THE REPORT OF THE QUEEN MARY COLLEGE EAST GREENLAND EXPEDITION 1968

THIS COPY OF THE REPORT OF THE

QUEEN MARY COLLEGE

EAST GREENLAND EXPEDITION

1968

IS PRESENTED TO

ERIC

IN APPRECIATION OF THE ENCOURAGEMENT

GIVEN TO THE EXPEDITION AND ITS MEMBERS

PREFACE

This report will be read, we hope, by the sponsors of the expedition, friends, groups who will seek guidance in preparing their own expeditions and by our own members in years to come who may wish to recall arduous but happy days. Obviously it will be difficult to satisfy all readers but our main intention is to make the report enjoyable reading. Since the technical work will be subsequently published elsewhere we have endeavoured to word that section of the report in as non-technical language as possible. Whilst members have had individual responsibilities for various sections of the report all members have been counselled for help in the preparation of each section. This report therefore is a further piece of total co-operation between members that has been a hall-mark of the project from its inception. In an endeavour to get the report published within four weeks of our return to the U.K. we have kept the team together in Queen Mary College until the last page was written. Admitting that editing, in general, tends to de-humanise a project this exercise has been kept to a minimum. Furthermore it was decided that each member should try to pass on the intimacy created during the preparatory and field work periods and so each person has contributed a "personal point of view" that has remained unedited.

All expeditions maintain they were "successful". We of the Q.M.C. East Greenland Expedition 1968 are just as emphatic because

(i) all members at all times thought of others before themselves,

(ii) irrespective of two serious accidents no compromise of the scientific programme was made,

(iii) eight new climbs were made including the first ascents of four peaks. In total some fifteen peaks were climbed,

(iv) It is intended to publish in the very near future four technical papers with the following titles and readers may write to Q.M.C. for reprints:

1. Measurement of surface velocities and ablation; Bersaerkebrae Gletscher, East Greenland 1968.
2. Surface strain rates on the Bersaerkebrae Gletscher, East Greenland 1968.
3. Observations on the formation of Dirt Cones: Bersaerkebrae Gletscher, East Greenland 1968.
4. Scree Fabric and Downslope Transfer near the Bersaerkebrae Gletscher, East Greenland 1968.

Finally the members say "Thank-you" to all who make this venture possible, we are most grateful. At times of difficulties we were glad to know we had your support.

K.J.M. LONDON
SEPTEMBER 1968

ACKNOWLEDGEMENTS

Every expedition that leaves the U.K. receives the assistance of many people. Our project gratefully accepted the generous assistance of a small army of helpers. It is hoped that in acknowledging their efforts we indicate, however briefly, our most sincere thanks.

At Queen Mary College, the Principal SIR HARRY W. MELVILLE and Registrar COL. R. P. TONG helped behind the scenes on several delicate issues. SIR GILBERT LAITHWAITE, College Governor and President of the Royal Geographical Society had previously shown interest in other College projects and he gave much encouragement to our scheme. The College Expeditions Committee comprising Dr. B. H. CHIRGWIN, Dr. B. W. HODDER, Dr. P. F. RAWSON, Dr. B. M. G. JONES, Mr. M. V. SAVILLE, Mr. G. E. CHURCH, MAJOR-GENERAL H. A. BORRADAILE, and several STUDENT SOCIETY REPRESENTATIVES including the PRESIDENT, gave advice and the all important first grant of money. Mr. C. E. EVERARD of the Geography Department accepted the responsibility of Home Agent and Mr. L. H. BURGES of Administration looked after the difficult problem of insurance cover. Dr. R. D. SUMMERS and NURSING SISTER JONES helped with all medical matters. The neat diagrams of this report are due to the work of MRS. G. GREEN and the expedition are also indebted to PROFESSOR A. E. SMAILES who gave his permission to use Geography Department equipment. Last and by no means least come the secretaries, LYNDA G., LINDA B., BERYL, CISSIE, ELAINE, KAY, CATHY, VALERIE, GRACE HILARY, and PETRA, the last named having typed the major part of this report.

The expedition received the co-operation of other expeditions in the field and regular contacts with Dr. P. FRIEND of Scott Polar Research Institute, Dr. I. SMART of Dundee University and Dr. M. SLESSER of Strathclyde University helped to smooth our transportation worries. Ft. Lt. DREW (R.A.F.) loaned one of our members some items of R.A.F. expedition equipment which proved most useful.

The expedition referees, Mr. A. STEPHENSON, Imperial College, Dr. M. HOLGATE, Nature Conservancy and Mr. E. E. SHIPTON must have made complimentary remarks beyond our hearing because of the subsequent support we were given. The initial planning period was made easier by the advice given by Dr. G. PERT, Mr. J. A. JACKSON and Mr. M. PETROVSKY all of whom had previously been to Greenland as had Mr. P. A. ASHWORTH of Queen Mary College who was one of the first geologists ever to go ashore at Mestersvig several years previously.

The Danish Ambassador to the U.K. ERLING KRISTIANSEN and Mr. K. PLOUGHMAN a member of the ambassador's staff helped with contacts in Denmark. Mr. E. HINTSTEINER of Nordisk Mineselskab and the mine manager at Mestersvig Mr. J. K. HANSEN were only two of many other Danes who helped the expedition.

In the last few weeks many unknown people at the end of telephones gave up their valuable time to help us. Even during the expedition help came from unexpected sources like Mr. B. HOLT, British Consul in Iceland and air force personnel of the ROYAL DANISH AIRFORCE.

The expedition would like to thank all firms, societies and institutes that provided the money, equipment and food for the venture; their generosity is noted elsewhere in this report. Mention must also be made of the large number of people from managing directors to delivery drivers who gave their time to help without our being aware of their assistance.

Special mention must be made to the ROYAL GEOGRAPHICAL SOCIETY, and MOUNT EVEREST FOUNDATION without whose moral support (as well as financial aid) no British expedition can gain widespread assistance. A most generous grant was made by an old College Friend, THE DRAPERS CO., and other generous grants of money were given by THE SCOTT POLAR RESEARCH INSTITUTE (GINO WATKINS MEMORIAL FUND), THE CHASE FOUNDATION, THE GOLDSMITHS COMPANY, SHELL INTERNATIONAL, THE CENTRAL RESEARCH FUND OF THE UNIVERSITY OF LONDON, THE GILCHRIST EDUCATIONAL TRUST and CHARRINGTON & CO. LTD.

CONTENTS

INDEX OF PHOTOGRAPHS

INDEX OF FOOD AND EQUIPMENT LISTS

LIST OF FIGURES AND TABLES

SUMMARY

The boat sailed from Leith on July 2nd with six of our eight members and the next two days were spent in lazy enjoyment of good food and first glimpses of the midnight sun. After a day to visit the sights of Reykjavik, the party flew out with the two other groups on a chartered aircraft.

On arrival at Mestersvig we were greeted by the manager of the Nordisk mine, Mr. J. K. Hansen, who was to help us so generously later on at the time of Miller's accident. We were able to buy at the mine fuel for the paraffin stoves and the two-stroke motor and also to hire a helicopter that the mining company had on trial at Mestersvig for that year. The night was spent in the "Grand Hotel", a comfortable wooden bunk house. Three helicopter lifts were needed the following morning to take all the gear and six members up to the site of the base camp on the Bersaerkerbrae Glacier.

They arrived in brilliant sunshine. Base camp was established and work on the Scientific Programme started immediately. Two stake lines, with a total of 23 stakes, were laid out across the glacier. Two types of stake were used, one of aluminium and one of an extremely light and durable plastic. The latter was the easier to handle. Holes of $1\frac{1}{4}$" dia. suitable for sinking the stakes were drilled 7' deep into the ice using a hand held motor drill which bored each hole in about 1/2 hour. The drilling was soon completed. We believed we were the first expedition (i) to use machine rather than hand drilling techniques and (ii) to use lightweight but rigid plastic rods as stakes. Most of the holes, however, had to be redrilled during the expedition owing to the high rate of ablation of the glacier.

Miller and Williams walked out from Mestersvig, so that all possible return routes were known in case of any accident, and arrived at base after two days. They traversed the col between the mine and the glacier, crossing the Skel River easily at a point just below the Skel glacier, and had found a well marked route along the true right lateral moraines of the Bersaerkerbrae Glacier.

In the first week the first excursion towards Col Major was made when Hird and Banaszek set off one morning taking food supplies towards the Col. They made very slow progress owing to knee deep snow, but managed to establish the first food dump.

In the meantime work had been progressing under Miller's guidance at the Lower Ice Fall. On completion of the drilling all members went down to the ice fall to take what were hoped to be the complete initial strain measurements. In fact it took three more trips for this to be done to our entire satisfaction.

On the 14th July Palmer and Hird went to the head of the glacier for four days hoping to set up a camp in the Gully Glacier. They were accompanied by Munro and Williams, who carried up climbing equipment and returned to base that evening. Deep soft snow covering extensive crevasse systems greatly hampered progress in the upper reaches of the glacier. Col Major was climbed and Camp II chosen at the foot of the Col.

On 16th July Keith Miller fell into a crevasse whilst taking more food up to Camp I and he had to be flown to Iceland for hospitalization (see page 48). The week following this accident, was one of renewed enthusiasm for the scientific programme; strain systems were laid out on the Bersaerkerbrae and Dunottar Glaciers, the Lower Ice Fall Survey was completed and the work on dirt cones started. Redrilling of stake holes was carried out where necessary. and the crevasse work completed. The 25th July saw the start of three days of bad weather - low cloud moved in from the sea and high cloud gave rise to slight sleet falls. Munro and Palmer walked to Mestersvig and back in this time in order to (i) investigate a low route following the Skel River, (ii) make preliminary arrangements for a helicopter lift at the end of August and (iii) to relieve the boredom caused by the poor weather.

Whilst out on "dirt-cone" work Hird fell into a glacier stream and was badly cut about the hands (see page 50). His sack, containing most of the strain survey results was lost and the next two days were spent in repeating this survey work.

It was now the end of the first month, and although the party had lost two of the most experienced climbers, climbing started in ernest. Beaumaris and Glamis were climbed by different parties on consecutive days, and after two days' rest, Bersaerkertinde.

The Scree Work was now in progress, and on return from Bersaerkertinde the climbing party helped finish this investigation before setting out for Col Major.

On 9th August Palmer, Williams, Munro and Banaszek went up to Camp II, and from there climbed Bersaerkerspire and Hjornespitz. They then went into Gully Glacier to set up Camp III.

At base camp, Drewry, Kanarens and Hird continued to take the regular ablation and weekly theodolite survey readings. Hird, recovering quickly from his accident, climbed Pimlico with Kanarens.

During the weekend of 17th August Banaszek returned to base and Hird joined the climbing party at Camp III. Indeed frequent changeover of personnel allowed a fair division of the scientific work between members.

A change of weather, introduced by two heavy snowfalls in the one week, upset the climbing plans although Lambeth and Danskitinde were climbed in this period from Camp III, and an unsuccessful attempt made on Blackwall by the base camp party. On 22nd August the climbing party returned to base.

In the following three days the Scientific Programme was completed, loads were taken down to a camp by the Skel river and two members set out for Mestersvig to arrange the final helicopter lift. All the gear was flown out from the Skel in one lift and the six remaining members walked back to Mestersvig arriving there on 27th August. The party left Greenland on 31st August by chartered aircraft and caught the boat from Reykjavik to Leith the same day.

INTRODUCTION

The Stauning Alps lie on the coast of North-East Greenland within the arctic circle at a latitude of 72° North. They are a complex of glaciers and mountains that extend over an area roughly 70 miles North-South and 35 miles East-West. They contain peaks rising to a height of nearly 10,000 feet above sea level, with faces up to 5,000 feet high.

During the last fifteen years the Danes have established a lead-zinc mine (now closed) and a weather station at a permanent base from which they are also prospecting for minerals. Previous scientific and mountaineering expeditions have used the base airstrip at Mestersvig as a starting-point for the Stauning Alps.

The mountains of the Stauning Alps are equal in grandeur to those of the European Alps and the area provides numerous opportunities for both exploration and scientific investigation in glaciology and geology. Although from 1954 onwards there have been several expeditions to this area the opportunities have by no means been exhausted. A party of eight members from Queen Mary College planned a scientific and mountaineering expedition to visit the area in the months of July and August 1968. It was proposed to spend most of the available time on a scientific programme and the remainder on exploration and mountaineering. The Bersaerkerbrae Glacier was chosen for several reasons (i) it is easy of access from Mestersvig, (ii) a 1963 expedition from Imperial College took flow measurements on the glacier and hence a comparative analysis could be undertaken (iii) there remained an area around the heads of the Bersaerkerbrae, Lang, Gully and Sefström Glaciers that could be usefully explored in more detail and a few unclimbed major peaks attempted.

THE BEGINNINGS

Our interest in the Stauning Alps was first aroused in March 1967 after a conversation between Keith Miller and Geof Pert who was a member of the 1963 Imperial College Expedition. Pert suggested that the Stauning Alps would be an ideal area for a first Queen Mary College expedition to Greenland.

After Easter 1967 R. Palmer and T. Hird began collecting information and making enquiries with the advice of Pert and Miller. Several members of the college mountaineering club showed considerable interest in a mountaineering expedition and it was apparent that there were enough people willing to form at least a six man expedition during the summer of 1968. Early in October 1967 Miller's trip to the Himalaya was postponed and he was invited to lead the Greenland project.

Two basic problems were travel and finance. To visit the Stauning Alps by the cheapest mode of transport it is necessary to travel to Iceland by boat and then charter an aircraft to Mestersvig. Six boat passages on the M/V "Gullfoss" to Reykjavik were booked with McGreggor, Gow & Holland. Inquiries were made with Iceland Air concerning the charter of an aircraft. Due to the high cost of chartering aircraft we hoped to share this large item of expense with at least one other party so as to make each individual expedition economically viable. Concerning finance, it seemed possible that we might receive a grant from the Queen Mary College Expeditions' Committee.

In October and November the planning started in earnest, there was a weekly meeting of all members. Numerous visits were made to the Royal Geographical Society's Library to study maps and reports of previous Greenland expeditions. We visited M. Petrovsky who was a member of the 1961 Bangor University Staunings Expedition and J. Jackson who was a member of the Sir (now Lord) Hunt's 1960 Expedition. An information file about the area was rapidly filled.

Tom Blakeney of The Mount Everest Foundation informed us of several proposed expeditions to Greenland. Eventually contact was made with a Dundee University Expedition led by Dr. Iain Smart in the hope of arranging a joint aircraft charter.

Lists of equipment and food were being compiled when the expedition re-orientated its objectives to make it a more scientific project. David Drewry joined the group and it was decided to devote most time to glaciological projects rather than to mountaineering.

There were now eight prospective members but it was not certain whether the expedition would consist of six or eight men. A personal contribution of ₤75 each was agreed upon. For various reasons one member had to withdraw from the expedition and his place was taken in February by Kanarens.

The problem of the aircraft charter had to be solved before formal applications for support could be submitted to the Mount Everest Foundation and Royal Geographical Society.

Miller, along with Iain Smart of Dundee, and Dr. Peter Friend, of Scott Polar Research Institute Cambridge, formed a charter group and this was organised by Dr. Friend. The charter was to fly from Reykjavik to Mestersvig on the 6th July. The return flight in September was arranged with Dr. M.Slesser of Glasgow who was organising a further charter.

An application for a grant was submitted to the Queen Mary College Expeditions' Committee and before Christmas we had their generous donation safely in our bank account.

Sufficient details of the expedition were now finalised to permit a comprehensive ten page prospectus to be printed. The formal applications to the M.E.F. and R.G.S. were quickly completed and submitted. A letter requesting permission to visit Greenland was sent to the Danish Ministry for Greenland via our own Foreign Office. We now drew up a long list of Societies, Foundations and Institutions from whom we thought we might receive financial help and in January letters accompanied by a copy of our prospectus were despatched to them all. The college doctor and nursing sister helped by giving us our injections and organising medical supplies. Munro, Banaszek and Kanarens attended a course in first aid. Miller and Drewry were already familiar with theodolite work but it was felt that it would be useful to have a further two surveyors and so Munro and Banaszek attended a week's surveying course at Silwood Park, Imperial College.

When the M.E.F./R.G.S. approved our expedition we had some headed notepaper printed and immediately wrote to some two to three hundred firms asking for assistance with equipment and food supplies. Untold numbers of letters were written and answered, culminating after several weeks in a hectic climax of packing and weighing. Up till the very day we left London it seemed improbable that all the arrangements would be completed in time. Indeed we were to collect some equipment on our way to Leith and Miller and Drewry were left to bring out more than nominal excess baggage by air 3 days later. The expedition had started.

THE NAMES OF MEMBERS, THEIR RESPONSIBILITIES AND EXPERIENCE

1. Leader, Surveyor and Treasurer

Keith J. Miller, B.Sc., F.R.G.S., Mechanical Engineering Department, Queen Mary College. (Now at Cambridge University c/o Faculty of Engineering)	Age 35 2 Karakoram expeditions 5 Alpine seasons

2. Deputy Leader and Assistant Food Officer

Richard J. Palmer, B.Sc., Physics Department, Queen Mary College.	Age 26 4 Alpine seasons

3. Day-to-day Business Manager and Secretary

Thomas A. Hird, B.Sc., Electrical Engineering Department, Queen Mary College	Age 23 2 Alpine seasons

4. Glaciologist and Scientific Equipment Officer

David Drewry, Geography Department, Queen Mary College	Age 20 Many geographical field course studies

5. General Equipment Officer

Eric Williams, Chemistry Department, Queen Mary College	Age 21 1 Alpine season

6. Surveyor and post expedition administrator

Malcolm Munro, Aeronautical Engineering Department, Queen Mary College	Age 20 1 Alpine season

7. <u>Food Officer and Assistant Surveyor</u>

Antony Banaszek,
Physics Department,
Queen Mary College

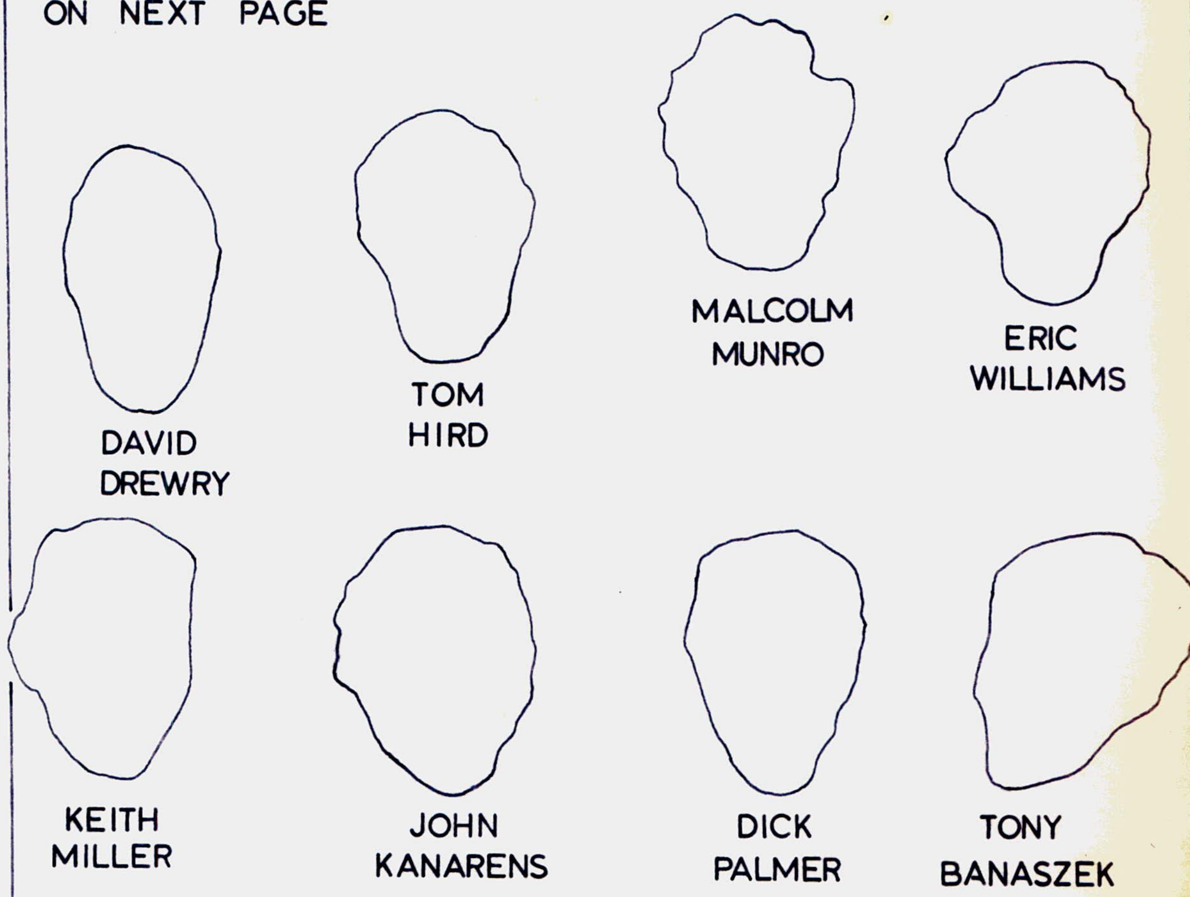
Age 20
1 Alpine season

8. <u>First Aid Officer</u>

John Kanarens,
Zoology Department,
Queen Mary College

Age 20
No previous mountaineering experience.

KEY TO PHOTOGRAPH
ON NEXT PAGE



MEMBERS OF EXPEDITION

MOUNTAINEERING ACTIVITIES

Mountaineering in the Staunings Alps differs in character considerably from that of the European Alps owing to the influence of a number of local factors. Members of the Expedition at first approached the climbing using European Alpine techniques but by degrees adapted to the local circumstances.

During the months of July and August it never gets dark in the Staunings and in July the sun does not even set. Also, during these months, there is normally a period of extremely fine, calm weather. In 1968, a comparitively poor season, the weather was bad enough to prevent climbing on only 8 days between July 7th (when base camp was set up) and August 16th. On the night of August 16th/17th a heavy snow-fall signalled a break in the weather. From this date onwards the weather was generally bad but no serious storms materialized.

The continuous daylight coupled with the calm weather allowed us to attempt longer and more serious climbs than would have been the case in the European Alps. It is possible to climb at any time of day or night and bivouacs may be sited for comfort rather than at the point reached at the onset of nightfall. Climbs sometimes involved one or more bivouacs but lost a lot of their epic character being apparently no more serious than one day climbs.

The lack of darkness means that snow conditions are generally poor in July but improve markedly with the colder nights in August. However, even then it is still possible to come across sun-softened snow slopes in the very early hours of the morning as happened on the descent from the Hjornespitz. To get the best snow conditions, climbing and glacier travel were usually done at night; almost complete reversal of day and night activities being more usual at the higher camps. This had the added advantage that day-time bivouacs became a warm doze in the sun rather than a desperately cold wait for dawn, as in the European Alps.

Exploration of the Staunings involved both rock and snow/ice climbing, the latter often providing the most attractive part of an ascent. The North faces of many of the higher peaks are characterised by large easy-angled snow-slopes which often give the easiest route of ascent. The snow is however usually underlaid by ice and can be dangerous when softened by the sun. The West and East faces give rock, ice or mixed climbing according to their configuration and height while on the South side a long and steep rock face with little or no snow is often found.

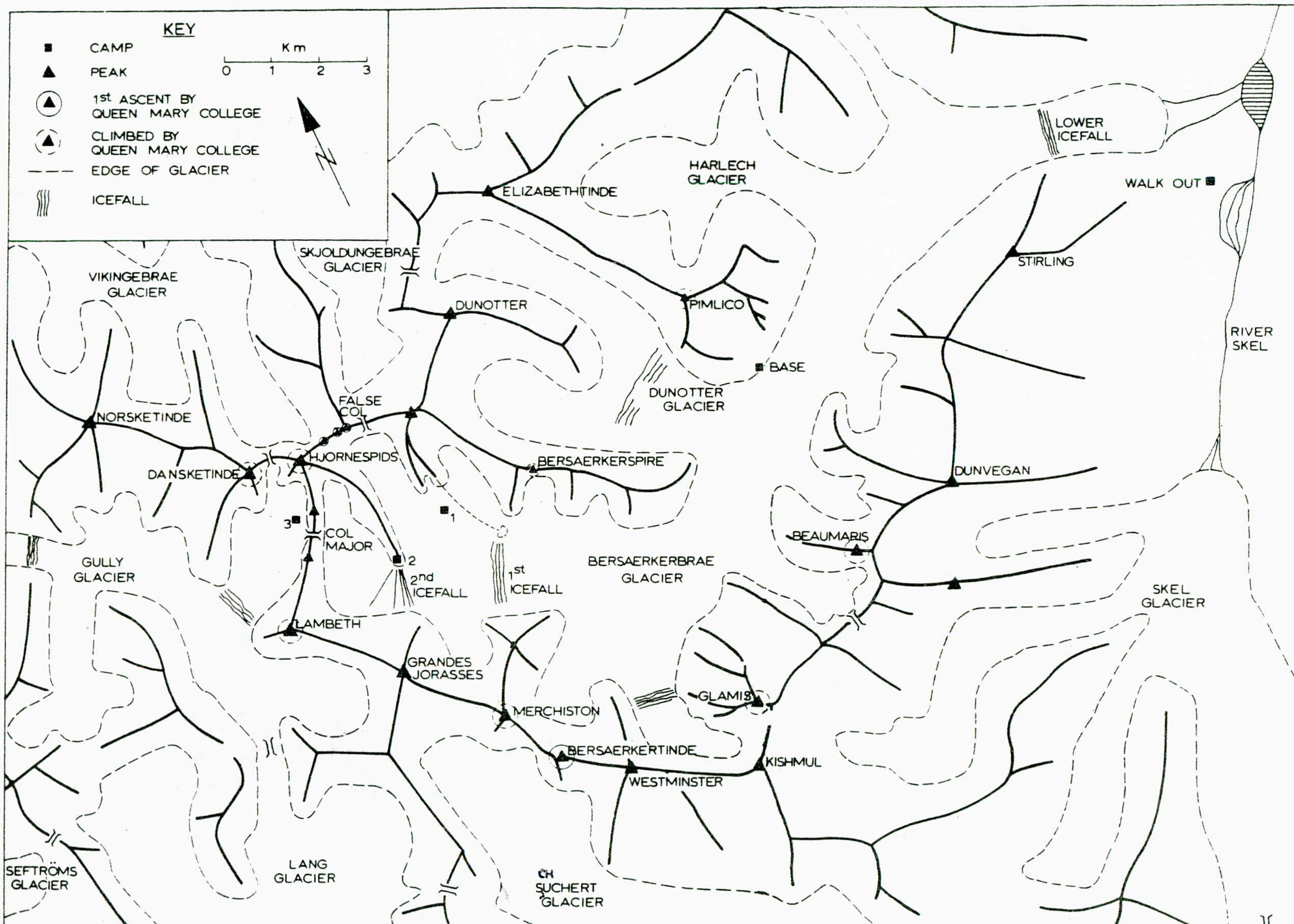


FIG. THE BERSAERKERBRAE GLACIER REGION; STAUNINGS ALPS.

The quality of the rock varies enormously from one part of the range to another. Usually a solid red granite in the centre of the range gives attractive climbing on sound rock whereas in the outlying areas extremely loose granite or sandstone is to be found.

In 1968 the snow level was much lower than usual, a special circumstance which exposed large amounts of loose rock normally covered with and held by snow and which vastly increased the dangers of rockfall. Rockfalls on a much larger scale than the Alps were observed. An example of frequent rockfalls was experienced on Col Major which was unusable between 9 a.m. and 6 p.m. due to the sun loosening the snow around unstable rock. This phenomenon on Col Major was apparently not experienced by parties in other years. The fascinating sight of rock pitons planted at least 30 feet up blank unclimable walls on the sides of the Col Major gully provided evidence of the snow level of former years.

The low snow level affected travel on the Bersaerkerbrae Glacier in two ways. In the early part of July there was still a covering of soft snow on the crevassed ice that became waist deep in places in the upper reaches. This made travel an exhausting if not a dangerous business, the snow not usually being firm enough to take the weight of a man. Glacier travel at this time was made much easier by probing crevasses with an 8 feet long aluminium tube borrowed from the scientific equipment.

By the beginning of August most of the glacier snow cover had melted and glacier travel was extremely easy, crevasses usually being obvious. Skis, if taken, would have been of very little use on the Bersaerkerbrae. The snow-shoes were seldom used.

The climbing and exploration programme was planned in three stages:

(1) A number of the more prominent peaks surrounding the Bersaerkerbrae to be ascended from base including, if possible, the hitherto unclimbed Bersaerkertinde. This was regarded as a training and acclimatisation phase for future explorations as well as accomplishing some ascents.

(2) Camps to be set up in the upper reaches of the Bersaerkerbrae and Gully Glaciers for explorations in the vicinity of Col Major.

(3) A traverse of the Staunings Alps through the Bersaerkerbrae, Gully, Sefströms, Lang, Suchert and Skel Glacier valleys and the exploration of some of the bordering areas.

Unfortunately the programme had to be greatly cut down owing to accidents to two of the most experienced climbers although one of them was able to resume climbing in the last few days. Stage (1) was carried out more or less as planned including the ascent of Bersaerkertinde. Stage (2) was partly completed but the lack of experienced climbers and the bad weather after August 16th greatly reduced the amount of exploration done in and around the Gully Glacier. Stage (3) was abandoned as it simply would not have left enough men at base camp to carry out the scientific programme.

The mountaineering activities are described in chronological order and brief descriptions of each ascent made are given. The ascents of the Bersaerkertinde and of the Hjornespitz by the North-East Ridge are described in greater detail as they involved almost entirely new ground.

