UNIVERSITY OF SHEFFIELD

OKSFJORDJOKULEN EXPEDITION

1986

Preliminary report

FORWARD

Mounting an expedition takes considerable effort, organisation and forward planning. We are indebted to all our sponsors who offered wide rangimg support and who made the expedition viable. In particular we wish to thank our Patron, His Grace, The Duke of Devonshire who was our first official sponsor. Friends and families offered help in many ways and they too are warmly acknowledged. In Norway we met kindness, generosity and unfailing help wherever we travelled and we are particularly indebted to the assistance and friendship of Helgi Andersen of Jokelfjord. Technical support was given by The University of Sheffield, Sheffield City Polytechnic and The Queens University of Belfast as well as many individual sponsors and local Sheffield firms.

The following account details the nine months of preparation for our expedition to Oksfjordjokulen, Troms, N. Norway and reports on the immediate events and scientific findings which resulted. A detailed scientific report will be written upon receipt of results from those members concerned with the various projects. Details of its availablility and contact addresses are given at the end of this report.

Expedition Leader

INTRODUCTION

Since 1979 four of the expedition members have been involved with investigations into the glacial history of the Lyngen Alps, N. Norway and a model has been described from this area which helps to understand the nature of glaciation in the Scottish Cairngorm Mountains over 10,000 years ago. During 1984, whilst surveying the plateau ice-caps in Lyngen, we caught sight of Oksfjordjokulen, over 40km to the NE. The area offered useful comparisons to existing long term studies yet remained largely unvisited this century, let alone the subject for detailed scientific study. The isolation and curious phenomena associated with parts of the large, 35km² ice-cap have permitted it to be considered "one of the strangest glaciers in the world". A careful and ambitious scientific programme was prepared with attention to logistical difficulties and fickle weather. This report outlines the background and history of the study area and gives attention to initial scientific findings arising from our exploration and survey of Oksfjordjokulen (Fig.1). As a result of these findings we are hopeful that future visits will be made and that regular measurements of certain phenomena will increase our understanding of the complex interplay of marginal ice-cap localities.

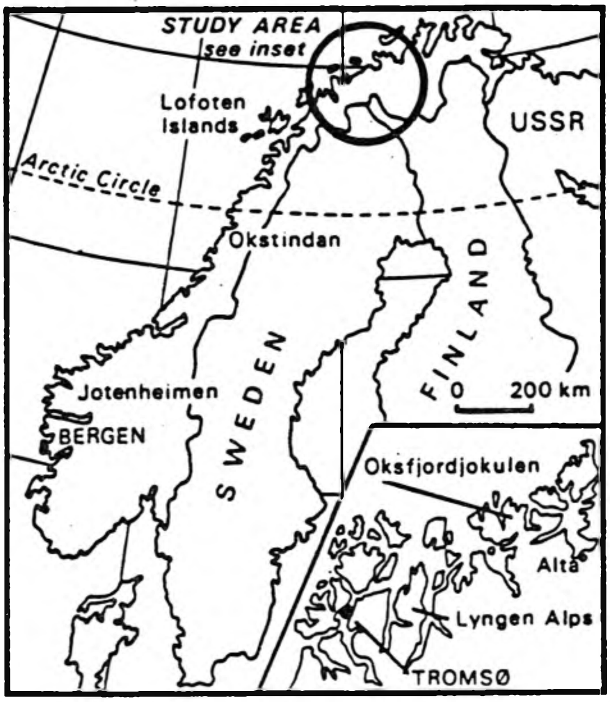


FIG. 1

HISTORY OF OKSFJORDJOKULEN

Although remote, the spectacular 'fall-jokul' at the head of Jokulfjord and which breaks off from the high plateau ice-cap of Oksfjordjokulen has been the subject of speculation and comment of many early travellers and scientists. Not least, Sir Archibald Geikie, an eminent Scottish glaciologist who graphically gave account of this "broken, shattered mass of glacier ice" which was in "constant commotion, cracking and crashing and discharging masses of ice and snow.. with a noise like the intermittent thunder of a battle". Geikie visited the glacier in 1863. His visit followed that of von Buch in 1810 and J.D. Forbes in 1851, who had sailed round the peninsula and recounted tales of native huts along the fiord shore being inundated by waves propagated by the impact of falling ice. Such spectacular accounts failed to bring direct comment in the early Sailing Directions for the West Coast of Norway published in 1865. A chance visit by three Englishmen in 1859 touches on the vagaries of the local ponies rather than the irregularities of the glacier, but their account as recorded by Kennedy in Peaks, Passes and Glaciers (1862) portrays their steady approach by rowing boat, steering their way between miniature icebergs before clambering out to explore the lower reaches of the glacier. It would appear from the literature that the first person to reach the ice plateau was another English explorer, G. Hastings, accompanied by his guide E. Hogrenning in 1898. The narratives of von Bayer (1889) and Rabout (1898) contribute further accounts of the 'tourists' view of the glacier. Details of the history and exploration of the glacier are excellently documented by Hoel and Werenskiold (1962)*. From local reports it is known that as recently as 1925 the glacier at the head of Jokelfjord extended out to the 'bar' at terminated in a cliff nearly 70m high.

The glacier was of commercial value up until 1949 due to the relative ease of ice procurement for the local fishing industry. Only two other glaciers in Norway have been used in this way and fishing fleets from as far away as Scotland would seek the ice with which to pack fish. Initially the ice was collected from the lagoon as it calved off the main glacier. so great was the demand that an 'ice association' was established in the early 1930's. However after 1937 blasting was used to dislodge blocks following recession of the ice terminus and eventually with the installation of a refrigeration plant in 1949 the ice exploitation ceased. During World War II the area acquired a very different role, offering sanctuary to the local inhabitants of Jokelfjord whose homes had been raised by Germans, (Lovenbury 1962)*

Today the fiord is the scene of an active fishing industry in the winter months whilst in the late spring and summer the locals pursue traditional Norwegian hay making. In spring and autumn reindeer are herded together and made to swim across the narrowest point of the fiord near to the bar in front of the fall-jokul. A few tourists visit the glacier by boat but rarely visit the ice-cap itself.

*Hoel & Werenskiold, 1962; Glaciers and Snowfields of Norway. Norsk Polarinstitutt Skrifter Nr 114, p.111-117.

