Project 750063

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Introduction

An investigation of the geomorphology and glacial history of the Carey Øer (Carey Islands), Greenland was carried out between July 18th and August 12th, 1976. The easternmost island in the group, Björlings Ø, is located approximately 100 km west-northwest of Dundas (Thule Air Base) and 45 km southwest of the nearest point on the coast of Greenland proper (Fig. 90.1). These isolated islands, because of their position between Greenland and Ellesmere Island, offered the promise of providing unique data bearing on the glacial history of northern Baffin Bay, and a one-day visit in 1974 had revealed the presence of deposits and features worthy of further investigation (Blake, 1975).

Travel to the Carey Islands was by a Greenlandair Charter (GLACE) Bell 204B helicopter under the administration of the Royal Greenland Trade Department at Dundas. This aircraft also was used to visit two of the outlying islands, Björlings Ø and Bordø (Table Island). Additional helicopter support to visit Fireø (Fourth Island) and to revisit Bordø was provided by the *U. S. C. G. C. Westwind.* The base camp utilized was that established by the "North Water Project" in 1972 (Müller *et al.*, 1973). Now this base is administered by Kommissionen for Videnskablige Undersøgelser i

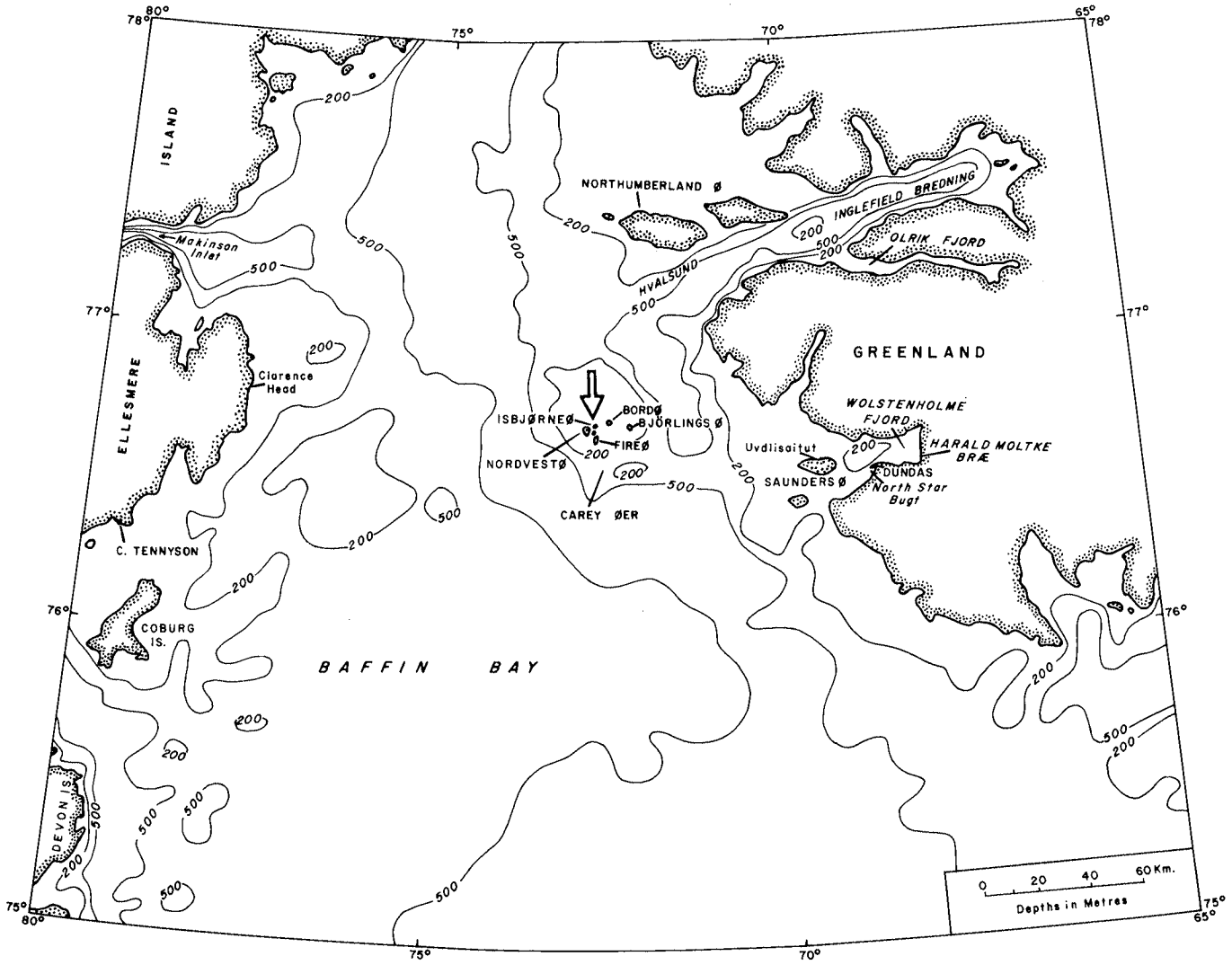

Figure 90.1. Location map, northern Baffin Bay. Adapted from Chart 896, "Arctic Bathymetry north of 72°, 0° to 90° West", Canadian Hydrographic Service, 1967. The arrow shows the general direction in which glacier ice once flowed across the Carey Islands.

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Table 90.1

Radiocarbon Age Determinations

Location	Approx. sample elev. (m) [1]	Material [2]	Field sample no.	Laboratory dating no.	Uncorrected age (conventional ^{14}C years before 1950) [3]	$\delta^{13}C$ ‰	Corrected age (conventional ^{14}C years before 1950)	Sample weight (g)	Counter (litres)	Pressure (atm)	No. of days counted	Remarks [4]
SE corner Nordvestø 76°42.8' N, 73°07' W	1.5	marine shells, *Balanus balanus* (L.)	BS-74-54	GSC-2102	3440 ± 130	+1.5	3460 ± 130	26.9	2	2	2	Shell fragments (41) in sand and gravel approx. 1.0 m below surface of cobble beaches. Calcite.