The mountaineering and exploration itinery

Base camp was set up on July 7th at a height of approximately 800 metres. It was situated on the left bank moraine of the Bersaerkerbrae Glacier slightly below the point of entry of the Dunotter Glacier.

Most of the early days were spent on the scientific programme but on July 10th Banaszek and Hird explored the upper Bersaerkerbrae Glacier in order to find a safe route to a possible camp I. Progress was extremely slow and difficult due to deep soft snow. A food dump was made near the left side of the glacier about 5 km. above base camp. A better route was found on the way back and this was used on July 14th by Hird, Munro, Palmer and Williams who established camp I on snow at about 1600 metres in a side arm of the upper Bersaerkerbrae Glacier. Hird and Palmer stayed here while Munro and Williams returned to base.

From camp I the exploration of the upper Bersaerkerbrae was to be continued and a route established up Col Major. Four days were allowed for the completion of this work.

A prominent col on the dividing ridge between the Bersaerkerbrae and Skjoldungebrae Glaciers was climbed from camp I on July 15th/16th. The crest of the col was reached after 500 metres of ice climbing up a gully that varied in steepness from 40 - 55 degrees. The far side led down steep snow and ice slopes to the head of the Skjoldungebrae Glacier. The ridge leading towards the Hjornespitz was explored for a short distance. The col was given the provisional name of "False Col".

Col Major was ascended from camp I on July 17th/18th. Its foot was reached easily by climbing up through the second icefall and crossing the upper snow basin of the Bersaerkerbrae Glacier. A 500 metres long ice gully dropped from the col to the head of the Bersaerkerbrae at an angle of 40 - 45 degrees. The sun was just beginning to shine on the gully but since there was no indication of stonefalls the ascent was started. Stonefalls soon began and rapidly increased in frequency so an escape was made to a rock ledge at the side of the gully followed by a wait until evening when the sun lost its effect. On resuming the ascent abseil pitons were placed in the rock wall at the end of each rope length to facilitate future ascents and descents with loads. The return to camp I from the col was made before the occurrence of morning stonefalls.

Loads of fuel and climbing equipment that had previously been carried to camp I were dumped on a rock spur in the upper snow basin on July 19th. This was to be the future site of camp II. The food previously dumped between base and camp I was also carried to site II before Hird and Palmer returned to base camp.

The next stage was to ascend some of the peaks close to base camp in preparation for a possible first ascent of the Bersaerkertinde.

From base camp on July 23rd, Banaszek and Palmer reconnoitred Glamis in order to find the best approach to the North Ridge. The route first tried was found to be impractical due to massive crevasses which split the upper snow basin from one side to the other but an alternative route was noted. The ridge itself when observed from close quarters looked much easier than had previously been supposed.

During the evening of July 31st, Kanerans, Munro and Williams left base camp to climb Beaumaris by the North-West ridge. It gave an easy and pleasant ascent partly on snow and partly on a narrow rock ridge. It was an initiation climb for J. Kanerans. A cairn erected in 1960 by J. Hunt and J. Jackson was found on the summit.

Banaszek and Palmer climbed Glamis by the North Ridge on August 1st/2nd using the alternative approach noted during their reconnaissance. A nearly horizontal rock ridge runs to the foot of the North Ridge and is separated from it by a narrow ice gully. The crest of the rock ridge was gained by making a traverse across the lower snow basin and up a tongue of ice. Easy scrambling up the side led to a gap in the ridge. The narrow crest gave pleasant scrambling to the foot of the North Ridge proper. The North Ridge has a steep lower section leading to a nearly horizontal shoulder. Above this an easy-angled ridge leads to the summit. Few difficulties were encountered on the ascent which was entirely on rock. The ascent took 10 hours from base camp and the descent was by the same route. A flag belonging to the 1963 Italian Glamis Expedition was found on the summit.

Between August 4th and 6th, Munro, Palmer and Williams made the first ascent of Bersaerkertinde. The ascent which was made via the summit of Merchiston took 20 hours of nearly continuous climbing. The climb is described in detail at the end of this section.

The next stage was to climb peaks in the neighbourhood of Col Major and establish a camp on the Gully Glacier. A single trip of 11 days with 4 men was planned. After 6 days one of the men would return to base and his place would be taken by Hird who was still recovering from a serious accident, see page 50.

On August 9th camp II was set up by Banaszek, Munro, Palmer and Williams at about 1800 metres on a rock spur in the upper snow basin of the Bersaerkerbrae Glacier, close to Col Major. Travel on the glacier was easy by this time, most of the surface snow having melted. Munro and Williams went back to collect provisions dumped near the first ice fall at the time of Miller's accident (see page 48), while Banaszek and Palmer went over to Col Major to find a route over the rimaye. The next night saw all the spare food and fuel from camp II carried up Col Major and dumped on the Gully Glacier at the future site of camp III. Col Major was descended before morning.

The party now split into two pairs, each climbing different peaks. On the night of August 12th, Banaszek and Williams left camp II to climb the Bersaerkerspire. They reached the ridge to the South-East of the peak but ran into difficulties near the summit. They descended to the Bersaerkerbrae Glacier and approached the summit by way of the North-West Ridge. This gave an easy and pleasant climb on surprisingly sound rock. Descent was by the North-West ridge.

Munro and Palmer left the same evening to climb the Hjornespitz via the "False Col" and the North-East ridge. Three previously unclimbed minor peaks on the North-East ridge of Hjornespitz were ascended en route. The ascent is described in detail at the end of this section.

On the night of August 14th/15th, Banaszek and Williams took one of the tents from camp II and set up camp III on the Gully Glacier by the food dump. The camp was on snow at about 2000 metres, some quarter of a mile North-West of the top of Col Major. The remainder of the camp was brought up the next night when Munro and Palmer had returned from the Hjornespitz.

The time was now scheduled for the changeover of one man. Banaszek and Palmer descended to base camp leaving Munro and Williams in camp III. Hird after his convalescence at base was now reasonably fit. As a training climb from base camp he had ascended Pimlico with Kanerans. Thus on the night of 17th/18th August, Hird and Palmer left base for camp III which they reached after 9 hours travelling through new snow.

Again the party split into two pairs, each with different objectives. Munro and Williams climbed Lambeth on August 19th by way of the North-West ridge. The climb was entirely on snow or ice with a coating of new snow and took 4 hours. An attempt to traverse from Lambeth to the Grandes Jarasses was abandoned because of the deteriorating weather. Return to camp III was by the route of ascent.

The same afternoon Hird and Palmer set off with bivouac equipment to climb Dansketinde and explore the ridge between Dansketinde and Norsketinde. Dansketinde was climbed by the East Ridge and North-East face although it was difficult to be sure of the exact summit since visibility was by then only about 100 metres. The ascent was entirely on snow and ice which required care in places where snow was underlaid by hard ice. The exploration of the Dansketinde - Norsketinde ridge was abandoned owing to mist and snow conditions and the line of ascent repeated on the descent.

The weather was now permanently poor and because of continuous mist and snowfalls camp III was evacuated on the 21st August. The climbing group returned directly to base in order to complete the scientific programme.

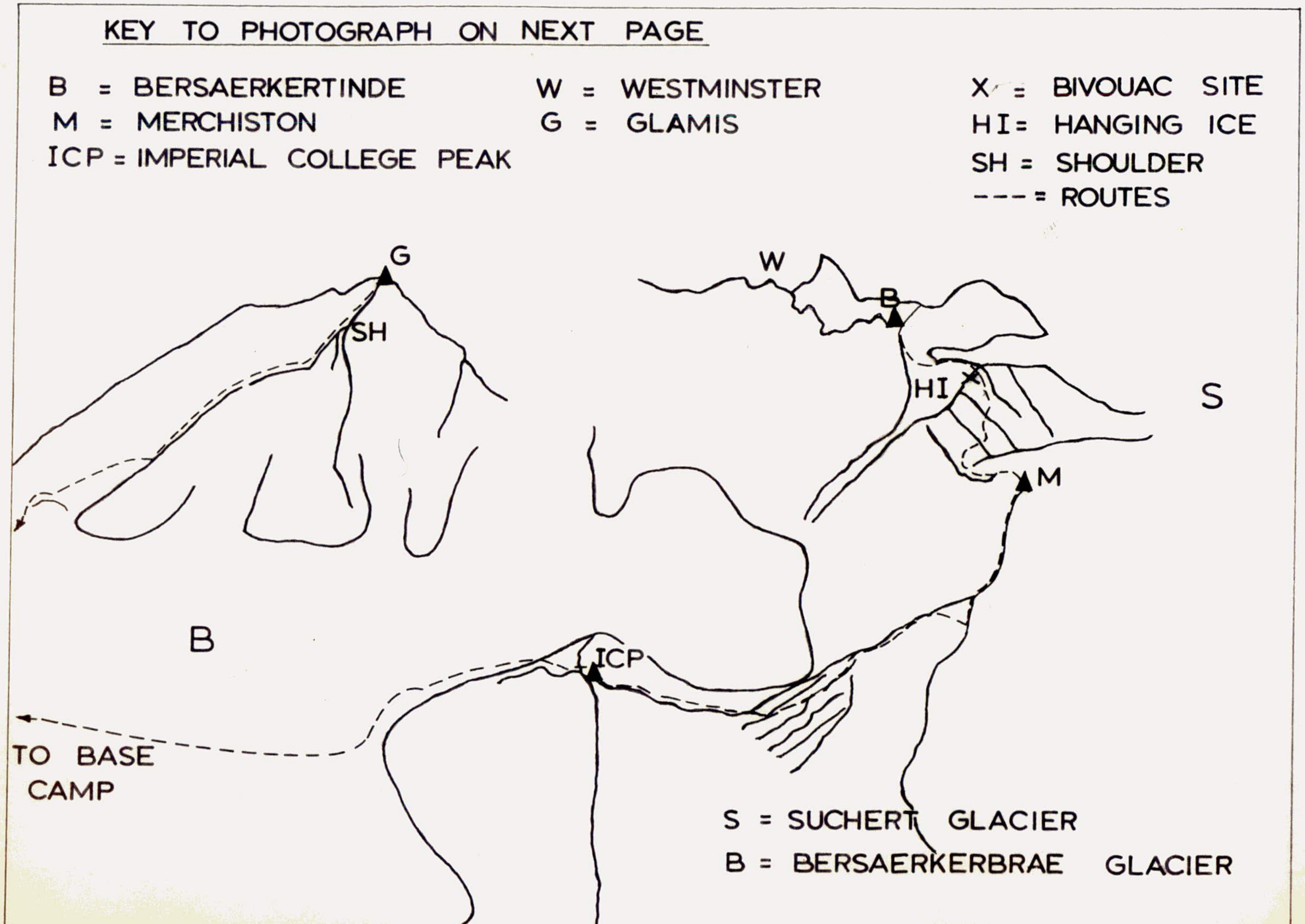
The ascent of Bersaerkertinde

Between the 4th and 6th of August Bersaerkertinde, the last major unclimbed peak bordering the Bersaerkerbrae Glacier, was climbed by Munro, Palmer and Williams. The ascent was made via an unnamed peak on the North-North-East spur of Merchiston and the summit of Merchiston itself.

To reach the foot of the South-East face of the unnamed peak took two hours in mist from base camp. A huge scree gully split the face and this was climbed to a spot between two small summits. The West and highest summit was climbed from the South by an unpleasantly loose rockface about 100 metres high. On the summit was a cairn erected by the Imperial College (1963) Expedition.

The peak is connected to the North-East face of Merchiston by a ridge. This was followed very easily by a curious rock shelf, "The Pathway", situated at the edge of the snow. The ridge merged into the North-East face at the foot of a series of parallel, decaying rock ridges separated by ice gullies, that are seen half covered by snow in the aerial photograph. The ridges were ascended diagonally to the right over extremely loose but not difficult rock. A snow basin was crossed and a snow face climbed near the right-hand side. A fine ice arete was then followed easily to the snowy summit of Merchiston which was reached at midnight, 12 hours after leaving base camp. The weather now began to clear and remained fine for the rest of the climb.

A snowy ridge that soon changed to rock led down to the gap between Bersaerkertinde and Merchiston. The crest of the rock ridge consisted of a series of tottering towers and so a very loose scree gully on the Suchert side was descended. The crest was regained lower down and followed to the gap which may be clearly seen from the Bersaerkerbrae Glacier. The way now led diagonally up and across a series of shattered ribs separated by ice gullies on the side of a ridge angled at 45 degrees



The Photograph on the next page is by courtesy of the Geodetic Institute of Denmark

to the main ridge. The former ridge is prominently seen from the Bersaerkerbrae Glacier, capped with a series of towers and forming the right-hand containing wall of a couloir of hanging ice. The climbing was fairly easy but occasionally one or two pitches of grade IV - V intervened. The crest of the ridge was crossed and a contour made round the top of the ice couloir. A snow ridge then led to the horizontal summit ridge of Bersaerkertinde which was reached at 8 a.m., 20 hours after leaving base camp. The Northern end of the ridge was known to be the highest point because of theodolite observations taken from base camp and here on the highest-looking tower was built a small cairn.

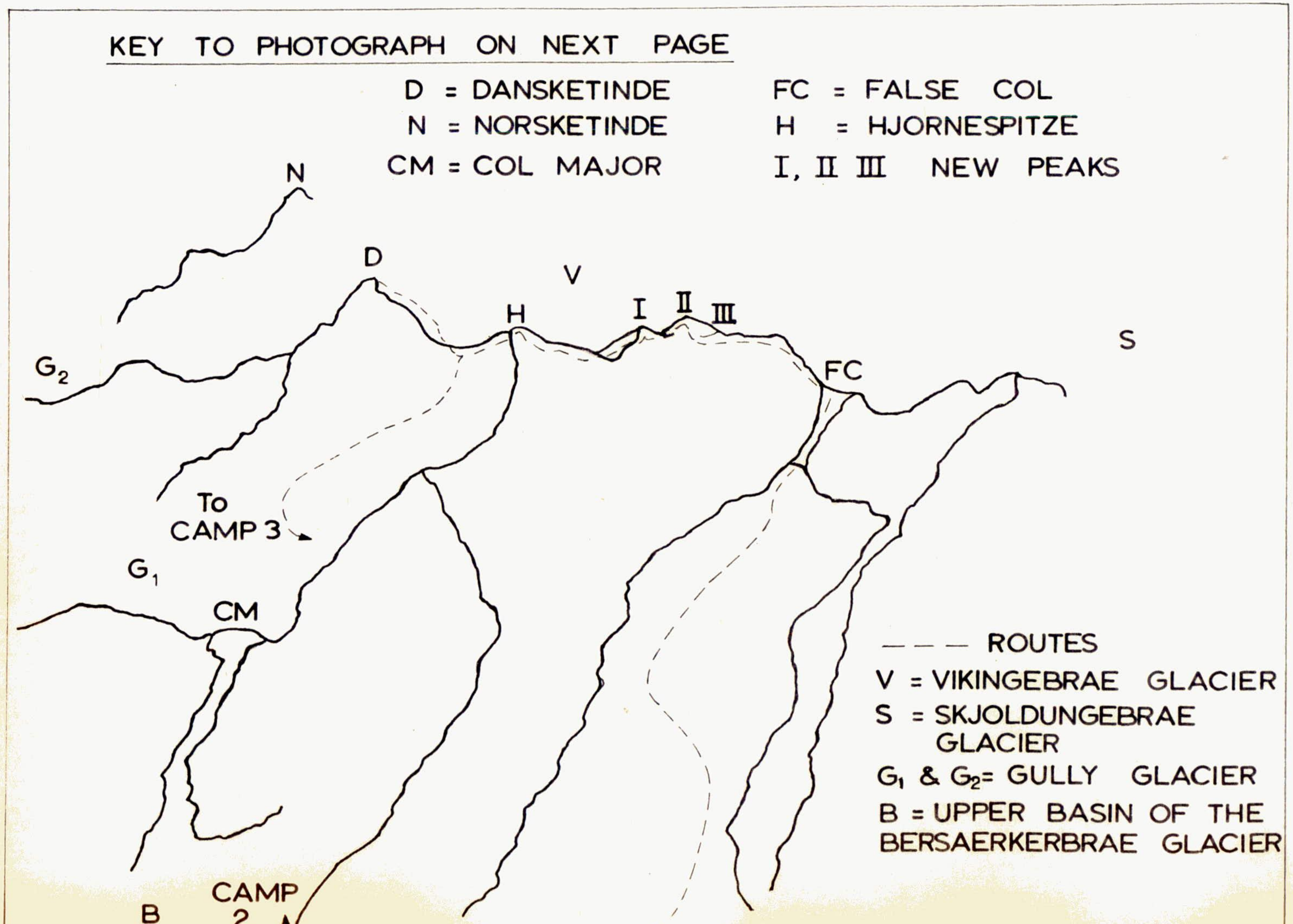
A superb view was to be had in all directions. The peak is higher than both its immediate neighbours Merchiston and Westminster and an uninterrupted view was to be had to the South for a hundred miles or more across range after range of sunlit mountains. Kong Oscars Fjord was clearly seen about 30 miles to the East. To the West the mountains of the central Staunings Alps were higher, Hjornespitz appearing particularly impressive. One was struck by the contrast between the Bersaerkerbrae and Suchert slopes of Bersaerkertinde. The former is a precipitous drop of nearly 1500 metres while gentle snow slopes on the Suchert side come within 600 metres of the summit.

Descending the snow, now softened by the morning sun, was more difficult than the ascent a few hours earlier. There was a tendency to slide on a carpet of snow that overlaid hard ice. On regaining the rock ridge a bivouac site was found where the party slept throughout the day. The descent, which followed the route of ascent was resumed at 6 p.m. and took a further 24 hours, including a short bivouac on "The Pathway".

The North-East ridge of Hjornespitz

The ridge was climbed from "False Col" to the summit of Hjornespitz between August 12th and August 14th by Munro and Palmer. Three minor peaks on the ridge were climbed en route. The ridge which divides the Bersaerkerbrae Glacier from initially the Skjoldungebrae Glacier and finally the Vikingebrae Glacier gave an interesting and enjoyable high altitude traverse. Difficulties were nowhere great and the rock was invariably sound.

Camp II was left at 10.30 p.m. to make use of good night-time snow conditions and the foot of the "False Col" was reached at midnight. Previously it had taken 4½ hours from camp I. The col was ascended and the ridge to the West of the col climbed on mixed rock and ice for about 4 rope lengths. A prominent rock step was now reached with a snow shoulder on the right. The shoulder was ignored as it seemed to lead off in the wrong direction and a chimney near the left-hand end of the wall was climbed. Easier ground above the step led on up, mainly on snow, to a snow ridge and plateau which gently rose to a couple of small rocky summits the highest of which was cairned and given the provisional name of "Bosigran". Its height is a little under 2700 metres. The weather was fine but on the ridge there was a very cold North wind.



The Photograph on the next page is by courtesy of the Geodetic Institute of Denmark

Ahead the snow dipped and then rose steeply to the base of a sharp spike of rock. Crampons were removed at the base of the rock and about 100 metres of very enjoyable rock climbing on firm rock of grade III - IV difficulty took the party on to a fine sharp summit. From the Bersaerkerbrae the peak is seen as the right-hand of two spikes. A cairn was built and the peak given the provisional name of "Lamorna". The height was probably just over 2700 metres.

A bivouac was made as soon as a ledge was found that was sheltered from the bitingly cold wind. A platform of loose stones was built to level the ledge and some porridge was cooked using a water supply of melted icicles. Sleeping bags which had been carried up from camp II ensured a good sleep.

At 10 p.m. after more food the party were ready to move on. Easy rocks were descended to the bottom of the gap between "Lamorna" and the next peak on the ridge. Easy ice led across and up to a snow gully. This was followed easily to the summit rocks which were reached just before midnight. The summit was cairned and given the provisional name of "Treyarnon".

Another larger dip in the ridge separated "Treyarnon" from Hjornespitz. Moderately steep but very firm snow led down into the dip for about 300 metres. Softer snow on top of ice led up on the North-East face of Hjornespitz. Due to the extreme cold the upper layer of snow adhered well to the ice. The summit of the Hjornespitz is in the form of a ridge running South-East - North-West. To the South-East of the summit tower the ridge drops precipitously but to the North-West of the summit tower the Gully Glacier could be seen below. Easy climbing followed along the crest between and round the towers. The summit tower was circled, climbing up from ledge to ledge until only a steep wall about 5 metres high split by a crack barred the way. The crack "went" in a pitch of grade IV - V in difficulty. The summit was reached at 3 a.m.

On the summit platform a small cairn was found containing a piece of white rag stained yellow - presumably McNaught-Davis's headscarf. Some time was spent admiring the magnificent view as the summit had been reached earlier than expected. The sight of the food dump 800 metres below on the snow of the Gully Glacier inspired confidence.

The reverie was rudely shattered about an hour later when a cloud cap started to form over the summit. A quick inspection showed that the same was happening over Dansketinde and other high peaks. A hurried descent was made from the summit and then down the snow on the North-East face for a short way. The morning sun had by this time softened the snow which was more awkward than on the ascent. The crest of the North-West ridge was regained and followed down over easy snow, ice and rocks to the head of a snow gully. This led easily down to a branch of the Gully Glacier and the food dump was soon reached. Col Major was descended the same evening to camp II.

PERSONAL IMPRESSIONS

K. J. MILLER

The favourable climate and continual daylight of Iceland were the first two unusual features that announced the beginning of the expedition for me. Both features were in contrast to the U.K. in early July 1968. Sleeping out in the open under clear bright skies took a little getting used to at the camp David and I set up just outside Reykjavik. The hospitality and friendliness of the Icelandic people were the next pleasant surprises. The airport transport manager allowed our party and the Dundee group to use one of the large hangers as a transit camp. I shall not forget playing football in that vast hanger nor the robustness of Dick's tackles.

It was a great relief when the Greenland-bound aircraft left the runway because I was convinced that the Dundee group, the Scott Polar Research Party and ourselves had overloaded the plane. The first sight of pack ice, so close to land that contained hot springs and geysers, amazed me. The Danes at Mestersvig were exceedingly helpful and I shall forever remember their warmth and sincerity.

The Stauning Alps took a little getting used to. Many of the features of the area are similar to what may be found in the Himalaya - for example numerous and fast flowing glacier surface streams. In consequence one expects the mountains to be bigger than what they are and distances to take far longer to cover than what they do. Such a state of affairs is a pleasurable surprise and one seldom encountered by mountaineers. Climbing and walking conditions were ideal in so far that one had settled weather, little wind, and 24 hours of daylight. This meant long climbs could be tackled with a high degree of confidence for continued fine weather.

Finally a note about my companions. The expedition could not have been a success without the immense effort of Tom who was responsible for much of the organisation especially so in the last few weeks before departure. His unselfish effort was a hallmark of this expedition. His accident which rendered him useless for two weeks must have frustrated him beyond description by words but I know that he never once grumbled. Dave was responsible for the scientific programme and his efforts will be acknowledged by those who read our publications. Dave probably worked on expedition affairs as long if not longer than anyone else. About Dick, the man who would frequently amuse us by sucking his false eye (have you ever been "stared-at" by the end of a tongue?), Dick was the energetic member always ready to move onwards - when he stopped eating, that is. He was responsible for the expedition after my accident and the excellent performance of the group is a relection of his abilities. Malcolm was the quiet one and as the days passed I knew that he was both mentally and physically one of the strongest members of the group. It was one of my regrets that I did not get the chance of sharing a few days' climbing with him. Malcolm is the sort of person who gets on with a job, such as preparing sections of this report, without even being asked to continue his assistance beyond his own brief. John, the effervescent lad, was the camp comedian, the expedition foil. He was the only member who came home heavier than when he left. John christened me 'The Master" - a title I took as a compliment. At the beginning John was the odd man out neither being a mountaineer nor a scientist but at the end all agreed that his inclusion in the party was our good fortune. I didn't get to know Tony very well but judging from the remarks of the other members it was clear that his participation in the project was more than welcomed. Tony was frequently to be found around the kitchen stores preparing meals which indicated his ability to quietly get on with the work even though it was not strictly speaking his turn. Eric was a fellow Lancastrian and so we spoke the same language. Perhaps this was the reason why we were good companions. Although exceedingly difficult to arouse in the morning he never grumbled about doing the uninteresting work of assistant to the surveyors. It was the walk out from Mestersvig to Base camp accompanied by Eric that provided me with one of my most pleasant memories of Greenland.

The above remarks do not completely indicate the fellowship shared by all members. No more can be said than - by a mixture of good luck and judgement the composition of the party was one that would be difficult to better.

PERSONAL IMPRESSIONS

R. J. Palmer

(extract from diary)

August 15th

Another twilight day. Up late (say two in the afternoon) to collect water and have breakfast. Finish breakfast leisurely and it's almost time for supper. This is the life!

Malcolm and I pack up the tent and our belongings which takes some time and gives quite a reasonable load. Off for Col Major at about 9 p.m.

We crampon straight up the middle cutting stances and putting in an ice-screw at the end of each rope length. Simple and relatively enjoyable but a bit knackering with a load. You start off from the stance striding up the ice and finish at the end of 150 feet more or less in a crawling position. However, we make reasonable progress.

We walk over to camp 3 to find a brew on and a meal in preparation. What it is to have mates! We sit half in the tent, out of the cold, for some time, eating, drinking, smoking and chatting. Reluctant to go down again but I suppose we must.

Tony and I set off in a beautiful, luminous, pre-sunrise, dawn. The sun is just starting to glow on the summit rocks and snows of Dansketinde. We reach the top of Col Major and stand stupified by the sight. Great bands of orange, purple and green stretch across the horizon to the North-East. The sun is just about to rise but is not yet visible. The higher peaks are lit by an orange glow but the valleys are still in deep purple dusk. Tony gets out his camera but only has one photograph left. I haven't brought my camera with me - of course.

We climb rapidly down Col Major and go across to the site of camp 2. Here Tony picks up his gear before we race off down to base camp dazzled by the early morning sun.

PERSONAL IMPRESSIONS

T. HIRD

It is difficult to appreciate the dedication on the part of all the members that was needed for the success of our expedition. At times in the past year I have wished that I had never heard of the Staunings, but when eventually we boarded the M/V "Gullfoss" in Leith I felt considerable satisfaction and relief that all the arrangements had been finalised and we could relax and enjoy ourselves in the next few days before reaching Greenland.

Anyone who appreciates wild and uninhabited country would like the Staunings, but there is more to be found than just remote mountains and glaciers, there is the charm of the Arctic. Where else could one stand on the summit of a high mountain and look down over huge glaciers, tundra covered hills (where billberries grow in profusion) to icebergs floating in the fjords, all observable at one o'clock in the morning.

Miller's accident and quick departure was a great shock for all of us, he had taken so much of the work and responsibilities that for a day or two we were completely lost without him. When a small group of people have to survive for two months in such close contact there is a danger of violent personal rivalries. Miller had been our anchor, giving stability to everyone. The expedition was still a success however with not the least of our achievements being the eventual development of a deep and tolerant understanding of one another.

"Why does anyone want to visit such dangerous and remote places?" is a standard question. One reply is "For excitement and adventure", but my personal reply would be "For peace and a short breathing space away from the pressures of civilisation."

I hope that maybe one day I will have an opportunity to visit the Staunings again.

PERSONAL IMPRESSIONS

J. Kanarens

East Greenland would impress most people, though as to how it would impress them I cannot say and can only speak for myself and say that it is the most dangerously exciting place that I have ever visited.

I am not a mountaineer and being dragged up one or two of the peaks by the experienced mountaineers in the party petrified me at first, but after a time I found it very rewarding to look down from a few thousand feet. Reaching the summits gave me no end of satisfaction.

The food I found boring and just sufficient. A wider variety of meats would have been gratefully received.

All members survived the two months without any arguments or major disagreements and the desire to return to Greenland was unanimous.

PERSONAL IMPRESSIONS

David J. Drewry

To express my feeling about our expedition - the personal ones of living together with seven other people for a couple of months - working, joking, sharing success and sometimes hardship - a short paragraph is meaningless, and I forgo the attempt.

As a scientist, however, whose interests lie in the realm of glaciology, this expedition provided an unparalleled experience. To carry out investigations in a part of the world so little understood was an exceptional opportunity, a valuable training and a fruitful enterprise. My only hope is that after the last dot and comma of our work is written, it will do justice to the fine time we had in Greenland and to the exhertions of my comrades who gave their efforts so unsparingly to our work.

A final question remains, 'when and where next?'

ACCOUNTS (Provisional)

INCOME

	£
Members contributions	600
Goldsmith's Company	350
QMC Expeditions Committee	300
Drapers Company	289
Chase Foundation	250
Mount Everest Foundation	250
University of London (Central Research Fund)	200
Shell International	75
Scott Polar Research Institute (Gino Watkins Memorial Fund)	50
Gilchrist Educational Trust	50
Charringtons	25
Miscellaneous	46
	2485

RESALE

Film	8
Air Freight Space	68
Equipment	40
	116

EXPENDITURE

Air Charter Charges	672.13. 0.
Helicopter Fees	383. 0. 0.
Equipment	395. 5. 1.
Shipping and Cartage costs	203.19. 3.
Publication costs (prelim. & full reports)	158. 8. 3.
Air Fares	145.16. 0.
Food	93.15.10.
Film	84. 4. 4.
Insurance (R.G.S. & Q.M.C.)	53.10. 0.
Rail Fares	52. 8. 0.
Organisation Expenses (Secretarial & visits)	47. 5. 0.
Scientific Equipment	39.12. 0.
Post-expedition London expenses	37.10. 0.
Iceland Expenses	31.15. 6.
Medical expenses	29.12. 3.
Post expedition repairs	22. 8. 6.
U.K. travel expenses	16.18. 0.
Greenland expenses	11.16. 0.
Petty cash items	7. 0. 0.
	2486.17. 0.