*Lovenbury, H. 1962; Oksfjordjokulen 1961, Exploration Review, p.18-22, p.30

PERSONNEL

Dr Anne F. Gellatly Leader	- Temporary Lecturer, University of Sheffield. Field experience in N. Norway, New Zealand, Greenland, Baffin Island and Himalaya.
Dr John E. Gordon	- Nature Conservancy Council, Peterborough. Field experience in N. Norway, S. Georgia, Antarctica, Greenland, Iceland.
Dr Jim D. Hansom	- Lecturer, University of Sheffield. Field experience in Iceland, S. Georgia, Antarctica, S. Shetlands, Faeroe Is.
Dr W. Brian Whalley	- Reader, Queens University Belfast. Field experience in N. Norway, Karakorum, Hindu Kush, Iceland, Alaska and Switzerland.
Dr Dave Twig	- Lecturer, Sheffield Polytechnic, Qualified Surveyor.
Mark Berrisford 21	- BSc Physical Geography/Geology. Graduate, University of Sheffield. Equipment Officer. S.U.S.S. Central Crete Expedition 1984
Tristan Firth 22	- BSc Physical Geography/ Geology. Graduate, University of Sheffield. Publicity Officer. Experience in mountaineering photography.
Erica Landy 21	- BSc Geography. Graduate, University of Sheffield. Provisions Officer. S.U. Canoe Club.
Andrew Hagger 19	- 2nd Year Geography Student, University of Sheffield Equipment Officer. S.U. Canoe Club
Chris Buchanan 19	- 1st Year Geography Student. BSES Lyngen Expedition 1984, Joint Treasurer, S.U. Canoe Club
Ruth Thomas 19	- 1st Year Geography Student. University of Sheffield. Joint Treasurer.
Lucy Grove M.D.	- Royal Free Hospital, London. Field experience in Baffin Island, Iceland, Kenya, India.

ADMINISTRATION AND LOGISTICS

PLANS:

Planning for the Expedition began in October 1985. We were fortunate in that decisions regarding the area to visit and the scientific justifications were quickly made. The article by Hoel & Werenskiold (1962) provided us with much useful information about Oksfjordjokulen. Selection of members was concluded by the end of October and our expedition to Oksfjordjokulen had also received a Patron - His Grace The Duke of Devonshire. A generous donation by the Duke also enabled us to open a bank account. Throughout November and December over 200 letters were written to various Trusts and Companies outlining our aims and seeking sponsorship and finance. Meanwhile we were offered the use of the Departments minibus which greatly facilitated in our budget planning. During the first two months we sought publicity from local radio stations, Radio Hallam and Radio Sheffield and this was followed up later with reports in the local evening newspaper.

Whilst activity on the fund-raising front was in full flight, the scientific programme was receiving new directions with the arrival of air photographs and maps. The photographs were obtained from Fjellanger Wideroe, Oslo. We were unable to get complete coverage of the whole peninsula and the fall-jokul at the head of Jokulfjord was, for the time being, to remain an unknown factor. The photographs cost £3.25 (Kr 34) each and delivery took 10 days. Maps of the area were ordered from Stanfords in London and they cost £3.25 each. Oksfjordjokulen features on one map, 1735 II 1:50000 series, 1979.

Searches through the literature can be tiring yet proved highly rewarding. Soon it became clear that a number of notable early scientists had known of the fall-jokul and we began to amass a number of exciting accounts of nineteenth century exploits in the area. Furthermore, we discovered that an expedition from Imperial College, London had surveyed the ice-cap in 1961. Amazingly all four members from that earlier expedition had remained in touch and we began to correspond with Howard Lovenbury. Our scientific programme began to be modified as we realised that the survey of 1961 provided an excellent base on which to make comparisons 25 years on. Table 1 provides a 'count down' of the planning stages. It can never be emphasised enough that everything takes time and that time quickly runs out.

Table 1

OCTOBER	- Decision to organise an Expedition to Arctic Norway - Letter Headed paper designed (not official) - Expedition members selected; 6 with previous expedition experience - Unofficial Prospectus designed and printed (c.300) - Invitation to Duke of Devonshire to serve as Expedition Patron
NOVEMBER	- Patron confirmed and letter headed paper completed - Contacted ALL trusts and funding bodies for details of awards and application forms - Ordered air photographs (Fjellanger Wideroe, Oslo) and maps (Stanfords, London) received within 2 weeks - Opened Bank deposit account with 4 designated signatories - Sent out 120 letters for sponsorship and donations - Contacted Norwegian Embassy re: permission - Negotiated ferry concession

DECEMBER - Application to Royal Society (closing date Dec. 15th)
- Application to University Expedition Fund (closing date Jan.1st)
- Application to Mount Everest Foundation (closing date Dec.31st)
- 1000 postcards printed for fund-raising
- c.100 fund raising letters sent to manufacturers
- Booked ferry crossing
- Arranged publicity on local radio

JANUARY - Application for The Explorers Club, N.Y. (closing date Feb.1)
- Application to Royal Geographical Society (closing date Jan.30)
- Application to Mick Burke Award (closing date January 31st)
- Arranged loan of survey equipment from Sheffield Polytechnic

FEBRUARY - Application to Gino Watkins Fund (closing date March 1)
- Application to Manchester Geographical Society (closing date March 1st)

MARCH - Literature searches at RGS & Alpine Club
- Talk by H. Lovenbury, Oksfjordjokulen Expedition 1961
- Organised equipment renewal and purchase
- Receipt of equipment on loan from Queens University Belfast

APRIL - Purchased main equipment (personal and expedition)
- Booked flights for JEG and JDH
- Checked passports
- Encouraged members to arrange dentist appointments

MAY - Organised Expedition medical kit (Student Health)
- Arranged insurance, Green Card and Equipment Hire
- Arranged packing date and demonstration of scientific equipment
- Arranged publicity in local newspapers and University Newsletter
- Checked equipment

JUNE - Confirmed travel bookings.
- Welcome addition of a qualified surveyor and doctor to the expedition
- Confirmed radio frequencies
- Contacted community at Alteidet
- Bought food and packed equipment

JULY - Vehicles left for Norway on July 2nd for 7 weeks.
- JDH, JEG and DT to Tromso July 10th
- LG to Tromso, July 15th

AUGUST - Expedition leaves Oksfjordjokulen August 6th
- JDH and JEG returned to GB on August 10th
- DT returned August 12th returning the Ford to Sheffield
- Expedition returns to Sheffield August 20th.

DIPLOMATIC CLEARANCE:
No official permission is required to visit Norway. It is advisable, however, to contact the Scientific Attache at the Norwegian Embassy (26 Belgrave Square, London) with details of all imported food and equipment as well as proposed plans to ensure no customs problems.

INSURANCE:
Each member of the expedition was fully insured for personal accident, medical expenses and personal loss. In addition comprehensive insurance was taken out against all expedition and scientific equipment. The loadings took into account the nature of the environment and the use of an inflatable to transport loads along Jokulfjord. Cover at £16.45 per head was arranged through the University of Sheffield. Additional equipment was insured against loss at a rate of 11p per £100 value. The same group arranged Green Cards and vehicle insurance. This package was substantially cheaper than other commercial companies and we received excellent assistance.