SW coast Isbjørneø 76°43.5' N, 73°04' W	19.5-20.0	marine shells, *Hiatella arctica* (L.)	BS-76-102	GSC-2372	7870 ± 70	+2.2	7900 ± 70	48.3	5	1	3	Intact shells (19 right and 8 left valves). Many paired valves in same deposit. Aragonite.
	8.0	marine shells, *Balanus balanus* (L.)	BS-76-61	GSC-2374	>38 000	+1.8	>38 000	48.2	5	1	3	Shell fragments (43) from intact individuals in living position on a single boulder. Calcite.
	2.5-3.5	marine shells, *Chlamys islandicus* (Müller)	BS-76-48	GSC-2367	38 200 ± 1100	+1.7	38 300 ± 1100	47.0	5	1	4	Shell fragments (22), but many intact and paired individuals in same deposit. Calcite plus <5% rhodochrosite.
Northern Nordvestø 76°44.2' N, 73°13' W	∿140	moss peat, *Aplodon wormskioldii* (Hornem.) R.Br.	BS-76-128 (253-258 cm)	GSC-2368	6280 ± 80	-23.5	6300 ± 80	9.2	2	2	3	Peat consists entirely of this moss species, interspersed with ice lenses.

[1] Elevations (rounded off to the nearest half-metre) were determined by Wild NK-10 level, using the approximate position of high tide as datum. The elevation of the peat on northern Nordvestø is only an approximate value determined by Paulin altimeter; it is uncorrected for temperature and pressure changes.

[2] The barnacle fragments comprising GSC-2102 were identified by Dr. E.L. Bousfield, National Museum of Natural Sciences, Ottawa; the other pelecypod and cirriped samples were identified by the writer. The moss in GSC-2368 was determined by Dr. G.R. Brassard, Dept. of Biology, Memorial University of Newfoundland, St. John's.

[3] All age determinations from the Radiocarbon Dating Laboratory, Geological Survey of Canada, are based on a ^{14}C half-life of 5568 ± 30 years and 0.95 of the activity of the NBS oxalic acid standard. Ages are quoted in conventional radiocarbon years before present (B.P.) where present is taken to be 1950. All finite age determinations from this laboratory are based on the 2σ criterion; i.e., there is a 95.5% probability that the correct age in conventional radiocarbon years lies within the stated limits of error. All "greater than" ages are based on the 4σ criterion (99.9% probability).

[4] Mineral identifications were carried out by A. Roberts of the X-ray Diffraction Laboratory.

