

*Photo: R.C.A.F.*

**Fig. 1.** Western Ward Hunt Island. The high hill (1,400 feet) is in the middle with the lake to the right. The ice on the lake melts around the edges only; in the centre it was 14 feet thick in mid-July. The final camp was on the "ice rise" to the left; the "ice rise" to the north of the island is also visible. Dirt on the ice shelf is mainly wind-borne and stream-borne material. In the distance the edge of the ice shelf and the polar pack can be seen. 4 July 1953.

# NORTHERN ELLESMERE ISLAND, 1953 AND 1954\*

G. Hattersley-Smith† and other members of the expeditions

**T**HERE have been few travellers in northern Ellesmere Island, and, until the present investigations, work in this region had been mainly exploratory. The following account mentions briefly the early visits and describes the journeys made by the expeditions of 1953 and 1954. Short appendices record some of the preliminary results in the fields of glaciology, geophysics, oceanography, and geology.

In 1876 Aldrich and his sailors, in the man-hauling tradition of those days, made a great sledge journey westward to Alert Point from Cape Sheridan, the winter quarters of the *Alert* (Captain Sir G. S. Nares, R.N.). Markham, of the same expedition, travelling northward from Cape Joseph Henry, reached latitude 83°20N., after the most arduous relaying over mountainous pressure ice, and Egerton journeyed up the valley of Wood River, southwest of winter quarters, to within sight of the ice cap of the United States Range. The members of the sledge parties, with few exceptions, suffered severely from scurvy, which caused the loss of two of the *Alert's* men and the abandonment of Nares's plans for a second season (*Parliamentary Paper*, 1877; Nares, 1878; Feilden and De Rance, 1878).

From 1881-4 Greely led the United States expedition to Lady Franklin Bay, spending two winters at Fort Conger on Discovery Harbour, and a third winter in disastrous retreat at Cape Sabine. In 1882 Pavey, Rice, and an Eskimo went north by the coastal route from Fort Conger trying to better Markham's "furthest north", but were forced back by open leads a few miles north of Cape Joseph Henry (Greely, 1886).

On his expedition of 1898-1902 Peary took up the quest for the north pole, which occupied him for the next decade. In 1902 he made his first foray along the north coast of Ellesmere Island, travelling from his base at Fort Conger with Greenlandic dog drivers. From Cape Hecla he turned north and reached latitude 84°17N., before being forced to return (Peary, 1907). On his 1905-6 expedition Peary wintered his ship, the *Roosevelt*, at Cape Sheridan. In the spring of 1906 he left land at Point Moss, and journeyed north to latitude 87°06N., before being forced back on the Greenland coast near Elison Ø. Only a few days after returning to his ship, Peary set out for the west with the intention of passing Aldrich's "farthest", and visiting the

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†Arctic Section, Defence Research Board of Canada.



unexplored coastline beyond to the northern limit of the survey of the Second Fram expedition (1898-1902) which had worked north up Nansen Sound. In this Peary was successful, and in fact reached "Cape Thomas Hubbard" (now Cape Stallworthy), the northern tip of Axel Heiberg Island. The journey back to Cape Sheridan in the height of the thaw season was probably the hardest Peary ever made (Peary, 1907). Peary "was ever a fighter", and in 1908 he again sailed north in the *Roosevelt* to winter quarters at Cape Sheridan, and in the following April attained his ultimate goal. On the north polar journey he travelled over the ice from Cape Columbia, where a large depot of stores had been laid by repeated sledge journeys from the expedition's winter quarters in the preceding months. Small depots were also placed as far west as Cape Fanshawe Martin, for possible use by returning parties caught by a westerly drift (Peary, 1910).

The north coast of Ellesmere Island was not visited again until 1920, when Comdr. Godfred Hansen on the Third Thule expedition laid depots at Fort Conger, Cape Richardson, and Cape Aldrich<sup>1</sup>, in support of Roald Amundsen's north polar drift in the *Maud*. Hansen made the long journey from Thule by dog team with Greenlandic drivers (Hansen, 1921).

The Lands Lokk area to the west was briefly visited in 1930 by H. K. E. Krüger and his two companions of the lost German expedition. They had journeyed north from Neqe, in northwest Greenland, via Bay Fiord and Nansen Sound, and later reached Cape Stallworthy, where their record was found by Cpl. H. W. Stallworthy on the search expedition of 1932. Their subsequent fate is unknown (*Polar Record*, 1934).

In 1935 the Oxford University Ellesmere Land expedition, based on Etah, sent one party by way of Fort Conger and Lake Hazen into the mountains of northern Ellesmere Island. A. W. Moore and the Greenlander Nukapinguaq reached a height of 9,000 feet, whence they had a view of the unknown land as far as the ice of the Arctic Ocean at Clements Markham Inlet on the north coast (Moore, 1936, p. 425).

It was not until after the Second World War that the U.S. Navy icebreaker *Edisto* and the U.S. Coastguard icebreaker *Eastwind* in 1948 reconnoitred the northeast coast of Ellesmere Island as far west as Cape Belknap, where a cache was laid for a future weather station. Two years later the weather station, Alert, was established just south of the cape.

In 1951 P. F. Bruggemann and S. D. MacDonald studied the biology around Alert, and made a trip up Wood River almost to the ice cap (Bruggemann and Calder, 1953; MacDonald, 1953). The next year P. Gadbois and C. Laverdière carried out a geographical survey within a 10 to 15 mile radius of the weather station (Gadbois and Laverdière, 1954).

In 1946 the discovery that huge floating ice masses, later known as ice islands, existed in the Arctic Ocean gave rise to speculation on their origin and possible strategic value. Subsequent flights and the study of air photographs strongly suggested that the ice shelf along the northern coast of Ellesmere Island was the most likely source area (Koenig *et al.*, 1952). On 19 March

<sup>1</sup>The Danes referred to this as the Cape Columbia Depot.

1952 the U.S. Air Force made the first landing on the ice island T3 to set up a weather station, which became a base for research in oceanography, hydrography, glaciology, and geophysics until May 1954 when the station was temporarily abandoned.<sup>1</sup> Flying from T3 in May 1952, Lt. Col. J. O. Fletcher, Lt. Col. W. P. Benedict, and A. P. Crary landed briefly on the Ellesmere Ice Shelf near Ward Hunt Island to examine the shelf, and at Cape Aldrich, farther east, to examine the Peary monument of 1909 and the Hansen cache of 1920 (Fletcher, 1953; Rodahl, 1953).

It seemed logical to follow up the work on T3 with a complementary program on the probable parent ice mass. The Defence Research Board of Canada, therefore, planned a reconnaissance in 1953, in cooperation with the Geological Survey of Canada, to prepare the way for detailed work on the ice shelf in 1954. It had been hoped that the U.S. Air Force Cambridge Research Center and the Snow, Ice, and Permafrost Research Establishment, Corps of Engineers, U.S. Army, which had sponsored the geophysical and glaciological studies respectively on T3, would participate, but, unfortunately, owing to prior commitments this was not possible in 1953. By great good fortune the 1954 party included A. P. Crary, geophysicist from A.F.C.R.C., and E. W. Marshall, glaciologist from S.I.P.R.E., both experienced men who between them had spent a total of more than twenty months on T3. The Geological Survey of Canada was interested in obtaining geological data from this almost unknown region and their officers—R. G. Blackadar in 1953, and R. L. Christie in 1954—not only made valuable contributions in their own field, but were also extremely helpful in other fields of study.

The expeditions of both years are grateful to the U.S. Air Force for the necessary logistic support, and to the Controller of the Canadian Meteorological Service and the staff of Alert Weather Station for the facilities and hospitality provided. Through the courtesy of the Danish authorities it was possible to enlist two Greenlanders who served as dog drivers for the first two months of each season. They were Rasmus Majak and Sigssuk in 1953, and Imina and Karkutirak in 1954.

### The 1953 expedition

In 1953 Blackadar and I were flown by the U.S. Air Force from Ottawa via Westover Air Force Base to Thule, where we arrived early on April 21. After picking up Rasmus Majak and his thirteen dogs, we continued to Alert, landing late that afternoon. Over 7,000 lb. of food and equipment had preceded us; most of this weight consisted of frozen horse meat as dog pemmican was not available. It soon became apparent that Majak was unwilling to accompany us on more than a day's trip from Alert without a Greenlandic companion; he remembered that Ahqioq had been the only Greenlandic on the Krüger expedition, and had not come back. This seemed to us a very reasonable point of view, and we requested the Danish authorities for the

<sup>1</sup>A small United States party, under the leadership of A. P. Crary, reoccupied the station in April 1955.

services of another Greenlander. Sigssuk arrived with six more dogs on April 28, and the following day we left with the two dog teams for the west by the coastal route, made historic by the journeys of Aldrich and Peary.

Our progress along the north coast as far as Point Moss was hindered by the rough pack ice and hummocky bay ice and the soft, often deep, snow which made it impossible for the dogs to haul more than about 600 lb. per komatik. Although we planned to be away from Alert for only about three weeks, the weight of the horse meat, three times that of an equivalent amount of dog pemmican, enforced relaying for the first part of the journey.

It was not, therefore, until May 11 that we reached Cape Columbia on our way to the main development of the ice shelf, which starts in Markham Bay west of Cape Columbia. Up to this time we spent the first nine hours or so of each day travelling, and geological work and ice and snow cover measurement had to be done after camping. We left food depots along the way to be used on the return trip.

Between Alert and Cape Columbia we visited three cairns left by previous expeditions. On View Hill (Feilden Peninsula) there stands the cairn built by Aldrich in 1876 and visited by Pavey in 1882, who removed Aldrich's record and left his own; we found nothing in the cairn. On the highest point of Crozier Island we visited the huge cairn built by Aldrich on his outward journey to Alert Point (*Parliamentary Paper*, 1877, p. 188). It was heavily banked with snow at the time of our visit on May 6, but on a subsequent visit Aldrich's record of 18 April 1876<sup>1</sup> came to light, somewhat discoloured in a rusty tin canister. The third cairn was a dismantled one at Cape Colan, which doubtless marked the site of the depot left at this point by Aldrich in 1876 or Peary in 1909—or of both.