TRAVEL AND TRANSPORT:
Eight members of the expedition and our supplies travelled by ferry and road to Oksfjordjokulen whilst the remaining four followed on by air. The 'overland' arrangements were facilitated by assistance from a number of people. The Department of Geography permitted the use of the minibus, and a roof rack was loaned from the Department of Botany. As an alternative to freighting scientific equipment, assistance with transporting supplies was kindly offered by Dr Elizabeth Clutton of the Department of Geography using her ½ ton covered Toyota truck. The vehicles departed GB on July 2nd and we reached Oksfjordjokulen late on the 7th covering a distance of 1415 miles. Travelling north the two vehicles covered large distance each day with few stops (Fig.2). The Ford transit was less economical on fuel averaging about 18-20 miles to the gallon. The petrol tank held around 27L and care had to be made not to allow the fuel to run low on the long open stretches of road. Both vehicles retained a spare fuel can to avoid running out of petrol.

Various ferry crossings were necessitated en route although recent tunnelling has reduced the number of essential crossings to two for the entire journey. The ferries cost between £7 and £15. Tunnel tolls were paid on two occasions and a road toll operates for traffic entering Bergen.

Travelling for up to 10 hours a day is tiring for both drivers and passengers. After spending the first night on a garage forecourt, was stayed at NAF campsites. These are well sign posted and star-rated according to facilities provided. Prices vary and we normally paid between 50p to £1 per person. On the return journey we carried plenty of fresh water and sought our own camp sites.

FIELD ADMINISTRATION:
A base camp was established on the bar at the head of Jokulfjord, fronting the lagoon and fall-jokul. A top camp was established and occupied for the duration of the expedition, its location being shown in Fig. 2. All food was procured in GB and packed in 10 man-day portions two weeks before our departure date. En route some general supplies were purchased. Fresh water was available at both camps. Cooking at Base camp was on a double gaz burner. Refill calor gaz cannister can be obtained but not very readily as garages do not advertise their availability. Two pressure cookers, large pans and a collapsible oven were used for cooking. Insufficient small billies were taken. Paraffin stoves were used at top camp and fly camps. Paraffin is fairly readily available in Norway but Methylated spirits is not, and Meta Tabs were brought from GB. Two stroke petrol was kept in supply for the boat and generator. The ice-drill was powered by propane gaz cylinders. The nearest supply of fuel was 25km away, and we endeavoured to remain self sufficient throughout the 4 week field work period.

FUND RAISING

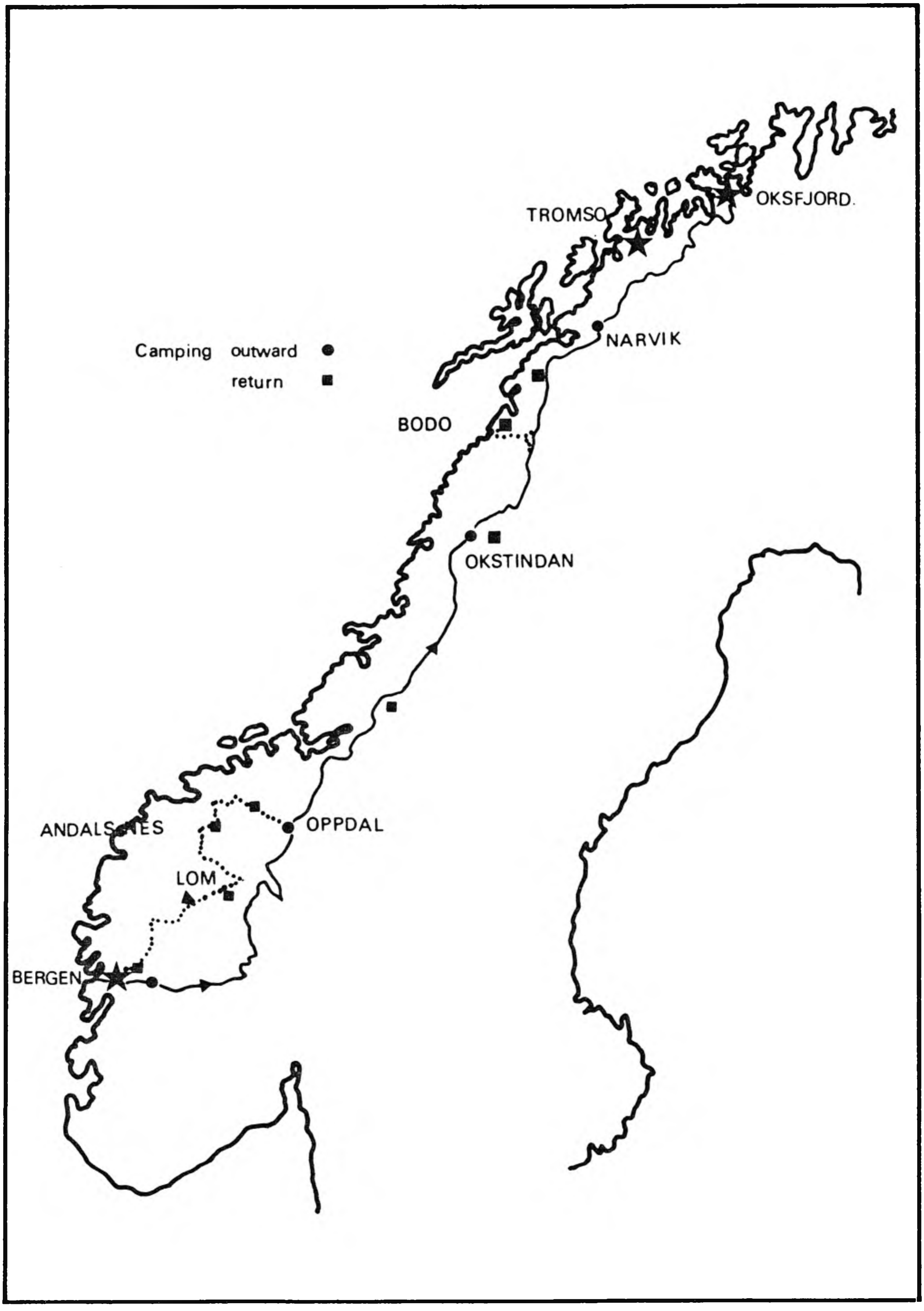
Estimates of the likely budget were derived from previous experience of visits to Arctic Norway. In October 1985 we were unprepared for the collapse of the Norwegian economy and the oil crisis that followed. We also underestimated the success we would achieve in fund raising. Clearly the early stages will always be depressing and slow. Rejections weigh heavy in the 'in' tray and you begrudge the cost of postage and photocopying. From the beginning we decided to aim high and produced a good quality, low cost prospectus. This attractive and informative leaflet eventually started to win us attention and we found ourselves the proud posessors of thermal underwear, clip boards and over 200 cleaning cloths. In November we struck upon the idea of producing our own postcard and trying to sell these to raise yet more funds. We selected a scene typical of the ice plateau of Arctic Norway and arranged for a print run of 1000. The cards cost c.11p each and for any sum over 50p we would post them back to people from the Arctic Circle. They arrived back from the printers on the last day of term and Chris lost no time in selling them to little old ladies as they queued at the bus stop outside the Department. This venture grew to be highly profitable and in one evening alone, £47 was raised by a team who visited local Public Houses in Sheffield.

