THE DEVON ISLAND EXPEDITION 1960-64

The establishment of the Arctic Institute's Devon Island Base Station and the progress of the research program in 1960 and 1961 were reported in brief summaries and preliminary field reports in Arctic 13:270-71 and 14:252-65, and a review of the research from September 1961 to September 1962 appeared in Arctic 15:317-320. Preliminary field reports for that period are presented here.


Photo: H. B. Sackang

View of the base camp from the meteorological tower, looking south, July 1962.

Glaciology, winter 1961-62

During the winter of 1961-62 work was divided between studies of glacier-, lake-, and sea-ice. (The author had no previous experience of lake- or sea-ice studies and as the amount of literature at the station was limited some of the work and comments may be reiterations of work already done elsewhere). The comments in this report are based on a perfunctory examination of some of the data and are liable to be rejected or modified when a more complete analysis has been done.

Ice samples were collected with a SIPRE corer, and slides made from them by melting horizontal or vertical sections. These sections were then examined for bubble structure, etc., with an 8x Leitz lens graduated in tenths of a millimetre. The sections were further studied between crossed polaroid plates for crystal shape and size. Photographs were taken of sections with a Voigtlander Vito BL camera fitted with two Focar close-up lenses. To complete the study certain sections were fixed in a universal stage to determine the orientation of the optic axes. The universal stage was constructed at the base, and was immersed in water to give a complete coverage of polar angles. This instrument, when partly frozen-in with ice forming on the bottom and sides of the water container, allowed a study of the ice to be carried out in a heated Jamesway hut where the vertical temperature gradient was favourably steep. The angles are accurate to within ± 5 degrees. Ice densities were measured in a pycnometer constructed from a can with a spout soldered in a position 2 cm. from the lip of the can. The volume of a mixture of gasoline and diesel oil displaced from the can was measured in a graduated cylinder. These results are accurate to within ±0.005/cm.^{3}.

Glacier ice

The greater part of the winter was spent in examining ice cored from nine stations on a profile extending from 3 km. above the firn line of the ice-cap to the steep slope on its northwestern edge. The study was a little hampered by worn teeth on the SIPRE ice corer, which was not able to recover complete cores. Records from the four core sites above the Ice-Cap Station (ca. 1400 m. above sea-level) are therefore less complete than those from the Ice-Cap Station 10-m. core and the four sites below it, where sharper cutting blades were used. The cores were cut into 10-cm.-long sections and melted down to a thickness suitable for study. The bubble structure, crystal size, and c-axis orientation were examined and photographs taken for later reference; 300 negatives were developed during the winter and another 340 negatives were processed on return from the field.

The ice, which is largely superimposed ice, and ice formed fairly close to the surface above the firn line, shows a general lack of regular banding. In the superimposed ice it is not possible to make a straightforward division into bubbly ice resulting from early summer soaking of winter snow, and clear blue ice developed from melt water formed *in situ* or from above the firn line. Minor variations in bubble structure are largely an inheritance of variations in snow structure. Firn layers in the superimposed ice, formed in years of above-average accumulation, provide reference levels for correlation between the various cores from above the Ice-Cap Station. Firn within 3 m. of the surface, approx. 20 km. below the firn line, is believed to represent firn formed above the firn line and brought back to near the surface by ablation and upward movement of ice in the ablation region. Another reference level besides isolated firn layers is provided by ice in which the crystal boundaries are occupied by continuous air bubbles. This ice has been taken to represent former surface ice formed at the height of the melting season where melting of impurities along crystal boundaries has occurred. The majority of bubbles show a direct relationship to crystal boundaries and those measuring less than 0.3 mm. are generally located there. Many bubbles have one surface related to the c-axis of a crystal, lying at right angles to it along the 0001 plane. Tyndal melt figures are abundantly evident throughout all cores. These figures showed various patterns, all based on a hexagonal figure normal to the c-axis.

Crystal diameters vary from ca. 0.1 cm. to 2.0 cm.; the usual range is 0.3-0.5 cm. in bubbly ice and 0.8-1.5 cm. in clear ice. Crystal size is probably related to the rate of formation of the ice. Some candling is evident at some levels in the superimposed ice and represents surface freezing of standing water.

The orientation of c-axes was observed in detail in the core from the Ice-Cap Station. Slides within a few cm. of each other were examined from separate horizons but no regular changes in orientation were observed. Fabric diagrams for each 30-cm. level have been drawn for all cores and a total of 75 have been completed. In cores from the Ice-Cap Station and from above the station no major concentrations have been found. Polar angles show a slight increase as the vertical is approached and a few horizons show a preference for c-axes within 30° to the normal to ice stratification. The orientations are probably the result of ice crystal c-axes developing from an already existing pattern in the snow crystals forming the winter snow. A definite pattern emerges at the top of the steep slope at the edge of the ice-cap. A core taken near a shear (?) moraine gave a pronounced concentration with a polar angle 45° to the surface, and a secondary concentration with a similar polar angle but differing in azimuth by 180°. The method of coring did not include a record of the core azimuth. A core from a ridge on a valley glacier leading from the ice-cap showed a similar pattern with c-axes aligned in the direction of bubble stretching. The pattern was found again half-way down the steep slope of the ice-cap edge.

The whole study has shown that although it is not possible to determine the position of the climatic equilibrium line by a study of the ice (as ice from above that line is moved below it by glacier movement) it is likely that it will be possible to obtain a more complete idea of the character of melting seasons in past years after the core diagrams have been integrated with others obtained from between the firn line and the top of the ice-cap.

Sea-ice

Sea-ice was studied in some detail in the deep inlet south of the base area. Cores were studied for crystal size, brine cell distribution and ice density. Comparisons can be made with other cores obtained at the oceanographic hut about 3 km. offshore, at various points in bay-ice, and in ice formed after mid-winter farther out in Jones Sound.

Sea-ice began to form in the bays on September 20 and by mid-November extended from headland to headland along the coast. The main body of Jones Sound did not freeze over until early January.

Cores were taken from the inlet at approximately 8-day intervals except for a period in mid-winter when the intervals were 27 days. Until December several cores were taken each time and indicated an ice-sheet of uniform thickness. This uniformity was maintained through most of the winter and was apparently due to the absence of a variable snow cover. Therefore, during the second half of winter one measurement was made every 8 days in an area rarely covered even with a thin snow cover. By April 17 a maximum variation of only 5 cm. in a total of 225 cm. was found in the area studied. The results show an overall growth rate of 1.1 cm./day. Variations in this rate agree with the changes in the thermal gradient in the lower 50 cm. of the ice sheet. A cursory examination of the data gives a growth rate of 2.1 cm./day for a thermal gradient of 0.5°C./cm. and 0.5 cm./day for 0.1°C./cm. The growth rate did not begin to decrease appreciably until late March and was then related to a decreasing thermal gradient caused by increased radiation, higher air temperatures, and a snow cover 4 cm. thick with occasional *skavler*.

The bay ice was affected by grounding. Cores taken approximately 9 km. from shore in Jones Sound in March gave thicknesses which were 56 and 76 cm. less than in the inlet, but this ice must have grown at twice the rate of the bay ice since growth started only in January.

The thermal structure of the inlet ice was measured with thermocouples at 10-cm. intervals to 50 cm. and then at depths of 75, 100, 150, and 200 cm. These were read whenever cores were taken and show a fairly gradual cooling of the ice up to the beginning of March. Subsequent warming down to 160 cm. levelled off and early April showed a further slight cooling throughout the sheet. The results provide an interesting comparison with ground temperatures at the station where falling surface temperatures were recorded until late February.

