have been climbed at a middle grade standard, but with considerable exposure, and at that time a very strong wind.

We had lunch at the col, and afterwards descended the same route, avoiding some falling rocks, and back to the skis. The snow was still pretty hard, but we gave the skis a go, as it was down-hill and all that would happen was falling

over. The skiing was very fast, and as soon as it was realised that you didn't have to fall over because you were going too fast, the descent became very exciting. Obstacles such as bumps, jumps, and the steepest parts of the hill, were not avoided, but searched out for extra fun! The descent took 50mins, with about 30 minutes was actual skiing, the rest being photo stops, and excited jibbering!

We arrived back in camp in the early afternoon, and after a rest, took down the camp, and moved off the glacier, encountering some very large crevasses. We pitched camp on the North side of the Lake so we could finish our science work.

Rupert Finn

EQUIPMENT REPORT

INTRODUCTION

This part of the report is not meant for bitter & twisted expeditioners to slag-off duff kit! Hopefully future expeditions will find this useful, for example, to see how much warm clothing they need to take.

I asked for comments on equipment from all the members of the expedition. It must be remembered that an expedition like this is extremely punishing on equipment. The complaints about equipment would probably not be noticed under 'normal' use. A rough rule of thumb is that a six week expedition is equivalent to three years casual weekend use. In some case (especially boots) this is an under estimation. Also bear in mind that most of our kit wasn't new, and had already survived one or even two similar expeditions.

PERSONAL EQUIPMENT

Boots

Two people wore plastic mountaineering boots, and three wore $\frac{3}{4}$ stiffened leather boots. On balance the plastic boots were best. In 'plastics', feet got very hot and sweaty on the load carries; they also hacked feet up badly during our self-rescue incident, due to the prolonged (36 hours) usage.. Their big advantage was being almost completely waterproof; it made the days of rain tolerable. Conditions were not really cold enough to justify plastic boots, except when we were on the Vatnajokull. Leather boots were perfectly adequate. Both types of boot wore down considerably.

Gaiters

All three leather boot wearers had Yeti Gaiters. These were only used for river crossings, and on the Icecap. The rocks would have eaten the rands very quickly. Berghaus Tronic Yeti Gaiters fitted the boots very well, but the Wild Country rands were far tougher. For plastic boots a good pair of Alpine gaiters proved totally adequate, and Yetis weren't used much for fear of rand damage.

Leg Wear

Three people lived in Helly Hanson Salopettes for the six weeks, and would do so again. Sewing on pockets is an excellent idea. Lighter weight salopettes were not warm enough by themselves on the Icecap, but were fine around base camp. Thermal trousers and light cotton trousers were worn by one, and the verdict was "adequate".

Upper Body

During the coldest part of the expedition the average upper body wear was four layers, plus a shell layer. Typically; Thermal, Shirt, Jumper, Fleece, Goretex coat. One person took a small duvet jacket, which was very useful.

Shell Clothing

Everyone had a Goretex coat, which preformed excellently. Detachable hoods were annoying, as was Goretex's capillary action when wet and not worn. In the 'static' setting of base-camp a PU Nylon coat was much better. Goretex overtrousers preformed better than cyclone (as they should!) but Hydro-dry was best, as they could be shaken dry (or drier).

Gloves

The best (Wild Country Extremities) preformed excellently, and everything else was unsatisfactory. Untaped seems leak, so it didn't matter what the fabric was, while the condensation in anything other than Goretex was considerable.

Sleeping Bags

Everyone had synthetic bags. Three people had Softee 12's (3-4 season) and all three people had to wear clothing in the bag more often than is reasonable expected. A four season bag is really necessary, and the one person with a 4+ season bag was warm enough.

Sleeping mats

Thermorest's are the business if you can afford them! They were however, at a disadvantage when we were bivvying on moraine containing volcanic glass! Extreme Karrimats are the only other mat capable one providing the warmth required on the Icecap. The Karrimats are much bigger and bulkier.