On May 11 we made camp on the ice-foot at Cape Aldrich and walked up the low headland to look at the Peary signpost nearby. The upper part of the post was broken off, and the board with Cape Columbia inscribed and the arm pointing to the north pole were hanging down. The arms were still stayed by the wires shown in Peary's photograph (Peary, 1910, *facing* p. 324). Lashed to the post were the ski and ski-pole left by Fletcher, Benedict, and Crary when they landed here in 1952 (Fletcher, 1953; Rodahl, 1953). An earthenware jar was standing at the foot of the cairn; although the lid was tightly clamped down, the rubber washer had perished and water had reduced the paper inside to pulp.

Two hundred yards west of the signpost we could see the broad komatik runners marking Hansen's cache, half buried in the snow. The cache contained a primus stove in a tin; a can of kerosene; two cases of sledge-rations put up by Beauvais of Copenhagen, with about half the food in good condition; a very fine shotgun-rifle in a tin box with cartridges by Kynoch and rifle shells; a crow-bar; and, most interesting of all, a small tin box containing Godfred Hansen's records, the plans for the depot journey to Cape Columbia, signed by Knud Rasmussen, and mail, all addressed to Captain Roald Amundsen (Fig. 4). All the papers were carefully wrapped in oiled silk, and were in as

<sup>1</sup>See p. 33.

perfect condition as on the day they were left. With the papers were two pairs of snow-goggles by Cornelius Knudsen of Copenhagen (Hansen, 1921).

On May 12 we mended the signpost and fixed Peary's broad runners from the cache to one of our komatiks to speed us on our return trip. In the afternoon Blackadar and I fixed marker poles on a remnant of the ice shelf in Parr Bay. The next morning in light drift and low visibility the whole party ascended the 1,800-foot eastern peak of Cooper Key Mountain. Unfortunately, there was no view from the summit, which was in cloud, and a 40-knot wind was blowing, but we found Peary's massive cairn with the broken stump of the ash stave he had fixed there. Near the top of the cairn, slipped into a crevice, was a small cocoa tin, the lid of which opened easily. Inside was the piece of Peary's north polar flag and the record which he had deposited on 8 June 1906 (Peary, 1907, p. 183; for facsimile of record see Stafford, 1954, p. 525).

On May 14 we visited Markham Bay (Fig. 3), following the ice-foot round Cooper Key Mountain before going out on the sea ice. Across the ice shelf in the mouth of the bay I aligned survey poles to act as movement and ablation markers, while Blackadar studied the geology. The tremendous rampart of blue ice blocks along the ice-foot of Cape Columbia rises to 40 feet, and testifies to the great driving force of the polar pack. Next day we were tent-bound at Cape Aldrich by a blizzard, with wind gusts up to 50 knots. On May 16 we set out for Alert. During the return trip, which took five days, we made a detour 5 miles down Clements Markham Inlet for geological work; there, a small and evidently starving hair seal on the ice provided one fresh meal for the dogs.

We left Alert again on May 27 for the small bay southwest of Point Moss to study the remnant of ice shelf in the bay and the local geology. On this occasion we followed the ice-foot around Cape Hecla, instead of taking the Sail Harbour route to Cape Colan as before, and the journey took four and a half days, including one day lying-up because of bad weather. On the return trip we made a detour 25 miles down Clements Markham Inlet, where we left a food depot for possible use later in the season. We arrived back at Alert on June 9.

Between June 12 and 15 we were away from Alert in the Cape Sheridan region making geological observations. During this time we laid a depot 12 miles inland from Floeberg Beach, backpacking for the last 4 miles the food which we planned to use later in the summer. There are cairns or monuments above Floeberg Beach commemorating the "British Arctic expedition" (1875-6), Niels Christian Petersen (d.1876), the *Roosevelt* (1905-6: two cairns), Ross G. Marvin (d.1909), and the U.S. Navy and Coast Guard (1950).

The Greenlanders were now extremely anxious to return to Thule for the summer hunting and there followed a frustrating, though unavoidable and not unpleasant, period of two weeks at Alert, waiting daily for an aircraft to take them out. They finally left on July 2, and the next day Blackadar and I departed on foot for Wood River and the United States Range, carrying loads of about 80 lb. each.

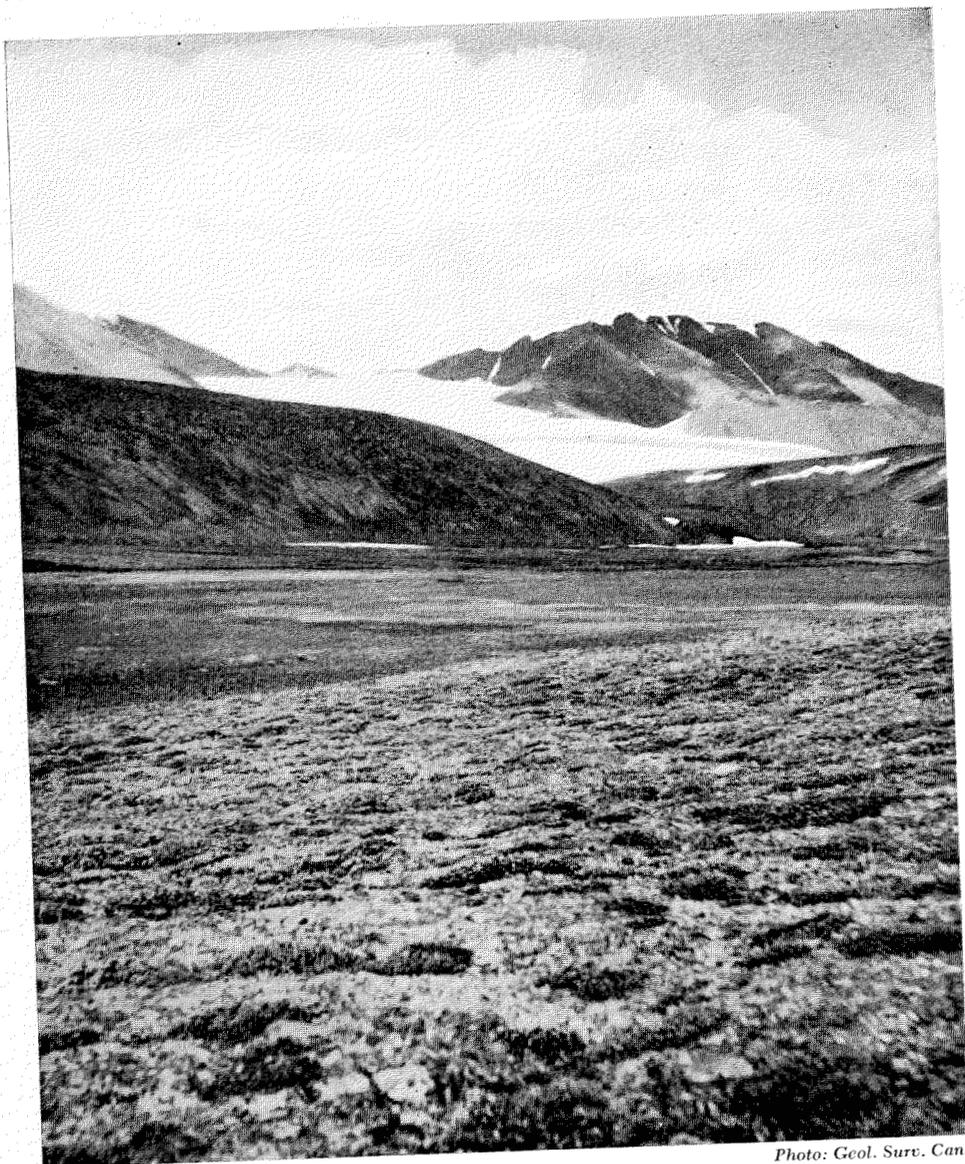


**Fig. 3.** Looking west across Markham Bay to Cape Nares. The faulted Permo-Carboniferous limestone unconformably overlies steeply dipping gneissic rocks. 2 May 1954.



**Fig. 4.** Majak, Sigssuk, and Hattersley-Smith examining the cache left by Godfred Hansen at Cape Aldrich. 12 May 1953.

*Photo: Geol. Surv. Can.*



*Photo: Geol. Surv. Can.*

**Fig. 5.** The United States Range, looking west from 10 miles south of the head of Wood River. Saxifrage growing in foreground; piedmont glacier in background. 11 July 1953.

The ice in Black Cliffs Bay was in a very puddled condition; in fact we crossed it just before it went out—a few days later and we would have had a long walk round the head of the bay. At the mouth of Wood River we picked up food from a cache laid by dog team in May. To reach this cache, which was on the north side of the river, we had to make a tricky fording of the thigh-deep, fast-flowing stream; we then threw the food across to our campsite on the south side.

On the afternoon of July 5 we started making our way up Wood River, carrying about 60 lb. each. The setting for this walk was delightful. In perfect weather we passed groups of muskoxen grazing amid purple saxifrage and yellow poppies, and glimpsed the snowclad mountains to the southwest. But the scrambling up and down the rocky spurs along the south side of the river with heavy packs marred our enjoyment. After averaging about 12 miles a day, we made our final camp a mile from the first big glacier lobe at the head of Wood River valley on July 7 (Fig. 5). We spent the next six days in trips to the glaciers nearby for snow and firn measurements, in an ascent of Mount Grant, 5,600 feet, and in a walk to the very large ice lobe 20 miles south of camp. Here we found Tertiary deposits with coal and plant remains near the 100-foot ice-cliff.

The weather deteriorated on July 13, and we left camp in light snow, reaching the mouth of Wood River next day. On the 15th, after a leisurely breakfast of scones cooked over an open fire of driftwood and muskox dung, we set out on a four-day trip up "Patterson River",<sup>1</sup> over the divide to the west, and back by "James Ross River", Feilden Peninsula, Porter Bay, and Cape Cresswell in overcast weather, with occasional light snow or sleet. On this trip Blackadar collected geological data, much of which had been obscured by snow on our earlier trips. We did not use our Clements Markham Inlet depot. We arrived back at the mouth of Wood River on July 18, and reached Alert the following day, after walking round the head of Black Cliffs Bay. We had covered over 300 miles during the seventeen days we had been away.