Future Income (approx.) £80

EXPECTED FUTURE BALANCE IN HAND £194.

EQUIPMENT REPORT

A comprehensive equipment list along with estimated weights was drawn up in November 1967. This list was slightly modified before a final list was adopted. The original weight estimates were surprisingly accurate. Weight was a critical factor in determining exactly what was and what was not taken. It had been our original intention to take skii and a sledge. Indeed a sledge had been designed by Malcolm with assistance from Q.M.C. staff after much research into this problem. Eventually it was weight considerations, together with further information about the Bersaerkerbrae area and the probable snow conditions, that decided us not to include skii and sledge in the final list. In the light of the 1968 weather and glacial conditions they would have proved to be a positive disadvantage.

The final equipment lists are given overleaf - pages 36 - 41 incl.

Key

B	≡	Black and Edgington
L	≡	Loaned
*	≡	Donation
†	≡	Reduced Price
£	≡	Full Price
M	≡	Members Kit

Note: Many firms generously gave a certain specific quantity of equipment but items in excess of this amount had to be paid for at trade or wholesale rates. In consequence items marked £ does not necessarily indicate all items from that supplier were paid for at cost price.

PACKAGING

The general equipment, scientific equipment, and food were packed for transportation as shown in table no. I

TABLE No I

Box	Description	Size	WEIGHT OF CONTENTS IN LBS. Food	Equipment General	Equipment Scientific
F.1	Fibreboard box	22" x 18" x18"	108		
F.2	Fibreboard box	22" x 18" x18"	108		
F.3	Fibreboard box	22" x 18" x18"	116		
F.4	Fibreboard box	22" x 18" x18"	113		
F.5	Fibreboard box	22" x 18" x18"	112		
F.6	Fibreboard box	22" x 18" x18"	113		
F.7	Fibreboard box	22" x 18" x18"	104		
F.8	Fibreboard box	22" x 18" x18"	92		
F.9	Fibreboard box	22" x 18" x18"	94		
F.10	Fibreboard box	22" x 18" x18"	94		
G.1	Fibreboard box	22" x 18" x18"		72	
G.2	Fibreboard box	22" x 18" x18"		71	
G.3	WOODEN TEA CHEST	20" x 19" x19"	8	71	
ICELAND BOX	WOODEN TEA CHEST	20" x 17" x17"	81	15	
WALK-IN BOX	Fibreboard box	22" x 18" x18"	41	42	
Sc.1	WOODEN TEA CHEST	24" x 19" x19"			89
Sc.2	Fibreboard box	51" x 13" x12"			30
Sc.3	SACK	122" x 7" x 7"			64
		TOTALS	1184	271	183

The 'Iceland box' referred to in table no. I contained the equipment and food required for the stay of the expedition in Iceland prior to the outward flight to Greenland. The equipment in this box was re-packed and taken to Greenland.

The 'Walk-in box' contained food and equipment sufficient for 4 men to 'walk in' to base camp from Maestersvig, i.e. a 12 man-day ration.

The packaging arrangements were for the most part satisfactory. The boxes were constructed from 2 mm thick fibreboard. When sealed by steel banding, the boxes were quite strong enough to hold 100 lb plus although a few boxes quickly lost their original shape. Lack of rigidity however was inconsequential in relation to their extreme lightness. One disadvantage of the boxes was that once the steel bands had been removed, they could not easily be re-sealed to make them rain or snow proof. This difficulty was overcome by using large sheets of polythene. The scientific and general equipment of a more delicate nature was put into wooden tea chests and adequately padded. Apart from two bags of sugar, all equipment and food arrived intact and undamaged at base-camp. David and Keith brought several items of equipment by air from the U.K. including several items that did not arrive before our ship sailed from Leith.

TENTS

The four tents were thoroughly checked and a few repairs carried out before they were packed. Since we did not include a spare tent in the equipment it was with relief that the continuously used tents did not suffer much damage. The only repairs that were necessary during the period of the expedition were the replacement of a few guy-lines. The comprehensive tent repair kit which we took was never used.

The Mead came in for some criticism because of its size. Although a marvellous little tent, it is rather cramped living for two people over an extensive period.

The two Mountain tents were used by the climbing party. They withstood the wind and snow at Camp III without any trouble.

One of the problems of living in tents at Camp III was condensation. This would form as ice encrustations on the inside of the tent. Since most of the cooking was done inside the tents, it was not long before water droplets formed on the inside of the tent and conditions got decidedly damp. Probably, we were not adventurous enough with our experiments in ventilation but we came to a silent agreement that it was far better to be warm and wet rather than cold and dry.

Fly sheets were not taken. Although the weather in the expedition zone was poor, their absence was more of a problem at base-camp than at any other camp, the precipitation being rain rather than snow. It was not long before someone had the idea of using the 'Space Blankets' as fly-sheets and they proved to be quite efficient.

The dozen 12 yd hanks of nylon line, taken principally as spare guy-lines, found many multifarious uses and proved to be a very useful item.

COOKING

All the paraffin stoves were overhauled and new washers and nipples fitted prior to their being packed. They behaved faultlessly throughout the period of the expedition and no further replacements or repairs were necessary. Cooking at base-camp involved only two 1 pint stoves. The climbing party also used two 1 pint stoves. The half pint stove was seldom used and was kept as a spare.

The cooking billys and pressure cookers were more than adequate for our needs. In fact, we could have managed with only two pressure cookers and one of the smaller billys. The pressure cookers were certainly worth their weight and were of just the right capacity for eight people. One of their advantages was that they could be filled with water, the lid attached, and kept inside the tent at night without any danger of the water spilling. Also the heating up of water in a sealed pressure cooker inside a tent is much less risky than if an open billy is used.

The metal funnels used for filling the stoves incorporated a filter which prevented grit and dirt getting into the fuel tanks. One fault of the funnels was that they rusted when left out in the open. Plastic funnels would have been better.

FUEL

All the fuel we required was obtained at Maestersvig, thereby allowing a considerable amount of additional items to be taken on the aircraft charter. Too much fuel was bought. The actual quantities used were: 14 gall of paraffin and 1 gall of two stroke.

A dozen $1\frac{3}{4}$ pint polythene paraffin bottles were taken and they were very useful. Half of them were used as water bottles and were especially handy at Camp III where one problem was keeping water from freezing. This problem was overcome by storing the water bottles inside the tents.

CARRYING

The two 'Cruiser' pack frames were by far the most comfortable to wear of those taken. The alloy pack frames were not sufficiently strong for the load carrying and they were bent and buckled before the end of the first week. The 'Cruisers' remained undamaged.

Elastic webbing, of which we took a great deal, was used for strapping climbing sacks and hessian sacks onto the pack frames. It was sometimes difficult to undo knots in the webbing and when wet and frozen it was rather stiff. Otherwise, the webbing was ideal material and preserved its elasticity throughout two months continuous use.

SUNDRIES

The mosquitos were small and few when we arrived in Maestersvig and were no problem on the 'walk in'. On the 'Walk out' they had been killed off by recent frost. Consequently, neither the mosquito-netting nor the anti-mosquito coils had to be used.

At the 'Walk out' camp, we obtained water from the Skel river. As the river was the watering place for a variety of animals, we used the sterilizing tablets to treat the water.

As previously mentioned, the 'space blankets' found use as makeshift fly-sheets. At Camp III they were used as additional ground-sheets but they added little in the way of ground insulation. One was used as a blanket when one of the expedition members was suffering from exposure and exhaustion. It was extremely effective in preserving body-heat although there was the inevitable water condensation.

Much of the food supplies was packed in a variety of plastic containers with either screw or press top lids. These containers were ideal, being light, strong and practically water-tight. When their contents were used up they were usually swiftly commandeered for packing personal gear. They are to be highly recommended for future expeditions.

CLIMBING

Most of the climbing was done on the two 300' 9 mm perlon ropes. They suffered greatly on the sharp, friable rock. One of the ropes was in fact badly cut 90' from one end. The 120' No. 4 was never used and need not have been taken. The No. 3 was useful for glacier travel.

Far too many abseil slings, abseil pegs and rock pegs were taken. Slings and pegs were seldom left behind - N. Wales attitudes are hard to shake-off it seems. Consequently they were used only when absolutely necessary. The ice-screws on the other hand were employed a great deal. The tubular Salewa screws were superior to the Stubai. However, when the air temperature was around freezing-point or below, the ice would freeze inside the tubular screws and thus prevent their use more than once. Under these conditions the Stubais were preferred.

The shafts of two ice-axes broke but not trouble was experienced with crampons.

A 'Jumar' prussiker was, fortunately called upon only once during the period of the expedition. Its worth was amply proved.

The snow-shoes were useful on only three or four occasions in the early period of the expedition when the snow was still deep and soft.

PERSONAL

The personal equipment of each expedition member weighed approximately 47 lb. A "personal equipment list" was more or less adhered to by everybody and contained many small items that could have been classified as expedition kit, i.e. pan scrubs, pot towels etc. The following items merit further comment.

CLOTHING

The clothing taken was entirely adequate. Two expedition members took Duvets. Although there were numerous occasions on which they drew envious and covetous looks, they were by no means essential. The Rohner 'Fishermen' socks and the nylon anoraks received their share of praise. The anoraks were made from 4 oz/sq yd nylon fabric with a polyurethane compound proofing. They were completely windproof and surprisingly hardwearing and tear resistant. The large zipped pouch pocket was exceedingly useful. The nylon over-trousers made from the same material were used only occasionally, since they tended to sweat excessively.

BOOTS

The boots chosen by the expedition were manufactured by Bally (model "Aiguille Verte"). There was no opportunity to break them in before arrival in Greenland and this possibly accounts for one member suffering from a few blisters early in the expedition. Nevertheless, almost all expressed the opinion that they were a very comfortable boot. Some went as far as to describe them as the most comfortable boots they had ever worn.

One annoying disadvantage of the boots, and one experienced by everybody, was that several D-ring lacing eyelets broke off. Even before arrival at base camp, two or three D-rings had been lost. This trouble persisted throughout the period of the expedition and repairs were effected by using B.A. nuts and bolts. Regretfully the supply of nuts and bolts was exhausted in the first 2 weeks.

SLEEPING BAGS

This item caused not a little concern among members. Regretfully our order of 8 Icelandic Specials was not checked before departure. Within a few hours of using our bags we discovered they were Icelandic standards and they did not give sufficient insulation. The mistake was immediately remedied by the suppliers on our return.

EQUIPMENT LIST SHEET No 1

DESCRIPTION	SUPPLIER	TERMS
1. TENTS		
2 BLACK'S MOUNTAIN TENTS	1 R.A.F., 1 Q.M.C.	L
1 BLACK'S ARCTIC GUINEA	Q.M.C.	L
1 MEAD	Q.M.C.	L
Repair Kit		
2 COPS SAILMAKER'S TWINE	B	+
2 SAILMAKER'S NEEDLES	B	+
1 COP TAN RUNWELL THREAD	B	+
1 "Awl-U-need"	B	+
1 doz 12 yd hanks 1/8" NYLON LINE	B	+
1 length TENT FABRIC	M	*
GROUNDSHEET PATCHES	M	*
2. COOKING		
4 1 pint paraffin stoves	Q.M.C.	L
1 1/2 pint paraffin stove	M	*
3 7 pint PRESSURE COOKERS	PRESTIGE	*+
2 5 pint BILLYS WITH FRYPAN LID	Y.H.A.	+
2 3 pint BILLYS	Y.H.A.	+
2 $2\frac{1}{2}$ pint BILLYS	M	*
4 METAL FUNNELS (with filters)	B	+
Spares		
5 pkts 1 pint stove spares and prickers	B	+
2 pkts 1/2 pint stove spares and prickers	B	+
3. FUEL		
19 gall PARAFFIN	Maestersvig Mine Co.	£
4 gall 2 STROKE OIL	Maestersvig Mine Co.	£
3 5 gall POLYTHENE JERRICANS	I.M. Steiner & Co. Ltd.,	+
2 2 gall POLYTHENE JERRICANS	B	+
1 4 gall POLYTHENE JERRICAN	Maestersvig Mine Co.	L
1 doz $1\frac{3}{4}$ pint POLYTHENE PARAFFIN BOTTLES	B	+
10 pkts 'PROFOL' SOLID FUEL	Promedico Products Ltd	*

EQUIPMENT LIST SHEET No 2

DESCRIPTION	SUPPLIER	TERMS
4. CARRYING		
5 alloy PACK FRAMES	B	†
2 'CRUISER' PACK FRAMES	R.A.F.	L
1 ex W.D. PACK FRAME	M	L
8 HESSIAN SACKS	JUTE INDUSTRIES LTD	£
ELASTIC WEBBING	CLUTSOM & KEMP	*
2 1 gall CANVAS BUCKETS	B	†
2 2 gall P.V.C. BUCKETS	B	†
5. CLEANING		
15 pkts of DETERGENT	PROCTOR & GAMBLE	*
4 large pkts 'BRILLO' SOAP PADS	BRILLO CO. LTD	*
18 TOILET ROLLS	VARIOUS	†
8 tins DUBBIN & POLISH (spare)	KIWI LTD., MELTONIAN WREN LTD.	*
2 BOOT BRUSHES	M	L
6. MEDICAL		
2 large FIRST-AID tins 1 small FIRST-AID tin	Q.M.C. NURSE JOHNSON & JOHNSON LTD. SMITH & NEPHEW HEATH, HICKS & PERKEN	* * * *
1 FIRST-AID BOOK	R.G.S.	£
7. CLIMBING		
2 300' 9 mm PERLON ROPES	Q.M.C.	L
1 150' 11 mm PERLON ROPES	Q.M.C.	L
1 150' No 3 NYLON ROPE	Q.M.C.	L
1 120' No 4 NYLON ROPE	Q.M.C.	L
2 ICE AXES (spare)	R.A.F.	L
3 pr CRAMPONS (spare)	M	L
4 pr CRAMPON STRAPS (spare)	Y.H.A.	†
4 pr SNOW GOGGLES (spare)	B	†
8 pr SNOWSHOES	Lillywhites	£
24 ABSEIL PITONS	Y.H.A.	†
4 'JUMAR' PRUSSIKERS	Y.H.A.	†
4 TUBULAR ICE-SCREWS	Y.H.A.	†
6 'STUBAI' ICE-SCREWS	M	L
1 doz ROCK PITONS	M	L
15 KARABINERS	M	L
20 ASSORTED SLINGS	M	L
100' 5 mm ABSEIL PERLON (24 slings)	Y.H.A.	†

EQUIPMENT LIST SHEET No 3

DESCRIPTION	SUPPLIER	TERMS
8. SUNDRIES		
64 rolls COLOUR FILM	KODAK	+
7 yds HEAVY NYLON MOSQUITO NETTING	B	+
2 pkts 'MOONTIGER' anti-mosquito COILS	B	+
1 FOLDING SPADE	B	+
2 UMBRELLAS	B.R. LOST PROPERTY	£
3 FLARES	F. DIACK & SON	*
1 SMOKE GRENADE (yellow)	F. DIACK & SON	*
100 boxes MATCHES	BRYANT & MAY, MORELANDS	*
1 SPRING BALANCE	GEO. SALTER & CO LTD.	*
1 TUBE 'BOSTIK 1'	B.B. CHEMICAL CO LTD.	*
3 METAL MIRRORS	B	+
POLYTHENE BAGS	BRITISH VISQUEEN, TRANSATLANTIC PLASTICS	*
PLASTIC CONTAINERS	A.W. GREGORY & CO LTD	*
2 tins WATER STERILIZING TABLETS	B	+
3 'SPACE' BLANKETS	SAMS BROS. LTD	*
1 large and 2 small VACUUM FLASKS	THERMOS LTD	*
3 large GAS-LIGHTER REFILLS	RONSON PRODUCTS LTD	*
1 BALL of STRING	Q.M.C.	*
2 SHARPENING STONES	-	
1 SCREWDRIVER	Q.M.C. ENG. DEPT.	L
1 pair PLIERS	Q.M.C. ENG. DEPT.	L
3500 CIGARETTES and 5lb TOBACCO	W.D. & H.O. WILLS	*
13 large Fibreboard BOXES	BOWATER PACKAGING LTD	*
3 WOODEN TEA CHESTS	Q.M.C.	*
9. PERSONAL		
1 LOG BOOK	MACNIVEN & CAMERON	*
1 pr BOOTS	BALLY KOFLACK	+
1 NYLON ANORAK	I.C.I. FIBRES and ABRIDGE OVERALLS	+
1 pr OVERTROUSERS	I.C.I. FIBRES and ABRIDGE OVERALLS	+
1 DUVET (optional).	M	
2 SWEATERS	WOLSEY, MONSANTO	* *
1 pr CLIMBING BREECHES	M	
1 pr PLIMSOLES or CAMPBOOTS	M	
1 pr LIGHTWEIGHT TROUSERS	M	

EQUIPMENT LIST SHEET No 4

DESCRIPTION	SUPPLIER	TERMS
9. PERSONAL (contd.)		
3 pr HEAVY SOCKS	ROHNER (1 pair)	*
2 pr LIGHT SOCKS	WOLSEY	*
3 pr UNDERPANTS	WOLSEY (1 pair)	*
2 VESTS	M	
2 SHIRTS	BRITISH VAN HEUSAN (1 shirt)	†
1 BALACLAVA	M	
2 pr INNER-GLOVES	M	
1 pr OVER-GLOVES (LEATHER)	HORACE SLEEP LTD.	*
1 pr STOPTOUTS	B	†
1 SLEEPING BAG (ICELANDIC)	B	†
1 FOAM RUBBER SHEET	DUNLOPILLO	*
or AIRBED	MACLELLAN & CO LTD	†
1 CLIMBING SACK OR KITBAG	M	
1 pr CRAMPONS	M	
1 ICE-AXE	M	
1 PEG HAMMER (optional)	M	
1 CRASH HAT (optional)	M	
2 pr SNOW GOGGLES	M	
1 COMPASS	M	
1 WHISTLE	M	
1 POCKET KNIFE	M	
1 LIGHTER (optional)	RONSON PRODUCTS LTD	*
1 TOWEL and 1 TEA TOWEL	ASHTON BROS LTD	*
1 TOOTHBRUSH	HALEX	*
2 bars SOAP and 1 large TOOTH-PASTE	COLGATE-PALMOLIVE	*
SHAVING KIT	M	
KNIFE, FORK and SPOON	M	
1 POLYTHENE MUG	Y.H.A.	†
1 POLYTHENE PLATE	I.M. STEINER & CO LTD	†
1 SEWING/DARNING KIT	M	
2 PENS	SCRIPTO	*
2 TINS DUBBIN and 1 TIN POLISH	KIWI MELTONIAN WREN	*
1 CAN OPENER	B	
2 TUBES GLACIER CREAM	B	
1 NYLON POT SCOURER	RUSTLESS CURTAIN ROD CO LTD	*
1 BOTTLE VITAMIN CAPSULES	BENCARD (BEECHAMS)	*
1 CAMERA	M	
1 NOVEL	M	

EQUIPMENT LIST SHEET No 5

DESCRIPTION	SUPPLIER	TERMS
10. SCIENTIFIC		
1 WATTS MICROPTIC THEODOLITE	R.G.S.	L
1 WATTS MICROPTIC PHOTOTHEODOLITE	R.G.S.	L
2 THEODOLITE TRIPODS	R.G.S.	L
1 PLANE TABLE	Q.M.C. Geog. Dept.	L
1 PLANE TABLE TRIPOD	Q.M.C. Geog. Dept.	L
1 BOX COMPASS	Q.M.C. Geog. Dept.	L
3 PRISMATIC COMPASSES	Q.M.C. Geog. Dept.	L
1 CLINOMETER	Q.M.C. Geog. Dept.	L
2 ABNEY LEVELS	Q.M.C. Geog. Dept.	L
2 ALTIMETERS	R.G.S.	L
1 ALIDADE	Q.M.C. Geog. Dept.	L
2 8" SOIL THERMOMETERS	Q.M.C. Geog. Dept.	L
2 12" SOIL THERMOMETERS	Q.M.C. Geog. Dept.	L
1 WHIRLING HYGROMETER	Q.M.C. Geog. Dept.	L
1 DRY THERMOMETER (-20 °C to +40 °C)	Q.M.C. Geog. Dept.	L
1 MIN THERMOMETER (-20 °C to +40 °C)	Q.M.C. Geog. Dept.	L
1 PARAFFIN WAXED THERMOMETER	Q.M.C. Geog. Dept.	L
1 WEEKLY CLOCK THERMOGRAPH (0 - 100 °F)	NEGRETTI ZAMBRA	L
2 pkts THERMOGRAPH CHARTS	NEGRETTI ZAMBRA	L
1 THEODOLITE CAMERA	R.G.S.	L
1 SPIRIT LEVEL	Q.M.C. Geog. Dept.	L
2 100' PLASTIC TAPES	Q.M.C. Geog. Dept.	L
2 6' STEEL TAPES		
4 BALLS of STRING	Q.M.C. Geog. Dept.	L
4 1 pint TINS OF PAINT (ORANGE)	I.C.I. PAINTS DIV.	*
40 NYLON FLAGS (ORANGE)	I.C.I. FIBRES	*
1 PAINT BRUSH		
2 20 oz. GEOLOGICAL HAMMERS	CUTROCK CO. LTD	*
1 POWER DRILL (TELES "EARTHWORM")	E.H. BENTALL & CO LTD	*
1 DRILL BRACE	L. FARNELL & CO LTD	£
1 MILD STEEL 1' RAM END	L. FARNELL & CO LTD	£
6 3' FLIGHT SHAFT EXTENSION RODS	L. FARNELL & CO LTD	£
1 ICE DRILL BIT	L. FARNELL & CO LTD	£
2 DRILL CHUCKS & KEY	E.H. BENTALL & CO LTD	*
1 BLOWER HOUSE ASSEMBLY (spare)	E.H. BENTALL & CO LTD	*
1 spare SPARK PLUG		
1 box DRILL ROD COUPLING SCREWS (spare)	L. FARNELL & CO LTD	£
1 tube SILICONE GREASE	L. FARNELL & CO LTD	£
1 pr 18" CALIPERS	Q.M.C. Geog. Dept.	L
1 3-square FILE	Q.M.C. Eng. Dept.	L
1 SMALL SCREWDRIVER	Q.M.C. Geog. Dept.	L
1 SMALL SPADE	Q.M.C. Geog. Dept.	L

EQUIPMENT LIST SHEET No 6

DESCRIPTION	SUPPLIER	TERMS
10. SCIENTIFIC (contd.)		
1 SLIDE RULE	BERRICK BROS. LTD	*
12 SHEETS 20" x 20" CARTRIDGE PAPER	Q.M.C. Geog. Dept.	*
3 SETS OF LOG TABLES	Q.M.C. Geog. Dept.	L
NOTEBOOKS	MACNIVENS CAMERON,	*
	W.H. SMITH & SON	*
2 reels ADHESIVE TAPE		
12 PENS	EAGLE PENCIL CO	*
12 MARKERS	ROWNEY, LEEDEX	*
12 PENCILS	VENUS, EASTERBROOK	*
4 PEN CASES		
26 AERIAL PHOTOGRAPHS		
19 1 mm PLASTIC STAKES	CHEMIDUS PLASTICS LTD	*
15 1/16" PLASTIC STAKES	CHEMIDUS PLASTICS LTD	*
4 1/16" ALUMINIUM STAKES	ALUMINIUM FEDERATION	*
The above 3 types of stake were approx. 1 inch dia.		

LIST 1

ALPHABETICAL LIST OF FIRMS / SOCIETIES / INSTITUTES WHO SUPPLIED EXPEDITION EQUIPMENT

NAME	ITEM	TERMS
ABRIDGE OVERALLS LTD	Nylon anorak manufacturers	†
ALLEN & HANBURYS LTD	Dequadin lozenges	*
ALUMINIUM FEDERATION	Aluminium tubular stakes	*
ALUMINIUM FOILS LTD	Aluminium foil	*
ASHTON BROS & CO LTD	Hand/tea towels	*
BALLY KOFLACK	Boots	†
B.B. CHEMICAL CO LTD	Bostik No. 1 adhesive	*
BENCARD (BEECHAMS)	Vitamin capsules	*
BERRICK BROS LTD	Slide Rules	*
BLACK & EDGINGTONS LTD	General Expedition equipment	†
BOWATER PACKAGING CO LTD	Cardboard boxes	*
BRILLO MANUFACTURING CO LTD	Brillo soap pads	*
BRITISH VAN HEUSEN LTD	Bush-shirts	†
BRITISH VISQUEEN LTD	Polythene bags	*
BRYANT & MAY LTD	Matches	*
CEAG LTD	1 large torch	*
CHEMIDUS PLASTICS	Plastic tubular stakes	*
CLUTSOM-PENN U.K. LTD	Elastic webbing	*
COLGATE-PALMOLIVE LTD	Soap and toothpaste	*
CUTROCK	Geological hammers	*
F. DIACK & SON	Flares and smoke grenade	*
DUNLOP RUBBER CO LTD	Foam-rubber sheets	*
EAGLE PENCIL CO LTD	Pencils and markers	*
H. J. GAINS LTD	Rubber stamp	*
L. HAIG & CO LTD	Biscuit tins	£
HALEX	Toothbrushes	*
HEATH, HICKS & PERKEN	Clinical thermometers	*
I.C.I. FIBRES LTD	Nylon anorak & flag material	*
I.C.I. PAINTS DIV	Paint	*
JOHNSON & JOHNSON LTD	Plasters and dressings	*
JUTE INDUSTRIES LTD	Hessian sacks	£
KEILAWARRA LTD	Drill motor spares	†
KIWI POLISH CO	Boot polish and dubbin	*
KODAK	Photographic film	†
LEEDEX LTD	Pens and markers	*
MACNIVEN & CAMERON LTD	'Memo' books	*
MELTONIAN WREN LTD	Boot polish and dubbin	*
MONSANTO TEXTILE LTD	Sweaters	*
PLASTIC HOLLOWARE (A.W. GREGORY & CO LTD)	Plastic containers	*
THE PRESTIGE GROUP	Pressure cookers	*†
PROCTOR & GAMBLE	Soap and detergent	*
PROMEDICO PRODUCTS LTD	'PROFOL' solid fuel	*
Q.M.C.M.C.	Climbing and camping equipment	L
R.A.F.M.C.	1 Tent, 2 ice-axes, 2 pack-frames	L
ROYAL GEOGRAPHICAL SOCIETY	Scientific equipment	L

LIST 2

NAME	ITEM	TERMS
JACOB ROHNER (FOLKMAN SPORT LTD)	Socks	*
RONSON PRODUCTS LTD (BULLOCK & TURNER)	Lighters	*
GEO ROWNEY & CO LTD	Pencils and markers	*
THE RUSTLESS CURTAIN ROD CO LTD	Nylon scourers	*
GEO SALTER & CO LTD	Spring balance	*
SAMS BROS. LTD	"Space" blankets	*
SCRIPTO PENS LTD	Pens	*
SHORT & MASON	Altimeter, Wet/dry thermometer	*
HORACE SLEEP LTD	Gloves and nylon quilted jacket	*
SMITH CLOCKS & WATCHES	'Everest' watches	+
SMITH & NEPHEW	Nivea cream and medical supplies	*
W.H. SMITH & SONS LTD	Notebooks	*
I. & M. STEINER LTD	Jerricans & plates (polythene)	+
HUGH STEVENSON & SONS LTD	Agents (see Bowater)	
THERMOS LTD	'Thermos' flasks	*
TRANSATLANTIC PLASTICS	Polythene bags	*
UNILEVER EXPORT LTD	Soap and toothpaste	*
VENUS EASTERBROOK	Pens and markers	*
W.D. & H.O. WILLS	Cigarettes and tobacco	*
WOLSEY LTD	Sweaters, socks, underwear	*
Y.H.A.	General Expedition equipment	+
BUCK & HICKMAN	Banding machine	£
J. MORELAND & SONS LTD	Matches	*
BENTALLS (E.H. BENTALL & CO LTD)	Drill Motor and spares	*
L. FARNELL & CO LTD	Drill Bit, Rods and spares	+
Q.M.C. ENGINEERING DEPT	Tools	L
Q.M.C. GEOGRAPHY DEPT.	Scientific equipment	L

Medical Report

Preparations

As there was not a trained Medical Officer in the team, two members attended a first aid course at evening classes and two other members were given basic training in first aid.

All members were advised to have T.A.B., Tetanus and small-pox injections, and these were administered by the Q.M.C. M.O. Dr. Summers and nursing sister Mrs. J. Jones. Besides the injections all members had a full medical and dental check-up.

The nursing sister at Q.M.C. Mrs. J. Jones helped considerably by compiling a list of medical equipment. It was the duty of every member to contact his own Doctor, with the intention of obtaining some of the drugs on prescription. This was not feasible on N.H.S. prescriptions and the drugs had to be purchased at the last minute, a private prescription being given by Dr. Summers.

NOTE

Sister Jones would appreciate more time when assisting future Q.M.C. expeditions, and also some idea of any weight restrictions in order that essentials should receive priority.

In the Field

By the end of the first week at base camp, most of the T.C.P. had been virtually wasted on cuts and scratches due to abrasions on the sharp ice. A bandaid plaster with antiseptic cream would have been sufficient, but we were not to know that later on the T.C.P. would have had a far more valuable use.

On 16.7.68 Keith Miller fell 25 feet down a crevasse and fractured two bones in his face.

It was decided that Miller would have to be flown to Iceland for medical treatment. Miller was a little dismayed at the thought of nurses seeing a somewhat dishevelled person and requested that at least his sodden socks be removed and feet be washed. This task was dutifully undertaken by the camp M.O. John Kanarens. Kanarens also cleaned away some of the facial blood clots.