Early in the New Year we negotiated a discount for the ferry from Newcastle to Bergen but were unable to get a reduction in air fares for two of the expedition who would fly out later in July. In February we were greatly ncouraged by the award of £600 from the University Expedition Fund. We were advised to increase our budget for insurance, however, as things turned out our original estimate was very accurate. Personal contributions were established at £250 for salaried members and £150 for students. In reality this sum would barely cover the transport costs and we were committed to fund-raising.
The success of fund raising is shown in the Appendix. The generosity of friends, relatives and local businesses is particularly marked. A substantial quantity of food and clothing was provided free or with substantial discount. A considerable amount of time goes into fund raising and although letter writing was speeded up using a word processor, the overall effort must amount to 1-2 man-days per week in the early stages reducing to about 1 man-day p.w. after Christmas. All responses were acknowledged and a careful account was made of all who had been contacted. On a number of occasions two different addresses for large firms were used and it was surprising how often we would received a negative reply from one site and a positive response from a separate department or section. Clearly perseverance and a 'bit of cheek' does pay! It is gratifying to learn that scientific expeditions are considered a priority for sponsorship with many well known companies. Alternatively, a disabled OAP on a scientific expedition for the first time could probably maximise on all good will around. We acknowledge all the firms, companies and individuals who supported this expedition. In thanking you we hope that you will continue to support others who are encouraged by the success of this venture.

Problems: We encountered few difficulties in managing the finance of the expedition. Two points:

- try to ensure that all cheques received are made out correctly to the expedition.
- if you are not a registered charity then some donations might have to be return

FIG. 2



TROMSO
OKSFJORD.
Camping outward ●
return ■
NARVIK
BODO
OKSTINDAN
ANDALSNES
OPPDAL
LOM
BERGEN

MEDICAL ARRANGEMENTS:
The University Health Service assisted with the selection and provision of necessary supplies. Queens University Belfast provided free of charge one medical kit plus analgesics. Two first aid kits were assembled for field use with additional small kits for short sorties away from either camp. A first aid kit donated by Smith and Nephew Ltd was retained in the vehicle at all times. The contents of the field first aid kits are detailed in the appendix. Each member of the expedition was supplied with Repel 100 insect repellant and Glacier cream.

FOOD:
Those of use who had been expeditioning a long time understood and knew the importance of FOOD not just for safety and health reasons but also for general moral. A considerable amount of time was put into arranging a wide selection of good quality, nutritious food items. We were aided by tremendous support from food manufacturers both in Great Britain and Norway. All donations were carefully stored in the Department and in June it was possible to appraise the situation and arrange purchase of items required. Details of quantities used are given in the appendix.

The food was packed in 12 man-day boxes (1 x 12, 2 x6, 3 x4 man days). The boxes were obtained from the University library and formerly held xerox paper. They were wrapped in light plastic bin liners and sealed with plastic tape. Two boxes fitted into most conventional backpacks and so were easily transported to the top camp. Four essential menus were arranged for the evening meals and an assortment of lunch items enhanced the variety. A typical food box for 6 people over two days contained:

> 1 tin porridge; 1 bottle 5 pints; 12 packets Healthy Life Biscuits; 1 box matches; 2 x 6 main meals; pasta/rice or potato; soup; apple flakes and custard; instant whip; 12 chocolate bars (assorted) 12 crunchy bars (Jordans or Shepherdboy bars); 24 tea bags; 12 coffee bags; 3 satchets fruit juice; 3 tins sild; 2 tins spam, cheese spread, cheese or 6 sticks pepperami; sauce mixes.

In addition each week a box of separate supplies comprising; margarine, additional biscuits, jam, marmalade, honey, syrup, spices, mustard, tinned pineapple, sweet corn, clean scourer and dish cloth was provided. A small treat was placed in each man-day box to accompany late-night drinks. A piece of fresh fruit was provided per person each day for the duration of the expedition and was very popular. Indeed it felt almost decadent to be eating an orange on an ice cap so far north. In addition a wealth of fruit cakes kept the expedition in good supply right to the last week.

The rations at first appeared excessive, particularly at Base camp where the diet could be supplemented with fresh fish and any excess food remaining from the initial journey north. Latterly the proportions were adjudged to be nearly right although insufficient tea bags were brought. It is satisfying to reflect that the only major complaint was to do with excess and not insufficiency!

SCIENTIFIC PROGRAMME

INTRODUCTION

The Oksfjord Peninsula (70°N 22°E) of maritime N. Norway is characterised by two ice caps between 950-1200m asl (Fig.3). Current work further South in the Lyngen Alps (69°N 20°E) shows that plateau ice caps above 1600m maintain a positive net balance whilst two nearby ice-caps below 1100m have been contracting since 1896. Thinning of these ice-caps produces 2 types of outlet glacier from the high plateaux; conventional valley glaciers, and detached glacier-cones, or 'fall-jokul', derived from ice-avalanches off the summits. The incidence of such avalanche events has been documented throughout the last 150 years. During periods of intensive ice avalanching, regenerated glacier cones build up against the mountain-side until the apex joins the feeder ice-cap. During periods of rapid glacier contraction, as occurred between 1932-1937, ice continues to avalanche although the two ice bodies may no longer be connected. The avalanches off Oksfjordjokulen frequently propel ice and rock debris out into a marine bay fronting the glacier. Calving ice sometimes chokes the bay which is demarcated by a boulder bar comprising debris up to 9m³ in size derived in this catastrophic manner. The peninsula was surveyed between 1891-1902 and the first map published in 1907. A further survey of the ice-cap was undertaken in 1961. Air photographs are available from 1947 onwards. No detailed survey of the fall-jokul environment has been published. Hence examination oof recent changes in glacier extent were believed to be instructive in the following respects:

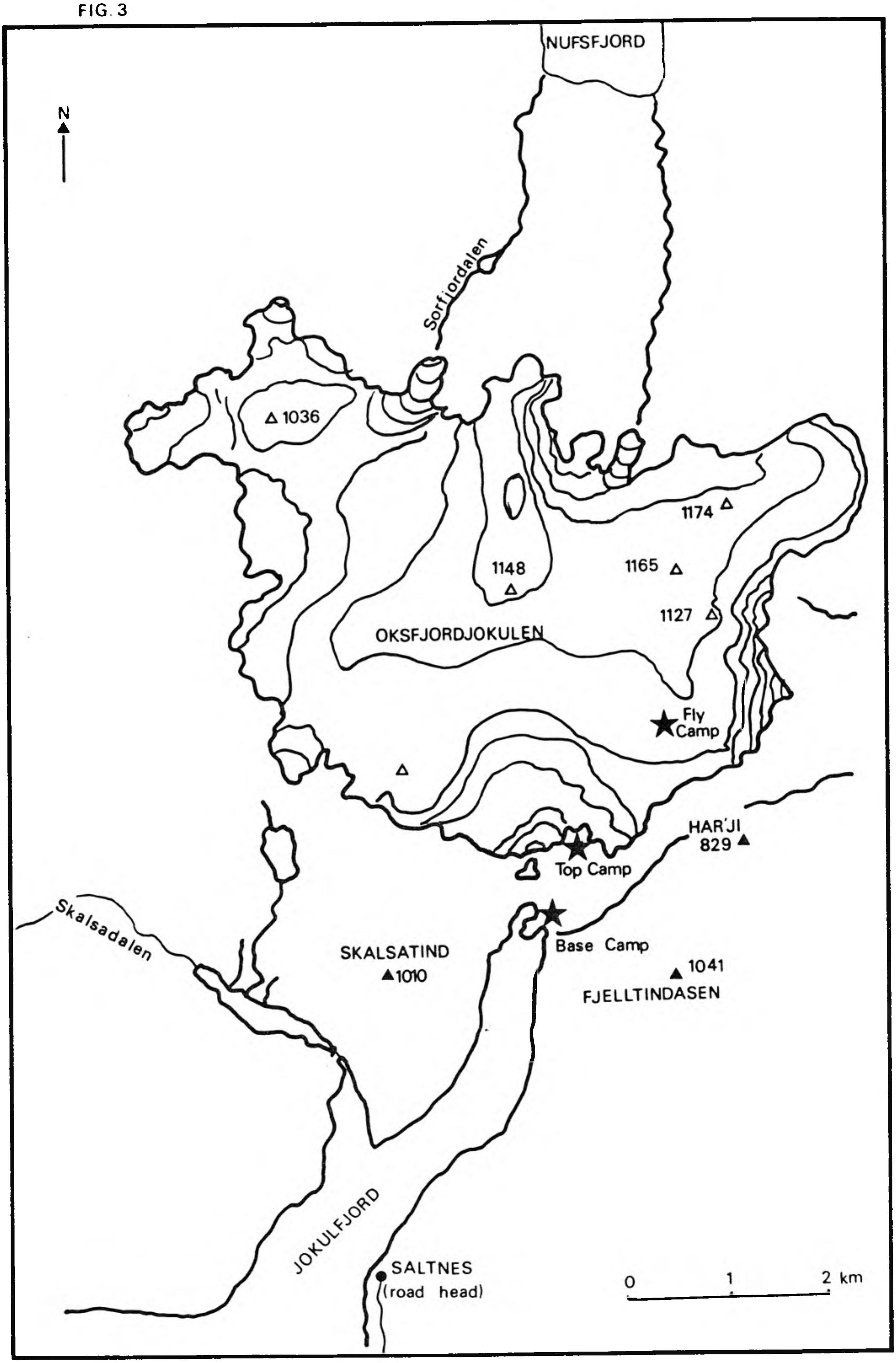
- to determine glacier responses to short term variations in climate
- as a comparison with detailed studies currently in progress on high plateau ice-caps in the Lyngen Alps
- to evaluate topographic controls on glacier nourishment
- to evaluate the geomorphic and sedimentological significance of fall-jokuls generated by ice calving from the plateau

From current investigations in N. Norway it was proposed that the ice-caps on the Oksfjord Peninsula must lie close to the present glaciation threshold. Two main projects were undertaken during the expedition to examine this hypothesis:

1. Survey of part of the Oksfjordjokulen ice-cap and its outlet glaciers to allow a comparison with the published survey of 1902 and the unpublished survey of 1961 (Lovenbury pers comm.). Use of radio-echo sounding to accomplish the following tasks; determining present ice volume; determining flow-lines of the ice-cap and, investigations of basal ice conditions. Excavation of the felsenmeer at the ice margins to investigate basal ice conditions, basal debris entrainment and depth of weathering in arctic conditions.

2. Investigation of the geomorphological impact of fall-jokul to examine the relationship of moraines and distinct glacio-marine sediments of the bay fronting the regenerated glacier. Sediment characteristics and the geomorphological nature of deposits were examined on present and past shorelines to establish the declining role of fall-jokul in the lagoon environment. The study involved survey mapping and sediment sampling of bottom and shore topography using radio-echo sounders, EDM and sediment coring.

FIG. 3



N
NUFSFJORD
Sorfjordalen
1036
1174
1165
1148
1127
OKSFJORDJOKULEN
Fly Camp
HAR'JI
829
Top Camp
Base Camp
Skalsadalen
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1010
1041
FJELLTINDASEN
JOKULFJORD
SALTNES
(road head)
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1
2 km

SURVEY OF ICE-CAP:

Introduction: The first survey of Oksfjordjokulen was commenced in 1893 and published in 1907 at a scale of 1:50 000. Co-ordinates are known of all four main trigonometrical stations established during this period. A revised edition was published in 1942 with no apparent revision of the ice-cap extent (Bergsfjorden 1:100 000, Sheet S4). Similarly, maps of the area produced in 1940 and in German, show no alteration to the earlier survey (Norwegen 1:50 000, Bergsfjord S4). In 1979 N.G.O. published the official 2nd Ed. of the 1:50 000 sheet, Oksfjordjokulen 1735 II.

Aerial photographs are available from 1945 (RAF, Swansea) and 1977-1979 (Fjellanger Wideroe AS, Oslo). In 1961, the Imperial College Exploration Board helped to fund an expedition to Oksfjordjokulen with the specific aim of producing accurate ground control from which to enable a map of the ice edge to be produced using earlier air photos. Using this unpublished survey, recent air photographs and our own revised ground survey we were able to determine recent fluctuations along the ice-cap perimeter as part of an overall assessment of environmental change in Arctic Norway.

Field Work; There are two basic projects associated with surveying of the ice cap. In addition survey assistance will be provided for the radio-echo survey of the ice-cap and elsewhere. Using a AGA Geodimeter (form of electronic distance measurement which is mounted on a Wild theodolite and tripod) and up to two additional theodolites with targets (prisms which register the sighting of the Geodimeter) the survey team undertook a survey of the southern edge of the ice-cap and traverse the ice-cap to produce profiles of the snow dome. The 1893 trigonometric stations were relocated as were the stations used by the 1961 expedition. Two portable hand sets (ICOM) were used and when the weather was settled during the second and third weeks, the work often continued until 2 or 3am.

a. Southern Ice Edge: Although the Imperial College Expedition 1961 did not map the ice edge as such, its position was from their survey which included photograph coverage from each of their survey stations. Just before departure from England, Michael Baker of Imperial College made available an updated report of the 1961 survey and we were able to repeat photographs of the stations and their surrounding area. These record changes in ice loss and accumulation patterns associated with the ice cap.

b. Profile Determinations: The determination of various profiles across the ice cap was tied in to the known positions of the Norwegian Geodetic Survey (NGO) and those determined by the I.C. 1961 Expedition. These will provide;

i) ice height profiles for comparison with any subsequent expedition.
ii) reference heights for the ice thickness determinations.
iii) reference points for a general map of ice features eg. snow hole digging, radio echo sounding.

All survey work was directed from Top Camp and involved one 'fly camp' at the 1st nunatak. This camp was later moved to 2nd nunatak for further work.