In the last days of July we attempted to walk to Fort Conger, using the food depot we had laid in June, but were foiled by bad weather and poor visibility. We contented ourselves with visiting an old camp, 12 miles south of Cape Sheridan, established by Giffard and Conybeare on 7 July 1876 (Conybeare, 1930, pp. 134-5) and discovered by John Lewis, Officer-in-Charge Alert Weather Station 1950-1 and 1953. We brought back two sleeping bags, some clothes, a pair of canvas boots, a thermometer, and a first aid kit.

Bad weather now set in, and, except for a three-day trip to Black Cape over the first snow of winter, we remained at Alert packing our equipment. We left by air on August 16 for Thule and the south.

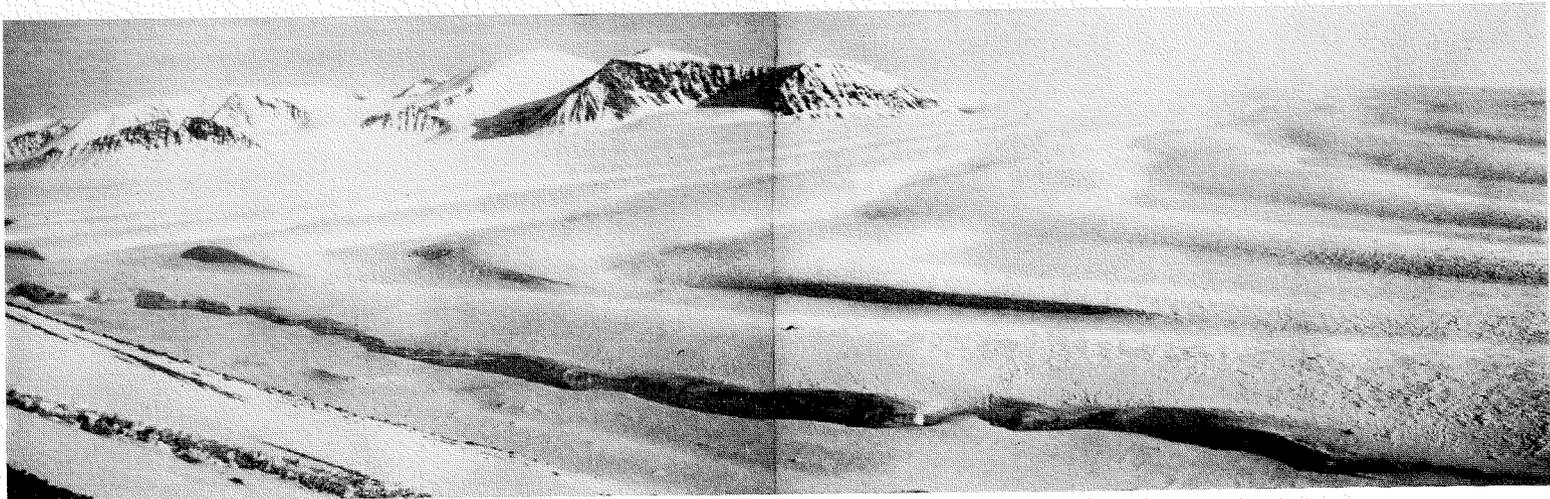
### The 1954 expedition

In 1954 Crary, Marshall, Christie, and I, with the Greenlanders Imina and Karkutirak, and twenty-four dogs, made our main camp on the ice shelf near Ward Hunt Island (Fig. 6), where we landed on April 24 in two ski-wheel C47 aircraft of Northeast Air Command. The first aircraft was piloted by Col. B. Hansen, Deputy Commander of Thule Air Base, and Col. W. L. Kimball, Commander of Thule Air Base, flew in with the second aircraft. We had food with us for several weeks and enough equipment to enable us

<sup>1</sup>Place names given in quotation marks are new names which have been submitted to the Board on Geographical Names but have not yet been adopted.



**Fig. 6.** The main camp on the ice shelf, looking south. 28 April 1954.



**Fig. 7.** The ice shelf in Ayles Bay, looking west. 3 June 1954.

to start work at once; the remainder of our food and equipment was to be brought in when weather permitted. The evening was calm and clear, with the temperature about zero, and the aircraft took off immediately after unloading. The next day a blizzard set in and lasted for two days, but we were well installed in our two pyramid and two mountain tents, with our food and equipment piled up outside.

On April 29 Marshall, Christie, and I with the Greenlanders went on a two-day trip to Cape Albert Edward; Christie made a geological traverse and Marshall and I took snow depth, density, and temperature measurements on the glacier south of the cape. While we were away, two more aircraft loads of food and equipment were flown in.

On May 2 Christie and I and the two Greenlanders left for Cape Columbia. The first night we camped in the middle of Markham Bay, and the following day, while Christie and Karkutirak travelled down Markham Bay to study the geology, Imina and I checked on the poles set up in 1953. Christie and Karkutirak had heavy going due to the deep soft snow a few miles south of camp, and the very steep sides of the troughs on the ice shelf in the fiord; they did not return until late afternoon. An hour later we left Markham Bay, and made camp that evening half a mile from the Peary signpost at Cape Aldrich. On May 4, with one dog team, we visited Parr Bay and recovered Hansen's note<sup>1</sup> from MacMillan's tide-gauge cairn, 3 miles south of Cape Aldrich at the site of "Crane City", Peary's advance base for the polar journey. The site was marked by broken sledges, boxes, and rusty tins. Unfortunately the iron pipe, the tip of which was the index mark of the tide gauge, had fallen down and so was worthless for further observations. While Christie and Karkutirak did geological work in Parr Bay, visiting Wood Point, I searched unsuccessfully for my poles set up in 1953 on the remnant of ice shelf in Parr Bay. We spent another day making observations near Cape Aldrich, and started back on May 6. The thick snow of the previous day slowed us down, after we had left the ice-foot of Cape Columbia, and we were eventually obliged to camp about 7 miles east of Ward Hunt Island. We reached the main camp just before noon the following day.

While we were away, Crary and Marshall had succeeded in coring a hole to a depth of nearly 80 feet in the ice shelf at the campsite. On May 8 we installed thermocouples at various depths in this deep hole. Next day, Crary and Christie with Imina set off down Disraeli Bay (Fig. 8) to map the geology and to take soundings, but they were forced to turn back near the mouth of the bay because of deep soft snow, for which the fan-style of dog driving is quite unsuitable. Even on skis travel was difficult. Meanwhile Marshall set up camp near the edge of the shelf north of the main camp to take ice cores.

It was at this time that Karkutirak informed me that he wished to go back to Thule for the hunting. Imina now seemed uncertain whether he, too, might not want to return before the end of the summer; he was definitely unwilling to stay unless another Greenlander came in to replace Karkutirak. Provided they would leave us enough dogs, it seemed best for both to go back to Thule

<sup>1</sup>See p. 34.



*Photo: R.C.A.F.*

**Fig. 8.** Looking south into Disraeli Bay at the beginning of the thaw season, showing the "Marvin Islands" at the entrance of the bay. Near the small island 10 miles from the entrance no bottom was recorded at 300 metres. 4 July 1953.

on the first available aircraft. Karkutirak kindly agreed to leave us ten of his twelve dogs and Imina agreed to leave four of his. We had the greatest regard and friendship for the Greenlanders, and fully appreciated their point of view.

Christie and I now started making preparations for our trip to the west; we would drive Karkutirak's dogs on this journey. In our absence Crary would go ahead with survey work and levelling on the ice shelf, while Marshall carried on his ice petrology.

Christie and I started west in perfect weather on May 14, intending to be away between twenty-one and twenty-four days. We carried a load of about 600 lb. on the komatik. Our plan was to reach Lands Lokk as fast as possible, cutting straight across the mouths of the deep fiords and travelling, for the most part, at some distance from the land. We would take longer on the return trip and make detours into the fiords for geological work.

The surface was good and we covered about 25 miles per day crossing Alert Point on May 18, the same date that 78 years earlier Aldrich had reached

July 5<sup>th</sup> 1906

Arrived here 4 - a. m.; June 24<sup>th</sup>  
from the Peary Arctic Club's  
Steamer Roosevelt, which was  
tered of C. Sheridan.

Have been very across the  
Channel to the next land to the  
west.

Am now returning to  
the Roosevelt. Delayed here now  
two days by stormy weather.

Expect to start in an hour  
or two.

The ice in every direction  
flooded deep with water.

R. E. Peary, U.S.N.



**Figs. 9 and 10.**  
Peary record and  
cairn at Cape  
Colgate. Christie  
beside cairn,  
22 May 1954.

Alert Point, his "farthest" (*Parliamentary Paper*, 1877, p. 213). On the point we noticed two caribou, which, with one seal in Phillips Bay on the way back, were the only game seen on this trip. From Cape Bourne onward, and throughout the return journey, Christie did geological work during the day, while I drove the dogs to some agreed campsite, where we met in the evening. At Cape Colgate we recovered Peary's record of 5 July 1906 from the cairn 200 feet above the shore (Figs. 9 and 10) (Peary, 1907, p. 219). The following day we made camp close to the westernmost point of the coastline. Nearby was a Peary cairn in which we found Krüger's record of 22 April 1930, soldered into a tin (Figs. 11 and 12) (*Polar Record*, 1934). On May 23 Christie and I walked down to Lands Lokk, leaving the dogs in camp.

On the return trip to the main camp, which took fourteen days, Christie completed the geological reconnaissance of the north coast of Ellesmere Island, and I made glaciological observations and brought back two 10-foot ice cores from the remnant of ice shelf west of Alert Point. At Cape Fanshawe Martin we kept a sharp lookout for Aldrich's cairn, but there was no sign of it from the shore or from the sea ice. Later I climbed the most likely looking hill, rising 300 feet above the shore, and there on top was the massive cairn, invisible from below because of the convexity of the slope. Aldrich's tin canister was found after some of the upper blocks of the cairn had been removed. It

Die Deutsche Arktische Expedition,  
von Nerke in Nordgrönland durch Bag-  
Fjord kommend, erreichte am 22. April 1930  
diesen von Peary erbauten Steinmann  
(kein Bericht vorgefunden).