Slides were taken at 15-20 cm. intervals from the cores and photographed through crossed polaroid plates. Except for the top 1 cm., the ice consisted of vertically elongated crystals with horizontal c-axes. Crystal size increased with depth in the sheet from crystals with a cross-sectional diameter of less than 1 cm. to crystals extending beyond the 7 cm.-diameter slide by 80 cm. In the cores taken farther out in Jones Sound crystals were smaller in the upper half of the sheet (i.e. compared to the inlet cores) and showed a more rapid increase in crystal size downwards. This suggests that crystal size is affected by the growth rate in the upper parts of the sheet, which is in agreement with observations on crystal growth in superimposed ice on glaciers.

Plate thicknesses were measured on each slide and averaged approximately 0.7 mm. from the midpoint of one brine cell to the midpoint of the next. No regular variations in plate width were observed, although at 120 cm. in the inlet sea-ice plates reached a width of 2.0 mm. A core taken from under a 70-cm. snowdrift to examine ice with a slow growth rate showed plates 0.8 mm. thick.

The continuity of brine cells was noted in horizontal sections and the cells showed a gradual increase from small vertical cylinders to continuous cells surrounding the plates toward the bottom of the sheet. Brine inclusions from the sharp edges of the plates were found to disappear first as the ice became further incorporated into the sheet.

As no salinity kit was available, densities were determined at 15-cm. intervals in the cores to attempt to trace brine migration and density variations depending on brine and air content. Air content is constant throughout the winter period and it was hoped that density variations would be a reflection of brine migration. Densities generally were in the range of 920-928 gm./dm.^{3} and after an initial density of approximately 930-940 gm./dm.^{3} at the bottom of the ice sheet rarely dropped below 920 gm./dm.^{3}. No valid variations were detected in the ice sheet from the surface to within 30 cm. of the base of the inlet ice sheet. Cores taken from the bay ice showed disturbed plates at a particular point in the column related to grounding on a rock. Densities above this disturbed area were 0.010 gm./cm.^{3} higher than below it and probably result from a restriction of the normal brine migration process by non-vertical plates. A stake pattern in this bay showed that the whole body of bay ice had moved 10 m. away from the shore since its formation so that grounding on the rock occurred at different levels from core to core.

Two cores were taken from Jones Sound within 30 m. of each other, one from under a 7-cm. snow cover and the other from under a 70-cm. snow cover. Densities were 0.010 gm./cm.^{3} lower in the ice, which was 30 cm. thinner where the thick snow cover retarded its growth. It is suggested that the lower density resulted from dispersed brine cell distribution and more efficient brine drainage because of slower freezing. The densities in the inlet where the ice was thicker than elsewhere were the highest overall densities measured.

The top 30 cm. of the cores from Jones Sound showed very low densities in the 887-895 gm./dm.^{3} range. Rapid near-surface ice formation trapped relatively high proportions of air. Below 30 cm. densities continued in the 920-928 gm./dm.^{3} range.

Old sea-ice that had withstood one summer was examined and found to contain few brine cells and to consist of low-density (890-917 gm./dm.^{3}) ice. Summer melting along plate boundaries and subsequent winter refreezing must have greatly reduced the salinity.

Lake-ice

Four lakes were studied for ice crystallography and one for its englacial temperature structure.

Lake I	(unofficial name, Provision Pond). Average depth 3 m. length 1.5 km., width 1 km., average ice thickness 200 cm. in early April.
Lake II	150 m. west of the station. Depth approximately 1-2 m., length 0.4 km. width 0.2 km., frozen throughout its depth.
Lake III	800 m. to the southeast of the station. Average depth 3-5 m., length 1 km., width 1 km., average ice thickness in mid-March 180-190 cm.
Lake IV	3 km. east of the station, depth approximately 3-5 m., length 0.4 km., width 0.4 km., thickness from one core 175 cm.

Six cores were taken from lake I, four from lake III and one from lake IV. In addition a 120- by 50- by 50-cm. block was hewn from lake II and an 80- by 20- by 40-cm. block from lake I; in each case the long dimension was the vertical. In all lakes coring was incomplete; cores shattered regularly 30 cm. below the ice surface, and recovery from the 60- to 90-cm. level was particularly poor.

In all lakes crystal size increased rapidly with increasing depth, from a cross-sectional diameter of less than 1 cm. at the surface to more than 25 cm. at 70 cm. depth. Crystals more than 70 cm. long have been traced.

Crystals are almost entirely vertically elongated but c-axes orientation varied from lake to lake and with depth in each lake. In lakes I and III the surface was composed of needles and irregular plates, the former with the c-axes between 40° and 60° to the horizontal and the long axis of the needle at right angles to the c-axes. Polar angles showed a wide range with a marked concentration at 20-35°. Near-vertical platy crystals, however, covered a large percentage of the area and below 5-cm. depth in the ice sheets of lakes I and III, polar angles less than 20° were dominant. Near the surface of lake I crystals with near-vertical c-axes predominated, with a secondary concentration of smaller crystals having near horizontal c-axes. This pattern continued down to ca. 60-70 cm. From here to a depth of 90 cm. a change occurred and crystals with horizontal c-axes occupied most of the ice sheet. This pattern occurred in each core, and the transition zone was just becoming apparent at the base of the ice block examined. Fragmentation of ice cores always occurred in the transition zone.

In lake III the pattern was different below 60 cm. Crystals with vertical c-axes occupied 90 per cent of the sheet down to 60 cm. but below that level crystals with c-axes at 55-70° formed a secondary minor concentration with a major one of crystals with horizontal c-axes. The 60- to 90-cm. zone in this lake had a large number of crystals with c-axes at 40-70°.

In lake IV the change in the orientation of the c-axes of the crystals from near vertical to horizontal did not occur until a depth of 110 cm. in the ice sheet.

An increase in the number of crystals with horizontal c-axes with depth has been observed before[1] and it has been suggested[2] that a change in the chemical composition of the lake water might change the maximum thermal conductivity of the crystals from parallel to the c-axes to normal. This results from an increase in impurities in the ice, forming insular pockets between the plates of a crystal (cf. sea-ice, and Tyndal melt figures in both lake- and glacier-ice). This may be applicable to lakes I, III and IV. Water samples were collected from under the ice in spring and again when the lakes were ice-free in August to determine the validity of this hypothesis.

In lake II an entirely different pattern has been observed. At the surface there was a remarkable concentration of crystals with c-axes at 50-80°. No angles less than 40° were recorded in 100 crystals and polar angles over 70° formed only 7 per cent of the total. Below the surface polar angles showed a slight increase in the lower range and changed the total range to 30-60°.

This lake was frozen to the bottom when examined in March and tubules appeared in the ice at a depth of ca. 50 cm. These were 1 mm. wide and of variable length. Changes in bubble structure occurred in horizontal lines throughout the lower part of the ice. Each tubule at a particular level showed slight dilation or terminated to be replaced by another immediately at its side. These tubules were occasionally affected by crystal boundaries and were bent to conform to boundary changes. At the level where these tubules appeared the water must have reached air saturation point. The core from lake IV showed a similar effect on a much smaller scale, ice from lake III contained occasional very slight tubules and that of lake I was bubble-free.

Temperatures in the ice sheet of lake I were measured with thermocouples. The first set was frozen in near the limnological hut but deep snow drifts gave results that were clearly atypical. Another set, made from thermocouple wire air-dropped in late December was frozen in on January 25. The new site was covered with 6 cm. of snow and the instruments were read at 9-day intervals until March, and thereafter at 4-day intervals. The original set of thermocouples, despite its atypical snow-cover that reached a thickness of 30 cm. by December, showed a considerable heat flow into the atmosphere in November and December. Surface temperatures on bare ice 80-90 cm. thick were 1 to 2.0°C. higher than on ice covered with 10 cm. of snow. On December 2 bare lake-ice was 7.8°C. warmer than the ground surface at the station. By February the difference between ground- and ice-surface temperatures had dropped to less than 1°C.

The overall temperature trends in the lake-ice were similar to those in the sea-ice. There was similar gradual cooling of the ice-sheet until March, followed by warming up. Snow accumulation (12 cm. snow at the instruments by April), higher air temperatures, and increasing radiation in March reduced the thermal gradient in the top half of the ice-sheet from 0.1°C./cm. in February to 0.05°C./cm. in early March.