RADIO-ECHO SOUNDING

Introduction: Radio-echo sounding was carried out both on the ice-cap and in the vicinity of the lagoon. Separate instruments were available for both projects.

Lagoon: Bottom and shoreline topography was investigated using radio-echo sounding techniques to determine the past environmental significance of the fall-jokul. It was possible to detect the presence of irregularities on the bottom topography of the lagoon and try to relate these to glacial deposits and large erratics resulting from previous periods of catastrophic avalanching. Such discoveries should enable us to reconstruct the magnitude and fequency of geomorphic events as they have affected the inner lagoon in deglacial times. This study has wider implications for work carried out on the deglaciation chronology of the peninsula and measurements of coastal shoreline characteristics. Radio-echo sounding was undertaken from the inflatable. The sounding was undertaken with a survey support team who were responsible for 'fixing' the location of the boat using the survey equipment.

Ice-cap: Intuitively perhaps, we would like to know the depth of a glacier or ice cap. Such interest is increased with the desire to explain the way glaciers move, erode and respond to climatic change. Yet ice depth is not easy to measure. Drilling beyond a few metres is hard work, expensive and requires a great deal of equipment. Seismic methods, although feasible, again require complex equipment for more than very shallow ice masses.

In the last 10 years however, various methods have been employed to allow sounding in temperate ice (that which is at thermal equilibrium as opposed to ice which is frozen to its bed). The system employed on Oksfjordjokulen was the USGS Monopulse system, better known as a pulsed, low frequency radar, designed by Steve Hodge *et al.* In this system, a pulse of energy is derived by stepping up a 24 V DC supply to 750 V and allowing this to 'avalanche' a series of transistors. The pulse was radiated into the ice through a resistively loaded dipole aerial. This consists of a length of wire laid out on the ice symmetrically in a line either side of the transmitter electronics box. Resistors of various values were soldered into this wire at specific points. Several lengths of antennae were used for differing ice thicknesses and emitted frequencies. The signal, reflected from the ice-bedrock interface was picked up by a similar aerial a short distance away and was fed directly to an oscilloscope. The emitted pulse was repeated at a given rate (5MH$_2$ in our system) and the trace on the 'scope showed the first return (the air wave of radiation from the transmitter aerial) and the reflected pulse form the bottom of the ice. By knowing the velocity of the propogation of electronmagnetic pulses through ice the delay between the 'first return' and the reflected pulse gave the depth from the surface to the bottom of the ice.

With the system employed its relative simplicity was traded off against some inconvenience. It is an analogue system so a recording (by camera) of the 'scope trace was necessary. This will be interpreted subsequently. Thus, it was not possible to obtain continuous profiles with any ease. Individual depth determinations ('drilling' in the parlance) are easiest but some reasnoble profiling was obtained by allowing a short spacing between 'drilling' positions. A farther requirement then was knowing the positions of the instrument on the ice. This was done with the Geodimeter.

The aim was to obtain several profiles across the ice cap (starting in the east) from south to north. At locations along the traverse lines, the ice depth was determined and the position from the ice edge surveyed.

GLACIOLOGY

Introduction: Investigations of the mass balance and general state of health of the ice-cap were carried out throughout the field work period. Work concentrated on the excavation and detailed description of a snowpit and, investigation of the stable isotope composition of subglacial ice.

Field work: The net accumulation of snow each year on the upper reaches of a glacier provide a record both of contemporary climatic conditions and the chemical composition of the precipitation. This record can be interpreted over a period of years from successive annual layers preserved in the snowpack. At Oksfjordjokulen a snow pit was dug to 5m and samples collected for laboratory analyses of oxygen isotopes, radioactivity levels, conductivity, sulphates and nitrates. The results will improve understanding of;

i. the degree of preservation of annual layering in the snowpack,
ii. the concentration levels of certain pollutants in the snowpack over the last 3-4 years,
iii. climatic variations and pollution trends over the last few decades

Recent work has shown that the stable isotope composition (oxygen and deuterium) of subglacial ice reflects the history of melting and refreezing at the base of a glacier, which has implications for glacier thermal regime and processes of debris entrainment. At Oksfjordjokulen, samples of debris-rich and clean glacier ice were collected from a range of situations including an extensive ice cave close to top camp, to determine what relationships exist between the stable isotope content of the ice, its debris content and inferred thermal history.

EXPERIMENTAL ROCK WEATHERING

Introduction: The summit blockfields which are exposed at the ice perimeter are an ideal location for investigations into environmental conditions during recent deglaciation. The blockfields are characterised by large boulders and weathered bedrock which have been partially 'sorted' through periglacial activity. The nature of processes leading to rock weathering and sorting in the blockfields is largely unknown or poorly understood. Investigations of present day mechanisms and understanding of the processes operating close to the ice edge may afford useful analogues for relict landforms which are present in the highlands of Britain. In contrast to sites known from elsewhere in N Norway, few extensive areas of sorted ground were found around the ice edge of Oksfjordjokulen. Areas of well-sorted patterned ground were recorded on some adjacent summits (Storfjellet, Svartfkellet) but were not investigated fully. Rather, work concentrated on continuous monitoring of rock breakdown as related to environmental gradients in temperature and insolation.

Field work: A detailed examination of high altitude rock weathering using an infra-red thermometer, donated by Land Instruments, was conducted throughout most of the expedition's scientific phases. Measurements of heat exchange capacity of blocks as related to air temperature and moisture should further existing knowledge of the 'critical' value that must be reached in order for mechanisms of weathering to occur. Such 'open-laboratory' type experiments help to examine real-life rock disintegration as opposed to the more usual, but very styalised laboratory-based experiments. A computer provided instant print-outs of the response of rocks to fluctuations in air temperature and the experiments, which could be run continuously, provide very useful data on rates of heat exchange between differing rock types.

HOLOCENE GLACIAL HISTORY

Introduction: It is probable that Finnmark was covered by ice during the last glacial maximum, possibly with the exception of small nuntaks in the western mountain area of Oksfjordjokulen. Studies of raised shore lines indicate that the maximum ice advance reached at least 70-120 km off the coast and farthest in the east.

Moraines indicate a number of halts in the succeeding ice recession. The oldest documented moraines of the Risvik sub-stage are not known from West Finnmark. Younger moraines of the Outer Porsanger sub-stage are regionally traceable and the subsequent Repparfjord sub-stage is recorded in the western part of Finnmark. This latter stage is correlated with the Skarpnes moraines of nearby Troms, C^{14}-dated at 12 000- 12 500 yrs BP. Distinct end moraines between the Repparfjord and Main sub-stages define the margins of active glaciers. The regionally best defined margin is the Gaissa substage.

The Main sub-stage moraines are usefully correlated with Tromso-Lyngen moraines of Troms district. This period of activity if C^{14}-dated to around 9000-8200 (Younger Dryas) or older. The main sub-stage was of considerable duration and may be interpreted as comprising a double advance. Distinctions between the Main sub-stage of c.9000 and the earlier Gaissa sub-stage is frequently difficult in the field and is complicated by the influence of local glaciation in the mountains of western Finnmark. The persistence of local ice long after the retreat of mainland ice and the survival of high plateau ice-caps can be documented with reference to suites of Holocene moraines.