One member, Tom Hird fell into a large glacier stream on 27.7.68 and at a second rescue attempt David Drewry was also pulled into the swift moving stream, some ½ mile further downstream. Hird suffered severe exposure. Both hands were stripped of skin, leaving a red, raw and very painful surface exposed. He also received a deep gash to the left leg. Drewry was relatively unharmed, but very chilled.

The following morning Hird was still shivering violently. The renewal of all dressings took over 5 hours.

Hird stayed in his sleeping bag for a week, only emerging every other day for treatment.

Hird's difficulties in the immediate post accident period were due to his inability to use his hands for any function. Tom's condition frequently gave rise to incidents that created much amusement for his colleagues.

Apart from these two major accidents the expedition members suffered little ill health, although Munro, whilst climbing fell 15 - 20 feet and began coughing up blood. This startled everyone at first but his complaint was of a temporary nature.

Conclusions

In future:

Take more - T.C.P., and cotton wool packs.

Apart from these two items our medical equipment was sufficient.

MEDICAL EQUIPMENT

LIST 1. ITEMS PROVIDED AT NO COST

QUANTITY	DESCRIPTION
20	Gelusil tablets
100	Aspirin tablets
2	Tubes Acriflex cream
2	Tubes Savlon cream
2	Tubes Dermaid cream
2 x 2oz.	T.C.P.
2	Allucid eye ointment
20 oz.	Optrex eye lotion
100	Senobot tablets
4 oz.	Kaolin mixture
2	Clinical thermometers
1	Scissors
4	Cotton wool packs
6	Gauze packs
6	Lint packs
6 x 1"	Cotton bandages
6 x 2"	Cotton bandages
6 x 3"	Cotton bandages
2 x 2½"	Crepe bandages
3 x 1"	Elastoplast bandage
6	Triangular bandages
12	Large wound dressings
12	Medium wound dressings
12	Small wound dressings
6	Eye pads
1	Medicine glass
	Assorted safety pins
	Dequadin throat lozenges
200	Vitamin pills
1	Tin of Nivea cream

MEDICAL EQUIPMENT		
LIST 2.	ITEMS PURCHASED	
QUANTITY	DESCRIPTION	USE
100	Quinalbarbitone tablets	Insomnia
30g	Penicillin powder	Packing deep wounds
10	Crystapen	Penicillin for Injections
10 x 2ml.	Disposable syringes	
10 x 2ml.	A pyrogen	
100	Entero-vioform tablets	Diarrhoea and vomiting
1	Tube Tineafax	Athlete's foot
100	Antistin tablets	Allergic reactions (e.g. to insect bites)
3	Tubes Histofax	Insect bites
3	Tubes Flypel	Insect repellant

The Crevasse Accident

The day started well. We left camp just before 1 a.m. having taken a little breakfast that had been prepared the previous evening and kept warm in our "thermos" flasks. The going was good but I was using a cheap type of expedition pack-frame for the first time and was forced to agree with the other members that it was a useless item. Somewhat selfishly I was sorry that I had lent my own sturdier frame to Dick two days previously. The snow line was fast retreating up the glacier and this coupled with the fact that the surface ice melt was partly frozen over at this early hour we were soon two miles upstream and out of sight of the lower reaches of the glacier and our camp. Continual hitching of the pack-frame to try to achieve a more evenly distributed load was tiring although the loads were not unduly heavy. In total we were both carrying about 58 lbf each comprising mainly food for a high dump. Above the snow-line we sometimes sank knee-deep in melt areas and after 3 hours deviated off the normal route to climb a steep subsiduary glacier on the true left bank hoping to avoid crossing more melt areas. It was to no avail and eventually it was necessary to return to the normal route. A small ice fall was climbed with no trouble but the pack lurched continually and I was getting more than a little annoyed. The crevasses, although snow covered and numerous were still obvious but we thought it best to traverse over from the crevassed area to the left bank after jumping a series of three crevasses, the first one being open, the second being covered but obvious and the third of which was partially uncovered. Jumping the first two necessiated a realignment of my pack and I took half a step out of sequence with Tony's footsteps. Between the second and third crevasses the area was in fact a soft bridge and the ground under my feet must have been on the unstable overhanging lip of the third crevasse. The fall was approximately 25 ft, clean and smooth. Tony employed the correct surface techniques and I prussiked up the rope after the rucksack and two remaining pieces of the pack-frame had been hoisted out.

I had several superficial facial cuts and subsequently learned of two fractures, one near the right temple and one under the right eye. A debate on possible courses of action was brief and we left both packs on the bridge and descended to base. I must here praise Tony for his considerations on the long journey back. It was a strange journey. I was angry, knowing from the size of my head that the expedition for me was over after so little time in the field and yet after so long a preparatory period; and yet I was thankful in the extreme at being so lucky in that I know the accident could have been far worse. I was frequently dizzy and refused to jump surface streams, thereby making the journey longer than it needed have been. At last we arrived at camp and the boys were just preparing to leave for the day's work. John bathed my face, David made food and drink. Eric and Malcolm made a record-breaking race back to Mestersvig for helicopter assistance.

Although my regrets on leaving this group were intense I was thankful that by this stage all the initial readings for the various glaciological programmes had been recorded and I knew my companions would not compromise the schedule of work we had formulated. The helicopter landed on the glacier close to camp, it was midnight and only 18 hours after the accident. Within seconds the expedition was, for me, over. No words can describe my sadness. The Danes at Mestersvig were wonderful and J. K. Hansen was very considerate. A Catalina of the Royal Danish Airforce was soon ready and I was flown to Iceland along with J. K. who sat and kept me company on the long flight. A minor operation quickly repaired the damage but a vivid red eye and a little facial numbness stayed for several weeks.

THE GLACIER STREAM ACCIDENT

T. HIRD

Saturday 27th July was sunny and David Drewry and I left base camp early. We intended to measure some of the dirt cones down near the lower icefall. After measuring a few cones along the Northern edge of the glacier we started to cross over to the Southern edge. Crossing the glacier close to the snout was difficult because here the melt water streams had gained so much force and volume that deep ice channels had been cut and these were far too wide to jump. We made precarious crossings over one or two until we came to a very fast flowing stream with steep banks. This stream was too wide to cross and as David had a bad foot and could not jump too well we walked upstream looking for a somewhat narrow ford. We walked more than half a mile past several bad stretches before we found a narrow and possible crossing. It was then about 3 p.m. Taking David's ice axe it was my intention to jump across and then cut a platform in the sloping ice on the opposite bank to assist David's landing.

Unfortunately, I slipped and within split seconds I was quickly swept downstream. It was impossible to stand up and since the banks were of steep ice I could not escape. Most of the time I balanced on my hands and feet facing downstream but as I went through the worst sections I was turned upside down and around and at those instants I could see David running along the bank shouting instructions, not that I could hear him properly. The freezing water soon had its effect, and once when David managed to catch hold of me I could not hang on. Suddenly David toppled and was in the stream beside me, and both of us were carried along blindly and frequently knocking into each other. When David managed to stop and crawl onto a possible exit bank I had not enough strength left and was carried on, slowly drowning in the cold water, until I was stopped by a large boulder in the side of the stream.

I have only a vague recollection of subsequent events and so I rely on David's continuation of the narrative.

When David reached me he found me delirious and lying on my back wedged against the boulder. It took him a long time to drag me up the bank. Exhausted and bleeding himself he had to leave me unconscious on the glacier while he returned to base camp for help. It was nearly two hours before he arrived at the camp.

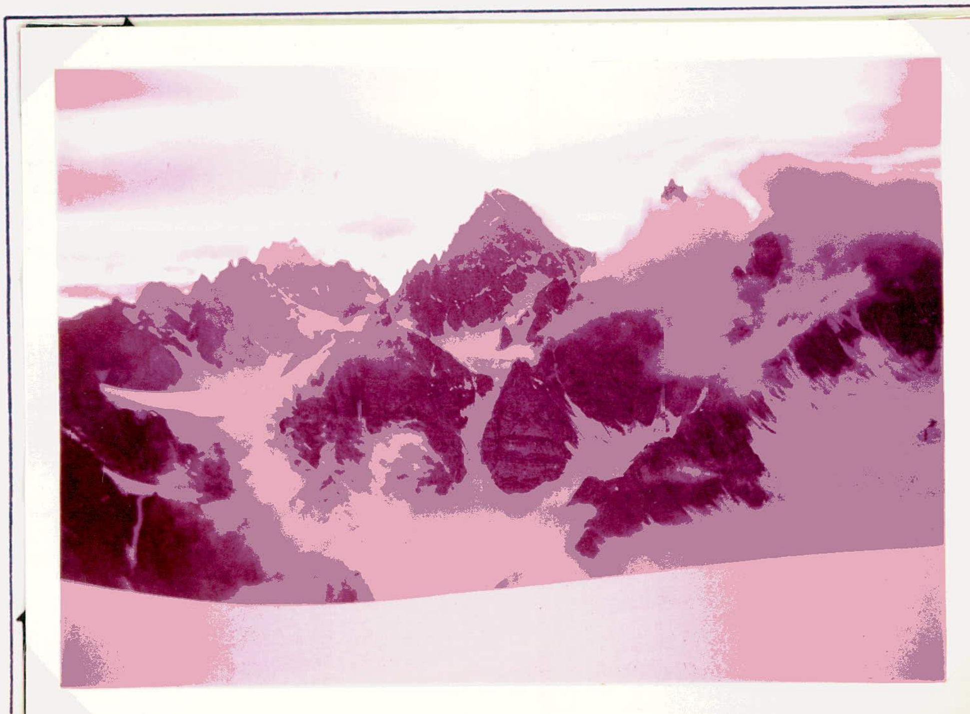
Fortunately, Banaszek, Kanarens and Williams were there. Drewry was suffering from shock and exposure and they quickly put him to bed. Kanarens and Williams quickly pieced together the story and left to look for me. Banaszek completed the bandaging of Drewry's hands and legs and then started after the other two.

To me it was a very strange dream. I dreamt I was standing on the glacier feeling very cold and looking at my torn hands. Periodically I would fall over and then struggle on again. Eventually I realised what had happened and started stumbling back towards the base camp. By the position of the sun it was late evening and I was worried about David. Progress was very slow and painful. The jumping of crevasses was impossible without falling over. After a long time I staggered into the camp and was relieved to find David in his tent. The others were still out looking for me and so David helped me out of my wet clothes, covered me in my duvet and pushed me into a sleeping bag where I shivered and moaned with cramp. The other three soon returned. They gave me hot soup and drinks and Kanarens attended to my wounds.

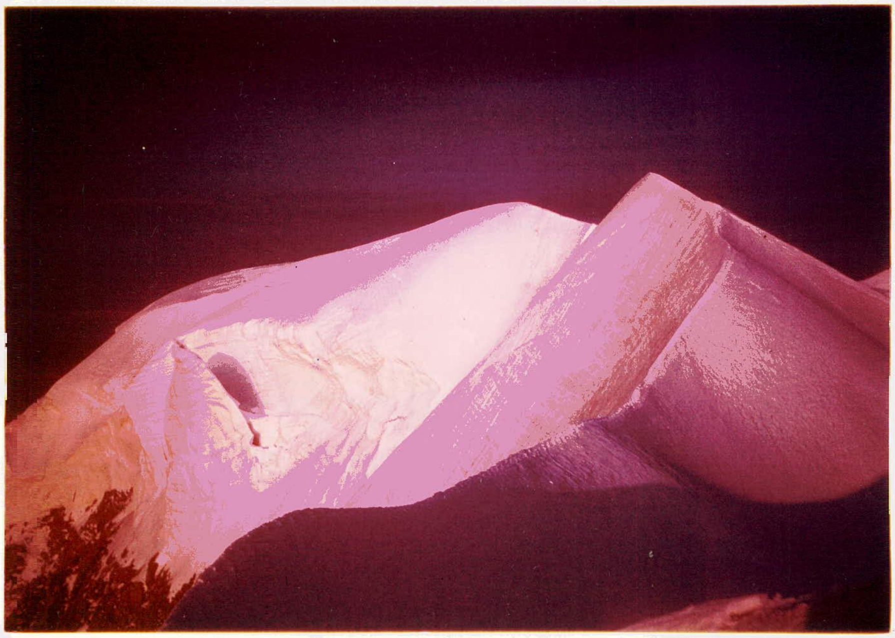
Apparently I had travelled nearly three quarters of a mile down the stream. Unfortunately my climbing sack containing scientific equipment and a log book with three weeks' scientific results plus my camera went down a moullin some quarter of a mile below the point where David pulled me out.

Three weeks later I was well enough to climb again. I am eternally indebted to all the members of the expedition for the help and concern they gave me that day and in the next week or two before I could look after myself again.

1. DRILLING STAKE HOLES



2. COL MAJOR BELOW DANSKETINDE



3. THE SUMMIT RIDGE OF MERCHISTON
AT MIDNIGHT

4. BERSAERKERTINDE AND MERCHISTON
FROM THE BERSAERKERBRAE GLACIER

5. UNDER THE BERSAERKERBRAE GLACIER

6. VIEW FROM THE BERSAERKERTINDE BIVOUAC

FOOD REPORT

T. BANASZEK

ESTIMATES

Provisional estimates of the quantity of food needed were based on the expedition being in the field for a period of eight weeks and spending most of the available man-hours in scientific work with only a small proportion of time on climbing and exploration activities. An adequate but separate diet for both programmes had to be formulated before calculating exact food quantities based on a 2 lb per man per day ration. The food reports of previous expeditions to the same area were studied.

List 1 shows the amounts of food and types of packaging used by the expedition. The food was divided into 22 x 16 man day rations for base camp and 12 x 8 man day rations for the climbing party. An additional 12 man day ration was included for a possible walk-out party from Mestersvig to the Bersaerkerbrae, and some tinned food taken for consumption in Reykjavik, Iceland.

The total weight of food amounted to 924 lbs, slightly exceeding the provisional estimate of 900 lbs.

In early April we approached food manufacturers that we thought might be willing to help us. Many firms were extremely generous in their reply, either donating quantities of their product free of charge, or at special expedition rates. With a few exceptions all the food was delivered to College by 18th June, leaving one week for packing.

PACKING

A high percentage of the food was dehydrated, and could therefore be packed in either plastic containers or polythene bags. The only tinned foods taken were cheese, margarine and corned beef. The following plastic containers were generously supplied by P. Gregory & Sons.

Table I

TYPE	CAPACITY
2 doz.	50 ml
2 doz.	250 ml
4 doz.	42 fl oz
12 doz.	12.75 fl oz

MENU

Throughout the period spent in the field the diet was found to be both varied and interesting, and there were few complaints as to quality or quantity. Regular meals were enjoyed at base camp, whilst the climbing party ate whenever possible!

A TYPICAL MENU	
Breakfast	Porridge, or cereal plus fruit and nut, or Weetabix Dried Egg Tea and biscuits
Lunch	Peanuts and raisins Chocolate Sweets Mint Cake and Fudge for climbers
Dinner	Soup Stew (either meat bar or savory mince) or Vesta Curry or Corned Beef Vegetables Apple Dice and Custard (alternate days) Cheese and biscuits Coffee

Various additions to the diet were made towards the end of the expedition when a large food cache was discovered at the Skel river.

COMMENTS

1. Cereal, plus fruit and nut was a breakfast cereal superior to porridge. It is easy to prepare and was therefore used by the climbing party at the bivouacs. The only regret was that we had not taken more.

2. Towards the end of the expedition Apple Dice was successfully used to supplement the breakfast cereal.

3. Processed cheese was used several times to prepare tasty dishes. Despite the fact that it was tinned, it was well worth taking and fortunately we had sufficient.

4. Meats. The basic food for our evening meal. We had sufficient dehydrated varieties (see lists) and this item was appreciated by us all despite its cost.

5. Vegetables. These were all in dehydrated form, and each variety had a different recommended cooking period. Carrots took the longest to cook properly. The use of pressure cookers saved much time in the preparation of these items.

6. Milk. two varieties of powdered milk were taken, and both needed some care in their preparation in order to avoid a non-uniform lumpy mix. When used successfully it gave to scrambled egg and porridge an extra creamy texture.

7. Dried Egg. Carelessness in the preparation during the early days often resulted in the formation of a powerful laxative. Towards the end of the expedition it became a popular breakfast, either in scrambled or fried form.

8. Biscuits. Too many varieties were taken. Some crispbreads crushed too easily, and consequently were not taken on climbing trips.

9. Beverages. consisted of a choice of tea, coffe, lemonade, chocolate or ovaltine. The latter became a particular favourite. The lemonade absorbed large quantities of sugar in its preparation, and was therefore considered to be a dispensable item for future expeditions.

10. Spreads. honey and jam were taken, both highly valued by members.

11. Mint cake and rum fudge. these formed the basis for the climbing group food, together with nuts and raisins.

12. Additives. Bovril, gravy mix, curry powder and spices were well worth including for flavouring stews and soups.

CONCLUSIONS

1. Each varient of plastic container (see page 59) had its advantages, and future expeditions should make a detailed study of the many types now available.

2. Our diet was probably more varied than most expeditions. Future expeditions may desire a much simpler diet shown in Table II.

TABLE II Recommended Rations for Future Expeditions

ITEM	WEIGHT (oz) PER MAN DAY
MARGARINE	1
CEREAL, FRUIT & NUT	2
MILK	2
SUGAR	6
EGG	1
BISCUITS	2
POTATO	2
VEGETABLE	0.31
MEAT	1.25
APPLE DICE	1
CHEESE	2
SALT	0.19

3. Pressure cookers are an essential item especially for the cooking of dehydrated foods.

LIST 1. FOOD TAKEN ON EXPEDITION

KEY

B = Base Camp Rations.
A = Climbing Group Rations.
wt/m-d = Weight per man-day.
P P = Plastic Pots
FW = Foil Wrap
GB = Glass Bottles
TF = Tin Foil. Pkt = Packet.
PB = Plastic Bags, C = Cardboard Boxes.
STC = Screw Top Container.
T = Tins, PW = Paper Wrap.
R PC = Rigid Plastic Container

ITEM	B wt/m-d oz	A wt/m-d oz	Total Weight and Packaging: B lb	B Container	A lb	A Container
1. Margarine	1	1	22	11 T	6	3 T
2. Porridge Oats	2	2	15	C	8	RPC
3. Cereal fruit & nut	2	2	21	PB	4	RPC
4. Weetabix	1.12	-	4.5	PW	-	-
5. Dried Milk	2	2	44	PW	12	PW
6. Sugar	5	5	110	PB	30	RPC
7. Dried Egg	1.5	1.5	33	PB	8	RPC
8. Digestives	1	1	22	PW	6	PW
9. Macvita	2	-	44	PW	-	-
10. Vita Weat	-	2.16	-	-	17.25	PW
11. Coffee	.12	.12	2.75	T	0.75	RPC
12. Tea bags	(2) bags	(2) bags	(704) bags		(192) bags	PB
13. Drkg. Choc.	.33	.33	7.25	PB	2	STC
14. Complan	1	1	22	PW	6	STC
15. Dried Potato	2	2	44	STC	12	STC
16. Dried Peas	.37	.37	8.25	PB	2.25	PB
17. Dried Beans	.25	.25	6.25	PB	1.75	PB
18. Dried Carrots	.19	.19	4.12	PB	1.12	PB
19. Dried Onions	.25	.25	5.5	PB	1.5	PB
20. Dried Meat	1.25	1.25	15	TF	2.5	TF
21. Savoury Mince	1.5	1.5	9	STC	3	STC
22. Vesta Curry	1/2 pkt	1/2 pkt	32pkts		16pkts	
23. Macoroni	1	1	4	C	2	RPC
24. Apple pieces	1	1	11	PB	3	STC
25. Cheese	2	2	44	T	12	T
26. Salt	.19	.19	4.12	RPC	1.12	RPC
27. Soup (2oz.pkt)	1/2 pkt	1/2 pkt	22	FW	12	FW
28. Honey	0.5	-	12	PP		
29. Chocolate	2	2	44	FW	12	FW
30. Lemonade crystals	.37	.50	8.5	GB	3	GB
31. Rum Fudge	-	1	-	-	6	TF
32. Mint Cake	-	3	-	-	18	PW
33. Peanuts	2	2	44	PB	12	PB
34. Glucose Sweets	-	1	-	-	6	T
35. Barley sugar	0.5	0.5	11	PB	3	PB
36. Raisins	0.5	2	11	PB	12	PB

LIST 1 FOOD TAKEN ON EXPEDITION, continued.

ITEM	B	A	Total Weight and Packaging			
			B		A	
	wt / m-d	wt / m-d				
	oz	oz	lb	Container	lb	Container
37. Corned Beef	4.5	-	9	T		
38. Vit. C. tablets	2 tabs.	2 tabs.	704 tabs		192 tabs	RPC
TOTALS	30	29	654		227	

Miscellany

Curry Powder (1 lb) in polythene bags
Pepper (1 lb) in polythene bags
Assorted spices and chillies
Gravy mix (2 lbs) in polythene bags
Bovril (6 lb) in jars
Ovaltine (12 lb) in tins
Custard Powder (2 lbs)
Jams 72 assorted 1 oz. pots
Ovaltine biscuits (6 lbs)

GRAND TOTAL 924 lb

We are much indebted to the following firms for their help and generosity.

KEY :- F = FREE T = TRADE D= AT DISCOUNT

Firms approached	Item	Terms
Australian Dried Fruit Board	Raisins	F
Barker & Dobson Ltd	Sweets	F
Batchelor Food Ltd	Dehydrated foods	T
Brooke Bond Tea Ltd	Tea and Coffee	F
Beecham (Food & Drink Division)	Tinned peas and carrots	F
Briess & Co. Ltd	Potato powder	F
Bovril Ltd	Bovril	T
Brown & Polson Ltd	Soups	D
J. Bibby & Son	Honey	T
British Egg Marketing Board	Dried Egg	F
Cerebos Ltd	Salt and pepper	F
J. & J. Colman Ltd	Potato powder	T
G. Costa & Co. Ltd	Tinned Ravioli	F
Caxtons Chocolate Co. Ltd	Chocolate	F
Percy Daltons Co. Ltd	Peanuts	T
Gill & Duffus Ltd	Drinking Chocolate	F
General Foods Ltd	Gravy mix, custard powder	F
Glaxo Laboratories	Ostermilk, Complan	F
H. J. Heinz Ltd	Tinned soups	F
P. J. Hunter & Co. Ltd	Cereal fruit & nut	F
Kavli Ltd	Cheese (processed)	D
Nesle Co. Ltd	Chocolate	T
Oxo	Corned Beef	F
Overseas Egg & Produce Co. Ltd	Dried egg	F
Peak Frean & Co. Ltd.	Biscuits	T
Pearce Duff & Co. Ltd	Custard Powder	F
L. E. Pritchett & Co. Ltd	Millac	F
Quaker Oats	Porridge, macaroni	F
George Romney Ltd	Kendal Mint Cake	D
James Robertson & Sons Ltd	Jams	F
Smith Kendon Ltd	Sweets	F
J. A. Sharwood & Co. Ltd	Curry powder	F
Tate & Lyle Ltd	Sugar	F
Thames Rice Milling Co. Ltd	Rice	F
United Biscuits Ltd	Biscuits	T
Unilever (Export) Ltd	Margarine	T
Unilever	Dehydrated foods	F
Vitamins Ltd	Vitamin tablets	F
A. Wander & Co. Ltd	Ovaltine	F
Weetabix Ltd	Weetabix	F
Watney, Combe, Reed & Co. Ltd	Beer	F
Wrigley & Co Ltd	Chewing Gum	F

SCIENTIFIC REPORT

CONTENTS

SCIENTIFIC REPORT

INTRODUCTION

The Arctic, because of difficulty of access and harshness of environment, remains one of the relatively unknown parts of the world. Scientific research in such areas is usually carried out by specially organised expeditions and the scientific purpose of the Queen Mary College East Greenland Expedition was glaciological and geomorphological research on the behaviour and character of a sub-polar glacier and the study of landforms of an intensely glaciated region. Investigations of this kind lead to a better understanding of the contemporary processes that are sculpturing the surface of the continents in high latitudes and altitudes and also assist in the interpretation of landforms of more temperate areas that were once ice-covered. Such areas include northern Eurasia and America, where much of the topography bears the imprint of the Pleistocene glaciation.

This report summarizes in layman's language the scientific work carried out by the Queen Mary College Expedition in the Staunings Alps during the summer of 1968, and is divided into sections, each devoted to a particular aspect of the programme. The report gives the reasons for undertaking particular investigations and how they were carried out in the field, together with a brief summary of the results obtained. Definitive accounts of selected research topics will be published in the scientific journals in the near future.

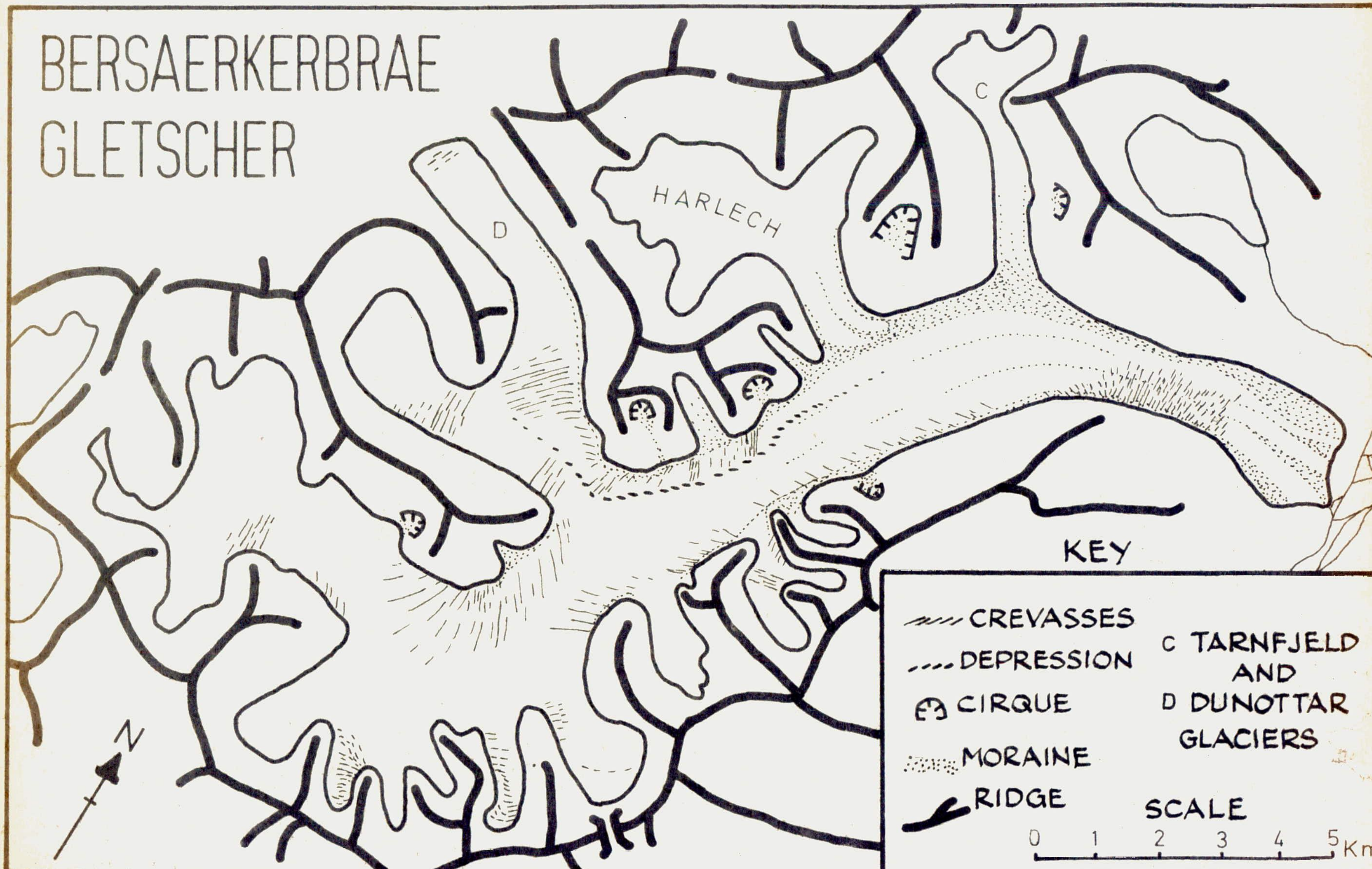


FIG 1 THE BERSAERKERBRAE GLACIER

2. THE CLIMATIC ENVIRONMENT

The climate experienced in Scoresby Land is Polar and semi-arid. Records show a mean monthly minimum of -22.2°C (Jan.) although an extreme daily minimum of -44.2°C (2nd March 1960) has been experienced. During January to March the lowest temperatures are usually recorded, often reaching -40°C on the coast. In 1962 Mesters Vig had 241 freezing days, 49 days when the temperature crossed freezing point and 75 frost free days. Daily freeze-thaw cycles are few in the coastal tracts and lower mountains. At Base Camp (880m) on the Bersaerkerbrae Gletscher 14 occasions were recorded during the expedition when the temperature passed through 0°C. This phenomenon is of great importance in glacial geomorphology. Since 1877 it has been considered that repeated freezing and thawing, both diurnally and seasonally, is one of the most potent mechanisms of rock disintegration and weathering. (Helland 1877; Johnson 1904; Lewis 1939 & 1940)[1]. Despite some doubt being cast on its efficiency and incidence (Grawe 1936; Fraser 1959)[2] it is still claimed as one of the major processes of landform sculpture in glacial and periglacial zones.