The rate of increase in thickness at the instrument site was not followed closely, but 10 measurements gave a rate very close to that of the sea-ice. Snow accumulation in February reduced this rate and it became appreciably smaller in mid-March.

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[2] Weeks, W.F. 1958. The structure of sea ice: a progress report. pp. 96-98. *In* Arctic Sea Ice. pub. 598, Natl. Acad Sci.—Natl Res. Coun. 271 pp.

Meteorology, winter 1961-62

The meteorological program for the winter 1961-2, carried out by two observers, A. Gill and C. W. Nicol, was as follows: observations were carried out at 0000, 0600, 0900, 1200, 1500, 1800, and 2100 hours LST (6 hours after GMT) and consisted of the standard synoptic observations of cloud, weather, visibility, pressure, dry- and wet-bulb thermometers, and wind speed and direction. The maximum and minimum thermometers were read at 0000, 0600, 1200 and 1800 hours. Measurements were made with an Eppley pyrheliometer, when sunlight was sufficient, and with Beckman and Whitley net-exchange and total-hemispheric radiometers. Wind and temperature profiles were measured at three levels, the mean wind speed was recorded with a Friez anemometer, and the ground- and snow-temperature profile was measured with thermocouples. Ground surface temperatures were read with mercury thermometers, one with a blackened bulb, until the ground temperatures reached −35°F. in December. A thermometer placed 1 cm. below the ground surface before it froze was read until this was made impracticable by snow. Six snow stakes were measured daily and densities were measured weekly.

The synoptic observations were coded and transmitted to the Department of Transport meteorological station at Resolute, via Eureka, commencing on October 1. Radio conditions were not always favourable and during the winter months we succeeded in transmitting about two-thirds of the observations. The completed data sheets have been sent to the Meteorological Branch, Department of Transport, Toronto, and the U.S. Weather Bureau, Washington, D.C.

Radiation

The Eppley pyrheliometer readings were discontinued because of darkness from October 25 until February 16. At other times, when cloud conditions were favourable, measurements were made with the instrument in the normal position, inverted, and shaded from the direct sunlight.

Measurements with the radiometers suffered only a few minor interruptions through broken wires and hoar frost. Once a fox wrought havoc among the wires and cables, but when they were buried in the snow there was no further trouble from that cause. Hoar frost on the transducers was kept to a minimum by covering them with plastic bags and protecting each instrument with a cloth bag between observations when hoar frost was likely. Frosting could be expected at any time during the absence of the sun. In spite of the precautions a certain amount of defrosting had to be done and since it was inconvenient to bring the radiometers indoors we found that defrosting was easily accomplished in about half an hour per instrument by placing a small gasoline stove in a box covering the instrument, to which at times more protection in the form of parkas had to be added. This method was only necessary during periods of heavy hoar frost deposits. At other times defrosting was accomplished by running the fans for an hour or so each day with both bags on the instrument.

Wind and temperature profiles

Three Casella revolution-counter anemometers were used on a 33-ft. aluminum mast, with thermocouples at the same levels. The thermocouples were housed in ventilators constructed from cans and electric fans. These broke down in mid-November, when radiation had ceased to be a problem and readings were taken without them until early March when the ventilators were again put into operation.

During October it became apparent that the prevailing wind direction was not northwest as expected, but varied about equally between southwest and southeast. The anemometers were shaded by the mast and other attachments. They were then rearranged and placed on short wooden arms, swivelled on the main arms, enabling the anemometers to be moved out of the way of any obstruction on the mast, whatever the wind direction. Subsequently, the only winds we were unable to measure were from the south-southeast, which were influenced by the camp buildings.

By November the winds were mainly from the east or southeast, usually less than 5 m.p.h., and appeared to be of a katabatic nature, coming from the ice-cap. These winds frequently were accompanied by a strong temperature inversion, and were usually stronger at the middle or lower levels of the mast. Once these easterly winds were established the southwest winds blew only infrequently at the base, usually accompanied by an increase in temperature, cloud, and light drifting of snow. Out on the sea-ice, however, southwest wind was several times reported while the east wind prevailed at the base. By mid-March, the sun was strong enough to break down the inversion at midday when the winds tended to be light and variable in direction.

General weather conditions

Snowfall was very light, and up to mid-winter the mean depth measured at six snow stakes was only 3 inches. During this time, gravel ridges and the large pieces of vegetation were exposed. Snowfall at the Christmas season raised the depth to 7 inches and gave almost complete cover. The depth increased to 10 inches by April.

During the absence of the sun there was almost continuous hoar frost, but fog-deposited rime was not reported until March.

Halo phenomena were fairly infrequent up to the end of February and were mainly unspectacular displays of simple haloes in high cloud. In March and April there were a few displays in cirrostratus and in ice crystal precipitation with 22° and 45° haloes and several parhelia and arcs of contact.

Unfortunately, complete hydrograph and thermograph records could not be maintained owing to the failure of the clocks to work at temperatures below about −20°F.

A. GILL

Oceanography, winter 1961-62

This preliminary report describes the winter cycle of biological, chemical, and physical oceanographic events in Jones Sound, N.W.T. In the summer of 1961 a study was made in the shallow, inshore waters of the sound of the annual phytoplankton flowering and photosynthesis, the depletion of the nutrient supply, and the variations in temperature and salinity. The present winter study is a logical continuation of that work, since, in addition to describing the gradual cooling of the sound, it demonstrates the restoration of nutrient supplies and the loss of oxygen, phenomena that both depend in part on the magnitude of the summer biological production.

These two chemical events are of more than local interest. One of the more important unsolved problems in marine biology concerns the utilization of inorganic nutrients by phytoplankton and the rate of their return to the inorganic state by chemical regeneration. This cycle involves oxygen since it is by oxidation of organic matter that the nutrients are returned to that simple inorganic state in which they are again available for primary biological utilization; thus, theoretically, an increase of biologically useful nutrients is accompanied by a decline of dissolved oxygen. The rate of regeneration of nutrients is of fundamental importance, since it seems that the magnitude of biological production is controlled by the nutrient cycle. Steeman-Nielsen[1] observed that "Taking all seas as a whole, it may be stated — as an approximation at least — that the replenishment of the nutrients in the productive surface layers is the essential factor determining the magnitude of organic production." Ketchum, *et al.*[2] state that information is "drastically needed" on the following questions, among others; "How frequently do the nutrients recycle during the annual production of the phytoplankton population? What is the rate of regeneration of essential nutrients as a result of decomposition of organic matter? How does this rate vary with temperature . . .?"

In temperate and tropical seas there are various hydrographic and biological factors that seriously complicate studies of the nutrient cycle. Laboratory studies are desirable but there always remains the question of their relevance to natural conditions.

In the Arctic the summer production occurs so rapidly and, though vigorous, lasts so short a time, and takes place at such low temperatures that it is most unlikely that it is affected by regeneration. Arctic waters in winter are relatively uncomplicated. Because of ice and snow cover, and little or no incident light for long periods of time, no photosynthesis or exchange with the atmosphere can occur. Since animal populations are undoubtedly very small, oxygen depletion by respiration must occur to a negligible degree. Most of the observed chemical changes can probably be attributed directly to chemical regeneration but there remains the question of influences due to mass movements, turbulence, and eddy diffusion, all of which can render interpretations difficult or uncertain.

Jones Sound should provide optimum conditions for studying nutrient regeneration. It is totally covered with ice and snow by mid-winter and its waters flow almost entirely from west to east, coming through narrow channels out of the Arctic Ocean. Due to ice cover, even in summer, probably little biological production occurs in these channels or in the Arctic Ocean. The IGY Drift Station Bravo obtained nutrient data at the Arctic Ocean end of the channels, and the Polar Continental Shelf Project is at work on hydrographic studies in the channels. Thus, with the present oceanographic program, thorough studies should be possible.