Wir gehen weiter zur Nordspitze  
von Heiberg-Land. Ein Schlitten, 1½ Hunde  
und drei Mann in gutem Zustande.

Åge Rose Bygare

A k 9 i 0 9

H. K. S. Krüger  
Leiter

Fig. 11. Record left by Krüger, four miles west of Cape Colgate.



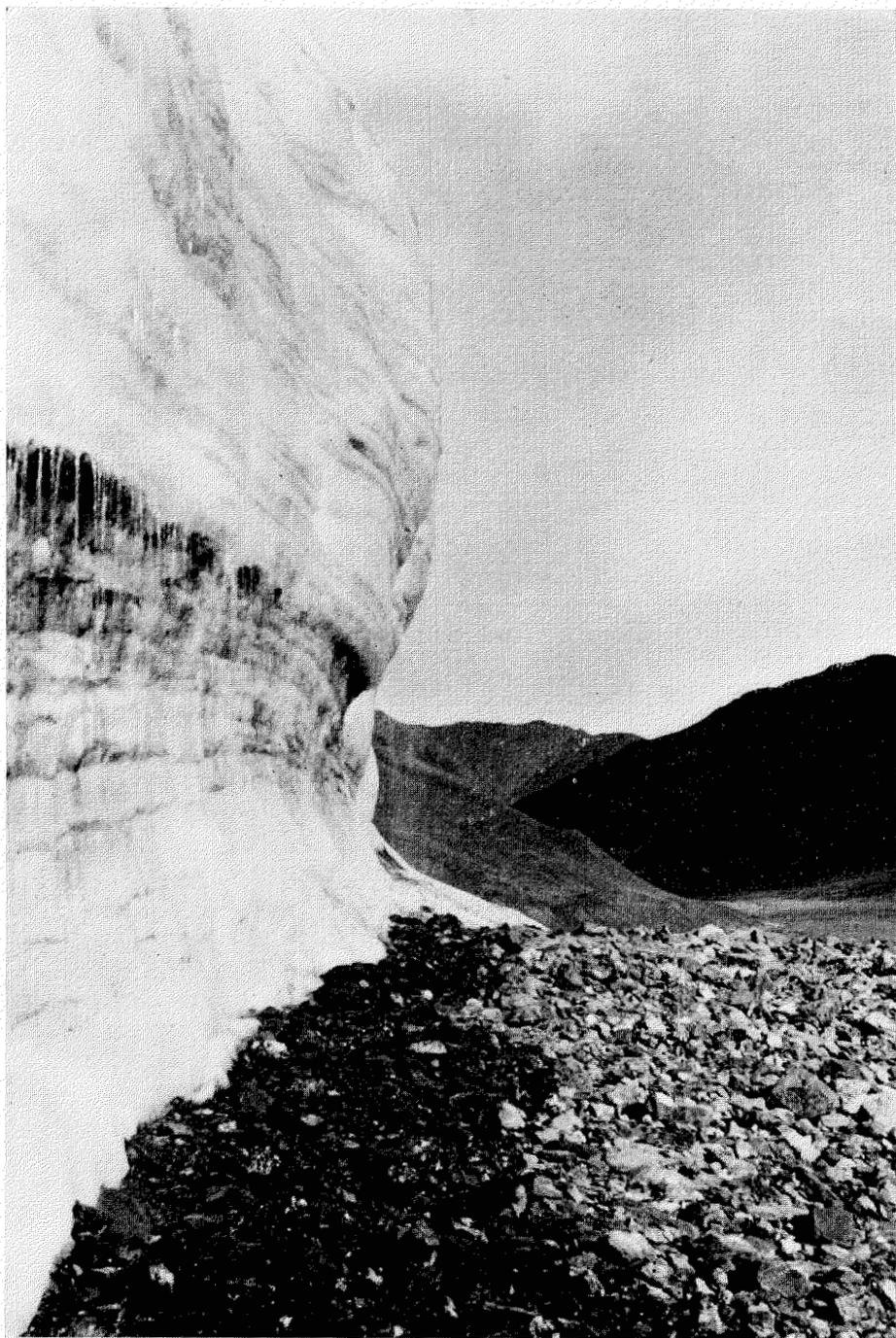
Fig. 12. Lands Lokk region looking southwest across Nansen Sound to Cape Stallworthy on Axel Heiberg Island. The arrow indicates the position of the cairn containing the Krüger record. "Bjare Strait" and "Krüger Island" are shown. A small ice island is just visible near the middle of the picture. 16 July 1950.

contained the record and copy of his chart<sup>1</sup> packed in a small inner canister, set in candle wax (*Parliamentary Paper*, 1877, pp. 216-7); both were excellently preserved. Shortly after leaving Cape Fanshawe Martin we picked up a tin of candy bars on the ice-foot, kindly dropped towards the end of April by the Royal Canadian Air Force for the benefit of any chance passers-by.

We arrived back at the main camp on June 6, to find Crary and Marshall in good spirits. Crary had been filling the time with survey, meteorological, and tidal observations, and Marshall had been very busy with his glaciological work. They had started levelling on the shelf over the 12 miles between land and the seaward edge and during the next week we completed this work.

Christie and I were surprised to find that the Greenlanders had not yet gone out. On June 15 it was decided that they should leave by dog team for Alert, since the ice shelf was in poor condition for landing. They reached Alert a week later, after a fairly hard trip through deep snow, and were flown by a C47 aircraft on the following day to near Kanak on the Greenland ice cap, whence they sledged down to their homes.

<sup>1</sup>See pp. 34 and 35.



**Fig. 13.** Terminal ice cliff of corrie glacier 10 miles inland from west side of Disraeli Bay. The ice cliff shown is about 30 feet high, but similar vertical cliffs elsewhere in northern Ellesmere Island may be as much as 100 feet high. 29 July 1954.

On June 15 Crary and I also left, with ten dogs, for the edge of the shelf to start the oceanographic program. In the course of the next week we obtained depths and bottom cores at eleven stations between the meridian of the main camp and that of Cape Discovery; at two of the stations we observed ocean temperatures and collected water samples for salinity determination. In the meantime Marshall and Christie set out on skis for M'Clintock Bay, with four dogs hauling a small pulka, to make a geological and glaciological reconnaissance up the western arm of this big fiord.

Crary and I returned to camp for one day, on June 24, to gather the last of the stores and equipment which had been dropped by Northeast Air Command the previous day. They had kindly included a case of oranges, a case of apples, and two cases of fresh meat which were most welcome. We then went back to the edge of the shelf, and headed eastward to obtain stations as far as Markham Bay. This trip resulted in eight more hydrographic stations, at one of which temperatures and water samples were also taken.

We returned to the main camp on July 1, and Marshall and Christie arrived from M'Clintock Bay three days later after a hard trip due to the thaw, which was now well advanced. There were blue lakes in the troughs and the snow on the ridges was slushy. Owing to the rapidity of the thaw Crary and I had had to leave our radio at the edge of the ice shelf. Therefore, on July 6, Crary, Marshall, and Christie, man-hauling a small pulka, travelled north to the radio to keep the pre-arranged schedule with Alert. At first they attempted to find ways round the trough lakes, but soon gave this up and waded through them. They made the trip in about eight hours, contacted Alert the following day, and came back to the main camp, through the forty-seven trough lakes, on July 8, after safeguarding the equipment left at the edge of the shelf.

We now decided to establish a temporary camp on Ward Hunt Island, and from July 11 to 20 three members of the party camped there, always leaving one member at the main camp. Geological investigations, sounding in the lake near the middle of the island (Fig. 1), plant collecting, and work on the nearby part of the shelf, including tide-gauge readings, occupied us during this pleasant period on land.

After we had all moved back to the main camp, we found that it was possible to get over to the "mainland" due south by wading through twenty-six trough lakes. From July 22 to August 14 all four members of the party spent varying periods on the "mainland". The geological reconnaissance was extended inland about 15 miles, some of the glaciers were visited (Fig. 13), and plants were collected. A spell of excellent weather at the end of July made walking a real delight in air balmy at a temperature of 55°F. Observations were also made on the ice shelf in Disraeli Bay, and soundings were taken along the landward edge.

Between July 31 and August 2 three of us made the wet and tortuous journey with the dogs to the edge of the shelf to make radio contact with Alert. This was a most unpleasant trip for the dogs, whose feet were quite badly cut. We brought back the other pyramid tent and some of Crary's



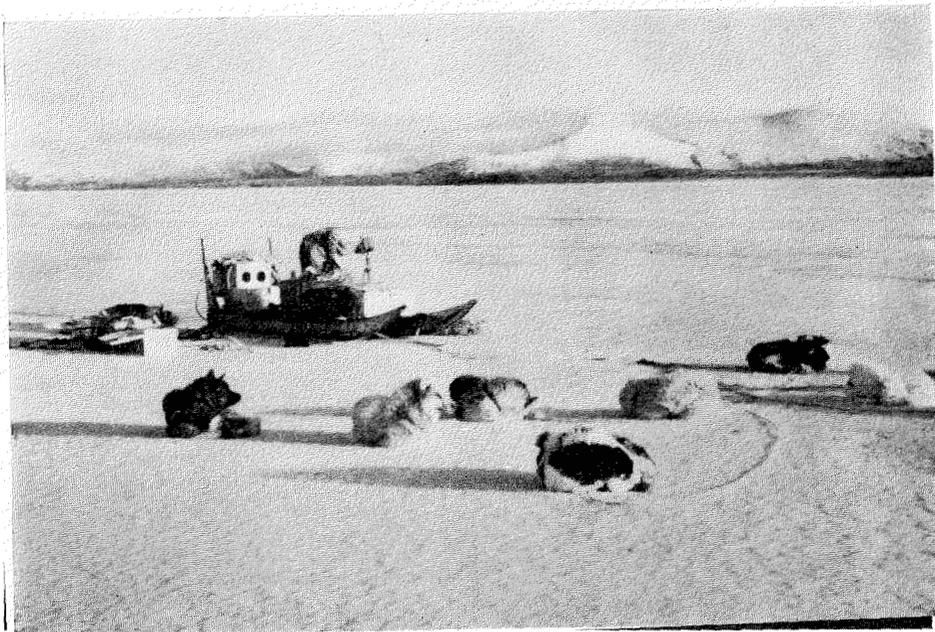
**Fig. 14.** Looking northeast along the landward edge of the "ice rise" near the "mainland" camp. To the right is the moat of nearly fresh water between the land and the "ice rise"; in the centre is the ice moat between the "ice rise" and the ice shelf; in the background is Ward Hunt Island. 24 July 1954.

seismic equipment which had been left at the shelf edge. Cary now started seismic work along the ridge running westward from the main camp towards Cape Discovery.