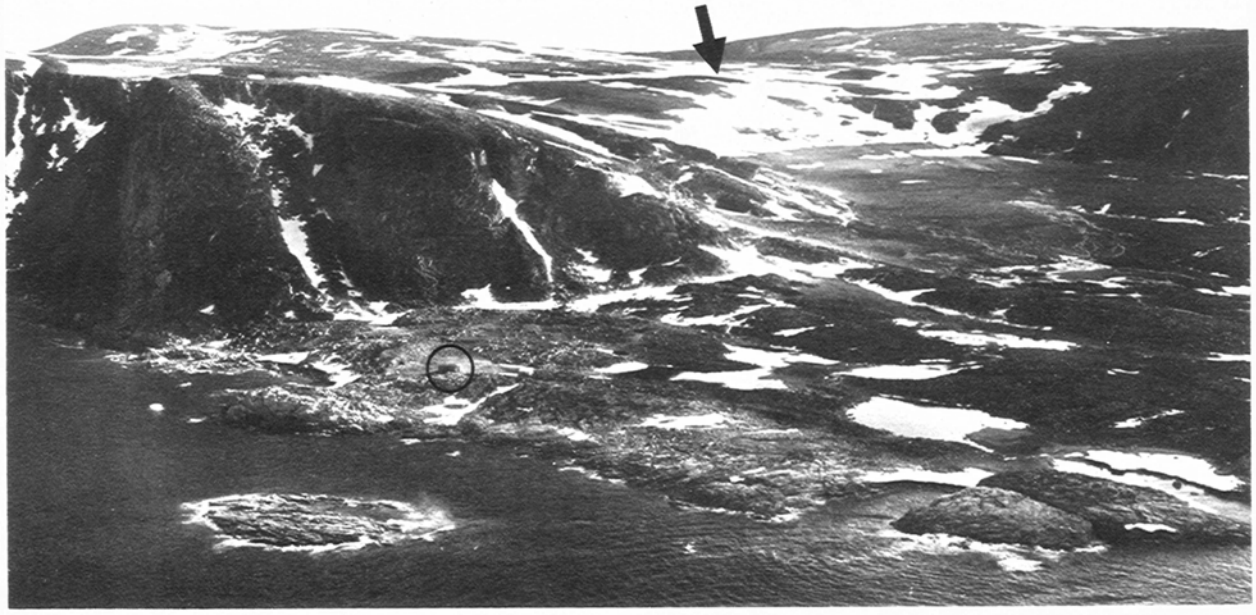

Figure 90. 2. Aerial view southwest at the strandflat along the north coast of Nordvestø. Note the rounded shape of the north-facing gneissic ridges above the base camp (circle). Striated and rounded rock surfaces abound on the plateau; the arrow indicates the position of the diabase ridge where Figure 90. 4 was taken, and one area of shelly till was directly beyond (southwest of) this ridge. July 23, 1976 (GSC-203107).

Figure 90. 3. Aerial view west along the northern coast of Björlings Ø. Note the rounded form of the main east-west ridge which forms the backbone of the island. The direction in which ice flowed across the plateau is indicated by the arrow. July 23, 1976 (GSC-203107A).

Grønland (the Commission for Scientific Investigations in Greenland), and it has been the site of both Swiss and Danish automatic weather stations, of which the latter is still in operation. The hut is situated on the strandflat at the northeast corner of Nordvestø (Northwest Island), and nearby a flight of raised beaches provides easy access to the plateau which makes up most of the island's area (Fig. 90.2). The nearest islands, such as Isbjørneø, were reached by means of a 4.2 m-long Canova rubber boat equipped with a 9.5 h.p. outboard motor. The field party was picked up by *C.S.S. Hudson* on August 12th and landed at Dundas the following day.

Field work was devoted to four main topics: (1) studying the stratigraphy of unconsolidated deposits exposed in coastal cliffs and collecting marine molluscs and cirripeds for absolute age determinations; (2) searching for evidence of glaciation, such as striated and polished rock surfaces, as well as erratic pebbles and boulders; (3) coring some of the numerous peat deposits on the islands; and (4) echo sounding to obtain data on the depth and configuration of the inter-island channels. The present report will deal chiefly with the radiocarbon age determinations (Table 90.1), four of which are on samples obtained in 1976.

Geomorphology and the Pattern of Ice Flow

The Carey Islands comprise six major islands (Fig. 90.1) and a considerable number of tiny islets. The bedrock is dominantly gneiss, although a number of diabase intrusives are present also (Wordie, 1938; Munck, 1941; Bendix-Almgreen *et al.*, 1967). The summit plateaus of five of the main islands lie between 125 and 170 m a.s.l., but elevations over 200 m occur only on Nordvestø, the largest of the group.