No attempt will be made to discuss the data completely in this preliminary report, whose purpose is to describe the data collected so far, and to indicate the main points of interest.

Methods

Ice began to form along the coast in mid-September but it was not until early November that it became solid and secure. A small house was set out on the ice about 2 miles from shore over 80 m. of water on November 11. Its position was approximately 75°45'N., 84°32'W., and sampling was carried out at that station through the winter.

Samples were collected in a Nansen bottle fitted with a protected reversing thermometer. Temperatures were not obtained on one occasion since the thermometer was adversely affected while en route to the station. Salinity samples were preserved for titration at the Woods Hole Oceanographic Institution. Oxygen, nitrite-plus-nitrate, phosphate, and silicate have been measured by the following methods, respectively: Winkler, Mullin and Riley[3], Deniges-Atkins (WHOI), and Mullin and Riley[4]. The nitrate values are probably not exact since it was not possible to control the temperature of the samples precisely during the reduction stage. The error probably amounts to about 10 per cent but it is believed that the data adequately represent the main aspects of the inorganic nitrogen cycle. The phosphate data are corrected for salt effect by a factor of 1.19. All the optical densities were measured on a Klett-Summerson photoelectric colorimeter.

Zooplankton were collected in vertical tows from 50 m. and from 80 m. No. 20 nets were used but after January a No. 10 collecting bucket was fitted to the cod end. The entire sample from each tow has been examined and counted.

Temperature

The data show gradual cooling through the winter with the deepest water at 80 m. being affected only in December. The water column from 0-50 m. cooled from about −1.74°C. to −1.80°C., but there was a considerable lag at 80 m. It was only by mid-February that the temperatures became nearly uniform at about −1.80°C. through the column. There was very little change thereafter.

Oxygen

The data for each date show a consistent decline in dissolved oxygen toward the bottom. The decrease is rather small from the surface to 50 m. but, until January, the rate of decline increased from 50 to 80 m. This type of distribution suggests an oxidation-reduction reaction with the bottom sediments that reached an equilibrium in January. An alternative explanation may be simply that the annual variations are limited to water above 80 m.

The oxygen content at 80 m. appears to be approximately constant through the winter but there was a general decline in oxygen between 0 m. and 50 m. from November until April. About 0.8 ml./l. was lost. The main loss occurred in January, followed by a smaller and more variable rate of loss.

Nutrients

The nutrients in general increased with depth on each date and increased through the column from November to January and then more slowly until April.

The phosphate and silicate data at 80 m. show higher and less fluctuating values than in the shallower depths. The values from 0-50 m. increased more rapidly from November to January than after January. By February the values tend to be the same for the whole column although still increasing slowly. Curves based on these data thus would be mirror images of the oxygen curves and strengthen the supposition of an oxidation-reduction occurring at the water-sediment interface, which approached equilibrium by January.

Superimposed on these general trends is a most interesting negative correlation between changes in phosphate and silicate concentrations at 80 m. from November into March. With 6 degrees of freedom, the correlation is statistically significant between the 2- and 5-per cent levels. This significance greatly reduces the probability of chance fluctuations but raises a difficult question. It would be expected that changes resulting from chemical or biological causes would affect the concentrations in the same direction and thus produce a positive correlation. The high statistical significance of the negative correlation occurring just off the bottom strongly suggests a chemical reaction with the sediments. Limnological literature indicates that such a reaction should produce a positive correlation but I am unaware of any similar oceanographic literature. The inverse correlation appears to end in mid-March, at about the time when oxygen approaches its lowest concentration. There has not been time to carry out full statistical treatment of the data and that may reveal more significant interrelationships. For the present I can offer no explanation for the negative phosphate-silicate correlation.

Nitrates show a relatively stable concentration at 80 m. but increasing values occur from 0-50 m. from November until late February or March. Since nitrogen is, in general, bound by organisms into more complex organic compounds than phosphorus or silicon, it is to be expected that the regeneration of nitrate will take longer than that of phosphate or silicate; thus in Jones Sound the nitrates reached their maximum values about a month after phosphates and silicate.

Zooplankton

The species collected are all typically arctic and the population is dominated by the copepods *Pseudocalanus minutus* and *Oithona similis.* The total population is very small and appears to be rather stable through the winter. A marked increase in *P. minutus* in March is undoubtedly due to a vertical migration from deeper waters, into which it had descended in mid-winter. This sudden reappearance of the copepod in the upper layers in March had been observed previously by Digby[5] at Scoresby Sound, East Greenland.

The only other winter zooplankton study in the Canadian Arctic is that of Grainger[6] at Igloolik. There are some interesting differences between the localities. One is the relatively large numbers of *O. similis* in Jones Sound as compared with the very few at Igloolik. Another is the presence of *Microcalanus pygmaeus,* which was not recorded at Igloolik.

S. Apollonio

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Geophysics, summer 1962

Program and field movement

During the 1962 field season the three-man geophysical party carried out a varied program which included: a gravity traverse of the ice-cap; studies of the electrical properties of snow, ice, and firn; and a movement survey of a previously established line of stakes on the Sverdrup Glacier. The party consisted of Lt. R. A. Tansey, a surveyor from the Royal Engineers posted to the expedition; and R. D. Hyndman and J. P. Greenhouse, both graduate students at the Institute of Earth Sciences, University of British Columbia. Principal articles of equipment were a Wild T_2 theodolite (a second T_2 arrived in July) two Keithley 600 A electrometers, 6000 metres of light electrical cable, a Philips PR 5000 conductivity meter, and a Worden gravimeter. Transportation on the ice-cap was provided by an Eliason motor-toboggan with a Nansen sledge.

The geophysical program was centred on a continuation of the geo-electric studies begun in the previous season when Dr. K. Vögtli took some 30 resistivity depth soundings on the Sverdrup Glacier. It was intended to spend most of the time allotted to geo-electric work in 1962 making similar measurements on the ice-cap, particularly above the firn line. The gravity survey was to complement resistivity depth measurements on the ice-cap and the accompanying levelling survey would tie in the glaciological stakes and yield a cross-section of the ice-cap suitable possibly for theoretical considerations of flow, etc.

The party arrived on Devon Island on May 20. The electrical cable was delayed en route and did not reach the island until the end of June; consequently, more time was allotted to the gravity survey than was originally planned. Fig. 1 shows the positions of the geophysical observations. Starting from a base line at a point of the plateau below the shear-plane moraines on the northwest edge of the ice-cap, the gravity survey was carried 30 miles in a direction S.30°E. to a point (Gravity Station 51) on the southern slope of the ice-cap. In addition, a branch traverse was run from the 25-mile point of the main traverse to the glaciological stake at the top of the ice-cap. This work occupied the party until the end of June and was interrupted by the evacuation on June 9 of Lt. Tansey to Thule for an appendicitis operation.

Following the arrival of the cable and the return of Lt. Tansey in early July, a period was spent at the Ice-Cap Station preparing the electrical gear. During this period advantage was taken of the Jacobsen-McGill Axel Heiberg Expedition's aircraft to establish a gravity station on the coast at the Base Station. This station will be tied in 1963 into the existing gravity network in the eastern Arctic.

After July 11 the party moved along the route of the gravity traverse to G. S. 51 taking resistivity measurements at 4-mile intervals. In general, two long profiles at right angles were read at each point and each profile occupied at least a day, as did the moving of camp between points. Of the five points only the first and last were below the firn line. It had been decided that on completing the geo-electric work to G. S. 51 the gravity survey should be extended to the nearest point of land on the southern coast, which is the plateau area to the northeast of Croker Bay. Bad weather together with poor surface conditions and vehicle breakdowns prolonged this stage by more than 2 weeks and to save time the station density on that part of the traverse had to be reduced. Following the return to G. S. 51, operations were shifted to the top of the ice-cap. Here two long geo-electric profiles were measured and resistivity readings on the firn and ice layers were taken to a depth of 7 m. in the glaciologist's deep snow pit. En route to the Ice-Cap Station from the top, profiles were measured at the two stakes above the firn line where 10-metre cores had been previously drilled and two shorter profiles were measured in the equilibrium zone between the firn line and Ice-Cap Station. The Ice-Cap Station was reached on August 12.