By August 14 we were all at the camp together, after a period of very wet weather with several inches of rain. During the summer the shelf lost about two feet of ice from its surface by melting. For the next two weeks we eagerly awaited a final freeze-up. Our hopes rose with any tendency of the thermometer to drop, which it did on August 17, only to soar above freezing again two days later. We wanted the freeze-up for easy travel, and also so that we could start drilling for ice cores which we planned to take south with us. It is technically difficult to drill in above freezing weather and the recovered cores do not keep. The late freeze-up was also delaying the time when the aircraft could land and take us out—an event originally scheduled for September 1, but which became daily more distant as the mercury stayed high. We have since found that the summer of 1954 was exceptionally mild in the far north.

We decided that an aircraft would be able to land on the "ice rise"<sup>1</sup> on the west side of Ward Hunt Island (Fig. 14) sooner than on the ice shelf, and started moving our main camp over there. Marshall took advantage of the

<sup>1</sup>"A mass of ice resting on rock and surrounded partly by an ice shelf and partly by sea" (Roberts, Roots, and Swithinbank, 1955). In this case it is surrounded partly by the ice shelf and partly by the ice-free part of Ward Hunt Island.



**Fig. 15.** Crary on the ice shelf with sledge loaded with equipment for a seismic traverse. Looking south towards land, a few miles west of Cape Discovery. 2 September 1954.

short spell of cold weather on August 17 and started drilling a deep hole in the "ice rise", with some assistance from the rest of us. Drilling was temporarily abandoned when the temperature rose again and about August 23, during a period of thaw, Marshall found a cache left by MacMillan on the north side of Ward Hunt Island; it contained a komatik, a canister of tea, some cans of stove fuel, a small lamp-stove, and three tins of Borden's condensed milk. MacMillan's record<sup>1</sup> states that the cache was laid on Peary's orders for possible use by parties returning from the north (MacMillan, 1934, p. 192).

In the meantime, we could no longer put off visiting the edge of the ice shelf again to make a radio contact and, if possible, bring back the radio. So on August 21 Crary and I made a rough two-day trip northward; fortunately there was a little recent snow which, though melting, prevented the dogs from cutting their feet. Crary used this opportunity to take further oceanographic measurements at the shelf edge for comparison with his measurements in June. From September 2 to 4 Crary and I travelled to Cape Discovery and extended the seismic traverse, started earlier, to the west, taking stations about every 2 miles (Fig. 15).

By September 5, the day before the sun set for the first time, the freeze-up had truly begun, and the temperature was around 15°F. On the 7th the whole party started for Markham Bay, with four of the dogs pulling the relashed komatik left by MacMillan. We camped in the bay that evening, and spent the next two days doing seismic work on the re-entrant of the ice shelf, and

<sup>1</sup>See p. 34.

glaciological and geological work. Marshall travelled about 10 miles up the bay to obtain ice cores from the fiord ice. The return to base camp took ten hours, as a new fall of snow the previous day made travelling slow. Next day, September 11, there was a welcome mail drop from a C47.

On September 12 Christie and I drove one dog team over to land, and brought back the equipment left at the old "mainland" camp. Two days later Crary and I travelled straight down to the edge of the shelf, across the now well-frozen trough lakes, collected further oceanographic data, and brought back all the equipment remaining there. On the 17th and 18th Crary and Christie made a last trip down Disraeli Bay for geological work and to take an oceanographic station, while Marshall and I cored two holes in the ice shelf—one at an old Peary expedition campsite, discovered earlier in the summer 3 miles west of Ward Hunt Island, the other near the edge of the Ward Hunt "ice rise".

By September 19 conditions were good for landing an aircraft on the "ice rise". On that day Col. W. L. Kimball flew in a C47 aircraft and took Christie, all the dogs, and some of the equipment to Alert, and thence to Thule the next day. The remaining three of us had all packed and were ready to leave, but a week of bad weather supervened. We finally left on September 26 in a C47 piloted by Maj. J. D. Pendergrass and, after a night at Alert, reached Thule the following morning in a C54 aircraft.

### **Glaciological Studies. By G. Hattersley-Smith**

In 1953 it was possible, for the first time, to make ground observations on the ice shelf with a general understanding of its character and extent, which came from a previous study of air photographs (Hattersley-Smith, in press); the few earlier travellers along this coast were of course denied this inestimable advantage. Unfortunately owing to logistic difficulties detailed work on the ice shelf could not be undertaken. In 1954, with the excellent support provided by Northeast Air Command, the reconnaissance of 1953 could be followed up by detailed work.

In Markham Bay, and on the remnants of the ice shelf near Cape Aldrich, and southwest of Point Moss, lines of poles were set up in May 1953 to measure change of surface level. The Point Moss region was not visited in 1954, and the poles near Cape Aldrich had evidently fallen down due to summer ablation. Of the three poles set up on the ice shelf in Markham Bay, only one was still standing on 6 May 1954, and this showed a surface increment of 3 inches of ice since 14 May 1953, due to the refreezing of meltwater. By the end of the 1954 season this pole had also been melted out. It was unfortunate that the poles were not set deeper, but nevertheless, it seems clear that, while there may be small surface increments in some years, over a period of years wastage will predominate, and will average a few inches each year. The 1954 season seems to have been unusually mild in the far north generally; at the main camp on the ice shelf, 3 miles west of Ward Hunt Island, 24 inches of ice were lost from

the surface by melting. That there has been no net accumulation on the ice shelf for at least the last 45 years was confirmed by the finding of a Peary expedition campsite on the surface of the shelf, 3 miles south of the main camp.

Theodolite observations on the pole in Markham Bay from a cairn on shore showed that there had been no noticeable mass movement of the ice shelf one way or the other along the line of the fiord between May 1953 and September 1954. Our observations were accurate enough to detect a movement of five feet.

The cores collected from the ice shelf indicate that the upper part of the shelf was built up by annual increments of water-saturated firn or by refrozen meltwater. It seems that temperature conditions during build-up cannot have differed greatly from those prevailing at the present time. The lower part of the ice shelf has probably been formed from the freezing of sea water, but to what extent this has taken place is not known. In 1954 it was apparent that about 20 feet of ice had formed by the freezing of sea water in the re-entrant of the shelf off Markham Bay, where a large ice island photographed in 1947 had broken away (Koenig *et al.*, 1952, pp. 76-7).

From the present gradual wastage deduced from surface observations, it is concluded that only a slight amelioration of climate would be extremely destructive to the ice shelf. For example, continual mild seasons, like that of 1954, would cause the whole of the present mass of the ice shelf to melt in about 80 years. Such an eventuality does not take into account 'rejuvenation' of the ice shelf by freezing of sea water of very low salinity to the under-surface, which, as already stated, can take place to a depth of at least 20 feet. It seems most improbable, however, that an ice shelf could have persisted through the climate of the 'postglacial optimum', 4,000 to 6,000 years ago, and it is perhaps unlikely to have existed even as recently as 500 B.C., when the climate was apparently still slightly warmer than that of today. Moreover, the ice shelf could not have existed when driftwood was deposited near present sea level on the "mainland" shore opposite Ward Hunt Island. This discovery in turn suggests a relatively recent age. The dating of this driftwood by the Carbon 14 method is now being undertaken by J. L. Kulp<sup>1</sup> of the Lamont Geological Observatory, Columbia University, and, if successful, will give a definite maximum age for the ice shelf.

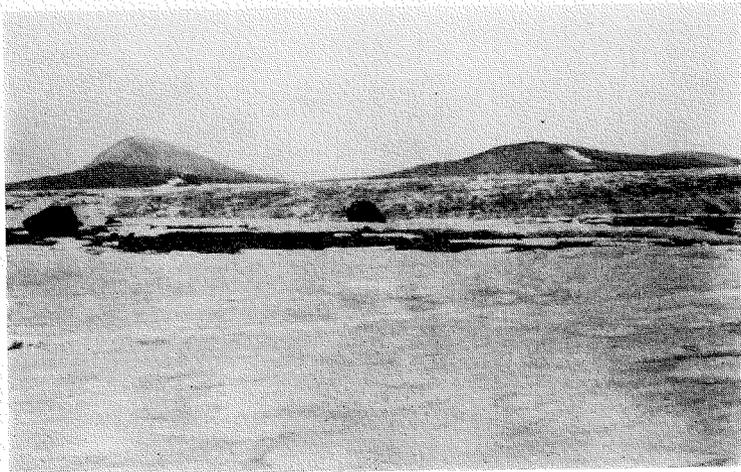
The possibility that land glaciers moving seaward down the fiords coalesced along the peripheral parts of the coast to form the ice shelf is discounted by the writer, who believes that the present ice shelf is and always has been essentially a static floating sheet which grew *in situ*.<sup>2</sup> Previous ice shelves, of dynamic character and greater extent, may have existed along this coast in earlier, more intensely glacial times. The present ice shelf has been affected by the glaciers which move down into the fiords to the extent that, in some places near the fiord sides, they have superposed themselves on the ice shelf,

<sup>1</sup>Under Contract AF. 19 (604)-1063 between Columbia University and U.S. Air Force Cambridge Research Center.