Weather stations at Mesters Vig and Scoresby Sound record an annual precipitation of between 27 and 43 cm, the heaviest precipitation being experienced in September, October and early November. The precipitation in this period occurs as snow. December and January remain fairly free of snowfall but between January and March further falls are common. Since the beginning of the 1960's snowfall has, however, been less than average in Scoresby Land. The spring months of May and early June are dry and in July and August there is only some 2 - 3 cm of rainfall. This later period is the melt season and much surface water becomes available, swelling streams and rivers that issue from the highland glaciers. These pro-glacial streams, heavily charged with detritus, provide for abundant erosion as well as a lubricant for mass movement. The rapid melt is aided by the high summer evaporation, little diurnal change in insolation (a function of daylight hours), low relative humidity and a warm föhn wind, usually experienced in July, that comes from the west or north-west. Only the surface layers thaw out, for Mesters Vig lies within the zone of permafrost. This has been reported to be 220 m thick in the Upper Schuchert Valley and 125 m thick in the Mesters Vig region.

During the course of the [illegible].M.C. Expedition, meteorological observations were taken twice daily at 10.00 hours and 22.00 hours. They included the following:

Atmospheric Pressure
Minimum Temperature
Dry-Bulb Temperature
Wet-Bulb Temperature
Temperatures by Thermograph (weekly)
Relative Humidity

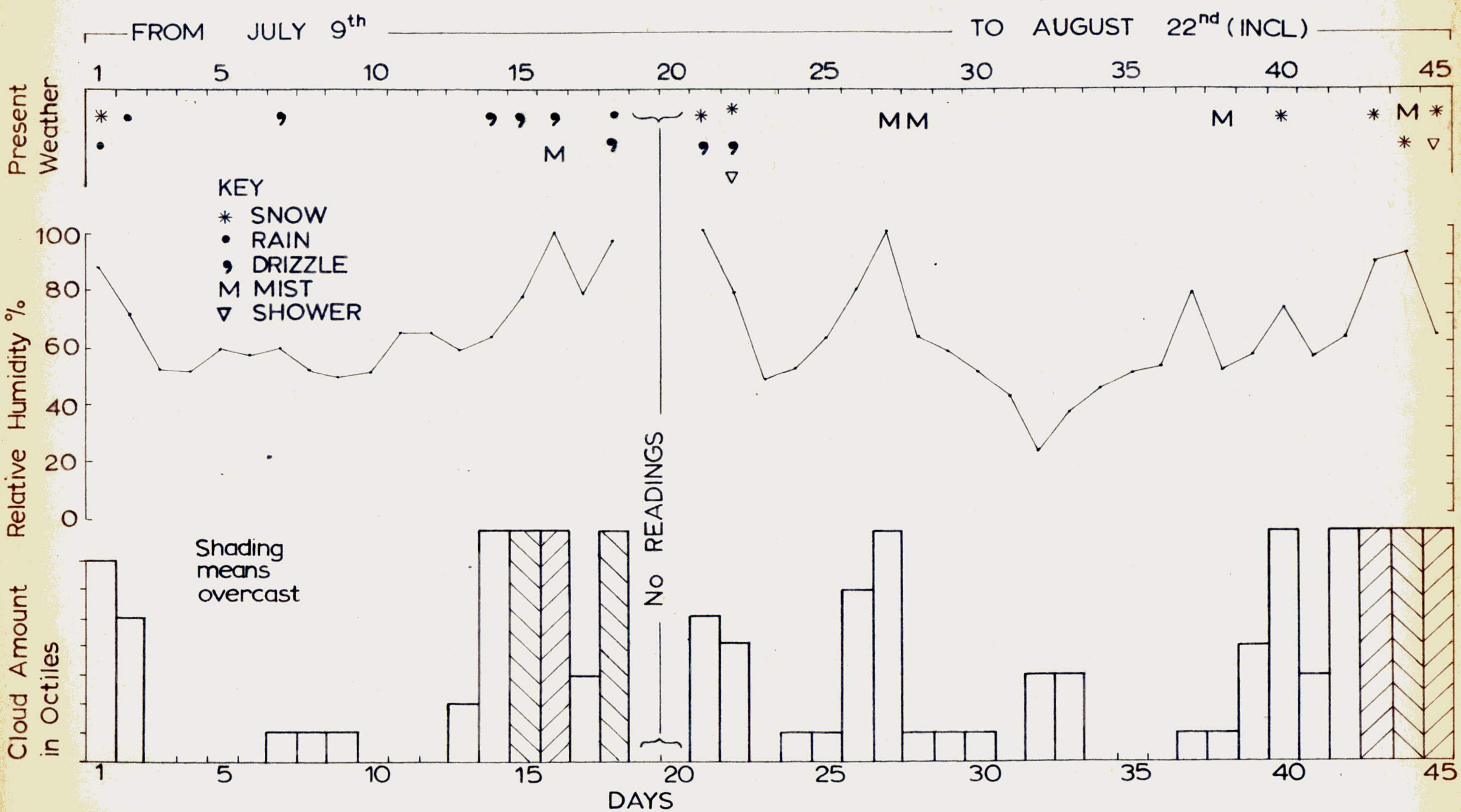
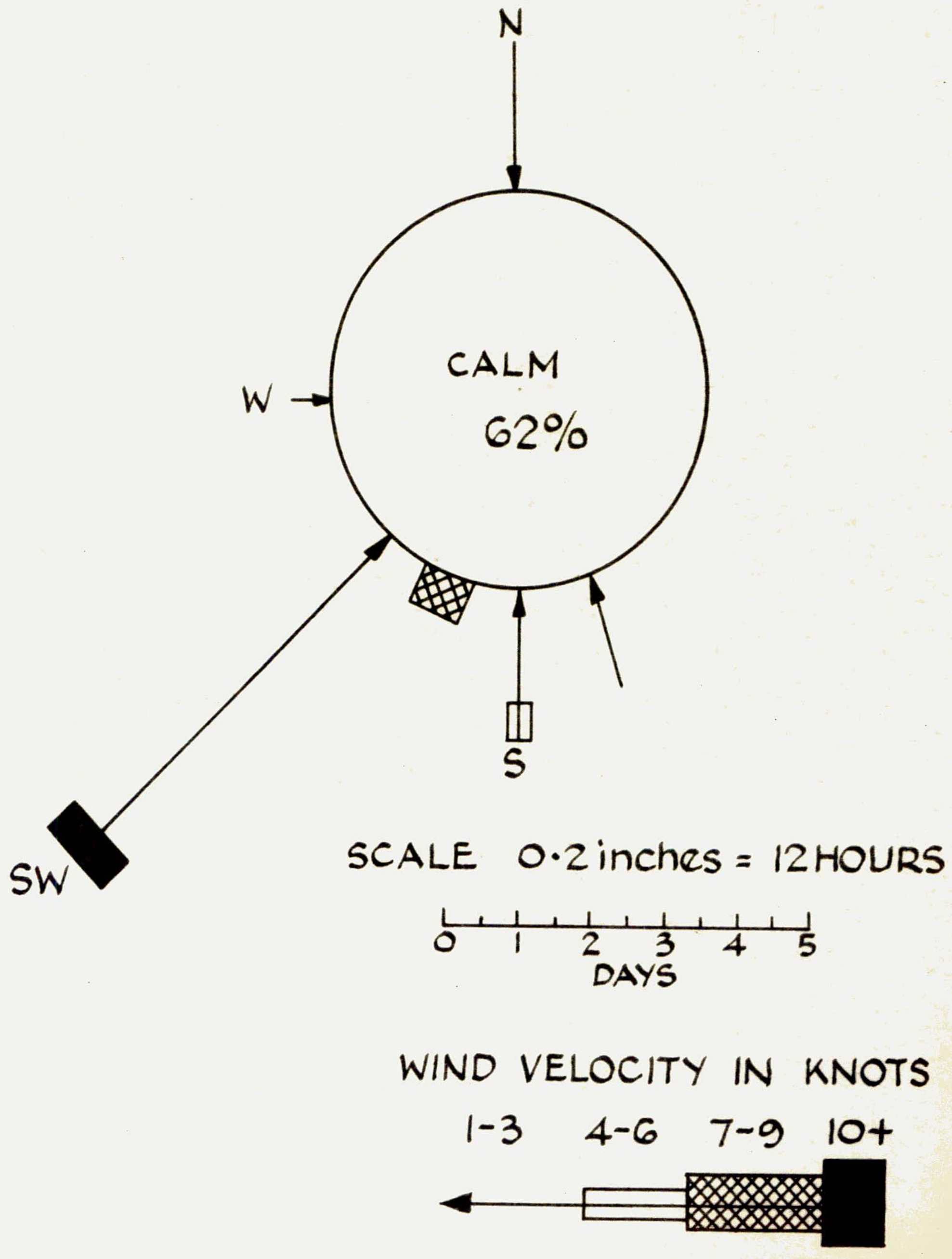


Fig. 2. A COMPOUND GRAPH OF (a) CLOUD AMOUNT (b) RELATIVE HUMIDITY and (c) PRESENT WEATHER RECORDED AT BASE CAMP [c. 1000m] BERSAERKERBRAE GLACIER, EAST GREENLAND JULY – AUGUST 1968

FIG. 3

COMPOUND ROSE
WIND DIRECTION & VELOCITY FOR 12 HOUR PERIODS
Recorded at Base Camp
Bersaerkerbrae Glacier
July – August 1968



KEY TO PHOTOGRAPHIC REPRINTS OF WEEKLY TEMPERATURE STRIPS

(PAGE 69)

Mon 15 JULY ——— Sun 21 JULY	STRIP 1
Sun 21 JULY ——— Mon 22 JULY	STRIP 2
Mon 22 JULY ——— Sun 28 JULY	STRIP 3
Mon 29 JULY ——— Sun 4 AUG	STRIP 4
Mon 5 AUG ——— Sun 11 AUG	STRIP 5
Mon 12 AUG ——— Sun 18 AUG	STRIP 6
Mon 19 AUG ——— Fri 23 AUG	STRIP 7

Note:– ACTUAL RECORDS ARE IN EXPEDITION FILES

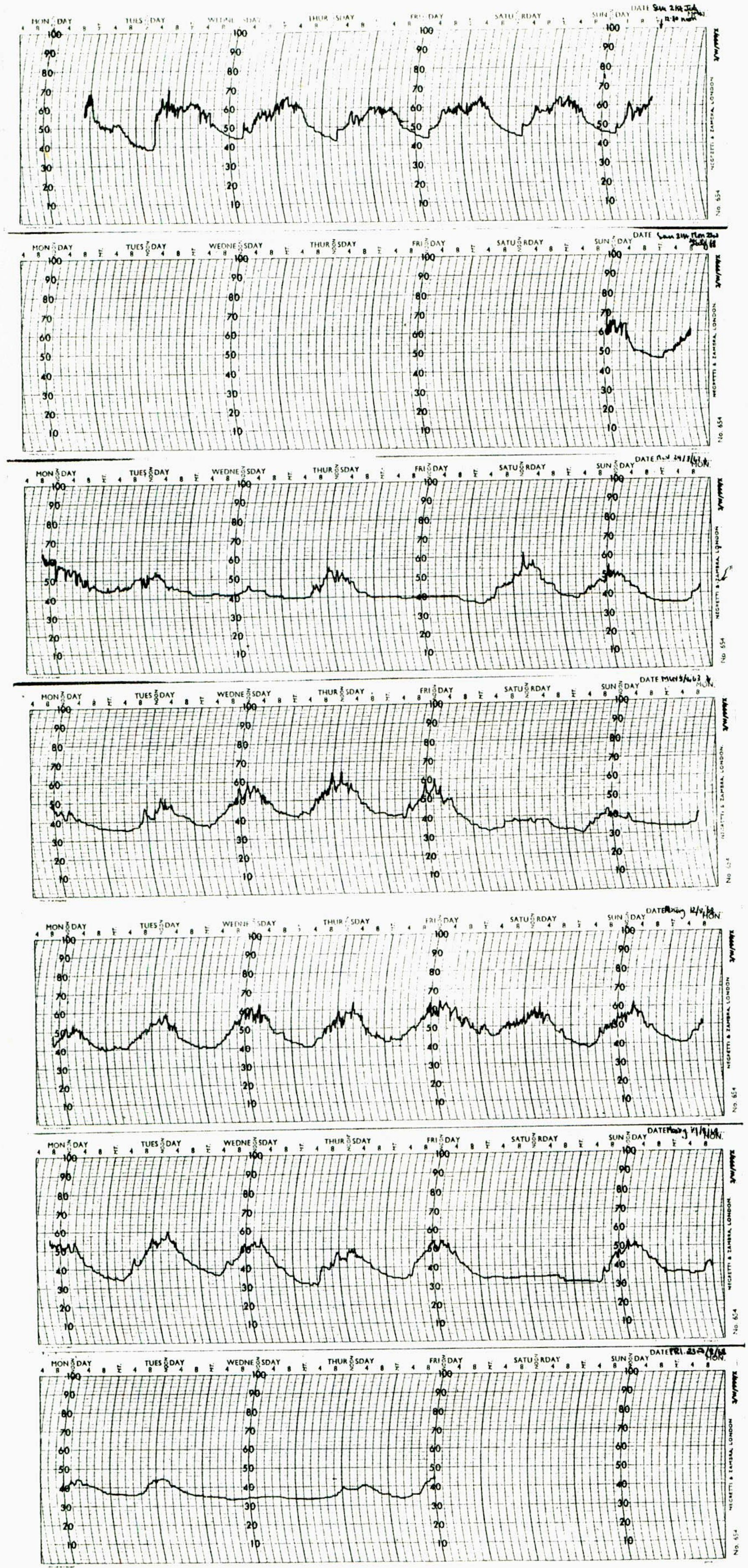


FIG 4

(for key see page 68)

Precipitation
Wind Direction
Wind Speed
Cloud Amount and Type

The instruments were housed on the left bank lateral moraine of the Bersaerkerbrae Gletscher, adjacent to Base Camp. The weekly thermograph was placed in an improvised Stevenson Screen and the other instruments were kept in an aerated stone pen. Measurements were taken from 22.00 hrs July 8 1968 until 10.00 hrs 23rd August 1968. Figures 2, 3 & 4 , summarize the more relevant information. It can be seen that during the expedition's field period, S.W. winds prevailed and although these seem to correspond with the winds that flow from high pressure centres over the Ice Cap, it should be remembered that local channelling of air streams down-valley can give misleading results. It should be noted that the Bersaerkerbrae Valley runs NE - SW, see Fig. 1 . In most years cold outflowing air from the central ice is predominant, but during July 1968 a N to NE air stream brought cold, stable conditions to this part of East Greenland, although small, stray, south-travelling depressions brought a little rain and drizzle. In August depressions coming in from the SW were predominant and brought precipitation in the form of snow to the higher, exposed areas of Scoresby Land. The total snowfall at Base Camp was 20 cm, falling at the end of August, whilst at 2100 m on the Upper Gully Gletscher (Camp III) 131 cm accumulated during the same period.

The records of the localized climatic environment (Figs. 2 & 3) besides giving an indication of the conditions experienced by the expedition are valuable when considering ablation and the processes of deep weathering and mass wasting.

3. VELOCITY MEASUREMENTS OF THE BERSAERKERBRAE GLETSCHER

One of the principal aims of the glaciological programme was to record the rate of flow of a zone of the Bersaerkerbrae Gletscher over a period of six weeks during the summer of 1968. Velocity measurements are invaluable in evaluating the mode and character of glacier movement and although this is a field of glaciology that has been extensively studied over the past 20 years the topic is still highly controversial and inadequately understood.

The basic proposition concerning glacier movement is that under an initial energy supply derived from a downslope gradient a certain volume and depth of ice will overcome basal and marginal friction and move either i) by a kind of flowage in which there is intergranular and intermolecular movement within the ice fabric itself, or ii) by the movement of the glacier 'en bloc' or by part of the glacier slipping and sliding over its bed. Both proposals have been studied theoretically[1], experimentally[2], and in actuality[3] but the detailed mechanisms involved and an assessment of their relative importance remains, as yet, in some doubt.

Early attempts at explaining the motion in glaciers propounded that ice acted as a viscous substance[4], but in the early 1950's work carried out by J. F. Nye showed that a plastic flow law gave a more realistic result[5].

Further work including laboratory experiments undertaken by J. W. Glen[6] established that under load ice deforms elastically and 'creeps' by intragranular slipping and recrystallisation. Glen derived a power flow law that gave even better results when compared with actual velocities than those obtained earlier under plastic flow conditions.

It had long been known, however, that some glaciers moved at high velocities of 1000 - 3000 m year^{-1}. The rate of movement obtained under plastic and power flow laws was often inadequate to explain these greater speeds. Equally it had been thought that a limiting boundary condition of zero velocity existed at the bed of a glacier[7] but in 1957 J. Weertman proposed that since a glacier bed is very uneven two effects - pressure melting and stress concentrations around basal irregularities - would lead to the release of water, so lubricating and facilitating the sliding of the glacier sole over its bed[8]. Even the movements by Weertman's sliding hypothesis, however, were insufficient to account for the velocities occurring in reality. Two years later modifications were put forward by L. Lliboutry[9] who considered a glacier becoming detached from its bed as it slipped over irregularities in the form of a series of parallel sine waves. Velocities of up to 100 m year^{-1} were obtained, but Lliboutry's early ideas contained a number of indeterminable assumptions.

Further work by Weertman[10] has shown that a basal film of water only 0.5 mm thick is sufficient to cause variations in the sliding of a glacier by up to 20%, and many field measurements of flow rates may be explained by the presence of basal water layers whose thickness is in the order of 1/10 the height of the controlling protruberence size.

The Q.M.C. Expedition measured velocities along two stake lines set across the Bersaerkerbrae Gletscher by means of weekly triangulation survey, in the hope that the measurements would yield information as to the type of flow operative in the glacier.

One of the stake lines was set out above the Dunottar Gletscher, the largest tributary glacier of the Bersaerkerbrae and the other was established below this glacier (Fig. 5), so that flow recordings with and without this additional ice could be deduced for the Bersaerkerbrae. The setting up of the stake lines on the glacier was begun on 8th July and was completed in time for the first survey to be made on 12th July. The upper line consisted of 10 stakes and the lower of 13 stakes.

Some of the stakes were of aluminium and some of plastic, the latter proving to be the most efficient and the easiest to handle at low temperatures. The plastic rods measured 10 feet x 1 inch diameter x 1/16 inch thick and were sunk to a depth of 5 - 6 feet in the glacier. Previous expeditions had laboriously drilled stake holes by hand but shortly before departure from the U.K. the Q.M.C. expedition secured, after a long search, an adapted Teles Earthworm 2-stroke drill. This machine saved both time and effort, holes being drilled in approximately 15 minutes. The machine was geared down to 120 rev/min and was constructed of lightweight materials. It is important that the drill speed should be approximately 100 rpm when drilling ice since high speeds cause the drill bit to 'dig-in' and jam. Quick refreezing of water melted by the drilling process then occurs, preventing the removal of the bit from the hole. With adapted flight-shaft rod extensions and an ice-bit, the drill pack was an extremely light and efficient unit. A bag of salt was kept at hand during drilling to minimise the possibility of the bit freezing in at near maximum depths.

The movement of the stakes on the Bersaerkerbrae Gletscher was measured by theodolite triangulation, the stakes being intersected from a base-line.

To minimise work and yet gain the optimum angular measurements a cross-glacier base-line was used, which was itself fixed from triangulation on the glacier. Fig. 5 shows the system adopted. The base-line was measured as 7182.5 feet (± 1.0 foot).

The end points of the base-line were set on the

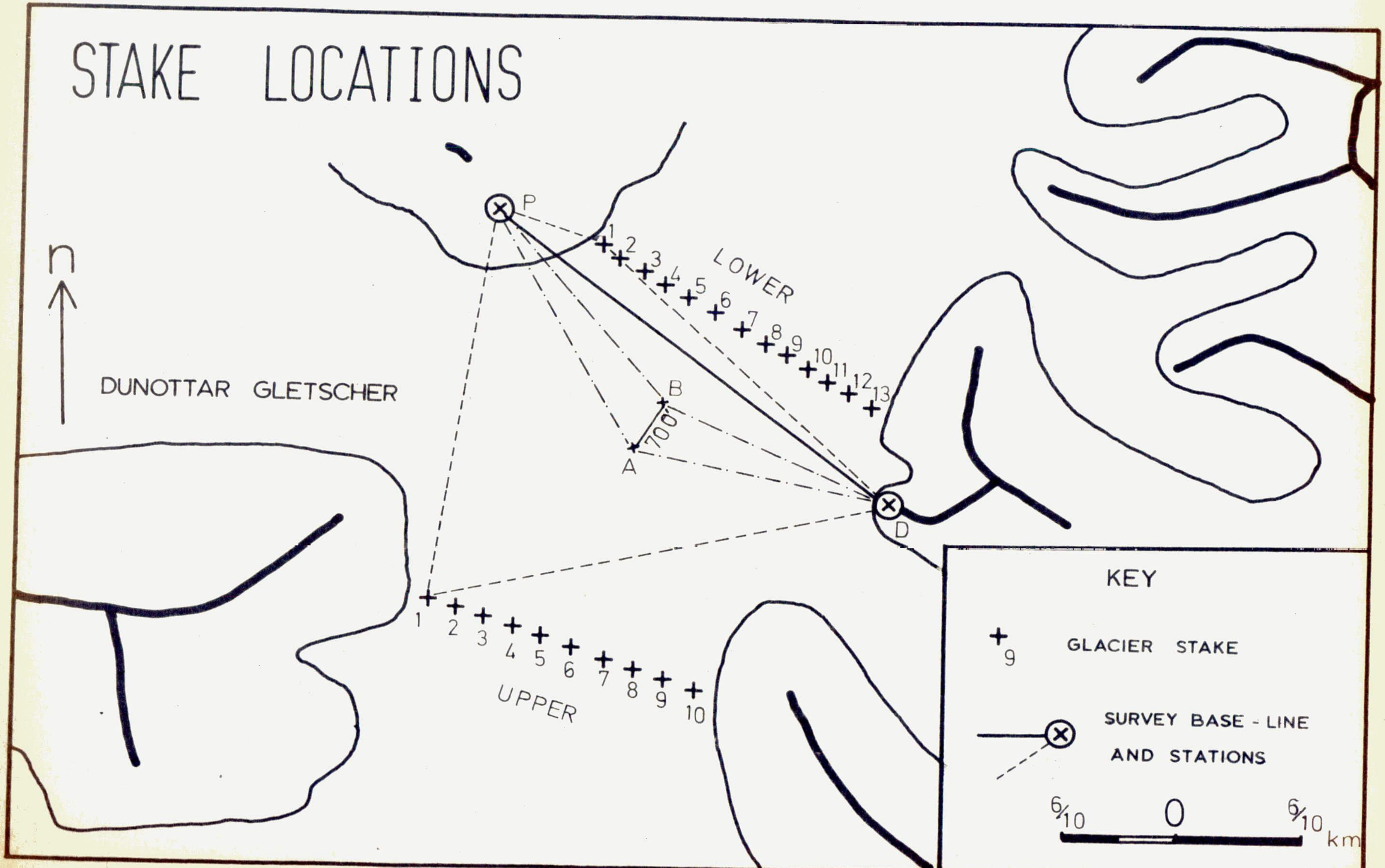


Fig. 5. STAKE LOCATIONS ON BERSAERKERBRAE GLACIER.

mountain sides and high enough to give complete intervisibility between all stakes. Weekly surveys were made on 12 July, 19 July, 26 July, 2 August, 9 August, 16 August and 23 August. The angular measurements have to be converted into vectors describing the path of each stake over the six week period and as the calculations are lengthy and laborious a computer programme is being prepared to work out the following indices:

1) Gross movement of each stake
2) Mean velocity of each stake
3) Mean velocity of upper and lower lines
4) Degree of deflection of stakes
5) Initial and final distance between stakes

The results are not yet available and for details readers are referred to our future publications. It can be stated, however, that a difference of some 2 minutes was often observed between weekly theodolite measurements.

4. ABLATION AND SURFACE REDUCTION

During the summer season some of the winter accumulation of snow melts away on the lower levels of a glacier. The loss of snow or ice from a glacier is termed ablation, and may be the result not only of melting but evaporation, wind, avalanche activity and the calving of icebergs in coastal localities. Although ablation is usually measured in cubic centimeters of water equivalent, this necessitates information on the density of the ice or snow. It was found impossible to measure ice densities during our expedition and so ablation recordings on the Bersaerkerbrae Gletscher are given in inches of surface lowering.

The recording of ablation is important in calculating the gross annual budget of a glacier, i.e. the net loss or gain of ice. Meltwater gained from the ablating ice surface may find its way down to the lower levels of a glacier via crevasses, moulins and the like and is thus a potential lubricant for the glacier bed, thereby assisting movement of ice by basal sliding (see Section 1). Certain distinct topographical forms are the product of ablation or differential ablation, i.e. ablation surfaces, glacier tables, ablation moraines, penitents and dirt cones. The last of these phenomena is discussed in Section 7.

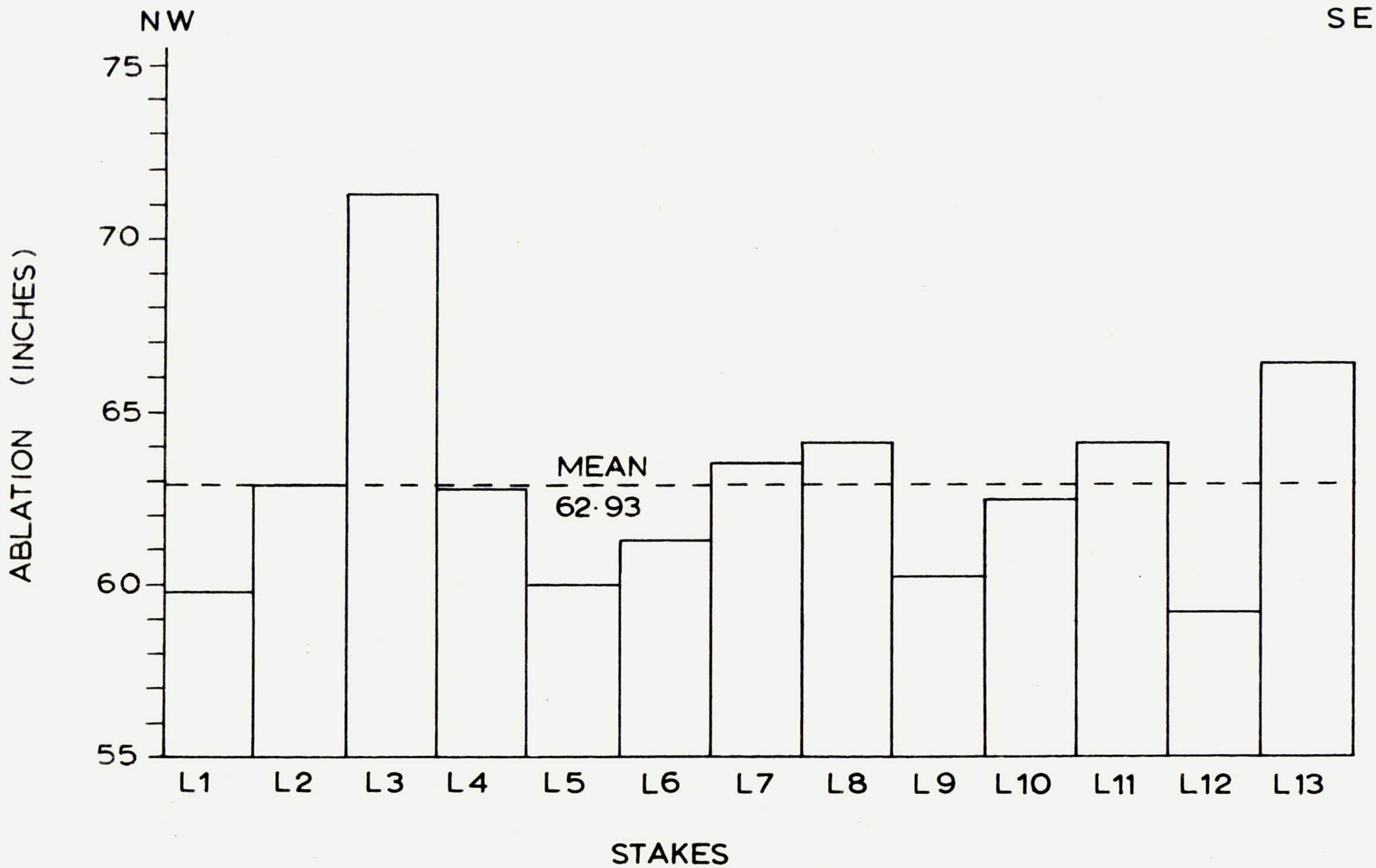


FIG. 6 TOTAL ABLATION ON LOWER STAKE LINE OF THE BERSAERKEBRAE GLETSCHER

(12 JULY UNTIL 22 AUGUST 1968)

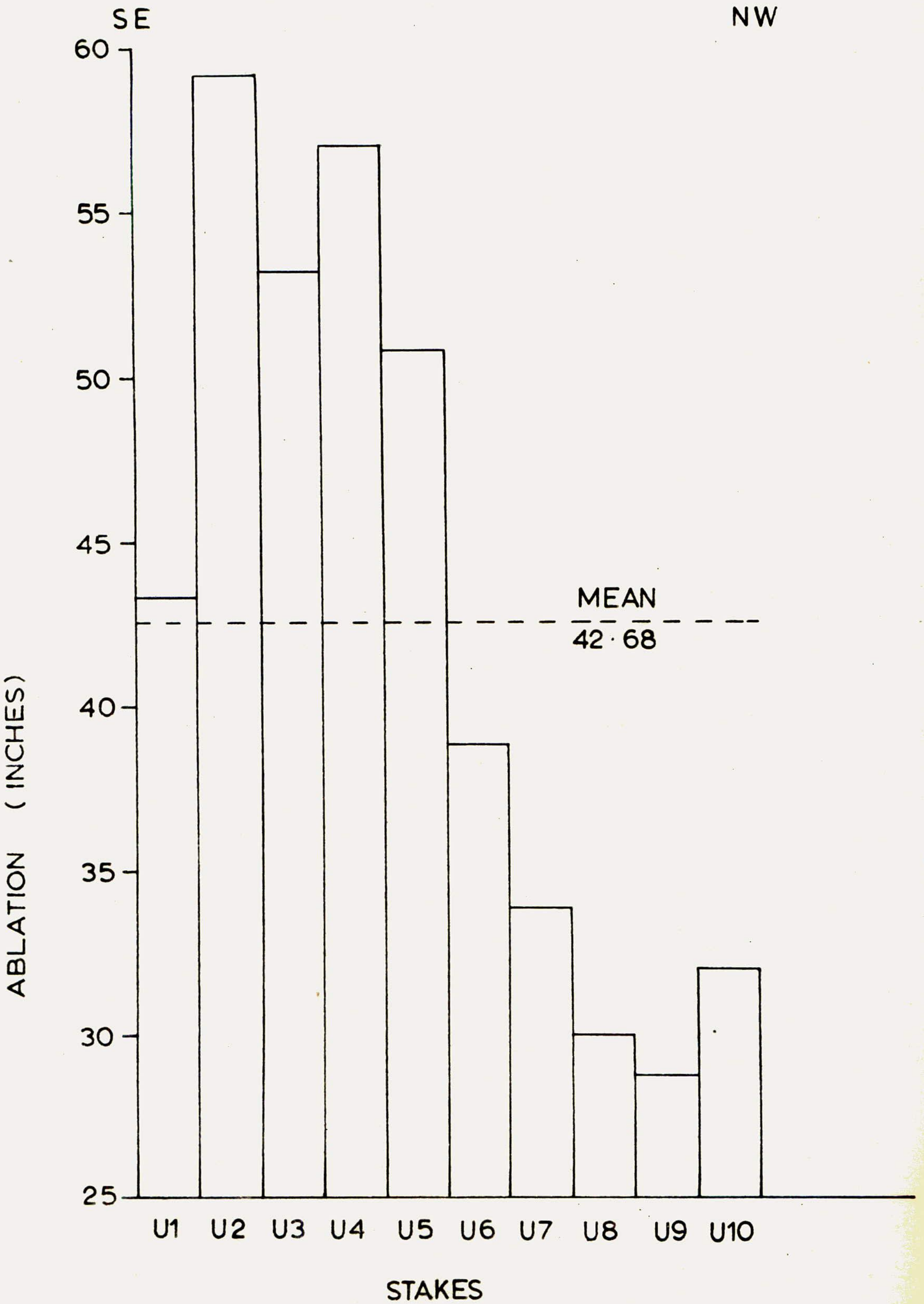


FIG. 7 TOTAL ABLATION ON UPPER STAKE LINE OF THE BERSAERKEBRAE GLETSCHER

(12 JULY UNTIL 22 AUGUST 1968)

Ablation was measured at each pole on both the upper and lower stake lines, and was determined by recording the difference between the top of the stake and the ice surface. Care had to be taken in selecting the ice surface to be used, since minor variations around the stake are significant. The highest ice surface was always taken and measurements are considered to be accurate to within $\pm \frac{1}{8}$ inch. Measurements were made every two days and during the period 12 July 1968 to 22 August 1968 the total mean reduction of the glacier surface along the lower stake line was $62\frac{1}{2}$ inches and on the upper line $42\frac{1}{4}$ inches. The difference is essentially a function of the higher altitude of the upper stake line which roughly delimited the firn-line at the beginning of July. The greater shadow protection this line received from the mountains on the NW side of the glacier was also significant. Figs. 6 and 7 show the total ablation across the upper and lower stake lines. In the case of the upper line the low ablation on stakes U6 - U10 was a result of shadow protection.