On August 15 survey and gravity equipment were back-packed 12 miles down the western tributary (locally known as the "Little Fox" glacier) to the first line of stakes on the Sverdrup Glacier. Surface conditions and the very poor state of the vehicle track made toboggan travel on the glacier out of the question at the time. During 10 days spent on the glacier the first line of 7 stakes was resurveyed using resection from cairns on the cliffs; vertical control for the stakes was re-established by levelling (some stakes had melted out and required redrilling); the gravimeter was read across the line; and one day was spent mapping the glaciologist's catchment area. A new track for the

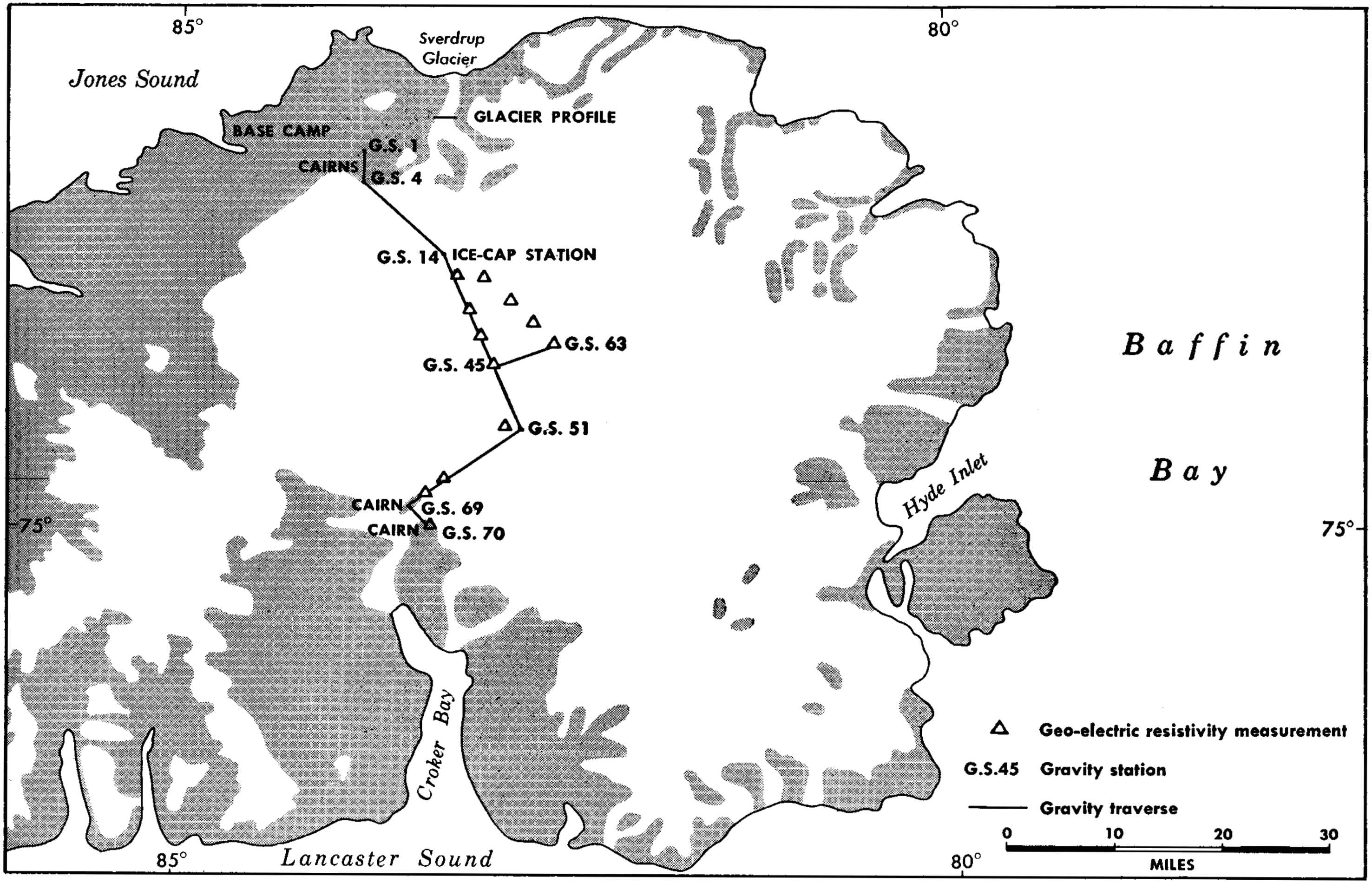

Fig. 1. Map of Devon Island ice-cap, showing positions of geophysical observations.

toboggan had been brought by boat from the Base Station to the glacier snout and this was picked up. Weather on the glacier was generally poor.

On returning to the head of the glacier on August 25, it was found that a fall of 10 inches of loose snow prevented the toboggan from pulling the load. It was not until September 3 that the surface was sufficiently packed to allow the return to the Ice-Cap Station. It had been planned to concentrate in the remaining field time on geo-electric depth measurements between the ice edge and the Ice-Cap Station. Despite three attempts to complete a profile near the shear-plane moraines, extreme dampness of the equipment and the consequent difficulty in insulating components made it impossible to obtain useful data. The opportunity was taken at this time to make a detailed survey of the shape of the ice-cap edge on a line running through the shear-plane moraines, using stadia distances and vertical angles. A resurvey in the future will yield useful information on ice-cap movement.

On returning to the Ice-Cap Station two more short geo-electric profiles were measured and two 8-metre cores were drilled to provide glaciological information for the electrical readings. The remaining field time was spent overhauling and packing equipment in preparation for an airlift on September 9.

Methods and preliminary results

(1) Gravity

The gravity program is described by R. Hyndman in an accompanying report. It suffices here to outline the method of survey and the inherent limitations on accuracy. The survey arrangement is shown in Fig. 2.

The theodolite was set up in turn at each of the gravity stations (G.S.) along the traverse with a subtense bar set over a stake (S) about 80 m. distant in a direction perpendicular to the traverse. At each station the distance *a* was measured with the subtense bar and four rounds of angles read to include the gravity and subtense stakes behind and ahead. Thus two independent values were obtained both for the distance *d* and the altitude difference between successive stations. On the main traverse the distance *d* did not exceed 1200 m.; on the branch traverse from G.S. 45 to the top and from G.S. 51 to Croker Bay greater spacings were necessary. At a few points along the traverse latitude and bearing were checked by sun shots and in September a star shot was taken at the Ice-Cap Station.

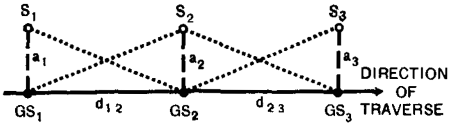

Fig. 2. Survey arrangement.

The most troublesome source of error in surveys over snow surfaces is the refraction effect on vertical angles. Ideally, two theodolites should be used to read vertical angles on each other simultaneously; however, even if two theodolites had been always available it is doubtful whether the three-man party could have worked such a system efficiently. Reading backwards and forwards between two stations with a reasonable time interval should cancel largely the refraction error. The actual magnitude of refraction effects will be known only after the results have been calculated. Accuracy of this method does not exceed 1:1000 and altitudes to within 10 m. would be expected at the end of the traverse. Errors in horizontal distances are relatively unimportant for the gravity work. It is hoped that all gravity depth measurements on the ice-cap will be correct within 10 per cent. Excluding the edge profile, 61 gravity stations were read on the ice-cap traverse.