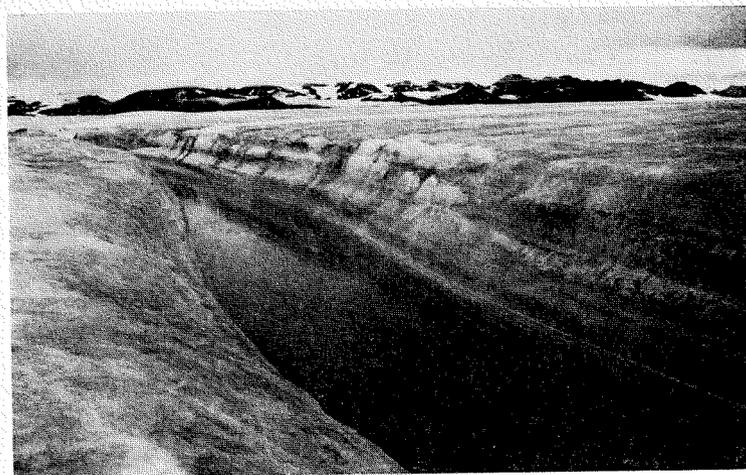
<sup>2</sup>See also Debenham, F. 1954. "The ice islands of the Arctic: a hypothesis". *Geogr. Rev.* Vol. 44, pp. 495-507.



**Fig. 16.** The large glacier 15 miles south of Alert Point, which has advanced across a marine terrace at an elevation of about 200 to 250 feet. 29 May 1954.



**Fig. 17.** Boulders near the edge of the ice shelf. Ward Hunt Island in background. 30 July 1954.



**Fig. 18.** Wide, steep-sided drainage channel on the ice shelf in the thaw season. Looking southeast to Disraeli Bay. 15 August 1954.

depositing moraines. By pressure against the shelf the glaciers have also imposed strain patterns, reflected in the disposition of the surface ridges and the drainage of the shelf. During the build-up of the ice shelf extensive developments of snowdrift ice formed in the lee of the fiord walls, and merged with the shelf. The snowdrift ice provided ramps down which meltwater streams carried the finer rock debris from the frost-shattered cliffs to the shelf; the boulders of medium or large size, as found on the edge of the shelf in Disraeli and M'Clintock bays, slid down these ramps from the cliffs above (Fig. 17). It also seems likely that the "ice rises", which cover some of the capes on the north coast of Ellesmere Island, developed at the same time as the ice shelf. It is thought that they may post-date raised beaches at the 15-foot level. Their present surface truncates depositional layers visible in vertical faces, usually on the east side of the "ice rise", indicating present wasting.

The considerable depth of water found beneath the ice shelf, rather than the relatively shoal water which had previously been expected, makes its present hold on the coast seem precarious. Some indication was found a few miles northeast of Cape Discovery of large cracks, which may mark the line of break-off of future ice islands. Similar cracks are visible in air photographs of Markham, M'Clintock, and Ayles bays.

The parallelism of the ice-shelf rolls to the coastline (Fig. 7) is most easily explained by forces acting from the sea, but the regularity of their spacing still remains an enigma, although it must be related to the thickness of the ice and to the depth of the water beneath. There is no doubt that the roll system, once started, will be perpetuated by the annual drainage (Fig. 18). An air photograph of ice in Hare Fiord, showing fractures, presumably associated with tidal action, spaced in a semi-regular manner, suggests a way in which a system of rolls might start. More or less regularly spaced "hedges" of pressure ice, separated by areas of smooth sea ice, in Yelverton Bay, also suggest a somewhat similar origin.<sup>1</sup>

Observations on land glaciers in northern Ellesmere Island have shown that there has been no marked recession in the last few decades. Vegetation right up to the high, cliffed fronts of piedmont glaciers coming down from the United States Range indicates that the glaciers are probably advancing. In 1953 a cairn was built near Cape Aldrich at a measured distance from the 80-foot ice-cliff, which parallels the shore for several hundred yards at the 200-foot level. Measurements in 1954 showed that the ice cliff had moved forward a distance of 20 feet. It is interesting to note that from Aldrich's sketch this cliff appears to have stood in roughly its present position in 1876 (*Parliamentary Paper*, 1877, facing p. 197).

The large glacier, which descends to the shore in a great icefall 15 miles due south of Alert Point, has advanced across a well-defined marine terrace at a height of 200 to 250 feet (Fig. 16). The appearance of the terminal moraines near the shore suggests lateral retreat of the glacier of not more

<sup>1</sup>We do not know what the response of a floating ice sheet is to tide and swell acting beneath it. The physicist may be able to provide the answer to this question, which would seem fundamental to an understanding of the rolls.

than 200 yards in recent decades. On the "mainland", to a height of 200 feet above the shore south of Ward Hunt Island, large heaps of talus and morainic material suggest that small snowdrift or corrie glaciers descended towards the shore in the not distant past. In Peary Land (north Greenland) Troelsen has correlated a glacial advance with the strand line at the 65-metre (213-foot) level (1952a, pp. 219-20), and in western Ellesmere Island he has reported a relatively late advance of the glaciers over the highest marine beach at about 465 feet (Troelsen, 1952b, p. 209). On the other hand Christie has reported undisturbed marine deposits with bivalve shells intact at a height of about 200 feet above sea level near the ice cliff of a small glacier above the shore of M'Clintock Bay. Furthermore the raised beaches on Ward Hunt Island up to a height of at least 125 feet above sea level have not been disturbed by glacial action. Kulp has used the Carbon 14 method to find the age of shells collected in 1954 from the latter beaches, and has arrived at a figure of 6,500 to 7,000 years (personal communication).

Tentative conclusions are that the glaciers in northern Ellesmere Island have not advanced greatly from their present positions since the formation of the marine beaches at the 200-foot level, and that recent minor extensions of land ice cover may have been contemporaneous with the development of the ice shelf. However, there is evidence of much more extensive glacierization in the more distant past in the Ward Hunt Island region. For example, an erratic piece of micro-granite, which can only have come from the "mainland", was found on Ward Hunt Island at a height of 1,100 feet (by aneroid). On the "mainland" glacial striae are very well-developed on an exposed rock ridge at a height of 2,500 feet, 5 miles southwest of the entrance to Disraeli Bay, in an area where now there are only a few rather inactive corrie glaciers. The more extensive glacierization must be presumed to predate the highest of the marine beaches so far found, namely at 300 feet.

Few data are available on the regime of the interior Highland Ice. In July 1953 the ice cap of the eastern part of the United States Range was visited, and the firn-line was found to be about 3,400 feet above sea level. At a height of about 5,000 feet density determinations showed that the surface accumulation for 1952-3 up to mid-summer was equivalent to about 7.5 inches of water, and that the net accumulation for 1951-2 was equivalent to about 6.3 inches of water. It is probable that the Highland Ice is in a state of near balance at the present time (Hattersley-Smith, in press).

The expeditions of 1953 and 1954 were concerned primarily with the ice shelf. A well-equipped expedition to the interior of northern Ellesmere Island is needed to fill an important gap in the glaciological knowledge of the north.

#### **Geophysical and Oceanographic Studies. By A. P. Crary\***

The U.S. Air Force Cambridge Research Center was mainly interested in possible correlations of the ice island T3 with the ice shelf, and the collection of geophysical data to increase our knowledge of the past and future of ice

\*U.S. Air Force Cambridge Research Center.

islands. The general geophysical activities during the five months of the 1954 expedition are given below.

*Survey:* A line survey north and south across the width of the ice shelf a few miles west of Ward Hunt Island was made in three stages: distances were chained between the ridge tops; a levelling survey of elevations was made of all ridges between land and sea level, and a vertical angle stadia survey was made of the elevation differences between troughs and ridges using a one-minute Keuffel and Esser engineering transit. The total width of the shelf at the survey line was 11.9 miles, with the ridge and trough system rather poorly developed in the last mile or so near the seaward edge. There were about 75 well developed ridge systems which had an average wave length of approximately 760 feet. The ridges rose to about 24 feet above sea level near the land and, excluding the part near the seaward edge of the shelf, the differences in height between ridge and trough averaged about 7 feet.

A base triangle of about 2,500 feet on a side was used to locate the transit position at the main campsite on the shelf with reference to the neighbouring parts of Ward Hunt Island and near shore hills of the mainland. From this transit position 8 sun-lines were taken for approximate position, and elevation angles were measured on about 40 peaks visible along the northern shore of Ellesmere Island.

Using the transit compass and true azimuths, about 50 values of magnetic declination were obtained. Most of these were located along the north-south survey line across the ice shelf. A declination anomaly of about 10 degrees was found a few miles northwest of Ward Hunt Island, and a few additional observations were made there for detail.

*Oceanography:* During the period June 15 to 30 Hattersley-Smith and I travelled by dog team along the outer edge of the ice shelf between M'Clintock and Markham bays, a total distance of approximately 60 miles, to collect oceanographic data. Nineteen stations were occupied at fairly regular intervals, taking advantage of open water formed by the active sea ice, which, for the most part, was fairly close to the edge of the shelf. At two of the stations, off the northwest edge, no bottom was reached with the 300 metres of hydrographic cable available. Minimum depths of 60 metres were obtained at three separate points along the area studied. The sea east of Ward Hunt Island was in general around 100 metres deep up to the entrance to Markham Bay, where a sounding of 285 metres was taken. A total of 14 bottom samples, up to about 9 inches in length, was made with a Phleger sampler. Lithological and micropaleontological examinations of these cores are being carried out by D. B. Ericson at the Lamont Geological Observatory, Columbia University. Observations of ocean temperatures and collection of samples for salinity determinations were made at three stations 20 to 25 miles apart. At the centre station, off-shore from Ward Hunt Island, these observations were repeated at three intervals during the summer, with special attention being given to shallower depths. On September 17 and 18, Christie and I made a sledge trip into Disraeli Bay. Conditions prevented us travelling as far into

the bay as had been planned, but a hydrographic station was made about 10 miles south of the bay entrance. No bottom was obtained with the 300 metres of wire at hand.

In general we found that ocean temperatures were slightly higher than those obtained from T3, well out in the Arctic Ocean. It is hoped that these temperatures and salinities and their changes during the summer months will provide the necessary background for study of past and present accretion on, or wasting off, the bottom of the shelf by the water draining from the land and the shelf surface.