In addition to the authors listed above, mention of features related to glaciation and emergence on Björlings Ø (Fig. 90.3) was made as early as the last century by Chamberlin (1895a, 1895b), on the basis of his observations during the Peary Auxiliary Expedition of 1894 to northwestern Greenland. Later visits to the islands were made by Koch in 1916 (Koch, 1928) and by the Godthaab Expedition 1928 (Riis-Carstensen, 1931), but none of these expeditions was in the vicinity of the Carey Islands for more than a few days.

Observations made in 1974 and 1976 revealed that erratics are abundant on the summit plateaus of all the major islands shown in Figure 90.1. In some places the ground surface takes on a varicoloured aspect, so numerous are the pebbles and cobbles of quartzite, sandstone, dolomite, conglomerate, granite, etc., whereas in other localities erratics are much more scattered. The rocks other than gneiss and diabase are all foreign to the Carey Islands, and the most logical source areas are to the northeast and north; cf. Dawes (1971) for a general summary of bedrock in North Greenland. Also, because of the sharp contacts between the diabase intrusives and the gneissic country rock on the plateau of Nordvestø, it was possible to see how boulders of one rock type have been plucked up and displaced southward onto the other rock type. Another type of erratic consists of fragments of marine mollusc shells. Bendix-Almgreen *et al.* (1967) were correct in suggesting that shell-rich till *should* occur, but they did not succeed in finding any. More time was available for searching in 1976, and as a result till containing a variety of shell fragments was discovered on both Nordvestø and Bordø. Both sites, at elevations >100 m a.s.l. (above the limit of Holocene boulder beaches), are situated in saddles on the plateaus, and the flow of glacier ice across the islands would have been concentrated in just such topographic depressions. As is shown in Figure 90.2, the shelly till on Nordvestø is south of an extensive area of raised beaches which occupies a re-entrant in the bastions of gneiss making up the north coast of Nordvestø. This re-entrant provided the easiest route by which ice could reach the interior of Nordvestø, and the older marine sediments, which can be presumed to underlie the Holocene boulder beaches, would have furnished a ready source of mollusc shells.

In addition to the evidence provided by the erratics, the presence of striated and rounded rock outcrops, accompanied by plucking on the lee (south) side and by numerous chattermarks and crescentic fractures, attests to the flow of ice from north to south (Figs. 90.4 and 90.5). Striated surfaces were found on the summit plateaus on Björlings Ø, on Fireø, and in many localities on Nordvestø, even on the highest ridge at elevations above 200 m. When these observations are coupled with the gross morphology of the islands – i.e. cliffs are better developed at the southern ends of all the major islands, whereas the north-facing exposures are only steep slopes at many sites (cf. Figs. 90.2 and 90.3) – there can be little doubt that these islands have been overridden by ice moving southward (Fig. 90.1). Presumably a major contribution to this southward flow came from ice which derived from Inglefield Bredning (Gulf) and Hvalsund (Whale Sound).

Marine Fauna and Radiocarbon Age Determinations

In the course of the brief visit to the Carey Islands in 1974, collections of marine fauna were made on the eastern side of Isbjørneø and near the southeastern tip of Nordvestø (Blake, 1975). During the flight to the Carey Islands in 1976, however, a site which appeared more promising was noticed at the southwestern corner of Isbjørneø (Fig. 90.6). Later in the summer this pocket of marine deposits was visited several times by boat, resulting in some extraordinarily rich and interesting collections of marine fauna. Comments in this preliminary report will be limited to the species actually utilized for dating (Table 90.1).

As is the case throughout the Carey Island, because of the virtually unlimited fetch available and the presence of open water for more of the year than is common at these high latitudes (Nutt, 1969), the surface of the marine deposits on Isbjørneø is made up of a veneer of cobble and boulder beaches (cf. Fig. 90.7). Beneath the surface boulders are finer grained deposits (mainly sand), although boulders are present throughout the

Figure 90. 4. Striated diabase outcrop above an extensive beach area on the north coast of Nordvestø (cf. Fig. 90. 2). The direction of ice flow was north to south, from left to right in the photograph. The hammer handle is 32. 5 cm long. July 30, 1976 (GSC-203107B).