Bivvy Bags

The only type of bivvy bag worth having for night-on-night use is made from 100% Goretex. Nylon groundsheet create condensation which builds up to intolerable levels if the bag cannot be aired for several days.

Ruck Sacks

Berghaus Cyclops Alp preformed excellently. The only draw back is when they are overloaded, the lid prevents head movement. Karrimor Jaguar S's also preformed well. They are a slightly better design, but were less durable. There was also a new Lowe sack, which was much loved by its owner.

Skis

We used Asnes Sondre Telemark; they were unfaultable. Ordinary leather mountaineering boots were used with Rotafella Super Telemark Cable bindings, which proved adequate, although it was difficult for novice skiers to keep the boot in the line of the ski. The plastic boots were fitted with a home-made binding (see Equipment Modifications & Original Equipment section).

COMMUNAL EQUIPMENT

Tents

We had a Wild Country Mountain Quasar, with three people in it, which performed superbly. We also had a strengthen Vango Hurricane Alpha. Without six extra guy points, and reinforced pole sleeves, this would have blown down on numerous occasions, but with strengthening it stood up when people couldn't. We also took The Big Tent (see Equipment Modifications & Original Equipment section). This was worth its weight (3kg) in gold to us, although it was full of small holes by the end.

Cookers

These were MSR Whisperlite Internationales. They preformed as well as could be expected with our old, dirty fuel. As they contained no sealed units, so could, and often were, completely stripped down and cleaned. Recommended.

Sledges

We used plastic kiddy sledges, fitted with shock-cord and towing string. They were excellent for their price. The lack of a solid trace made descents difficult (or fast!).

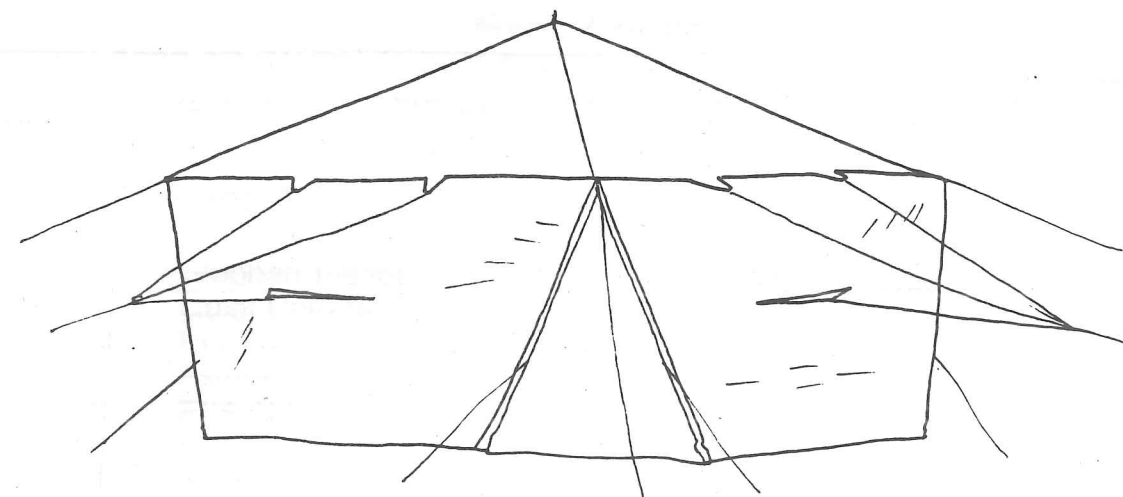
Other useful equipment which we didn't take, but would take next time:

Wellies
Miniflares

EQUIPMENT MODIFICATIONS & ORIGINAL EQUIPMENT

The Big Tent:

This was a single-skin light-weight PU nylon tent. It used ski poles as poles. These were tied together to form four 'A' poles. The centre was also held up by ski poles. The use of ski poles, meant the total weight of the tent was only 3kg, while having standing headroom, and floor space to sleep five. The tent never blew down, but we took it down as the wind built past a force 5. We pulled the poles out, and stoned it down, this was the cause of the numerous small holes. Cost: £100.00