The oceanographic equipment: Nansen bottles, reversing thermometers, and Phleger sampler were loaned by the Woods Hole Oceanographic Institution, where the analysis of the water samples will be carried out.

*Seismic studies:* It had been hoped that systematic seismic studies could be made of the depth of the water under the ice shelf. However, the seismic operations were not started until August and sledging was not possible until early in September, hence water depths were obtained only in limited areas. A total of twenty-eight seismic stations was occupied and at the majority of these good bottom reflections were received. Along the ridge, running west from the main campsite, a deep canyon was found with a maximum depth of about 850 metres. This is believed to be the Disraeli Bay channel which probably continues northwest to the corner of the shelf, where depths were greater than 300 metres. A velocity profile was made at one site over deep water, using variations of reflection time with distance, in order to make certain that the reflections were not from a sub-bottom horizon. Nearly all of the seismic records across this channel provide some information on the slopes of the bottom and on sub-bottom reflection data. Because of the limitations of the equipment used and the large amount of energy present in the surface Rayleigh wave, it was difficult to obtain depth data when the combined thickness of the ice shelf and the water below was less than about 250 feet. Some shallow depths were taken by using a seismic arrangement that would allow the reflected energy to appear on the record before the surface Rayleigh wave.

A few records were made to find the thickness of the ice shelf itself. At two sites use was made of the vertically polarized transverse wave set up by large explosions. Reflections from the ice-water interface were also obtained in some cases, using the horizontally polarized transverse wave set up locally by mechanical means. In general, the thicknesses obtained, up to 150 feet, confirmed depths as calculated from ice surface elevations above sea level.

During the latter part of the summer, air temperatures dropped considerably and thermal contraction caused much cracking near the surface of the ice. At times the cracking was so frequent as to interfere with the seismic recordings; we were also troubled by the series of tremors "triggered off" when large explosive charges were fired, which obscured recordings of later phases. Advantage was, however, taken of these tremors, and during periods of their maximum frequency several recordings were made with three-component detector units. As they resembled miniature earthquakes, they should give considerable information on the character of the ice. Recordings



Fig. 19. Tide-crack system near the south side of the Ward Hunt Island "ice rise".  
15 August 1954.

were made both on the ice shelf and on the ice field immediately west of Ward Hunt Island.

During the course of the seismic studies, a multiple pulse was obtained when shooting detonators in water-filled cylindrical holes. This multiple pulse has been observed in water but, as far as is known, has not been noted before in cylindrical holes. Variation of the pulse time with diameter of the hole was studied. This modification of the pulse time is possibly a function of the elastic constants of the ice and may prove useful in that regard.

*Tide-crack physics:* Proximity to Ward Hunt Island made possible a limited number of tidal motion studies in the stress zone between the floating ice shelf and the anchored "ice rise". This zone is characterized by a series of discontinuous shallow surface cracks. The elevations and extents of these tidal cracks were surveyed over a length of about 5 miles. The hinging action of the cracks was recorded on a rotary drum over a total of about 40 days and bubble levels, accurate to 30 seconds and to 1 minute, were also located across this tidal zone and read visually.

An interesting feature of the Ward Hunt tide crack system was the high elevation it attained in limited areas on the south side of the "ice rise" and directly opposite on the north side. This is believed to be a deep channel now filled with ice. Studies were also made of the old tide cracks which were exposed during the maximum melting (Fig. 19). Some data were obtained on the location and elevation of these old cracks, which were more numerous on the present "ice rise" than on the present ice shelf. They may reflect to some extent past changes in sea level and ice coverage.

A limited survey was made along the edge of the "ice rise" on the Ellesmere shore southwest of Ward Hunt Island. This "ice rise" is immediately south of the shelf proper and separated from it by a 300-foot moat of thin level ice where the drainage from land seems to have prevented build-up into an ice shelf. Measurements, taken at various places where the tide crack or the thin ice had been eroded through, showed an apparent correlation between the elevation of the active tide crack and the depth of water. Tidal recordings were also made in the waters near Ward Hunt Island and in M'Clintock Bay by Christie.

*Ice temperature:* Thermocouples were located in two holes on the ice shelf which were drilled for glaciological studies. The first of these was on the ridge at the main campsite and was drilled to about 80 feet. Salt water penetration in the bottom of this hole prevented the use of thermocouples below 70 feet, and undoubtedly influenced the temperatures somewhat at that level. A total of 10 thermocouples was located in this hole and read about once a week from early May to late September. The winter cold wave only penetrated through about the top 40 feet, below which the temperature remained at approximately  $-12^{\circ}\text{C}$ . A comparison of approximate temperatures obtained during drilling in this hole, with those in the second hole in an adjoining trough, showed a difference of about  $7^{\circ}\text{C}$  to depths of 35 feet, where the trough hole was abandoned. The higher trough temperatures are probably due to heat obtained from the freezing of the lake waters the previous fall. Thermocouples were also placed to a depth of 59 feet in a hole drilled on the top of the Ward Hunt "ice rise" in early September. At lower levels the temperatures here were nearly constant at about  $-17^{\circ}\text{C}$ .

*Tritium dating:* About 17 gallons of meltwater from the surface of the "ice rise" near Ward Hunt Island have been sent to J. L. Kulp for dating by the tritium method.

*Meteorological data:* Weather observations were made twice daily, near local noon and local midnight, during our entire stay. Except during short periods at the edge of the ice shelf, all observations were taken at the main camp. The following were recorded: air temperature, surface pressure, sky condition, visibility, cloud cover, and the direction and strength of the wind. During the period April 24 to September 26, minimum temperatures of  $-10^{\circ}\text{F}$  and  $-3^{\circ}\text{F}$  were recorded in early May and late September respectively, and a maximum of  $42^{\circ}\text{F}$  occurred in late July. The winds were remarkably constant in direction, mainly east or west, with all the heavy storms coming from the west.

*Aerobiological collection:* A total of 59 sets of treated slides were exposed in a continuous series between May and September for the collection of airborne pollen. These slides are being examined by N. Polunin of the Osborn Botanical Laboratory at Yale University.

*Willow collection:* Approximately 50 willows (*Salix arctica*) were collected in a limited area on the western slope of Ward Hunt Island for dendrochronological studies. It is expected they will extend back to 50 years or more; correlations will be attempted with willows found on ice island, T3.

*Communications:* Radio communication equipment consisted of a Harvey-Wells Bandmaster transmitter and a service receiver, R-100/URR. Both units were capable of operation on either 110 volts a.c. or d.c. A PE214 power unit delivering 300 watts was used as the a.c. source and for charging the wet batteries.

Frequencies used primarily were 3760 kc. for contacts with Alert Weather Station, and either 3452.5 kc. or 4220 kc. for contact with Thule Air Base and with aircraft. A total of 45 contacts was made with Alert, and through the cooperation of the station 38 official and 83 personal messages were handled.

### Geological Observations, 1954.\* By R. L. Christie†

The geology of the north coast of Ellesmere Island was essentially unknown, except for information brought back by H. W. Feilden of the British Arctic expedition of 1875-6 and by Admiral Peary in 1906, until 1953 when the geology from Alert westwards to Cape Columbia was studied by R. G. Blackadar (Blackadar, 1954; *Arctic*, 1954). In 1954 the coastal survey was continued to Lands Lökk.

The geological history is complex; formations of several ages and of various lithological types are found, and there is evidence of several periods of tectonic activity. The general geology appears to be as follows: an extensive gneiss and schist terrain of unknown age has been intruded by coarse-grained igneous rocks; extensive highly folded volcanic flow, tuff, and greywacke formations of early Paleozoic age or older occur, and presumably overlie the gneiss and schist; the volcanic sedimentary formations appear to be overlain by a moderately to severely folded early Paleozoic slate, sandstone, and limestone formation, and by fossiliferous, moderately folded, late Paleozoic limestone; dykes of fine-grained igneous rock cut all these formations; a small amount of poorly consolidated mudstone and sandstone of probably late Mesozoic or Tertiary age rests upon the eroded schists. Inland, stratified rocks are widespread, but they have not been correlated with certainty with the formations found at the coast.

The larger part of Ellesmere Island is within the Innuitian geological province.<sup>1</sup> Speculation has been made that northern Ellesmere Island is part of a eugeosyncline and is the core of the Innuitian orogenic system. The occurrence of volcanic and greywacke rocks suggests that a eugeosynclinal axis lay nearby in the past; they are possibly equivalent in age and orogenic history to early Paleozoic miogeosynclinal rocks of the eastern and northeastern coasts of the island. The existence of intense folding and intrusions of granitic, basic, and ultrabasic rocks support the hypothesis that the region is the core of an orogenic system. Metamorphic rocks of high grade indicate a long history of tectonic activity.

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†Geologist, Geological Survey of Canada.

<sup>1</sup>First used in 1954 by Y. O. Fortier (1955) to describe the mountain system extending from the Beaufort Sea across the Queen Elizabeth Islands to Greenland.

*The rocks between Cape Columbia and Lands Lokk*

As described and named by R. G. Blackadar (1954), the Cape Columbia group, which consists mainly of biotite-feldspar gneiss, occurs at Cape Columbia. To the west, from Cape Nares to Ward Hunt Island, the gneiss formation is overlain, with angular unconformity, by moderately folded fossiliferous limestone of late Paleozoic age which appears to be equivalent to the Feilden group of northeastern Ellesmere Island. The unconformity is strikingly evident on the steep east face of Cape Nares (Fig. 3).

The mountains in the vicinity of Disraeli Bay are composed of a thick tightly folded formation including andesitic to basaltic flows, thick beds of breccias, tuffs, greywacke, and slate, and thin beds of quartzite and crystalline limestone. These rocks are slightly altered to chlorite-rock or "greenstone" in places; the low metamorphic grade contrasts with the more or less high-grade metamorphism of the Cape Columbia group. In the southern and western parts of M'Clintock Bay, the volcanic-sedimentary formation appears to be overlain by moderately to severely folded early Paleozoic slates, sandstones, and limestone. At the head of M'Clintock Bay a metamorphic rock, micaceous quartzite, occurs which is similar to parts of the ancient gneissic formation on Ward Hunt Island. The quartzite is overlain unconformably by almost flat-lying sandstones containing some non-marine fossils. The sandstone formation is very extensive; it appears to make up the high, glacier-hung mountains to the south and east, where, however, it is more or less distorted into open folds and some irregular overthrust folds.