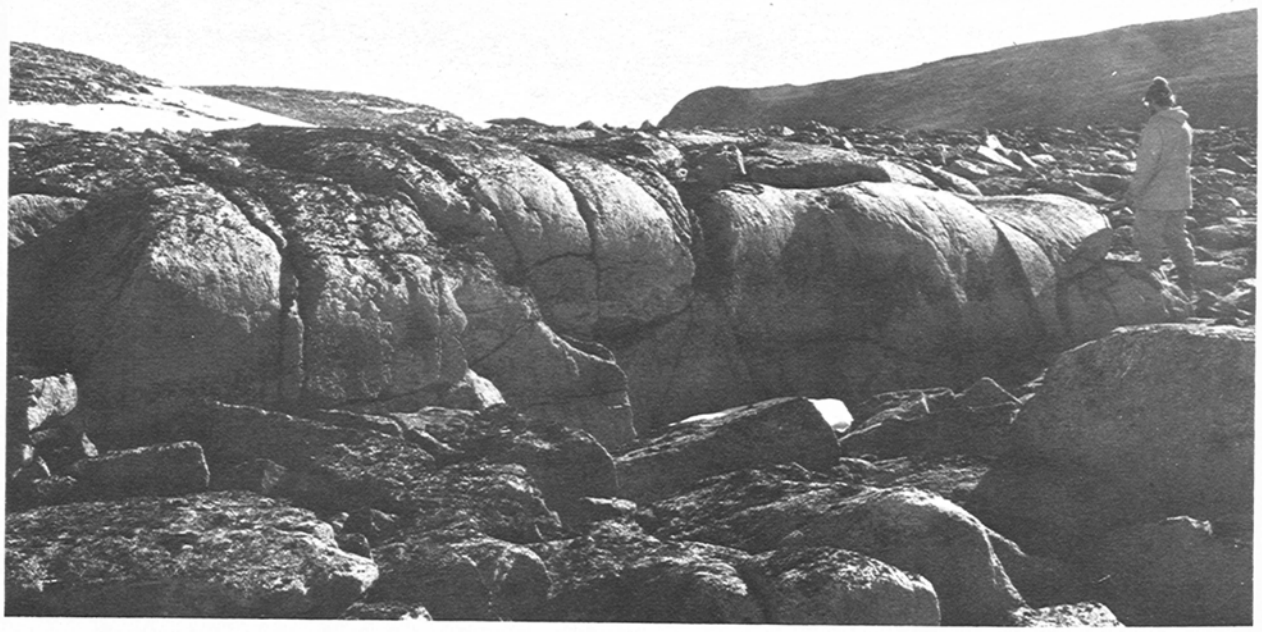

Figure 90. 5. View south-southwest at a rounded outcrop of gneiss in central Nordvestø. The direction of ice flow was toward the deep valley whose west wall is visible on the skyline. August 11, 1976 (GSC-203107C).