Recordings of ablation made during July and August in 1963[1] on 3 stake lines established some 5 - 11 Km further down the glacier and close to the snout, gave maximum losses of 61 and 78 inches on the upper and lower stake lines respectively. As the 1963 measurements were at altitudes some 100 and 750 meters lower than those of 1968 it appears that 1968 experienced greater ablation. Less winter snowfall, better summer weather, fewer cloudy days and more insolation are probable reasons for these differences.

Results showed that in the course of the 1968 summer the melting rate decreased as the more dense ice below the winter snow became exposed at the surface, but by the end of August accumulation was occurring as snowfall covered the glacier along the stake lines and ablation ceased. What ablation, if any, took place after 22 August is not known but since the winter season commences towards the beginning of September it would probably be small and sporadic.

5. STRAIN RATE AND SURFACE DEFORMATION ON THE BERSAERKERBRAE GLETSCHER

The motion of ice is controlled by three major factors, i) the gradient of the glacier bed, ii) the volume and depth of ice and

iii) the potential energy not expended overcoming basal and marginal friction. Furthermore ice may deform under applied stress in three ways.

1. It may deform elastically and this normally occurs instantaneously with the application of stress. If the stress is discontinued the ice returns to its original shape and volume.

2. Plastic deformation is also experienced by ice after the yield point has been reached and with the continued application of stress the ice 'creeps' and a straight line relationship exists between log. $\dot{e}$ and log. r (strain rate and stress) giving the flow law of ice:

$$\dot{e} = k r^n$$ (Glen 1958)[1]

3. When undergoing elastic or relatively rapid plastic deformation from persistent stress the ice reaches breaking point and rupture occurs. Hair line cracks, crevasses and ice-falls represent the rupture stage in glacier ice and indicate high stress concentrations.

A valley glacier has a highly complex three-dimensional distribution of stress because a glacier does not consist of an idealized straight channel filled with ice flowing at a constant rate. A glacier, during its downslope transfer, may experience irregularities in its bed shape , the entry of tributary ice streams of varying velocities, the effects of projecting rock spurs, changes in the orientation of its channel and varying bed gradients. Factors such as these give rise to perturbations in the stress field of the ice. In places the ice may be subject to intense compression, buckling the surface into a series of ridges, with folding and distortion of the ice fabric. Elsewhere the glacier may be in tension with cracks, crevasses and broken ice characterizing the upper ruptured layers. A further complication is that glaciers in cold polar climates have properties different from those of more temperate latitudes. Cold ice can withstand higher shear stresses and polar glaciers therefore may exhibit dissimilar deformational characteristics not only in degree but in type. The tensile layers and crevasses may be deeper and change more slowly.

There are, as yet, far too few measurements of stress and strain rates in glaciers, and during the summer of 1968 the Q.M.C. Expedition carried out a number of investigations into the rate and areal distribution of surface strain on the Bersaerkerbrae Gletscher. Our results hope to provide some short-term indication of strain.

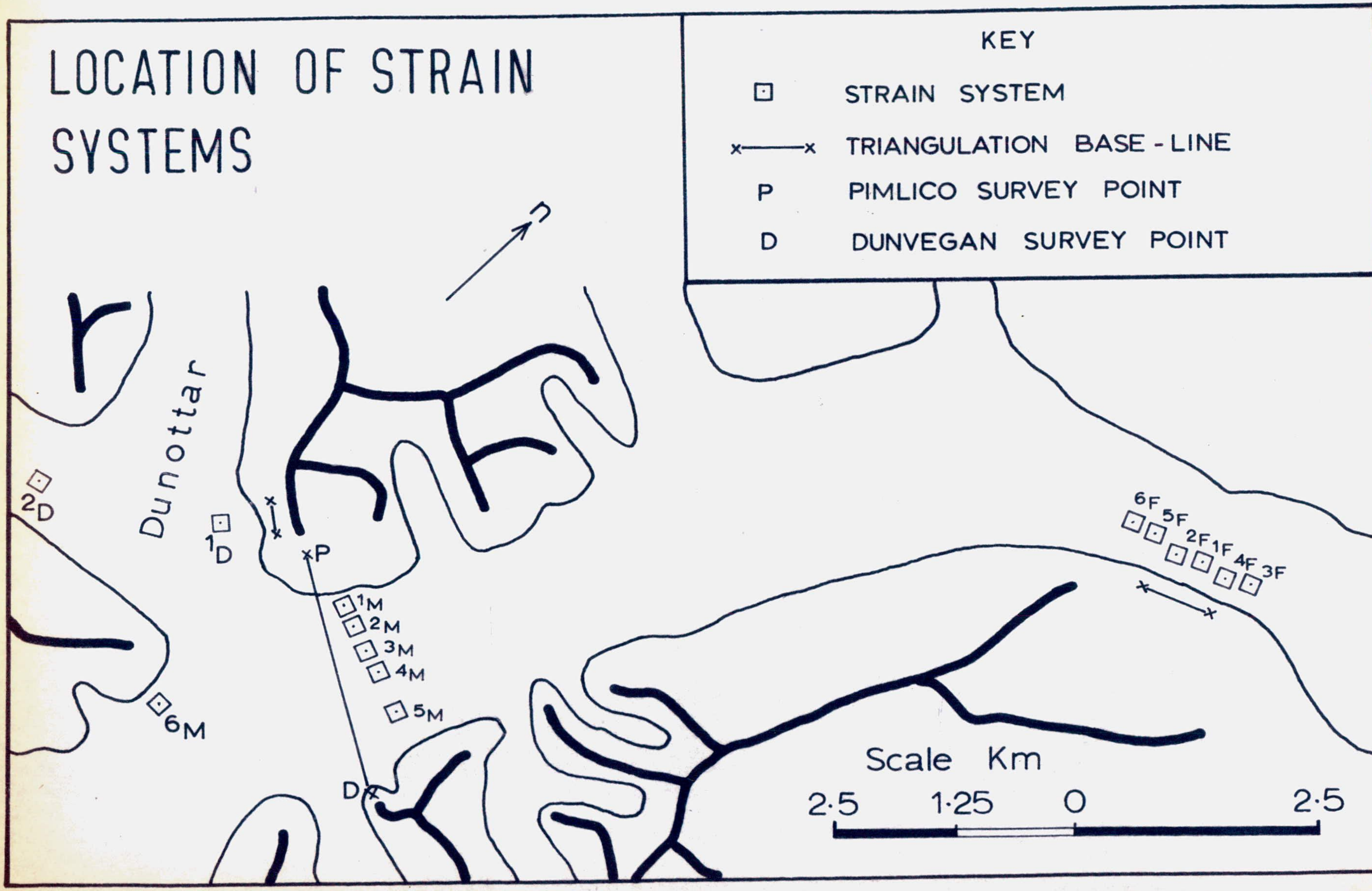


Fig. 8. LOCATION OF STRAIN SYSTEMS, BERSAERKERBRAE GLACIER.

In order to measure strain rates on the surface of a glacier it is necessary to set up a number of stakes or markers in a pattern and to record the rate of change of the distances between them[2]. A simple pattern or 'strain system' used on the Bersaerkerbrae Gletscher consisted of five points (a square and central point). More complex grids of 7 and 9 points were also used. To obtain the three independent components of the strain rate tensor from the observed values the least squares method of Bond as described by Nye[3] is used.

Four groups of strain systems were laid out on the Bersaerkerbrae Gletscher under differing surface conditions. One group of six systems were placed on a large ice-fall at the lower end of the glacier about one mile up from the snout. They were positioned just before, in and at the lower end of the ice-fall. Another group of five was laid out across the glacier along the lower stake line. Marginal crevasses and contiguous ice-surfaces were covered by these systems. One grid was placed on the upper stake line between stakes U9 and U10 in an area of abundant marginal crevasses. Two more strain systems were positioned below an ice-fall on the major tributary glacier of the Bersaerkerbrae, the Dunottar, see page 79.

The points on the grids were marked by large stones on which there were painted orange crosses. In the lower stake line group stakes number L1, L2, L7, L8, L12 and L13 were used to mark some of the points. Distances between the grid markers were measured by tape and the positions of the systems fixed by theodolite triangulation from nearby base-lines established off the glacier. Intersection was made to the central point of the grid and to one other suitable marker.

The lower ice-fall systems were laid out and fully surveyed on 18th July. The lower stake line systems on 20th July and the Dunottar and upper systems on 21st July. The loss of most of this information in a near fatal stream accident of 27th July necessitated the complete resurvey of all the strain grids. That this was completed by the 30th July reflects the conscientiousness and hard work of the party. The final taping and theodolite survey took place on 24th August, during the evacuation of the expedition.

Although there are as yet no results available from this part of the programme some general comments can be made. Little change was observed in the strain systems across the lower stake line. This was expected since there were only a few marginal crevasses, and there appeared to be little deformation of the glacier surface.

Some small change occurred to the Dunottar Gletscher systems but the six grids in the lower ice-fall showed a considerable amount of movement and here the ice was very active. Large crevasses had opened up during the three-week period and one marker stone was lost down one of them.

When the results have been fully analysed they are expected to show that strain rate distributions within the Bersaerkerbrae Gletscher are very varied. In some areas there is little or no surface deformation, stress being directly translated into flow. In other places rapid and large changes of topography indicate that the glacier ice is yielding and rupturing around stress concentrations caused by irregularities in flow and channel shape.

6. TOPOGRAPHICAL CROSS-PROFILES OF THE BERSAERKERBRAE GLACIER

A series of topographical cross-profiles were taken across the surface of the Bersaerkerbrae Gletscher. This information will be important in helping to distinguish different ice bodies in the glacier in conjunction with the velocity measurements and strain-rate analyses. The profiles were made along both the upper and lower stake lines, by means of abney level and tape. The survey involved the measurement of 105 facets on the lower line and 75 on the upper line.

The results are being plotted and will appear in a subsequent report.

7. THE DYNAMICS AND CHARACTERISTICS OF DIRT CONES

Dirt cones appear as mounds of sand or grit on the surface of a glacier and range in size from a few inches to 8 to 10 feet in height. 'Cone' is a somewhat misleading term since the feature is often elongated and rarely appears as a regular, conical form.

Furthermore, the cones are not solely composed of sand or grit for they are ice- or snow-cored and have only a thin covering of detritus, often less than 1 cm in thickness. Despite their abundance on glaciers (tens of thousands have been observed by Lewis on Bruarjökull and by Swithinbank on Skaftarjökull in Iceland)[1] little more than a qualitative assessment has been made of these distinctive forms.

One of the earliest accounts of the formation of dirt cones was given by Agassiz in 1840[2]. Further mention was made by Russell (1893)[3] who recorded a cone 24 meters in height on the Malaspina Glacier. Other references are given at the end of this section.[4] All writers agree that the dirt cone is the product of differential ablation. The debris (sand, grit, etc.) resting on a glacier surface protects the underlying ice from ablation so that with the lowering of the surrounding unprotected ice-surface a mound is produced.

Basic measurements of dirt cones are needed as there are no records of their rates of growth or of their general form; nor is it known whether they originate only under very localized and restricted conditions or whether they are ubiquitous to glaciers in general.

Lewis (1940), who went into some qualitative detail on the mode of formation of dirt cones in Iceland thought that most of the cones were aligned in sub-parallel series that conformed to the crevasse system existing on the ice-body in question. The material making up the cones was a sandy loam which had its origin as 1) wind-borne sediment concentrated by the action of running water (meltstreams), 2) detritus sludged down onto the glacier sides, and 3) overthrusted material brought to the surface. During the summer of 1968 the A.M.C. Expedition had opportunity to examine a number of dirt cones on the Bersaerkerbrae Gletscher and compare their formation and character with those described by Lewis and later writers. The aim was a rigourous and quantitative assessment of the environmental and internal parameters governing the growth and form of these features.

General Observations

The location of dirt cones on the Bersaerkerbrae Gletscher is remarkable for its localization. Fig. 9 shows the position of the major areas of dirt cones. As can be seen they are concentrated in the lower part of the glacier at the ice margins.

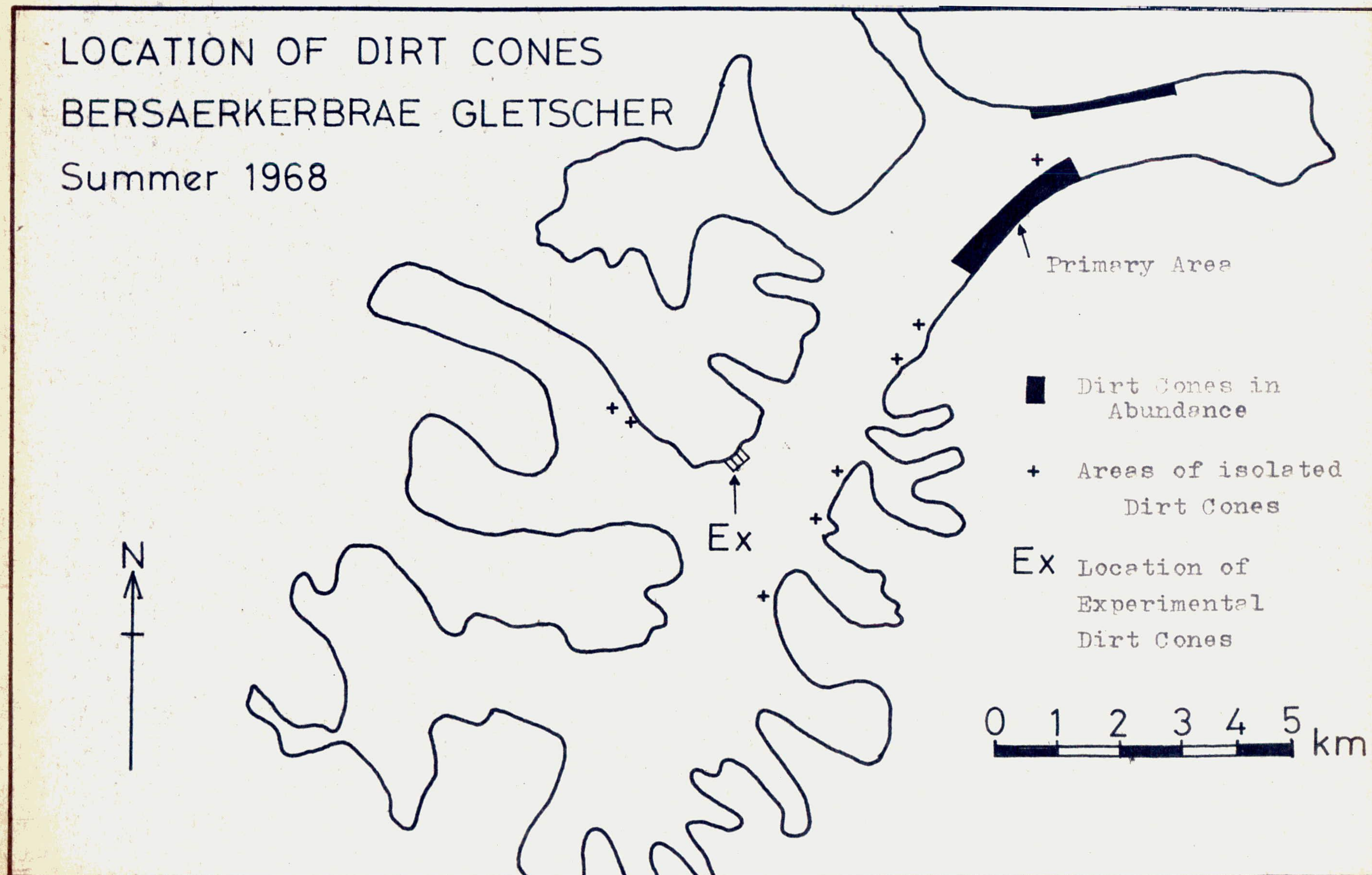


Fig. 9. LOCATION OF DIRT CONES ON BERSAERKERBRAE GLACIER.

The main body lies on the right bank in an area below a steep section of the glacier and above the lower Ice Fall. In this vicinity upwards of 100 cones are to be found along the margin of the lateral moraines and the ice. In the other areas the dirt cones are less frequent and often found in relative isolation.

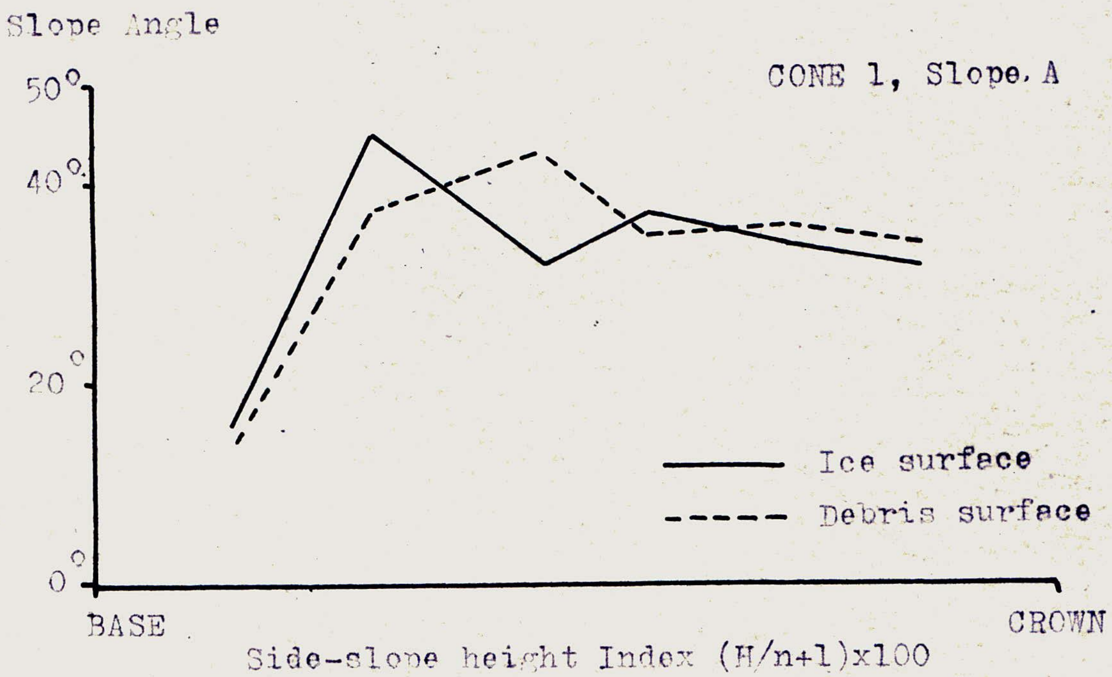
The sediment that forms the cones appears to be derived from the large lateral moraine systems that flank the lower sides of the Bersaerkerbrae. Fines washed out of the lateral and somewhat higher medial moraines travel down the steep gradient directly above the major cone area. The surface streams are channelled towards the edge of the glacier by the slope, and when the velocity is checked in both the meltwater rivers and rills by the levelling out of the glacier, the sediment is deposited and concentrated in pools and shallows.

The streams that fret the glacier surface are constantly changing their courses, as the glacier changes due to continued ablation. Divertion and capture are frequent and often an old dry channel network will remain, filled with sediment which thickens locally. Ablation of the surrounding ice leads to an upraising of the stream channel should the sediment cover be continuous, and sinuous ridges 6" - 8" in height with a thin veneer of silt are common sights. At intervals along such a ridge, dirt cones occur where the local thickening of the sediment has allowed greater protection to the ice, thereby giving more effective cover for a developing ice core. Observations of such phenomena are clear evidence that the dirt cones on the Bersaerkerbrae are the product of differential ablation of stream-laid detritus. There was no evidence to support Lewis's hypothesis that dirt cones form in shallow crevasses or at the junction of a number of crevasses. Often a linear series of cones as described above can be seen to be displaced by marginal crevasses running transverse to the direction of dirt cone propagation. The alignment of all the cones is down-glacier and parallel to the flow of meltwater streams. Thus it appears that, on the Bersaerkerbrae, the hypothesis of a crevasse origin for dirt cones is untenable. The concept of overthrusting is equally unacceptable for all cones are visibly the product of debris concentrated by fluvial action in later abandoned water courses. No examples were found of upraised stratified sediments. The fluctuation in meltwater discharge and the temporary nature of even the largest stream channels means that there is a constant sorting of detritus and little time for the establishment of thick, layered deposits.

Fig. 10.

DEBRIS SLOPE AND ICE SURFACE RELATIONSHIPS IN

DIRT CONES



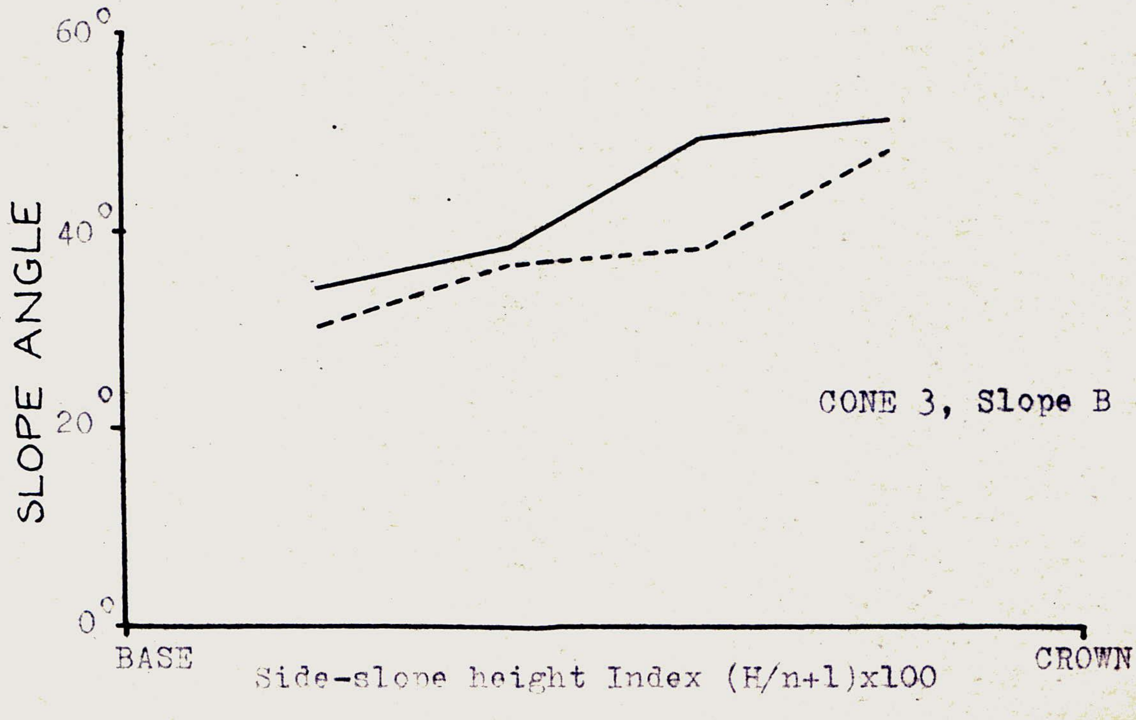


Fig. 11.

DEBRIS SLOPE AND ICE SURFACE RELATIONSHIPS.