The edge profile consisted of 26 stations spaced by 40 to 50 m. Stadia distances are correct within 0.2 per cent.

The resection method used in the glacier resurvey is described in the surveyors' report for 1961. This year a more accurate theodolite was used and altitude differences between stakes are correct to ± 2 cm.

(2) Geo-electric measurements

The methods and theory were described in the report for 1961. Briefly, the electrode configuration most frequently used, that of Schlumberger, involves measurement of the electric field strength on the surface of the ice at a point midway between two current electrodes as shown in Figure 3 (inset).

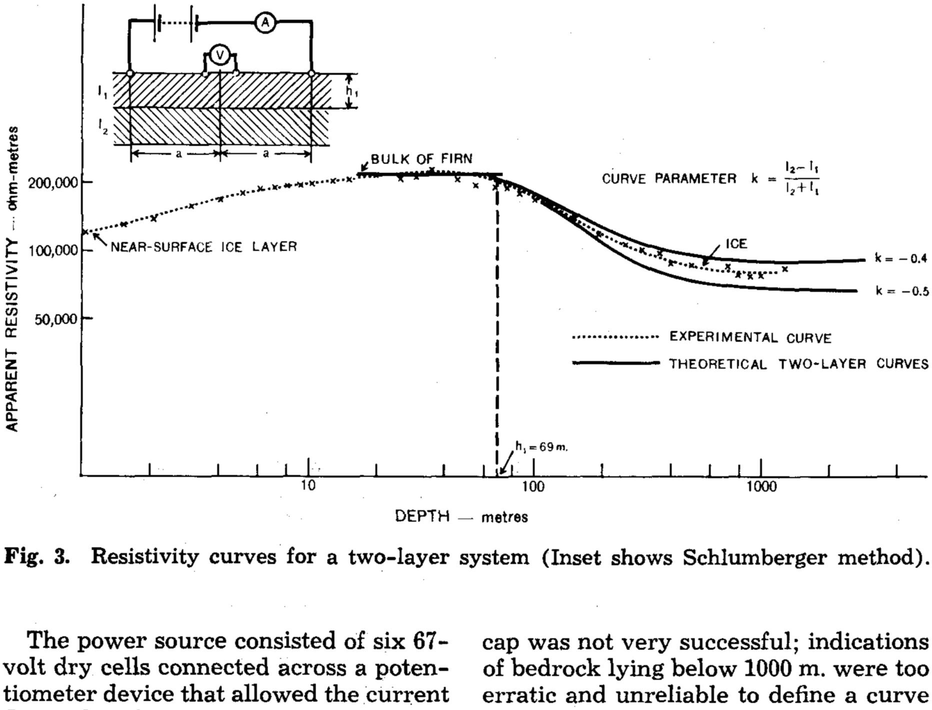

Fig. 3. Resistivity curves for a two-layer system (Inset shows Schlumberger method).

The power source consisted of six 67-volt dry cells connected across a potentiometer device that allowed the current flow to be adjusted. By means of switching, any of the four leads could be connected to any of the four electrodes. Among other things this allowed the current through the ground to be quickly reversed. Voltages in the centre were read with the Keithley electrometer, an instrument whose high input impedance (10^{14} ohms) prevents distortion of the field it is measuring. Current (seldom greater than two ma.) was read with a Simpson multimeter. The meters and switching circuits were placed on a canvas-covered wooden case, the instruments being padded and electrically insulated with foam slabs covered with plastic.

The 6000 m. of cable were rolled on 10 reels, each of which weighed about 8 lbs. Electrode separations of 5200 m. (2a) were possible. At separations much over 2000 m. however, insufficient power coupled with trouble from earth currents and one or two poorly understood effects made readings unreliable. As a result, depth sounding on the upper ice-cap was not very successful; indications of bedrock lying below 1000 m. were too erratic and unreliable to define a curve suitable for interpretation. The difficulties mentioned could probably be overcome simply with a commutating system (as in the Gish-Rooney method) and certainly with a much greater power supply. However, it should be pointed out that a layer of firn 70 m. thick can effectively obscure an ice-bedrock interface at, e.g., 1200 m., using interpretation with theoretical curves. As a result of these difficulties the emphasis was placed on obtaining the firn curve and not on the deep soundings. Ice depths will thus be given by the gravity survey alone.

Firn on an ice-cap is not a distinct layer but merges gradually into the ice below. Thus it is not to be expected that the firn-ice transition would conform to two-layer theoretical curves but rather to curves for a depth-dependent resistivity function. It is none the less surprising how close the firn-ice curve approaches the two-layer case in some instances. Resistivity of the firn varied between 125,000 and 250,000 ohm-metres, the value depending on the density of ice layers. Thus the contrast with ice having resistivities of 50,000 to 80,000 ohm-metres is marked. The firn curve from the top of the ice-cap and the two-layer theoretical curves are shown in Fig. 3.

Of interest also was the variation of resistivity within the ice itself. Independent measurements on snow, firn, and surface ice, coupled with glaciological evidence (pits, cores, temperatures) should provide clues to the causes of these variations. It is hoped that the firn curves obtained this summer, in conjuction with pit and core data, can be used as a basis for formulating theoretical curves of use in obtaining information on both the depth and the nature of firn layers.

The conductivity of melt samples of snow cover, firn, and ice were measured in the field using the Philips conductivity meter operated from a d.c. invertor and storage battery. Field techniques were not precise enough to detect systematic variations with altitude, location, etc. if such existed. The conductivity of all samples varied between 1.4×10^3 and 5.6×10^3 ohm-metres.

The assistance of Dr. Fritz Müller in obtaining certain equipment is gratefully acknowledged as well as the loan by the Institute of Earth Sciences, University of British Columbia, of the conductivity meter and gravimeter.

J. P. GREENHOUSE

Gravity survey, summer 1962

The gravity work was aimed at determining ice thicknesses and underlying topography of the western half of the Devon Island Ice-Cap. The profiles measured are shown in Fig. 1. Gravity stations were established at intervals of approximately 1.5 km. on the major 80-km. traverse and on a 15-km. traverse to the top of the ice-cap. In addition a detailed survey 0.5 km. in length was run across the northwestern edge of the ice-cap with stations at intervals of 50 m. to investigate morainal material in the ice, and a profile of seven stations was read across the Sverdrup Glacier to make comparisons with geoelectric depth soundings. All the readings on the ice-cap were tied to a gravity base at the Base Station on the north coast.

The gravity measurements were made with Worden gravimeter No. 35 on loan from the University of British Columbia Geophysics Laboratory. This meter has a calibration supplied by the manufacturer of 0.4187 milligals per scale division and instrument drift was found to be less than 0.1 mgals. per hour. The survey techniques used are described by J. P. Greenhouse in the accompanying report. A total of 96 gravity stations was occupied.

Ice-cap thickness

The gravity method of determining the thickness of glacial ice utilizes the large contrast in density and thus gravitational attraction, between ice and the underlying rock. The Bouguer gravity anomaly (i.e., observed gravity differences with suitable corrections) is calculated using the density of ice for stations on the ice-cap relative to a base established on the bedrock. The altitude of the rock surface below a station on the ice relative to this base is then given by:

$$h = \frac{\text{Bouguer anomaly}}{2\pi G(\Delta \delta)}$$

(using density of ice)

where:

G is the gravitation constant and
$\Delta\delta$ is the density contrast between the rock and ice.

With the exception of the edges and the control stations off the ice-cap, the slopes were sufficiently gentle to require no topographic correction. The error so introduced in these stations should be negligible.

The altitude values are expected to be correct within ± 20 cm./km. of traverse with the exception of the southern seven stations where difficult conditions should decrease the accuracy to ± 40 cm./km. The accumulated error should be ± 10 m. at the top of the ice-cap.

The latitude corrections are expected to introduce an error of less than ± 0.01 mgals/km.