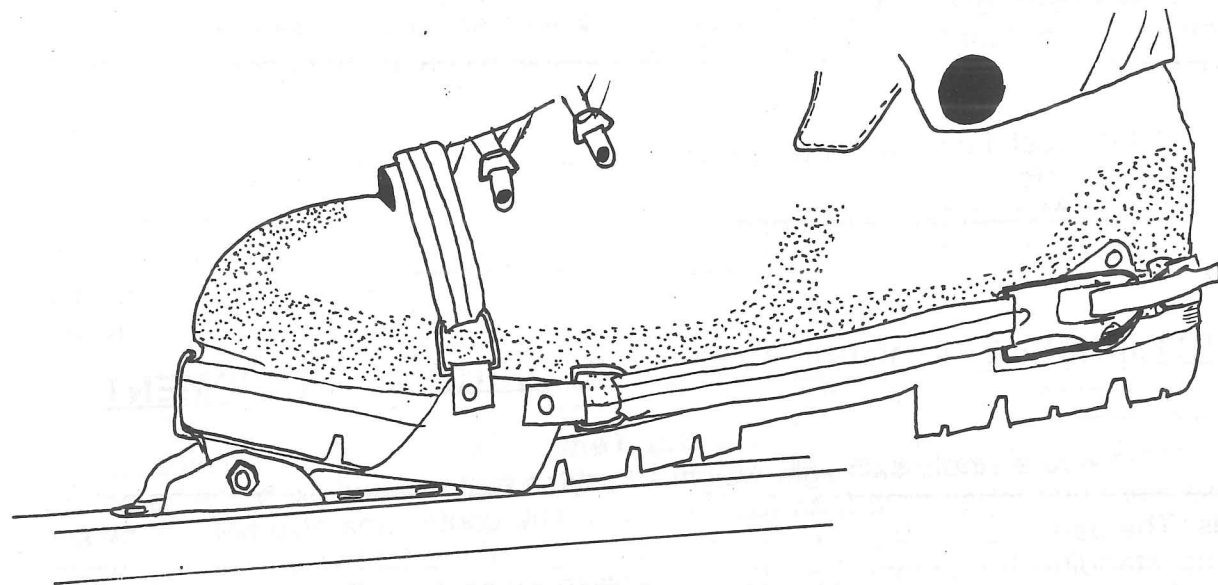


Hurricane "Mountain" Alpha:

The standard Vango Hurricane Alpha had a snow/rock valence sewn all the way around it. Also four extra guy points were added between the existing guys and the ground. These greatly increased stability. Two further guy points held the back of the tent up (using ski poles or ice axes to provide the upward pull). The sleeves to the poles all had six inch nails "Araldited" into them. This strengthening was visibly necessary, as one sleeve cracked, but the tent was saved by the nail. These modifications made this a full four season tent.

Plastic Boot Ski Bindings for Nordic Skis:

Having been told that the only place in the world that made these, had stopped making them, we had no option but to make our own. The basic principle was a hinged toe slot into which the boot was strapped. The binding was made of stainless steel. They performed excellently. There were no reliability problems, nor foot alignment problems until we went downhill (and then they were better than the leather mountaineering boots in ordinary bindings).



Stephen Fisher

THE TEAM

Stephen Fisher (Expedition Leader)

Aged 19. Completed his first year at Cambridge University, studying Natural Sciences. Previous expedition experience: British Schools Exploring Society Svalbard 1990 (summer), and led Swdex '91, a four week expedition to Northern Sweden (YET Approved).

Walter Borough

Aged 19. Going to study Chemistry at Imperial College, London, having taken a year out mainly in the States. Previous expedition experience: BSES East Greenland 1991.

Rollo Home

Aged 19. Completed his first year at St Mary's College, London, studying Geography. Previous expedition experience: BSES Yukon 1990, and Swedex '91.