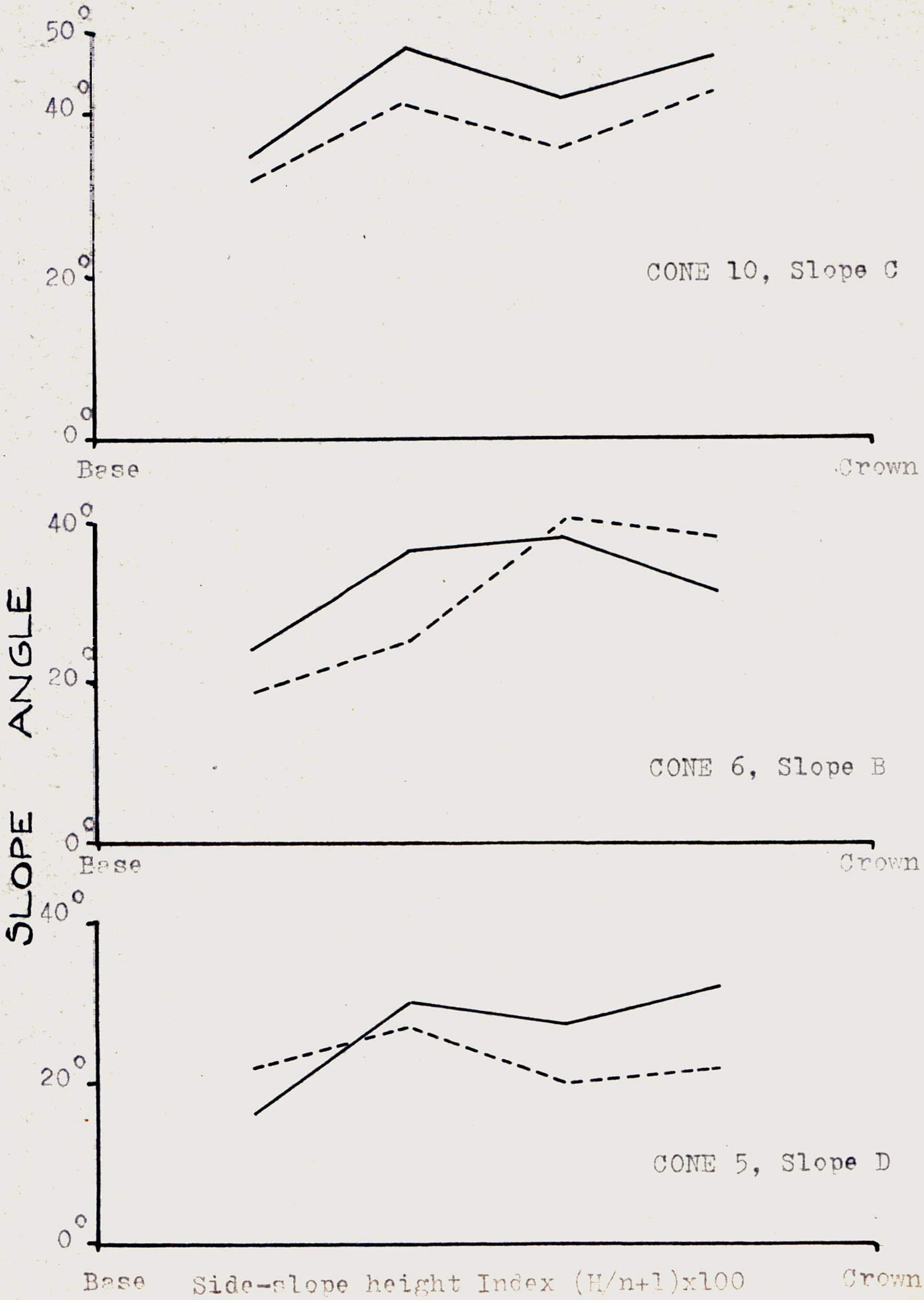
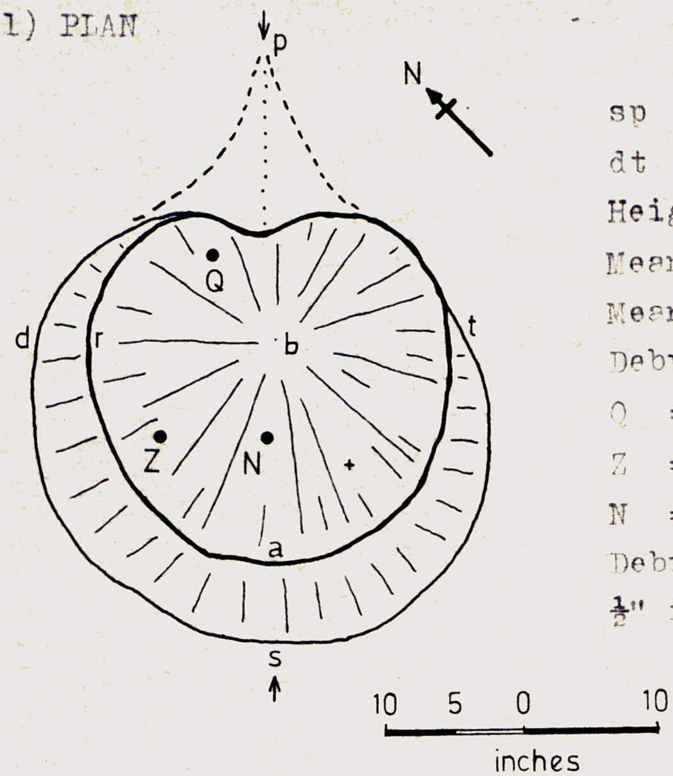


Fig. 12.

DIRT CONE (EXPERIMENTAL No.III)

(1) PLAN



sp = 30½"

dt = 31"

Height at b = 11½"

Mean slope rb = 38°

Mean slope ab = 30½°

Debris thickness at:

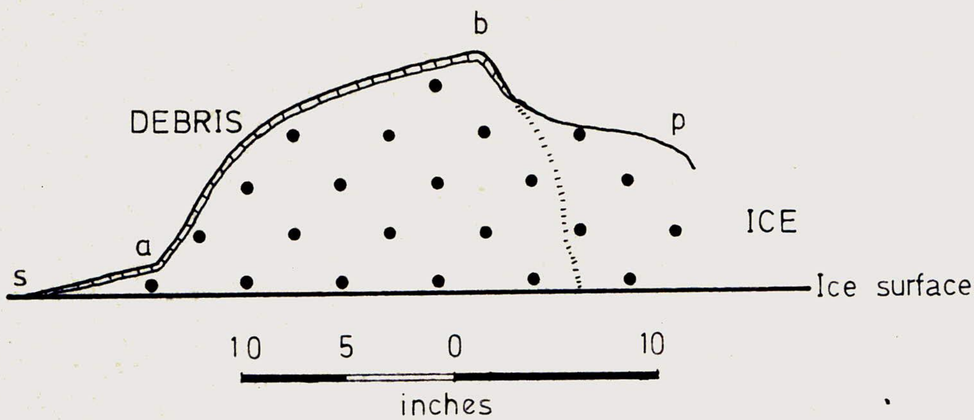
Q = 3/8"

Z = 1"

N = 1¼"

Debris temperatures taken ½" in at point +

(2) PROFILE ALONG 's - p'



Field Measurements

For each cone investigated the maximum length, maximum width and maximum height above the ice surface were recorded. The angle of the superincumbent material was measured by clinometer along lines across the cone. Normally three lines were chosen, and between 3 and 6 angular measurements were taken along each line at regular intervals up the cone slopes. The debris that lay over the ice core was scraped away at the sections of the cone previously used for measuring detritus angles. The slope of the now exposed ice surface was measured in positions analagous to those of the debris. Thus slopes of both debris and underlying ice surfaces were recorded.

The thickness of the sediment covering the ice of the cones was measured at selected points over the cone and a sample of the detritus taken for particle-size analysis.

Each cone investigated in the above way was sketched in plan and photographed.

Results of Field Measurements

The height of the dirt cones varied from 9 to 33 inches, the widths from 26 to 89 inches, and lengths from 29 to 194 inches. One cone not examined in detail was observed to stand some 5 feet above the glacier surface, but this is exceptional for the Bersaerkerbrae.

Angles measured on the detritus cover and the ice surface yielded interesting relationships (Figs. 10 & 11). As can be seen the angles for the debris are in some cases lower in the basal part of the cone than the corresponding angles for ice. In the upper part of the cone the debris angle is in almost all cases greater than the underlying ice surface. This means that the superficial sediment is more thickly developed on the top of the cone.

In the graphs the non-dimensional notation 'side-slope height index $(H/(n+1)) \times 100$' is used in order to represent all cones, no matter what their size or the number of angular measurements taken. In this formula, H = height of cone and n = number of measurements taken. The resulting index gives the location of any angle taken on a cone in relation to its position on the cone slope in terms of a gradient of units 0 to 100, representing the base and crown of 'a standard cone'. Thus corresponding relationships may be drawn from many and varied cone measurements. The measurements of cone slope show that whilst the detritus slope remains fairly constant and develops at roughly the same declivity, the ice surface degrades itself. In general the sediment shows a slight concavity of surface, the underlying ice a convexity. These indicate two fundamentally different processes operating on the dirt cones. A wasting and melting takes place on the ice which is greatest at the crown since the air temperature surrounding the cone shows a marked gradient from the ice surface upwards. On the detritus the process is of downslope transfer of the partly saturated sediment. This transfer is in response to the lowering of the ice surface around the base of the cone, thus steepening the slope toe.

The sediment that covers the ice core of dirt cones is relatively thin. On cones examined in the field it was usually ½ inch thick and never reached more than 1 inch . Sample analysis is still in progress, but some estimates can be made of sediment particle size. The predominant particle size was 0.6 - 2.0 mm (coarse sand). Occasionally there is some finer and/or coarser material incorporated into the sand, i.e. silt (0.002 - 0.06 mm), gravel (2 - 60 mm) and some cobbles (60 - 200 mm).

The best developed cones were found in monomodal, coarse sand deposits. These observations accord well with results obtained from experiments carried out on dirt cones, which appear to form only where the sediment cover is of a critical size. No cones were seen to form in silts or clays, though there was no lack of such material. Nor did coarse gravels or cobbles produce cones on their own.

Experimental Dirt Cones

Studies of the dirt cones of the Bersaerkerbrae suggested that the following relationships should be further investigated:

i) debris size and cone dimension,
ii) degree of ablation and cone size,
iii) the role of the sediment layer in the protection/ablation balance on the flanks of cones.

A series of experimental dirt cones were 'grown' under controlled and observable conditions to gain information on the following: to see whether or not cones on the Bersaerkerbrae form only of coarse sand; to see if any variation in the initial shape and thickness of sediment influenced cone formation and growth. Ablation was also recorded to determine the correlation between the rate of ablation and dirt-cone growth.

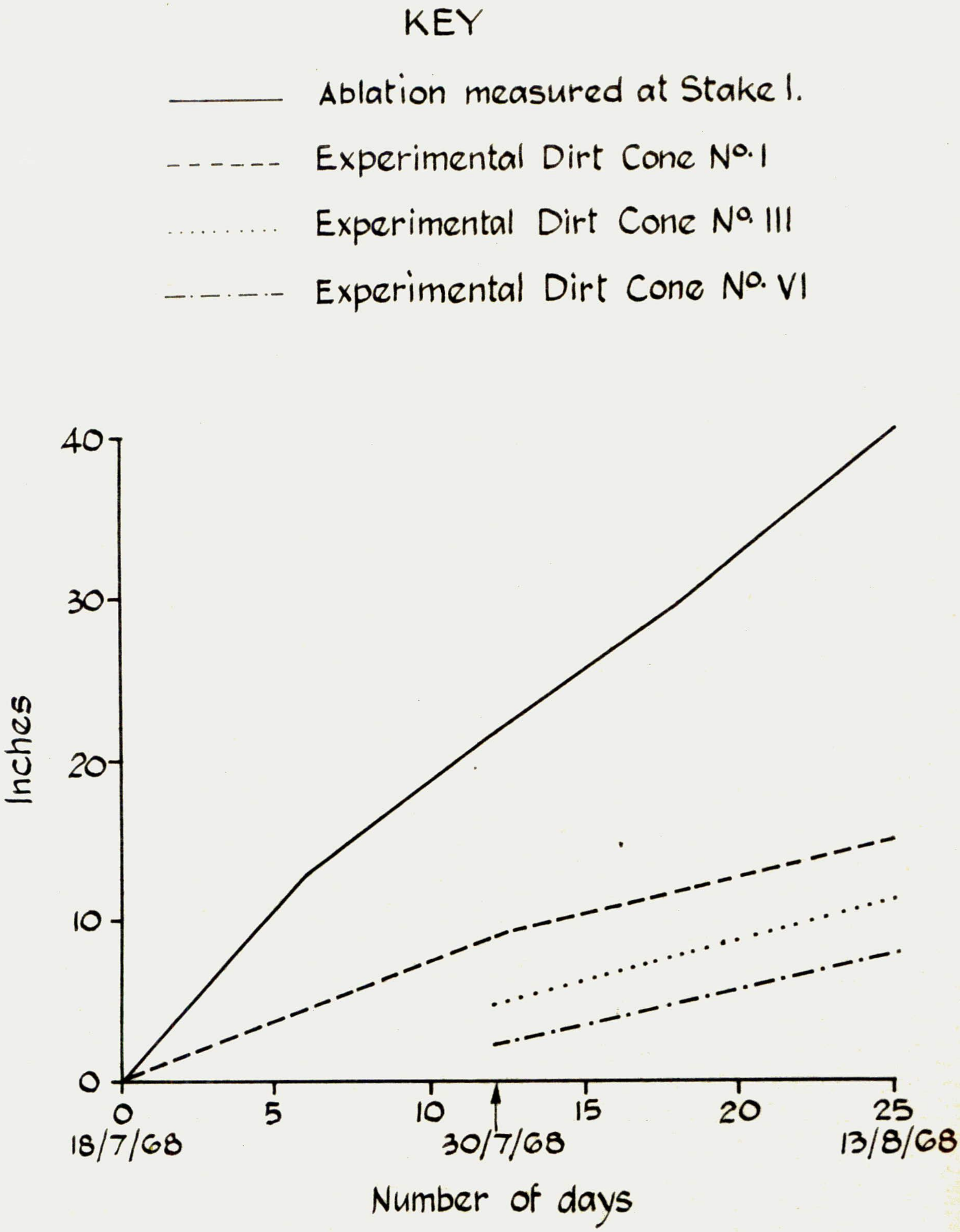


FIG. 13 ABALATION AND THE GROWTH OF EXPERIMENTAL DIRT CONES

Seven areas of sediment were spread on the glacier surface close to base camp, in 3 measured quantities and of specific shapes. Table 1 p. 92 gives data on the type of sediment and the initial dimensions.

After two weeks the sediment at some of the experimental plots had been left upstanding relative to the ice surface. Table 2 summarizes the situation on 13th August.

It can be seen that true cones formed only at experimental plots I, III and VI. Plot V was slightly raised but is considered relatively insignificant. Plot II, composed of fine sand, produced no cone, the sediment merely sludging over the ice surface. To see whether this result was a function of laying the sediment in a flat oval shape $\frac{3}{8}$" - $\frac{1}{2}$" thick, the same grain-sized sediment was laid in a cone form as plot VII. After 7 days this showed appreciable sludging and verified our assumption that the material was incompetent for cone formation. The most spectacular experiment was plot IV, a fine silt. This was spread 2" thick but even so the whole mass, charged with melting water, moved or 'sludged' a distance of some 20 feet and no cone was formed.

A simple Growth Factor (F) has been calculated to indicate the growth rate in successful cones and to see how this is related to the ablation of the ice surface. The gross ablation (G_a) obtaining over 'x', a specific time, is divided into ten times the total height increase (H) of either the ice or the debris surface on the dirt cone, (H given in Table 2, p92). The factor scale (between 1 and 10) will indicate no increase of height with ablation if F = 1. Where F = 10 the rate of cone growth is equal to that of ablation.

Of the plots that developed into cones, No. 1 was the best developed at the end of the time period, but this cone had been 'grown' for twice as long as the others and consisted of a greater quantity of sediment. The growth of its ice core was, however, less than that of plot III ($F_{ice\ III}$ = 5.52, $F_{ice\ I}$ = 4.28) for a similar period, although the debris height increased less ($F_{debris\ III}$ = 3.68, $F_{debris\ I}$ = 3.80). The differences are probably a function of the initial shape of the plots, No. III having been laid out as a cone, so facilitating rapid growth and affording greater protection to the ice surface. Plot I was 'grown' from a flat oblong plot and possibly shows a more realistic development.

Cone plot VI showed a moderate growth (F_{ice} = 3.68) although the debris height increase was similar to that of III (F_{debris} = 3.55). Cone V developed very little during the period of the experiment.

Fig. 14.

EXPERIMENTAL STUDY OF DIRT CONE GROWTH

Table No 1 Data at beginning of programme

CONE	Dimensions inches	SEDIMENT	Thickness inches	STUDY BEGAN
I	40 x 27	Monomodal (coarse sand)	1½ - 2	19-7-68
II	40 x 25	Monomodal) (fine sand)	⅜ - ½	30-7-68
III	19 x 17	Polymodal (coarse sand + pebbles)	4½ (CONE)	30-7-68
IV	21 x 19	Monomodal (fine silt)	2	30-7-68
V	18 x 16½	Polymodal (15% coarse sand 85% cobbles)	3½ - 4	30-7-68
VI	21 x 20	Polymodal (50% coarse sand 50% cobbles)	2¼	30-7-68
VII	12 x 10½	Monomodal (fine sand)	5 (CONE)	14-8-68

Table No 2 Cone development data after 'P' days

CONE	Dimensions inches	H Height inches	Sediment Thickness inches	G_a Gross Ablation inches	F Growth Factor ($10H/G_a$)		P
					ICE	DEBRIS	
I	33 x 33	8	¼ - 1	21	4·28	3·8	11
I	44½ x 44½	6	¼ - 1	19	2·47	2·2	14
II	71 x 68	No cone	⅛	19	0	0	14
III	31 x 30½	11½	⅜ - ¼	19	5·52	3·68	14
IV	240 (sludge)	No cone	< 1/10	19	0	0	14
V	27½ x 24½	4¼	3 - 4	19	0·40	0·13	14
VI	27½ x 27½	7⅝	¾ - 1	19	3·68	3·55	14
VII	16 x 15	2½ No cone	2½	4	0	0	7

The most interesting fact to emerge from a study of ablation and growth rates in dirt cones is that they rarely develop at more than half the ablation rate. There is, therefore, a degradation of the ice itself within the cone, but at a lower rate than the surrounding ice surface. The assumption made by Lewis that the initial surface of the ice is preserved at the top of the ice-core seems unjustified. Swithinbank and Krenek assumed that there is no degradation of the ice core, until the cone is mature, then decay ensues with the thinning of the sediment cover. Although the latter stage probably occurs, the ice-core undergoes continuous melting and reduction at about 0.75 to 0.5 of the ablation rate on nearby unprotected ice surfaces. This relationship holds whether the sediment veneer is ½" or 4½" in thickness. The growth of dirt cones is clearly a more complex process than had been previously envisaged.

The differential growth rates discussed above are also a function of sediment size. It appears that fine, easily mobilized material such as a silt or fine sand with little cohesion, does not produce dirt cones. Coarse fragments, such as gravel or cobbles, will not produce a cone for there is no continuous cover on the ice and melting takes place in the interstices. From our observations and experiments a threshold value of sediment size can be postulated for dirt cone inception, which is a medium grained sand of 0.2 - 0.6 mm. At the other end of the scale gravels of diameter greater than 20 mm do not produce distinctive cones. Bewteen these limits there is a gradation of cone development. The optimum grain size appears to fall in the coarse sand grade. Fig. 15 summarizes these findings.

If a coarse material is mixed with sand a dirt cone will still develop. Thus poly-modal deposits containing large particles will produce a cone if a sand element is present in sufficient quantity to form a protective cover to the ice.

Temperature Observations

Temperature observations were made to determine melting characteristics of the ice core and to study the variations that might result due to differing thicknesses of sediment cover. Although comprehensive results are not yet available Fig. 16 has been constructed for a 12-hour period to give a preliminary idea of temporal temperature fluctuations.

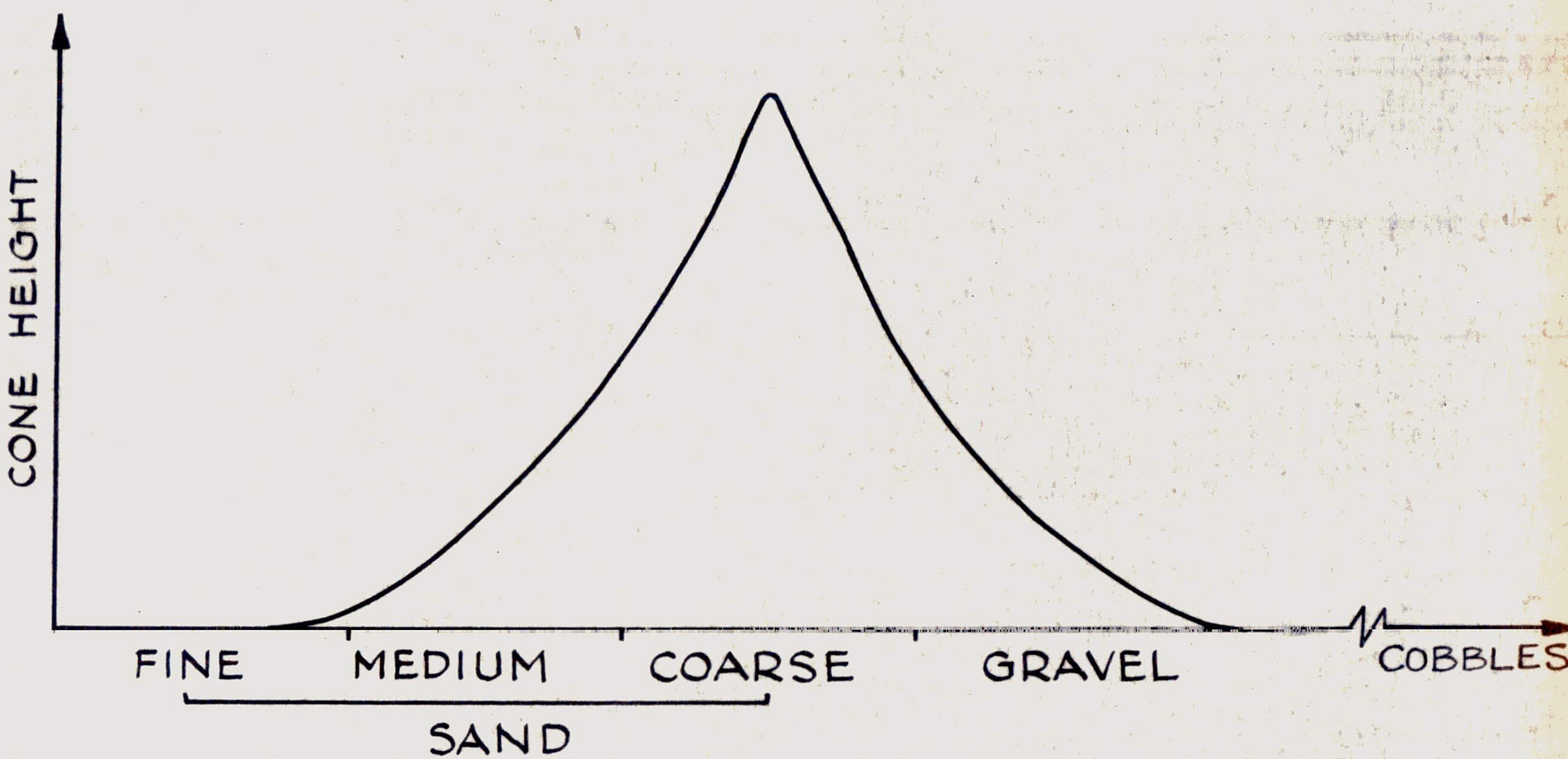


FIG 15 Theoretical Relationship between Cone Height & Type of Sediment

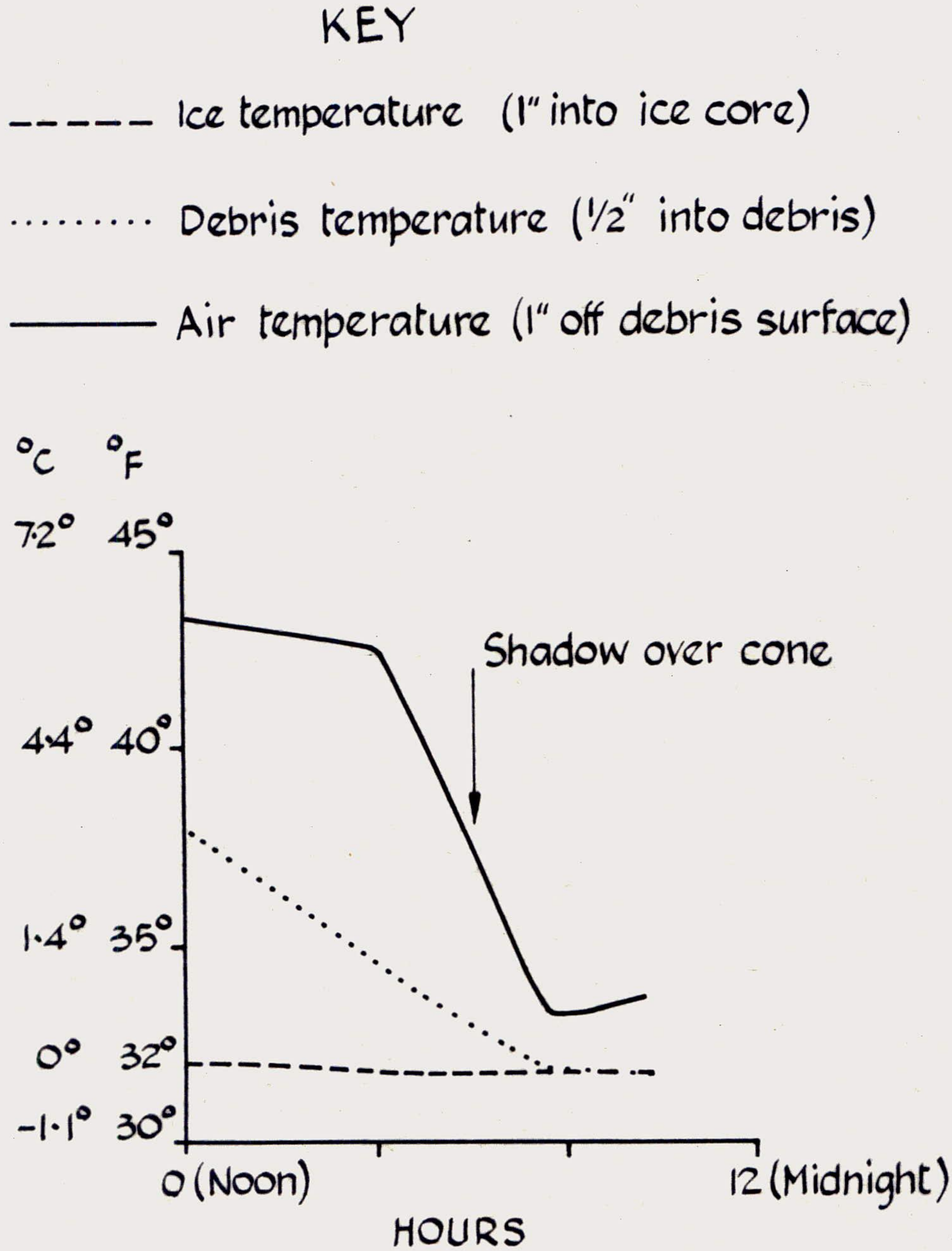


Fig. 16. TEMPORAL VARIATIONS IN TEMPERATURE THROUGH A DIRT CONE

Temperatures for Experimental Cone I were taken i) at 1" depth in the ice core, ii) half-way through the debris cover and, iii) 1" away from the debris surface. At mid-day the ice temperature was 0°C, that of the debris 3.3°C and that of the air 6.2°C. By 19.00 hours a shadow was cast over the cone and temperatures in the debris and air plummetted. The ice temperatures showed little fluctuation and the debris temperature was then the same as that of the ice.

From Fig 16 it can be concluded that melting of the ice edges takes place during the period of direct insolation when there is a sharp gradient between the air, debris and ice. This is further emphasized by a result of up to 4.7°C in cone III, at the ice-debris contact. During shadow conditions both the debris and ice temperatures were below freezing and no melting took place.

Alignment of Cones

In the experimental plots notice was taken of any tendency for preferential development to take place on particular sides of a cone. On those plots that produced cones the north-north-east side was the least developed and had the gentler slopes. On this side there was often no debris cover and ice formed the cone side The slopes facing south-south-west were steepest. Fig. 12 illustrates these features for cone III.

The reason for this phenomenon is not difficult to find. When the sun is in the north to north-east it is at its lowest declivity and is obscured from the glacier surface by a mountain ridge. Thus at all times of the day the north-north-east slopes never receive direct sunlight, whilst the other sides of the cone especially to the south and south-west, receive abundant sunshine. Thus melting and hence greater development take place in those parts of the dirt cone receiving maximum insolation.

On the natural cones examined similar, but no means as prominent, situations occurred. In natural dirt cones the attitude of the initial sediment deposit is the primary factor in orientation. Direction of maximum insolation is important in subsidiary and secondary realignment of slopes.

These observations raise some doubt concerning the statement by Lewis that 'steeper slopes ... apparently do not face any particular direction'.

Conclusion

A few initial and tentative hypotheses have been proposed concerning the origin, development and characteristics of dirt cones, based on observations made on the Bersaerkerbrae Gletscher and on experimental man-made cones. More detailed results will be published on the completion of this work but it is hoped that the above summary provides some indication of the research carried out on a little known and fascinating glacial phenomenon.

8. PERIGLACIAL INVESTIGATIONS

Distinct geomorphological processes characterize the denudation of the land surface in areas adjacent to those covered by ice. W. Lozinski, in 1910, proposed that such an environment should be termed 'periglacial'.[1] Freeze-thaw has been claimed as the primary process of weathering under such conditions and some writers accord only a minor role to fluvial activity, though recent work by Rapp has indicated that the transporting role of water in such regions is often the most significant.[2]

The periglacial zone is characterized by perma-frost conditions and ground ice.[3] Often the upper 'active' layer suffers ice wedging or deformation by involution[4]. The ground surface, too, may be distorted by hummocking or blistered by the formation of pingos[5]. Secondary differentiation of material on the tundra is termed patterning and patterns are usually classified by shape and degree of sorting[6]. Stone circles, nets, polygons, steps and stripes represent a series that is dependent primarily on gradient. Circles exist at angles of $2^\circ - 6^\circ$ whilst at angles of $15^\circ - 30^\circ$ steps and stripes predominate.

Solifluxion, the removal of waste by the slow flowing of water-lubricated debris,[7] represents one of the major processes of mass movement under periglacial conditions. The rate of movement of flowing debris can be quite high but the auxiliary component of solifluxion, creep, has yielded varying rates of between 3 cm year^{-1} to 10 cm in 24 hours.[8]

Further dominant aspects of periglacial areas are wind action and erosion by snow[9]. Deep weathering by freeze-thaw and chemical action on mountain slopes have been cited in earlier sections of this report and are very active and distinct phenomena. The weathered rock is removed by free-fall or avalanche activity. It may form talus cones against the mountain side or streams may remove and concentrate the material, often producing alluvial fans where gradients change.

The above introduction outlines the basic processes and landforms that characterize a periglacial environment. In the Staunings Alps many of these processes are at work. Although some are relatively well understood, others have received but scant attention and thus remain fruitful fields for research. One such field is the talus slope or scree. Talus slopes are accumulations of rock-debris often cone-shaped, formed close to a mountain wall, and which have fallen from the rock face above. The slope profile is straight or very slightly concave upwards, the inclination being 30° - 40°, and the material is assorted angular rock fragments. Big boulders characterize the talus base, where they form a so-called basal fringe. It is important to distinguish the talus cone from similar phenomena - the alluvial cone, the avalanche boulder tongue and the rockslide tongue. A detailed differentiation has been given by Rapp[10] (Fig. 17).