The suggested densities for rock and ice are 2.67 gm./cc. and 0.91 gm./cc. respectively. Rock densities will be checked with geological results in the surrounding areas and ice densities with glaciological cores. At higher altitudes of the ice-cap a correction should be applied to account for the lower density of the surface layer as determined by glaciological cores, pits and geoelectric profiles. Errors in these densities should introduce an error of less than 4 per cent in the computed ice thicknesses.

The total error from all these sources should be less than ± 10 per cent, which is equivalent to about ± 100 m. at the centre of the ice cap.

A further large source of error lies in regional changes in gravity values, or isostatic anomalies. These may only be estimated from the values at stations off the ice-cap, assuming a linear gradient of gravity between these points.

It should be noted that in all depth computations the rock surface is assumed to approximate an infinite level sheet. The rock topography below the ice may thus be defined only to the extent that its features are large compared with the ice thickness. Small sharp features are smoothed out to be indistinguishable from those that are larger but with less relief.

Glacier thickness

In computing the glacier profile, the altitudes, latitudes, and densities should introduce negligible errors. The major error lies in computing topographical corrections and determining reference gravity value for a zero ice-thickness at the edges of the glacier. These are particularly critical due to the almost vertical walls of this glacier valley. It is expected that the depth may be computed within ± 20 per cent and an approximate shape given.

Computation of ice thicknesses and more precise estimates of accuracy and sources of error require reduction of the survey results.

R. D. HYNDMAN

Glaciology, summer 1962

Introduction

The glaciological program for the summer of 1962 was basically a continuation and extension of work started in 1961. The greater part of the program was divided between a study of the mass balance of the ice-cap and run-off measurements, using the chromate-dilution method, on the Sverdrup Glacier. The glaciological routes are shown in Figure 4.

The 1961 profile of 22 stakes (excluding lateral profiles) was increased to 44 between the altitudes of 400 ft. on the glacier and 6,000 ft. on the top of the ice-cap. These were spaced at 100-foot-altitude intervals on the glacier and near the expected net accumulation line, and at 200-foot-altitude intervals elsewhere. The length of the profile is about 39 miles. This profile was extended down the southeast side of the ice-cap to a point north of the Cunningham Mountains (southeast profile), and 20 stakes were spaced at 200-foot-altitude intervals with a concentration at 100-foot-altitude intervals near the expected net accumulation line. Terrain potentially dangerous for a single Weasel prevented a continuation of this profile directly

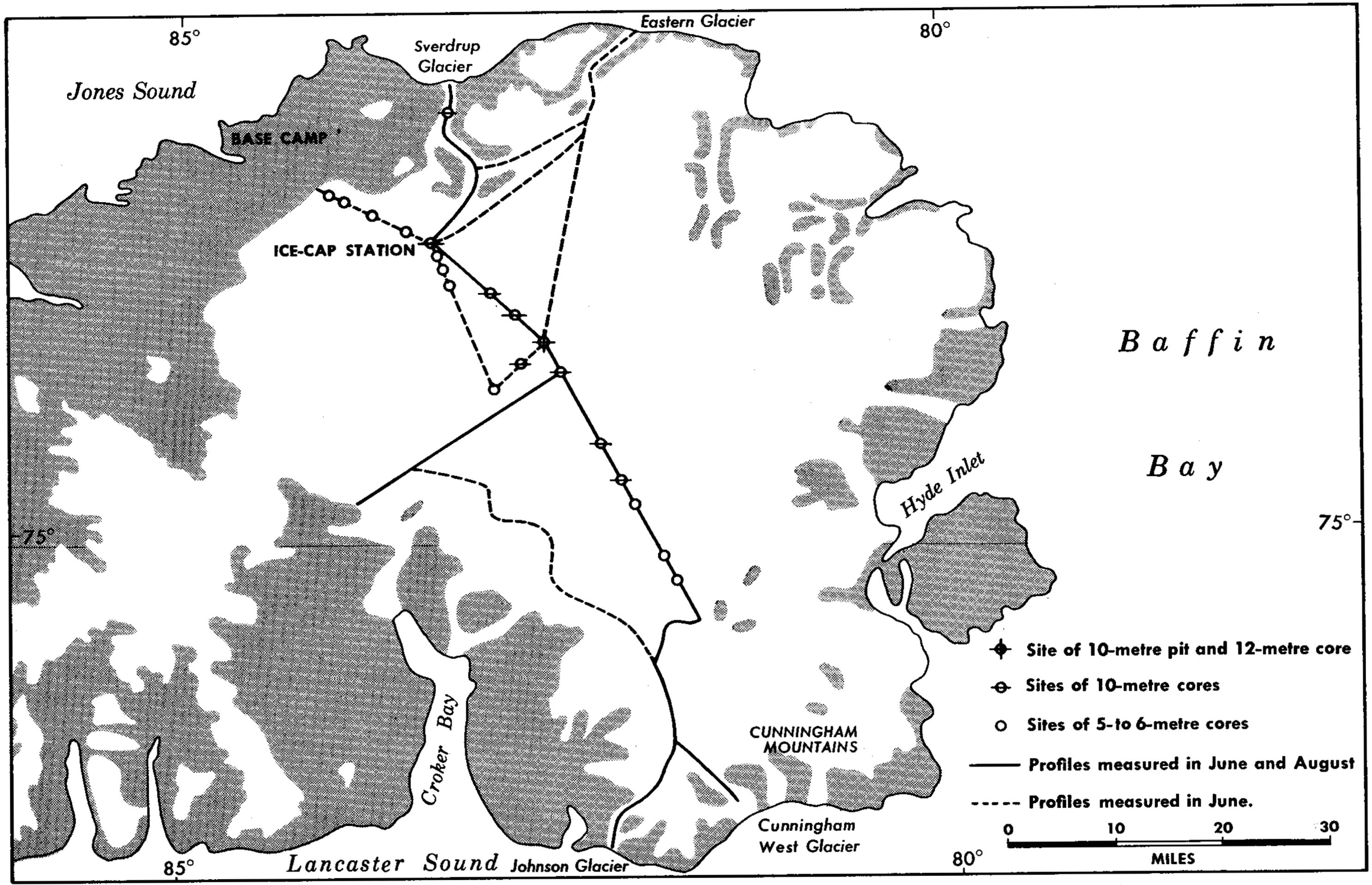

Fig. 4. Map of Devon Island ice-cap, showing traverses and sites of glaciological investigations.

down a valley glacier to sea-level. Instead, 9 stakes completed the profile from the top of a ridge at 3000 ft. to the west of Cunningham West Glacier down to 800 ft. above sea-level on the same glacier. A supplementary longitudinal profile of 7 stakes was set into the Johnson Glacier a few miles to the west.

A line of 23 stakes was set up from the edge of the ice-cap 5 miles west of Croker Bay West Glacier to the top of the ice-cap. The last major profile consisted of 19 stakes from the top of the ice-cap on a course N. 15° E. and along the "Eastern Glacier". These were all sited on the same basis as those on the southeast profile.

On all traverses the winter snow was studied in detail. Pits were dug every mile for stratigraphic records, and every second mile or at each stake densities, temperatures, grain size, and stratigraphy were recorded. These were supplemented by numerous measurements of depth of snow along the route. The total gives a very accurate picture of accumulation on the ice-cap for the period beginning with the end of the 1961 melting for the whole area except the eastern side.

The stakes were remeasured at the end of August and pits dug to examine the effect of the melting season. The profile from the top of the ice-cap to the "Eastern Glacier" could not be remeasured because of vehicle failure.

The profile from the Sverdrup Glacier to the top of the ice-cap was measured on several occasions and the more detailed pattern of stakes on the glacier was used during run-off measurements. This consisted of a longitudinal profile of 23 stakes and 4 profiles across the glacier below 1000 ft. This gave a total of 36 stakes on the glacier.