Holocene moraines are hitherto unrecorded and few Neoglacial advances have been accurately dated this far north in Scandinavia. During the last few hundred years glaciers enlarged in a period commonly termed The Little Ice Age. Evidence of past fluctuations of the ice extent are to be found by mapping the outer limits of former glacier advances using moraines and other proxy evidence.

Two large ice-caps and several smaller, residual ice-fields survive on Oksfjord peninsula. In former times, ice from Oksfjord joined the glacier flowing out of Stjernsundet which sent a lobe into Græsdalen. The resulting moraine reaches c.100m a.s.l. Low ridges which resemble De Geer moraines (cross valley moraines) occur inland, noticeable in Ullsjorden and Tverrfjord, and these can be clearly identified on air photographs. In each case, the glacier retreat took place in a shallow fjord. Fluctuations of the ice-caps have occurred throughout the Holocene. The largest tongue of Oksfjordjokulen, Jokelfjordbreen forms a regenerated glacier - Nedrebreen. This glacier appears to have retreated considerable in recent times as has the glacier in Storelvdalen to the east of the ice-cap and those glaciers flowing to the north into Sorfjordalen and Fjordalen.

Table 2

	Top Camp	Base Camp
Average precipitation	37.5 ml	33.4 ml
Highest precipitation	260 ml	245 ml
Lowest precipitation	0 ml	0 ml
Average wind speed	322 m	331 m
Highest wind speed	729 m	579 m
Lowest wind speed	5 m	0 m
Highest temperature	18° C	26° C
Lowest temperature	3° C	-6° C
Maximum humidity	105 %	92 %
Lowest humidity	52 %	43 %

NB. Values for wind and precipitation uncorrected

SURVEY OF THE FALL-JOKUL

Introduction: The fall-jokul is a consequence of active ablation from the high ice-cap which is manifested in a series of spectacular avalanches. It is technically a regenerated glacier which has accumulated at the base of the plateau perimeter. During periods of excessive ablation, the cone has built up and almost joined the lowermost extension of the outlet glacier from Oksfjordjokulen, 1000m above. The fall-jokul is named Nedrebreen or Lower Glacier.

Sketches, photographs and early surveys have resulted in an interesting archival collection of the appearance of Nedrebreen. In 1961 a detailed survey of the cone was undertaken by Imperial College Expedition (c/o Howard Lovenbury). This survey paid particular attention to the changes during the summer season of the lower cone. This study was repeated on arrival and shortly before our departure thereby allowing an accurate comparison with the glacier state 25 years ago.

METEOROLOGY

Shortly after arrival two weather stations were established, one at base camp as close to the Nedrebreen glacier as possible whilst still maintaining a degree of accessibility and the other at the top camp on the edge of the ice cap. Base camp station was sited on a bar modified by coastal processes, approximately 400m from the foot of the regenerated glacier and at a little more than sea level. The top camp station was located on the moraines which surroun the edge of the ice cap and was at a height of approximately 700m.

Both stations recorded air temperature and humidity using a thermohydrograph, wind speed using an anemometer and precipitation with a 5" cone and measuring cylinder. Measurements were made on a twice daily basis at 8am and 8pm, The duration for which these stations were in operation differed due to people being present at these camps but both stations were operational for at least three weeks. A summary of results can be in seen in the accompanying table which shows average values and minimum/maximums obtained during the fieldwork period (Table 2).

Table 2 demonstrates the importance of temperature inversions which characterised the field sites. A reading of -6°C at base camp compared to one of 3°C for top camp at the same time is related to the strong microclimatic effects created by downdraughts of cool air off the plateau at night

GLACIAL GEOMORPHOLOGY

Introduction: Landforms relating to the glacier were examined on the plateau edge where a sequence of moraines and ice-moulded surfaces were mapped. Attempts were made to relate these to the overall history of glacier history on Oksfjordjokulen. Up to three moraines showing distinctive stages of rock weathering, plant colonisation and soil development were identified around the ice edge. Smoothed bedrock surfaces were carefully examined for details of ice striations and the various surfaces tested using a schmidt hammer to determine any variation in surface weathering with apparent increase in age with distance from the present ice margin. The significance of the ancient plateau rim moraines can only be fully understood with recourse to an examination of the depositional sequences in the major outlet valleys of the ice-cap.

Field work: Moraines in the major outlet valleys to the south, east and north of the ice-cap were examined during a number of exploratory visits. A series of remarkably well preserved moraine sequences were described from each valley with up to three separate phases of late-glacial deposition present in valleys associated with the outlet glaciers of Oksfjordjokelen, Langfjordjokulen and Svartfjell. A complex sequence of Neoglacial moraines are documented although no dating control is available at present. In Nufsfjord, three peat bogs separated by moraines were cored and basal samples collected. The outer moraine at c. 30m OD was washed by subsequent marine action whilst elsewhere some outer moraines were cut by late glacial shoreline activity.

Regional correlations of the late-glacial deposits are restricted by the absence of an adequate dating tool. Soil samples were collected from the oldest deposits to draw comparison with known dated surfaces from elsewhere in N. Norway. The association with shoreline features offers the strongest hope of understanding the chronological sequence of Holocene glacial events.

The most recent changes in glacier extent are recorded by archival material and a number of photographs, lithographs and written descriptions were used in order to reconstruct former ice limits during the last 200 years. The outlet glaciers of all three ice caps on the Peninsula have exhibit a marked shrinkage which appears to continue up to the present day. The detailed survey carried out this summer will confirm recent trends since 1961.

RAISED SEA LEVELS AND DEGLACIATION

Introduction: The study of raised shore lines requires a knowledge of the relationship between shore features and the sea level at the time of their development. Work on the nature of shore forms and raised sea levels as affected by marine abrasion and frost action will be undertaken initially in the vicinity of Jokulfjord.

Clear signs of raised sea levels can be seen almost everywhere along the coast of Finnmark. The raised features are typically beach ridges and terraces both in sedimentary material and bedrock. The rock terraces tend to indicate relatively stable sea level in former times (line of equilibrium), while beach ridges and terraces in sediments could be derived from any sinking sea level. Additional features which help to characterise former shorelines include deltas, truncated melt channels or occasional boulder trains pushed up by the sea ice in winter.

As with the glacial history, considerable information is known about regional patterns of deglaciations and shoreline changes yet no detailed study existed for Western Finnmark and the area of Oksfjordjokulen. Fieldwork this summer aims to evaluate the sequence of raised shorelines and relate these to past fluctuations in regional and local ice patterns.