Little quantitative investigation of the areal components, slope form and general characteristics of scree weathering products has been attempted, although ideas as to how weathered debris would form and rest had been put forward as far back as 1729, but until 1945 little had been contributed to a rigorous understanding of the differentiation of material on, and the movement of, talus slopes. Rapp is one of the few workers in this field to attempt some meaningful assessment of movement rates on talus slopes in Sweden and Norway. Creep is thought to be important, as is rolling, sliding and internal shearing. These ideas have not been postulated under more than subjective assumptions nor critically tested.[11]

During the months of July and August there was ample opportunity for the Expedition to observe and examine talus in the neighbourhood of the Bersaerkerbrae Gletscher. Detailed analyses were carried out on scree slopes above a tributary glacier. It was hoped that the investigations would yield some quantitative statement on the character of the sediment forming sub-polar screes, as well as an assessment on the mode of downslope transfer of material. At the same time the opportunity was taken to test the relative efficiency of different sampling techniques of scree debris.

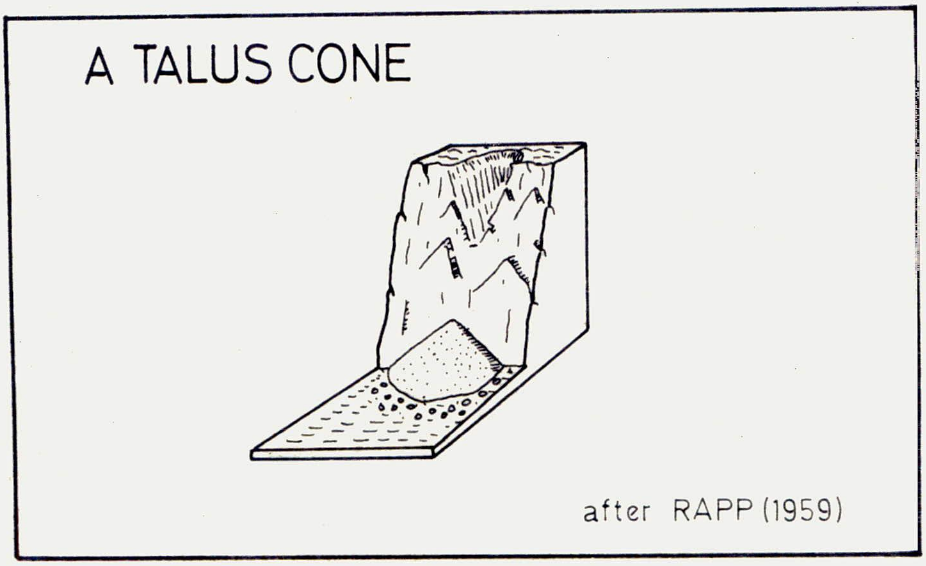


FIG 17 A TALUS CONE

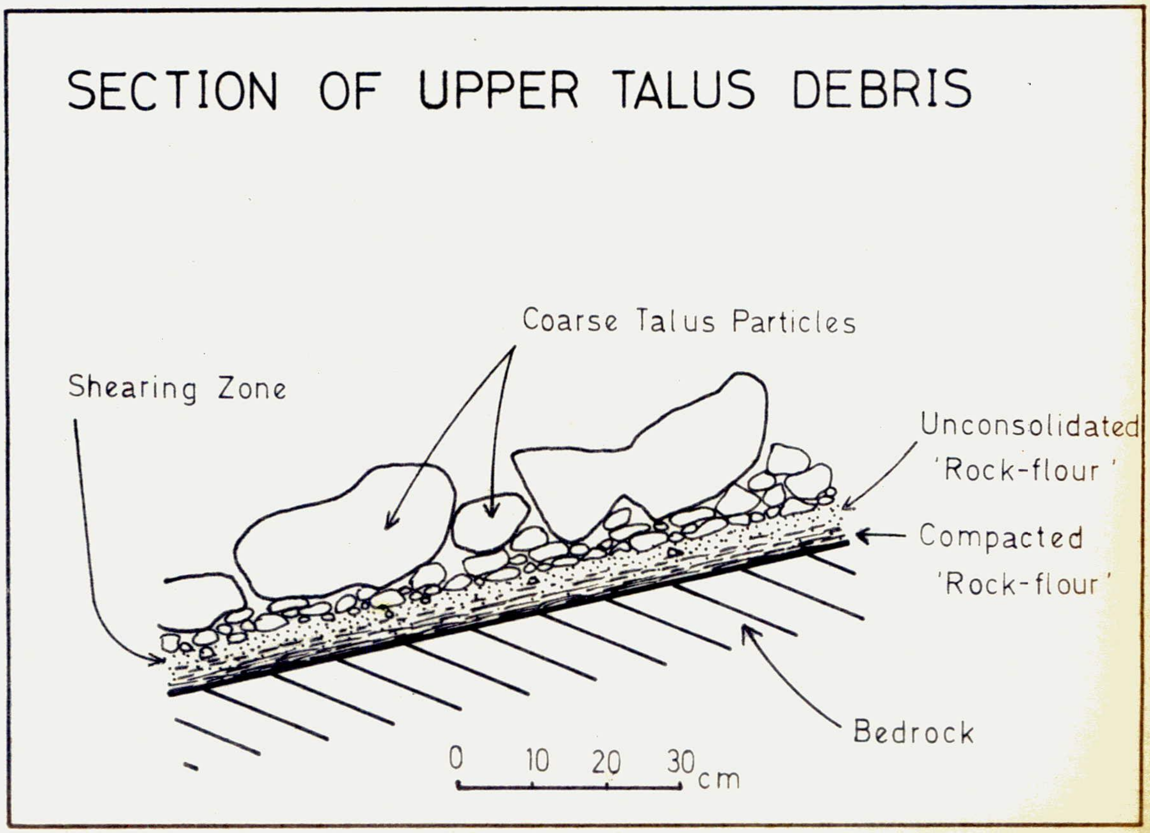


FIG 18 TALUS DETAIL

9. EFFICIENCY TESTS OF SAMPLING GRIDS FOR SCREE DEBRIS

When attempting to take measurements of scree debris it is necessary to sample the total population of particles on the talus cone surface; to this end two sampling grids were used. Since there are distinct variations in sediment size and orientation between the upper slope and the lower toe of a talus cone any method of sampling must take into account these differences. It is known that, due to fall sorting, the coarsest material is usually found at the base of the scree, while the finer sediment characterizes the higher parts.

When sampling begins a grid network is laid out over the slope, and the required measurements are made at the grid intersections. The number of sample points can be varied by varying the mesh size. The two grids used in the field were a conical or normal interval grid and a rectangular semi-logarithmic interval grid (Fig. 20 p. 102). A conical grid fits a scree more exactly being analogous in shape, and most points fall on the talus surface. An ordinary rectangular grid has the disadvantage that on the upper part of the slope fewer of the mesh intersections lie on the scree and consequently fewer debris samples are taken.

In order to sample both the basal and upper extremities efficiently a vertical logarithmic scale can be used so that a finer mesh occurs on the upper part of the slopes where the sediment is more comminuted and particular. Hence the rectangular grid utilizes a semi-logarithmic spacing.

The measurements made at sample points were of size, shape and degree of rounding and orientation of the particles on a talus slope. At each point five contiguous particles were measured for length of major axis (L), length of minor axis (M) and the axis length of the perpendicular to the major projection plane (S), (see Fig. 21 p. 104). The orientation of the long axis was also recorded by prismatic compass. The measurements were used to compute indices of volume, maximum projection area, maximum projection sphericity, shape, and flatness for the total sample. The mean, standard deviation, variance, skewness and kurtosis are also calculated for the indices. This information has been processed with the aid of a computer[1] using a programme that required only the input of L, M and S.

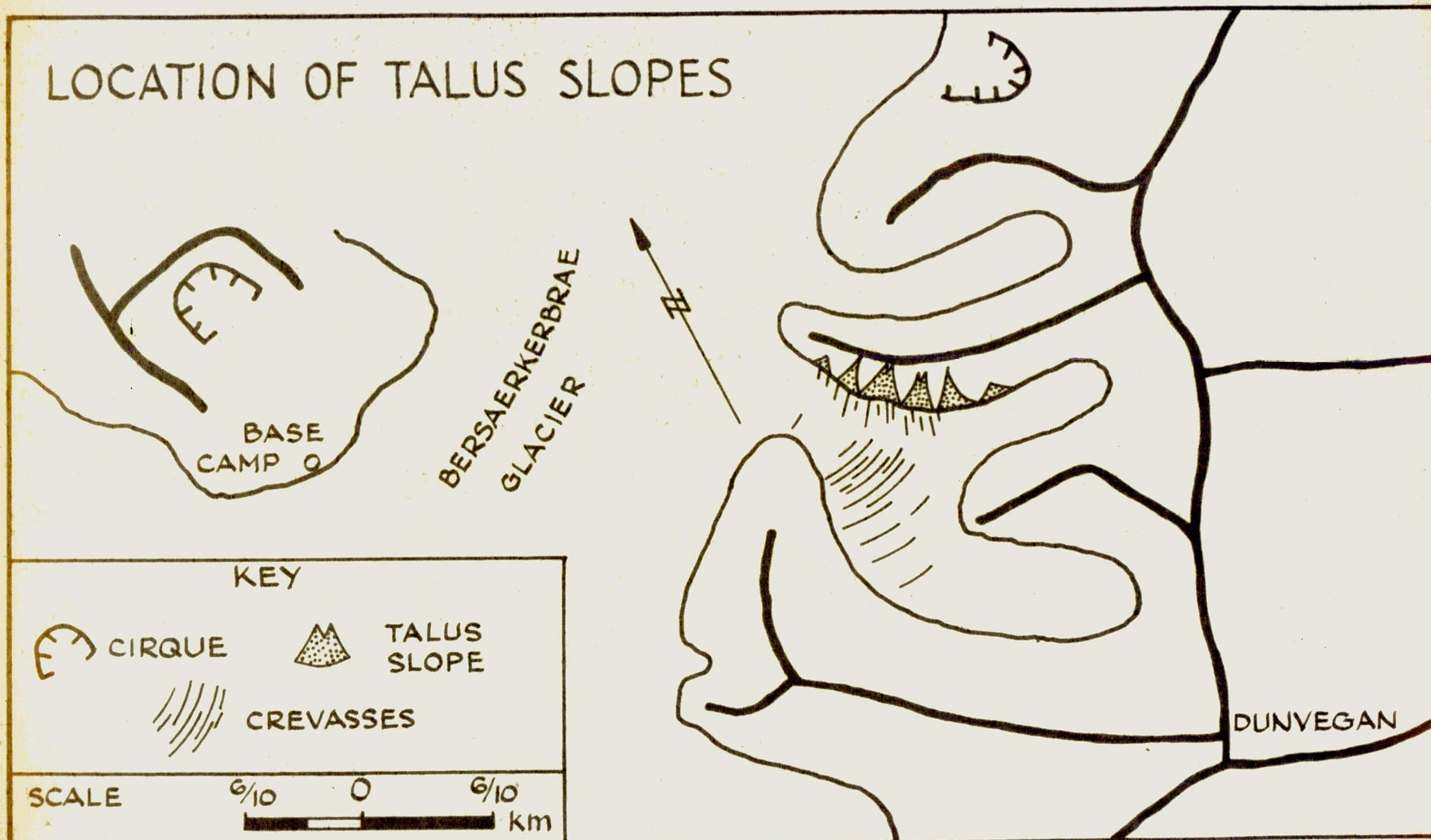
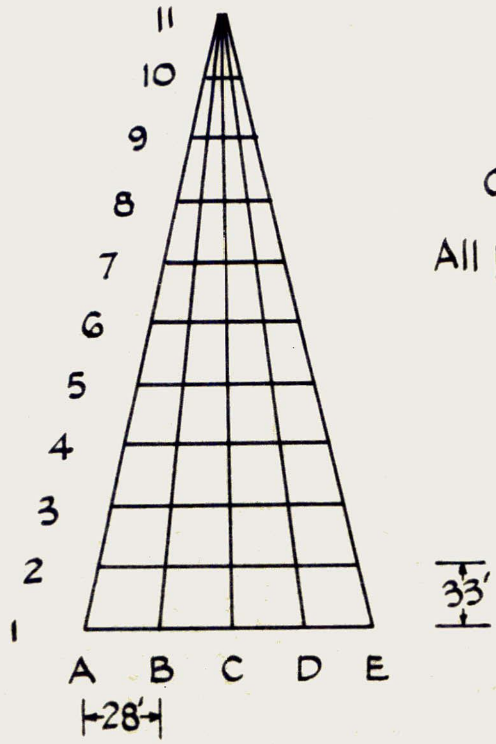
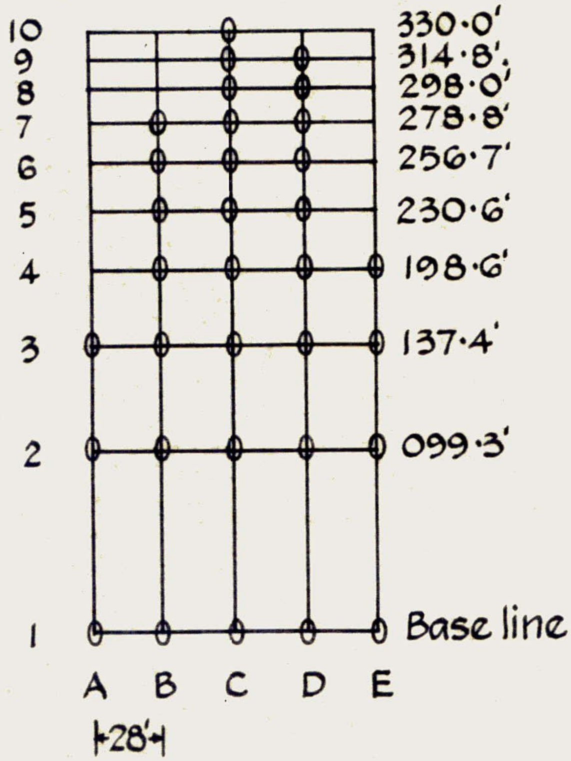


FIG. 19 LOCATION OF TALUS SLOPES



CONICAL (NORMAL)

All points sampled



RECTANGULAR (SEMI LOGARITHMIC)

0 = Points sampled

FIG. 20 SAMPLING GRIDS FOR UNCONSOLIDATED TALUS DEPOSITS

Although only a preliminary statement can be made at this stage, it appears that the log. mesh samples yield results all slightly greater in size than those for the conic normal. This may reflect, i) fewer samples taken on the log. grid, and ii) concentration of log. grid samples in the lower (coarser) part of the talus slope. How significant these differences are is as yet difficult to ascertain but they may well prove to be important; hence further work on unconsolidated deposits must take into account the grid form and sample frequency as significant factors in scree analyses.

10. SCREE FABRIC AND OBSERVATIONS OF DOWNSLOPE TRANSFER

The screes shown on Fig. 19 p.101 rise up to about 148.5 m. They are cone shaped, though somewhat elongated; their bases are, however, twisted to point down-glacier, a function of active ice motion at their toes. The bases comprise a steep tongue which falls down onto a series of lateral moraines at the edge of the glacier. Fig. 23 p.105 shows a profile of one of the screes and indicates the position of the ice and moraines. It would appear that there is active removal at the base of the talus via the moraines and glacier.

The basal debris on the upper part of the scree is a fine rock flour. This is found next to the bedrock and is compacted, dried and, in depth acts as a fairly rigid substratum, usually 5 - 8 cm thick. This comminuted rock flour probably results from the attrition of larger particles and the direct weathering of bedrock. In the upper third of the scree the rock flour forms ridges 3 - 7 m across that alternative with concave gullies of the same amplitude (20 - 30 cm deep), but the ridges contain coarser fragmental material lying over the finer sediment (Fig. 18).

The debris above this finer layer becomes coarser down slope, often attaining maximum sizes of 100 cm blocks. The mean size (in cm) of the sampled particles over the whole scree gives for Scree No. 1, L = 18.05, M = 10.93, S = 6.19. The particles on the talus surface are predominantly bladed and platy in character. Shape is defined according to the indices shown on Folk's diagram (Fig. 22). By compiling a frequency distribution according to this classification we arrive at:

C	CE	CB	CP	E	B	P	VE	VB	VP
2.1%	3.0%	5.2%	9.9%	14.1%	18.4%	10.3%	16.3%	15.7%	5.9%

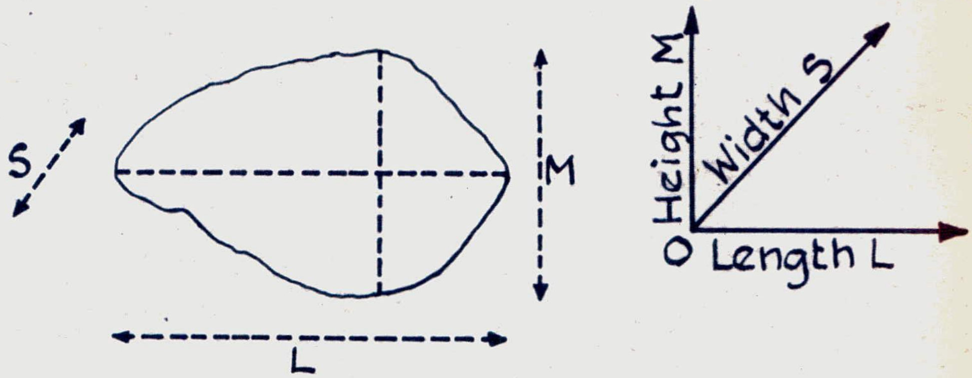


FIG. 21 PARTICLE DIMENSIONS

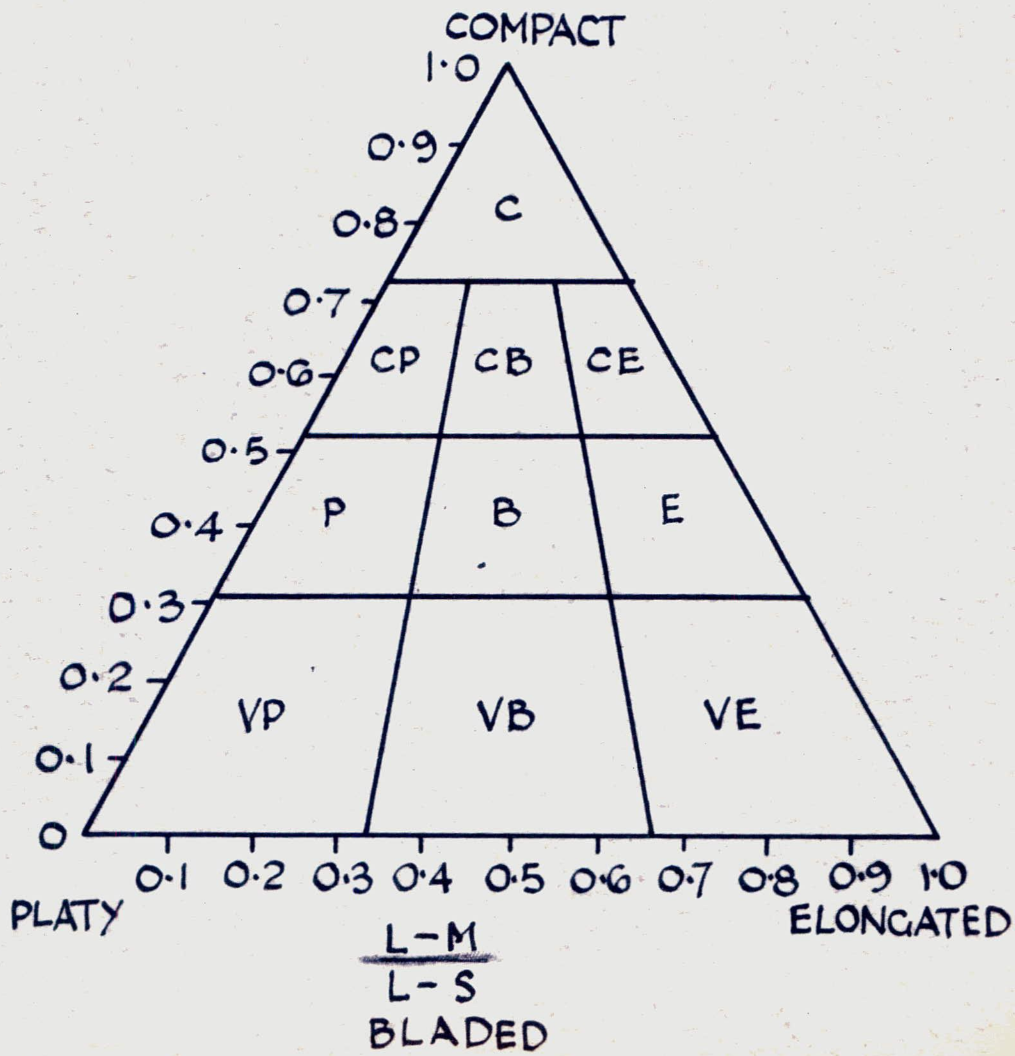


FIG 22 SHAPE FORM TRIANGLE

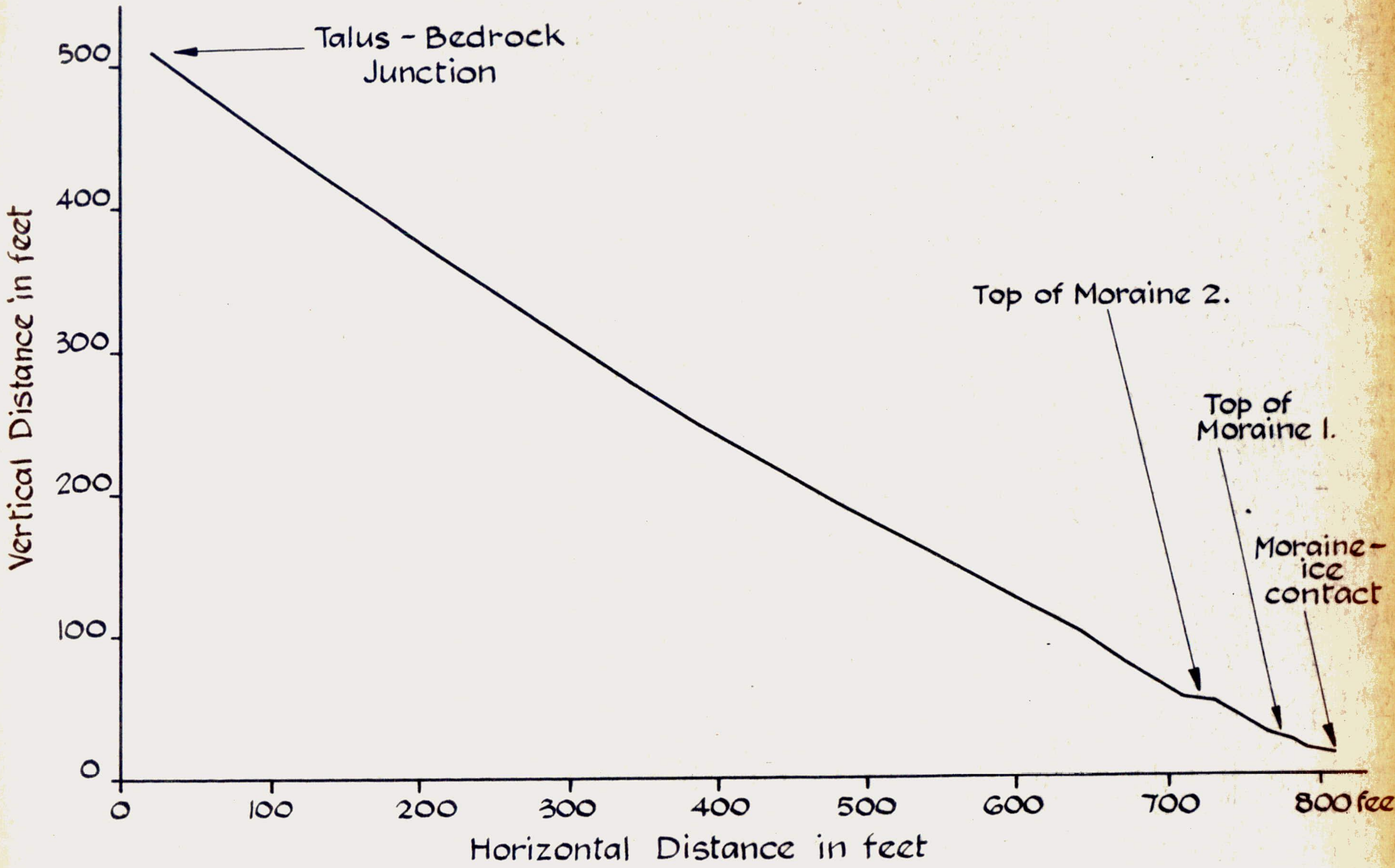


FIG 23 PROFILE OF SCREE No. 1.

These results accord well with observations on the type of bedrock from which the fragments are developed. These are schistose and slaty Precambrian sediments that exhibit strong cleavage and foliation being fissile along the cleavage planes and hence produce a bladed, elongated weathered particle.

Mention was made above of a fine 'flour' underlying coarser material on the surface of the scree. This juxtaposition of readily distinguishable sediment types is felt to be important in the downslope transfer of the weathered layer. There are two essential components to this movement, block creep and layer shearing. Shearing characterizes the upper part of the scree and creep becomes predominant downslope. The convexity of the scree in the latitudinal plane towards the base and the concavity exhibited in the upper part are both a function of the relative disposition and frequency of these phenomena.

When a large individual block weathers out from the high rock outcrops of the mountain wall it falls onto the scree decreasing the shear strength of the talus by altering the coefficient of static friction. The scree debris lies at an angle just below that of its critical stability. Since the angle of rest in unconsolidated material approaches 40° it is reasonable to suppose that on talus where the slope declivity steepens towards the apex, stability will bear an inverse relationship to elevation on the scree surface. Thus successively smaller increments of shear stress are required to alter the stability of surface material upslope. Hence the phenomenon of mass disturbance by shearing is more likely to occur on the upper slopes.

The force required for incipient motion (Δf) on a talus slope is:

$$\Delta f = Mg\,(\cos\alpha \tan\phi - \sin\beta)$$

where M = Mass of particle to be moved
g = Gravitational acceleration
β = Slope angle
ϕ = Coefficient of static friction of sediment.

With rockfall impact the upper debris layer will shear away above the point of contact. This is because on a slope the particle below supports the particle above. The layer that shears does so not along a distinct plane but on the layer of finer sediment which acts as a lubricating transitional shear-zone. The amount of downslope transfer of the shearing mass (T_m) can be considered by the general equation:

$$Tn = \Delta f / Ij$$

where I = Impact velocity of falling particle j

The volume of material that shears due to the rockfall (s) is

$$s = Ij \Big/ \sum_{n=1}^{n=x} \Delta f$$

where $Ij \geqslant Mg(\cos\alpha \tan\phi - \sin\beta) \geqslant 0$

At greater distances upslope from the point of rockfall impact, there is a decrease in the effects of the fall, as there are successively smaller transfers of momentum through and dilation to the debris above due to the presence of air spaces between particles and the degree of touching. Both these factors determine compaction, cohesion and what may be termed interstitial absorption of energy in the unconsolidated deposits.

The amount of downward movement of the sheared layer is essentially governed by the thickness and extent of the lubricating layer beneath. The material below the moving mass is also important, for this is rucked up at the leading edge of the shearing body. This becomes incorporated into the moving debris, thus dissipating momentum and tending to cut the mass off from its previously lubricating layer. If an increase in sediment size occurs downslope this tends to stabilise the mass. The loss of energy by frictional drag at the sides and base of the shearing layers is one of the major factors in arresting movement.

The mass of material that shears is usually not a rigid layer, for the majority of the particles are in congruent, yet independent, motion. Thus the concept of true shearing of a homogenous mass over a distinct shear plane is difficult to apply. At this juncture it is possible to consider transfer in terms of flow. The similarity of movement of masses of debris on screes to flowage is probably a relationship that depends on the thickness of the yielding talus, the size of particles, their roundness and shape, the upward flux of momentum, the velocity of movement and the distance involved.

The second factor in the downslope transfer of material is creep, which predominates in the lower part of the scree. At these levels a coarsening of the talus sediment means that increasingly large blocks have to fall from above to create the shear-flowage previously discussed. A rock descending from the mountain wall may create a local shearing of debris at one level but further downslope will fail to alter the scree stability to any appreciable degree. Where this happens the blocks continue down the scree independently until arrested by frictional resistance. This individual block movement is a creep effect. The rock particles that experience such a movement are (i) those that fall from above, (ii) those dislodged as single fragmentsby falling blocks (as opposed to fragments displaced in a shearing mass), (iii) those lost from shearing layers and (iv) those disturbed by animals, etc. All make their way down the slope with the coarsest particles toward the toe.

The above discussion illustrates some of the facets of this section of the scientific programme. The analysis and determination of the relationships that appertain to the screes studied will be the subject of a forthcoming publication.

11 Conclusions

The scientific work of the expedition involving glacial, periglacial and climate observations has been outlined. The glacial studies were concerned with, (i) velocity and strain distributions of zones on the surface of the Bersaerkerbrae Glacier, (ii) ablation, and (iii) the character and formation of dirt cones. Periglacial studies centred on the analysis of scree composition, distribution and downslope movement of the weathered rock fragments. Weather parameters were recorded throughout the expedition period and climatic conditions recorded in graphical form.

Since this report was required for distribution with a few weeks of the expedition's return, there has not been time to complete the analyses of all the data collected. More detailed and completed analyses will be presented in future publications, and these may be obtained from the Queen Mary College library.

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