Two thermocouple sets consisting of copper-constantan elements were installed on the top of the ice-cap at 6000 ft. altitude and on the Sverdrup Glacier at 1000 ft. With the set installed at 4,300 ft. near the Ice-Cap Station last year, there is now a reasonable coverage of the major budget zones on the northwest side of the ice-cap. Elements have been set at 1-m.-intervals to 12 m. on the glacier and to 10 m. at the other two sites. The Ice-Cap Station set was read weekly during the melting season, the glacier set was read five times between May and August, and the set at the top of the ice-cap was read in early July and late August. The 10-m. thermocouple at the top of the ice-cap gave unreliable readings, but all readings from the other three sets were satisfactory.

A series of 10-metre-long cores were taken on the snow traverses. Cores were examined from stations 2, 4, and 6 miles from the top of the ice-cap on the southeastern route and 8 miles from the top on the northwestern route. Cores 5 m. long were taken just below the firn line on the southeastern route and in an area of unusually high accumulation just to the north of the Cunningham Mountains. These supplement cores taken in 1961 along a profile near the southwestern route and in the region of the firn line on the northwest side. Densities, grain size, and stratigraphy were recorded at the core sites.

As a control for these cores, a pit was excavated to 10 m. at the top of the ice-cap. A 12-m. core was taken from the base of the pit giving a total depth of 22 m. Densities, grain size, stratigraphy, and temperatures were recorded throughout. The stratigraphy was analyzed on the basis of a pattern formulated in discussion with Dr. Fritz Müller at the site. The pit penetrated the firn to deposits from the year 1938. The core stratigraphy has not yet been analysed but should give tentative figures extending back to the early part of the century. The information from this site now includes the 22-m. pit and core, a series of shallow pits and trenches, and two 10-m. cores.

Run-off measurements were made on the Sverdrup Glacier in July and early August using dilution equipment lent by the Jacobsen-McGill Axel Heiberg Expedition. An Ott water-level recorder was set up in a supra-glacial stream in the second week of July. The recorder trace was checked by measurements with the dichromate-dilution method and occasionally with an Ott current meter. Measurements were made at 3-hour intervals on 4 separate days when the weather was similar at the Ice-Cap Station, the Base Station, and the glacier. These should allow the radiation measurements from the Ice-Cap Station and the Base Station to be used in conjunction with meteorological measurements taken at the glacier camp. The last named included wind speeds at 1- and 5-m. heights, temperatures and humidities at 1-m. height, and cloud observations.

Ice ablation in the catchment area was measured at three ablatometers. Each of these consisted of 3 stakes in the form of a triangle connected by a wire marked every 10 cm. Measurements from these marks to the ice surface when averaged give an accurate reading of ice ablation. The camp ablatometer was read every 6 hours and the other two (one at the mid-point of the catchment area and the other at its head) at the beginning and end of a series of three-hour run-off measurements. The catchment area, which measured approximately 1600 by 100 m., was surveyed by the expedition surveyor at the end of the melting season.

Run-off measurements covered the period from July 14 to August 11; and this included the period of fastest melting. During the same period the stake profiles were read every 10 days. Within a few days of the conclusion of the measurements the melt-streams were filled with drifted snow.

Results

The snow traverses revealed an area of high accumulation on the southeastern side of the ice-cap. Snow depths (not converted to water equivalents) were lowest on the northwestern side of the ice-cap (30 cm.) and highest on the southeastern side (ca. 130 cm.). On the latter profile there was a gradual increase in the depth of winter snow ca. 10 miles from the top of the ice-cap. South of the climatic firn line a broad valley, aligned east-west and ending in Hyde Inlet, introduced an abrupt change in the snow depth. The depth increased from 80 to 100 cm. on the north slope to 130 cm. on the southern slope of the valley; this depth was found to persist right to the Cunningham Mts. The increase was accompanied by the reappearance of firn to a depth of 3 to 5 m. The southwestern and northern routes gave snow depths in the 40- to 50-cm. range although the Eastern Glacier had a snow cover of 80 to 100 cm. The snow depth greatly influenced the effect of the melting season. Preliminary approximate figures for the height of the net accumulation line for the budget year 1961-62 were 4900 ft. on the northwestern, 3000 ft. on the southeastern and 4100 ft. on the southwestern side. Superimposed ice was an important form of accumulation (up to 30 cm. of ice) except on the northwestern side, where the net accumulation line was situated slightly above the climatic firn line. The cores taken in spring indicate that this variation is not peculiar to 1961-62. The climatic firn line lies considerably lower on the southeastern side than elsewhere and a large firn outlier of 100 miles^2 north of the Cunningham Mts. has brought the firn line down to about 3500 ft. during at least the last 4 years.

Comparison with results of 1961 from the Sverdrup Glacier and the northwestern side of the ice-cap indicates a much higher order of ablation for this season. Despite this the pit studies above the firn line show that ice layers were more characteristic for the 1960-61 summer. This suggests that ice layering is largely dependent on the rate of progress of melting rather than on the length of the melting period.

During the period of maximum melting, radiation was the most important single factor on the Sverdrup Glacier and there was relatively little altitudinal difference in the amount of ice removed.

The stake profiles across the glacier indicate that the data from the longitudinal profile alone exaggerate the amount of ablation. This is basically due to the fact that the ice near the sides of a glacier is bubbly, has small crystals and a higher albedo than ice near the centre. Differences of ablation are therefore greatest in periods when the influence of radiation is highest. This factor does not apply to the ice-cap where variations in ice structure are unimportant.

It was originally intended to continue the petrofabric work begun during the winter. Lack of time only allowed an examination of superimposed ice from 1961-62 and of some glacier ice between crossed polaroids. However, in early May 1962 a few ice samples from the Sverdrup Glacier were examined in a u - stage immersed in water. One of these samples from a depth of 1 m. gave an unexpected pattern of four maxima typical of temperate but not of polar ice (the observed temperatures place the glacier in the sub-polar category). Unfortunately the optic axes of only 50 crystals were oriented, which is insufficient for a satisfactory fabric diagram. A further sample from 12 m. gave a different pattern. This pattern was similar to those determined by Rigsby in Greenland but it was much weaker; 200 optic axes were oriented in this sample. Both samples were from the centre of the glacier. These specimens plus others examined during the winter of 1961-62 suggest that further petrofabric work would be very profitable. The geo-electric and gravity surveys together with the levelling survey provide a good background for a more precise interpretation of petrofabric results. So far, all that can be said is that the strength of the concentrations depends on stresses set up in channelled ice and ice towards the edge of the ice-cap rather than on distance from the source. This is suggested by random orientations found in ice at the head of the Sverdrup Glacier, which is as far from the firn line as ice showing strong concentrations at the edge of the ice-cap northwest of the Ice-Cap Station.

R. M. KOERNER

Reviews

POINT HOPE. An Eskimo village in transition. By JAMES W. VANSTONE. *The American Ethnological Society. Seattle: University of Washington Press. 1962. 8¾ x 5¾ inches, x + 177 pages, 3 maps, 3 figures, 7 plates. $5.25.*

KOBUK RIVER PEOPLE. By J. L. GIDDINGS. University of Alaska Studies of Northern Peoples, Number 1. *College: Department of Anthropology and Geography, University of Alaska. 1961. Paper, 6 x 9 inches, 166 pages, sketch map, 4 plates. $2.50.*

The two books on western Alaska reviewed here contribute to our knowledge of the area in different ways; they represent different approaches and achieve different levels of complexity.

Dr. VanStone's monograph is concerned with the community at Point Hope. It approaches the subject in a style that might be called the "ethnographic present", covering the entire seasonal cycle, and providing detailed information in a number of sections on housing and subsistence, the life cycle, community structure, the individual, economic organization, and religion. A series of clearly formulated questions posing problems that face the community provide us, together with Dr. VanStone's answers, with a view into the future and the alternatives from which the people of Point Hope probably will have to choose.

The community in question achieved a rather remarkable balance between hunting, on the one hand, and wage labour and economics (in store-keeping), on the other. The extent to which