Rupert Finn

Aged 19. Completed his first year at Imperial College London, reading Electronics & Computer Systems, now moved to Sheffield University (no prizes for guessing why). Previous expedition experience: BSES East Greenland 1991.

Mark Cooper

Aged 19. Completed his first year at Southampton University, studying Physical Geography and Geology. Previous expedition experience: BSES Iceland 1991.

Contact Addresses:

Stephen Fisher,
Quiet Cottage,
Hittisleigh Mill,
Exeter.
EX6 6LD

Mark Cooper
10 St David's Hill,
Exeter,
Devon.

MENUS

We packed all of our food in 42 separate bags before we left this country. One bag for each day. This meant there was minimal sorting to be done in the field. The bags were not divided into set menus, rather each was a unique mix.

BREAKFAST		
1. Either	Muesli	100g
Or	Porridge	70g
2. Either	Kipper Fillets	2/5 tin
Or	Sardines	2/5 tin
Or	Mackerel Fillets	2/5 tin
Or	Tinned Sausage & Beans	2/5 tin
3.	Dried Full Fat Milk	3/5 pint
LUNCH		
1. Either	Healthylife Biscuits	1 packet
or	Corned Beef	2/5 tin
or	Tinned Pilchards	2/5 tin
or	Tuna	3/5 tin
or	Luncheon meat	2/5 tin
2. Either	Honey	1/10 pot
or	Chocolate Spread	1/10 pot
or	Jam	1/10 pot
3. Either	Mars Bar	1
or	Snickers	1
4.	Packet of Biscuits	2/5
EVENING MEAL		
1. Either	Farmhouse Casserole	1/12 box
or	Chicken Supreme	
or	Chicken Curry	
or	Beef Curry	
or	Mince Beef	
or	Sweet & Sour Pork	
2. Either	Rice	60g
or	Pasta	70g
or	Yeomans (dehydrated Potato)	'2 portions'
3. Either	Custard	2/5 packet
with	Dried Apple Flakes	2/5 packet
or	Dried Dates	2/5 packet
or	Dried Apricots	2/5 packet
Or	Bird's Hot Crunch	2/5 packet
EXTRAS		
1.	Tea	1 bag
2.	Coffee	1 portion
3.	Sugar	60g
4.	Boiled Sweets	2
5.	Hot Chocolate	1 cup

USEFUL ADDRESSES

IN THIS COUNTRY:

Stanford's Maps & Charts,
12-14 Long Acre,
London.
WC2E 9LP

Icelandic Embassy,
1 Eaton Terrace,
London.
SW1W 8EY

The British Mountaineering Council,
Crawford House,
Precinct Centre,
Booth Street East,
Manchester.
M13 9R2

The Iceland Information Centre,
Tony Escritt,
PO Box 434
Harrow,
Middlesex.
HA1 3HY

The Expedition Advisory Centre,
at the Royal Geographical Society,
1 Kensington Gore,
London.
SW7 2AR

Expedition Freight,
Pant y Cafn,
Llanberis,
Gwynedd.
LL55 4UW

West Mercia Insurance Services,
High Street,
Wombourne,
Nr Wolverhampton.
WV5 9DN

The Royal Geographical Society,
1 Kensington Gore,
London.
SW7 2AR

Nordic Ski Imports,
Aviemore,
Inverness-shire,
Scotland.
PH22 1QH

IN ICELAND:

Helgi Björnsson,
Dunhagen 5,
107 Reykjavik.

Icelandic Customs,
PO Box 5350,
IS-125 Reykjavik.

National Energy Authority:
Orkustofun,
Grensarvegar 9,
108 Reykjavik.

Icelandic Geodetic Survey:
Landmælingar Island,
Laugavegi 178,
125 Reykjavik.

Icelandic National Life-saving Society:
Slysavarnarfelag Island,
Grandagardi 14,
Reykjavik.

Icelandic Glaciology Society:
Jöklarannsóknafelag Island,
PO Box 5128
Reykjavik.

Outdoor Pursuits Shop:
Skátábúdin,
Snorrabraut 60,
121 Reykjavik.