Fieldwork: Determining a 'bench mark' such as the 'upper marine limit' from which to produce accurate field surveys is normally riddled with inaccuracies and so it is important to employ several methods to obtain dependable results. The marine limit is the boundary between beach gravel and abrasion marks, but this is frequently obliterated by the deposition of sediment or cryogenic processes. Field work concentrated on levelling the various features and determining the absolute heights of different terraces in adjacent areas. Studies were initially centred on the shoreline features along Jokulfjord. Later, work was extended into Nufsfjord and Kvaengenfjord offering extensive regional synopsis of the behaviour of changing sea levels. Associated with the deglacial history of coastal features were numerous trapped embayments and low lying bogs. Where possible, basal samples were collected using a Russian corer. These should provide excellent records of environmental conditions during the last 10000 years.

MEDICAL REPORT

Lucy, a qualified medical doctor, joined us for two weeks whilst in Oksfjordjokulen, and Brian, who was in Norway for the whole period, holds a current St Johns Ambulance Certificate. Throughout the entire expedition no serious injury or illness was sustained. Some notable injuries included a badly bruised kneecap, assorted cuts and blisters from pulling the starter handle on the boat. One serious instance of snow blindness was recorded as a result of a prolonged period of surveying when it was awkward to wear sunglasses and site onto stations.

The summer was notable for the absence of insects although repel was used from time to time when camping in other areas. Glacier cream was needed when working on the ice cap to provide initial protection. The following list itimises the medical kit that was taken. An asterix indicates if the items were used.

DRESSINGS AND BANDAGES:
Crepe 2; Conforming 7; Triangular 1; Turigrip support 2; Melolin 6 large, 4 small; Cotton wool; *Sterile swab 6; *Adhesive tape, 2 rolls; Adhesive bandage 1 roll; Steriprep wound tissue 6; *Adhesive plasters 1 roll; *Assorted plasters 1 bag; medi swabs 1 box;

CREAMS AND OINTMENTS:
*Anthisan 2; *Savlon Antiseptic 1; *Mycil; Anusol; Optrex eye lotion; *Muscular pain spray; Savlodil solution 9satchets; Neo cortep eye/ear drops 3; Chloamphenicol eye ointment drops 2 plus satchets; Hydrocortisone ointment; Brolene eye drops 1; Terra-cortril ointment 1; Fucidin ointment 1; Flypel insect red 1; Mycota Powder 1;

TABLETS AND DRUGS:
Paracodal 100 tablets; Paracetamol/codene 1 bottle; Aludrox (indigestion) 1 box; Piritron; Te-tracycline pills 1; Noctamid sleeping 1; Sudafed 2 box; Septrim antibiotic 100 tablets; Imodium (diarrhoea) 90 capsules; strepsils 1; senokot 1; Andrews 1 tin; Dextrosols 2 tubes; Diuralyte cherry 4; Pripesen 1.

During the fund raising drug companies were approached for assistance. We are grateful for the support received from Smith & Nephew Ltd. We would like to recommend that in future, expeditions receiving the support of The University of Sheffield should receive assistance from The Student Health Centre.

FOOD

Typical rations per day for 12 people:

12 x 100g packs Healthy Life Biscuits
1 tin Morn Flakes oats
1 bottle 5 pints
24 tea bags
12 coffee bags
Jam 400g, Marmalade 100g
12 bars chocolate (Topics, marathons, mars, yorkie)
12 crunchy bars (Jordans, Letec, Shepherdboy)
12 pieces fresh fruit
5 L fruit juice (grapefruit, orange)
12 pints soup (assorted)
1.4 Batchelors dehydrated meat
4pkts vegeburgers
2 Colmans sauce mixes
125g mixed veg. or 100g dried peas
500g pasta or spaghetti
1lb digestives
1lb sweet biscuits (Hobnobs, Ginger nuts)
200g Dried fruit
125g custard powder
100g Instant whip
250g margarine
1 box matches
6 tins sild or sardine *or*
4 tins spam *or*
12 sticks pepperami *or*
30g cheese *or*
3 tins chicken spread

In addition 2 large catering packs of Drinking Chocolate and one of coffee were bought to supplement the above. A wide range of spices were included but the Colman Sauce mixes were preferred and the variety was appreciated. Sild and pepperami were the preferred lunches and cheese spreads were popular. Topics and Yorkies were eagerly sought after and the additional crunchy bars provided useful nibbling between meals. The occasional tin of pineapple or sweetcorn helped to add variety. A general supply of sugar, marmite, golden syrup, honey and lemon essence was maintained. Cake and scone mixes were successfully cooked in an oven. Each Sunday a fruit cake was consumed with relish.

When travelling the food varied slightly. Shredded wheat and muesli replaced porridge, and dehydrated food was exchanged for tinned burgers, casserole, corned beef and chicken. Throughout the expedition, the only marked shortage was of custard powder and tea bags. It is noteworthy that at base camp the food was generously supplemented with local supplies of freshly caught fish.

The variety, quality and quantity of food consumed during the expedition is largely due to the generosity of sponsors who are acknowledged.

INCOME:

Personal Contributions	2500.00
Royal Society	1800.00
New York Explorers Trust	629.18
Sheffield University	600.00
Mount Everest Foundation	300.00
Lord Leverhulme	250.00
Manchester Geographical Soc.	200.00
Royal Geographical Soc.	150.00
The Duke of Devonshire	100.00
Gino Watkins Trust	100.00
Royal Jubilee Trust	100.00
Croydon LEA	75.00
C.V. Home Furnishing	50.00
Silverton Mill	50.00
Exeter LEA	50.00
Arnold R. Horwell	20.00
Gregorys Ltd	10.00
A.J.W. Milner	10.00
Mole Valley Farmers	5.00
Total	6999.18

EXPENDITURE

Radios	926.91
Ferry 8 return passages	690.25
Airfares, 2 @ £306	612.00
2 @ £250	500.00
Air fare B'fast-Manch.rtn	97.00
Insurance	369.04
Food	654.97
Petrol in Norway	820.00
Ferries, Road Tolls	142.00
Climbing.Camping equipment	436.45
Camera Film	415.00
Servicing vehicle	145.54
Servicing outboard	136.39
Stoves, Fuel, Primus spares	164.80
Cooking equipment etc	114.87
Stationary, postage, printing	123.40
Maps 12 @ 3.25	39.00
Route maps	45.00
Air photos	65.00
2 star petrol boat	74.35
Ice drill supplies	80.00
Medical kit	30.97
Drugs	45.71
Scope Hood	39.02
Brake Blocks	26.00
Camp sites	45.50
Postage for postcards	68.00
Incidentals in Norway	56.00
Fishing boat hire	30.00
Total	6908.17

Balance remaining of £91.01 to be used to help finance report and service of Ford pickup truck. Some climbing and camping equipment to be sold to support funding of analyses. The radios were bought with funding for scientific work and will be retained for use on field work for a fixed hire charge to be administered by AFG.

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The Expedition gratefully acknowledges the support of all trusts, scientific bodies and individuals who awarded money for this venture as shown in the Financial Report. In addition we acknowledge the generous support of the following companies and individuals who enabled the expedition to be a success:

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