On Cape Richards and Cape Fanshawe Martin there are outcrops of coarse-grained, plutonic rocks: granite and various norites and peridotites. These rocks intrude a quartzite that appears to be part of an extensive metamorphic terrain to the southwest.

Metamorphic rocks underlie the coast mountains from Ayles Bay to Alert Point. They are divisible into two lithological groups: medium- to coarse-grained gneiss and augen-gneiss, and micaceous quartzite, quartzite, mica-schist, and marble. The first group occurs on Cape Bicknor and Cape Evans. The second group underlies the region of Yelverton Bay and Alert Point, and appears to occur a few miles inland from Cape Bicknor and Cape Evans; the bedding in this group of sedimentary rocks is tightly folded, but little consistency in attitude is evident.

A few square miles of Alert Point is underlain by a poorly consolidated mudstone-sandstone formation which has, at least locally, been very violently contorted. South of Alert Point, a stock of fresh-looking granite lies adjacent to, and probably cuts, the schists and gneisses.

Between Phillips Bay and Cape Bourne a greywacke formation occurs. Greywacke, greywacke-tuff, and argillaceous greywacke have been fairly tightly folded, and slaty cleavage has been developed. Bedding trends northeast and east.

Between Cape Bourne and the westernmost extremity of northern Ellesmere Island there is a group of strongly folded, variously altered, andesitic flow-rocks and minor argillaceous and tuffaceous sedimentary rocks. Locally,

the volcanic rocks have been intruded and hybridized by dioritic to aplitic igneous bodies. At Lands Lokk fossiliferous, late Paleozoic limestone appears to overlie the steep-dipping volcanic rocks and to dip gently to the southeast. The limestone formation also outcrops up a fiord east of Cape Bourne as an outlier or extension of the structure at Lands Lokk.

### New Names

New place names have been suggested only where necessary for the satisfactory description of the coastline and of the limited inland region travelled by the expeditions of 1953 and 1954. The following names, which for the most part commemorate members of earlier expeditions who are not already commemorated in the region, have been submitted to the Board on Geographical Names for their approval:

Ben Creek: A small stream flowing into Disraeli Bay.

Bjare Strait: For Age Rose Bjare of the German Arctic expedition, 1930.

Borup Point: For George Borup of the Peary expedition, 1908-9.

Cape MacMillan: For D. B. MacMillan of the Peary expedition, 1908-9.

Hansen Point: For Comdr. Godfred Hansen, leader of the Third Thule expedition, 1919-20.

James Ross River: Flowing into James Ross Bay.

Krüger Island: For H. K. E. Krüger, leader of the German Arctic expedition, 1930.

Marvin Islands: For Ross G. Marvin of the Peary expedition, 1905-6, 1908-9.

Matt Henson Bay: For Mathew Henson of the Peary expedition, 1905-6, 1908-9.

Moss Bay: Near Point Moss.

Patterson River: Flowing into Patterson Bay.

### Texts of records which have not been published in facsimile

#### On Crozier Island

H.M.S. "ALERT," at Winter Quarters  
(Lat. 82° 27' North. Long. 61° 22' West.)

HMS Discovery in Latitude 81°4'N Long 65.08 West.

This Island was visited by a sledge party from Her Britannic Majesty's ship "Alert" - Monday April 17<sup>th</sup> 1876 - under the command of Lieutenants Aldrich & Giffard who are on their way exploring the Northern Coast of Grant Land.

Names of Members of the Party

Joseph Good

1

Wm. Wood

Hen. Mann

Adam Ayles

Thos. Stubbs

David Mitchell

Lieut. Giffard

Thos. Stuckberry

Rupert<sup>2</sup> Symons

Geo. Cranstone

Wm. Ellard

Wm. Woolley

Wm. Lorimer

Wm. Gore

Another party under Commr. Markham & Lieut. Parr are forcing their way due North over the Ice.

April 18<sup>th</sup> 1876

Pelham Aldrich

Lieutenant, Royal Navy

<sup>1</sup>Record torn, presumably removing name of James Doidge.

<sup>2</sup>Given as "Robert" in *Parliamentary Paper* (1877).

**At Cape Fanshawe Martin**

H.M.S. "ALERT," at Winter Quarters  
(Lat. 82. 27 North. Long. 61. 22 West.)

HMS "Discovery" Latitude 81. 41 N. Longitude 65. 8 W.

This Cairn was built by the "Challenger" sledge crew detached in an exploring position to the Westward from HMS "Alert" G. S. Nares Esq. Captain. No cairn has been built westward of this one, and this does *not* mark the farthest position attained by the party. The extreme position is shewn in the accompanying chart, as across three more bays and some 43 miles beyond this Cairn.

In addition to this sledge expedition a Northern Division under the command of Commander Markham is endeavouring to force its way Northward over the Ice — and HMS "Discovery" has parties away performing similar duties on the North shores of Greenland.

The "Challenger" is now 52 days from the ship & on the homeward journey.

Names of the Party.<sup>1</sup>

Joseph Good

Jas Doidge

May 24<sup>th</sup> 1876.

Serjeant Major Wood

Thos Stubbs

Hv Mann

David Mitchell

Pelham Aldrich. Lieutenant in command of the party.

**At Cape Aldrich**

3<sup>rd</sup> Thulexpedition

Norges Depotexpedition til Kapt. Roald Amundsen

April 21 1920

In this cairn was found a record from Mr. McMillan of the Peary Club North-Polar-expedition 1908-09 dated Dec. 1908. It states that McMillan lived here for a months<sup>2</sup> to take tidal observations. The tidal igloo was situated South 8° East 77 feet 9 inches from the iron pipe, the top of which was 8.37 feet above Zero of the gauge.

The original Record was spoiled by the dogs during night, so I have had to make this brief statement.

Godfred Hansen  
Comm. R.N.  
Denmark

**On Ward Hunt Island**

Sunday, March 21, 1909.

To whom it may concern:

at the request  
of Commander R. E.  
Peary, who is now  
out on the Polar Sea  
at about lat 85, I  
am leaving this cache  
as a possible aid to  
some one landing  
near here by a  
westerly drift.

D. B. McMillan  
Assistant.

<sup>1</sup>The name of Adam Ayles was obviously omitted by mistake. In *Parliamentary Paper* (1877, p. 216) it records that he built the cairn with Lieutenant Aldrich.

<sup>2</sup>The sense is not quite clear, but reference is made to MacMillan's occupation of the tidal igloo from 17 November to 13 December 1908 (Peary, 1910, pp. 157 and 305).

**Message left by Aldrich on the chart at Cape Fanshawe Martin**

This chart has been roughly sketched in under a variety of circumstances on the outward Journey. Fogs and bad weather have sometimes been experienced. The Latitude of the North Cape is about 83.5 N. and that of Cape Alert<sup>1</sup> will be about 82.20 N. The Longitude may be considerably adrift as it is judged merely from the estimated distances run by the sledges.

Pelham Aldrich  
Lieutenant  
HMS "Alert"

May 24<sup>th</sup> 1876  
Her Majesty's Birthday

**Records and Relics Recovered**

Site	Expedition	Year	Leader	Records and Relics
<b>In 1953</b>				
12 miles south of Cape Sheridan	"British Arctic"	1875-6	Capt. Sir G. S. Nares, R.N.	Clothing and equipment from camp established by Lieut. G. A. Giffard and Sub-Lieut. C. I. M. Conybeare, R.N., on 7 July 1876.
Crozier Island	"British Arctic"	1875-6	Capt. Sir G. S. Nares, R.N.	Record signed by Lieut. Pelham Aldrich, R.N., and dated 18 April 1876.
Eastern summit of Cooper Key Mt., Cape Columbia	"Peary Arctic Club"	1905-6	Comdr. R. E. Peary, U.S.N.	Piece of United States flag, and record signed by R. E. Peary and dated 8 June 1906.
Cape Sheridan	"Peary Arctic Club"	1908-9	Comdr. R. E. Peary, U.S.N.	Man pemmican by Armour Co., Chicago.
Cape Aldrich	"Third Thule" (in support of Capt. Roald Amundsen's North Polar drift in the <i>Maud</i> )	1919-20	Comdr. Godfred Hansen, R.Dan.N.	Sledge-rations by Beauvais of Copenhagen; shotgun-rifle and ammunition; primus stove; kerosene; mail and dispatches for Capt. Roald Amundsen; 2 pairs of snow-goggles.
<b>In 1954</b>				
Cape Fanshawe Martin	"British Arctic"	1875-6	Capt. Sir G. S. Nares, R.N.	Chart and record signed by Lieut. Pelham Aldrich, R.N., and dated 24 May 1876.
Cape Colgate	"Peary Arctic Club"	1905-6	Comdr. R. E. Peary, U.S.N.	Record signed by R. E. Peary and dated 5 July 1906.
Ward Hunt Island (north side)	"Peary Arctic Club"	1908-9	Comdr. R. E. Peary, U.S.N.	Record signed by D. B. MacMillan and dated 21 March 1909; komatik; lamp-stove; 6 cans of stove fuel; canister of tea; 3 cans of milk.
Ice shelf 3 miles south of main camp	"Peary Arctic Club"	1908-9	Comdr. R. E. Peary, U.S.N.	Tins etc., at old campsite.
3 miles south of Cape Aldrich	"Third Thule"	1919-20	Comdr. Godfred Hansen, R.Dan.N.	Record signed by Godfred Hansen, dated 21 April 1920, and left in MacMillan's tide gauge.
4 miles west of Cape Colgate	"German Arctic"	1930	Dr. H. K. E. Krüger	Record signed by H.K.E. Krüger and dated 22 April 1930.

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<sup>1</sup>Alert Point on Fig. 2.

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