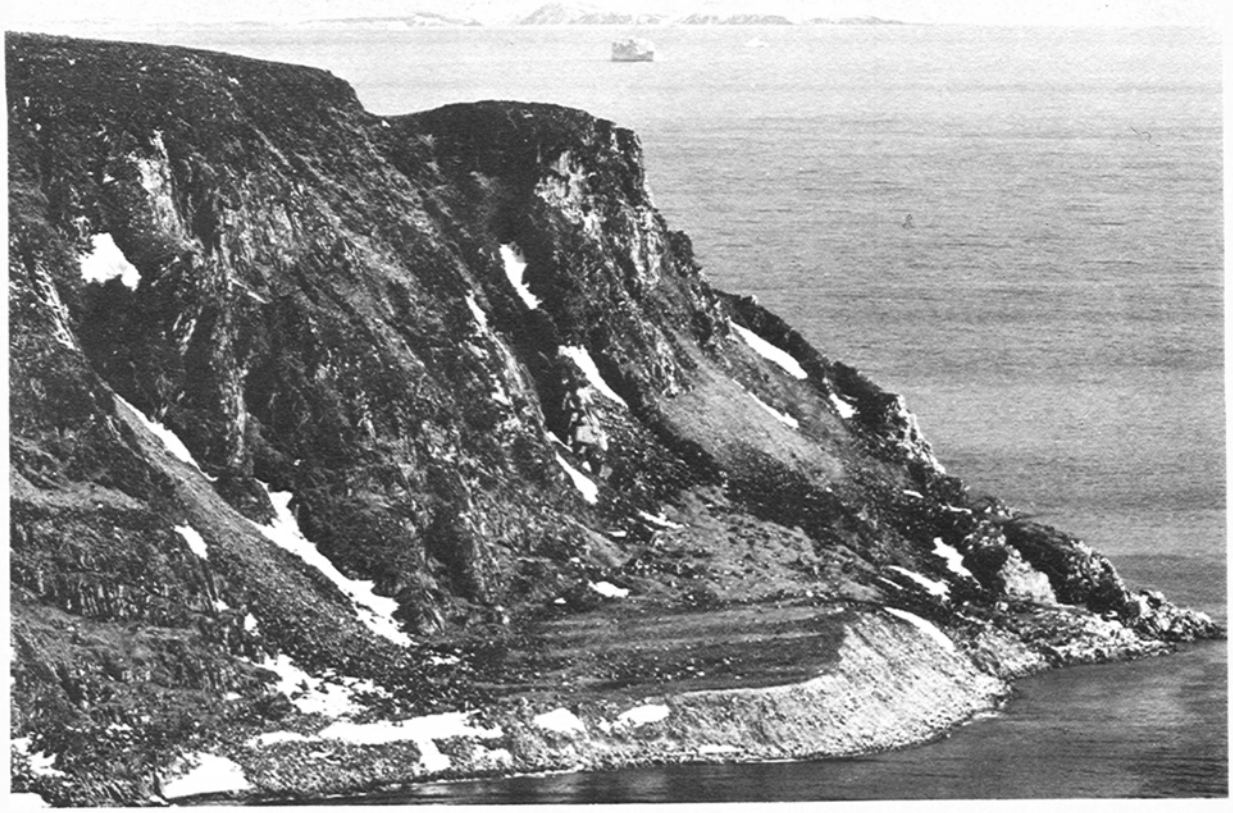

Figure 90. 6. Telephoto view southeast from Nordvestø at the southwestern corner of Isbjørneø. The 25 m-high section of unconsolidated sediments here has a veneer of Holocene cobble-boulder beaches which are underlain by marine deposits more than 38 000 years old (GSC-2374; Table 90. 1). July 19, 1976 (GSC-203107D).

Figure 90. 7. Boulder beaches in the major valley extending inland from the south coast of Nordvestø. Spruce (*Picea* sp.) driftwood was found where the two people are standing, at an elevation of some 20 to 25 m. Many of the boulders comprising these beaches are over 30 cm in diameter. July 30, 1976 (GSC-203107E).

25 m-high section. Most surprising, perhaps, was the discovery of many intact, commonly paired, valves of the Iceland Scallop, *Chlamys islandicus*, in sand and in voids between boulders near the base of the section. Such large and well preserved individuals are rare in deposits which the writer has investigated elsewhere around northern Baffin Bay; in fact, because of its fragile nature this species usually occurs only as fragments. The largest intact individual, with a height of 9.8 cm and a length of 9.3 cm, is larger than any of the living individuals reported by Ockelmann (1958) from East Greenland and Jan Mayen, or than those from emerged marine deposits in the northern part of West Greenland (Laursen, 1944). Because the finite radiocarbon age determined for these shells (38 300 ± 1100 years, GSC-2367; Table 90.1) is largely a function of statistics, it seems wisest to regard this value as a minimum age.

Higher in this section, in a zone characterized by an abundance of massive boulders (some over 1 m in diameter), numerous individuals of the Northern Ridged Barnacle, *Balanus balanus*, still were attached to rock surfaces. These shells, also extremely well preserved, were expected to be of Holocene age, but they, too, are beyond the limit of radiocarbon dating (>38 000 years, GSC-2374; Table 90.1).

Near the top of the section, just beneath the veneer of boulder beaches at approximately the 20 m level, the fauna is dominated by the Arctic Saxicave, *Hiatella arctica*, including many intact and paired valves. These pelecypod shells, with an age of 7900 ± 70 years (GSC-2372; Table 90.1), represent the oldest Holocene material dated so far from the Carey Islands.

None of the shell samples discussed above can be related to a specific position of the shoreline, nor can the barnacle fragments from an elevation of 1.5 m in southern Nordvestø (3460 ± 130 years, GSC-2102; Table 90.1). The highest beaches at the Isbjørneø locality shown in Figure 90.6 are about 30 m a.s.l.; above that elevation there is too much turf and scree masking the surface for beaches to be discernible. On Nordvestø at the locality shown in Figure 90.7, however, Bendix-Almgreen *et al.* (1967) reported that the boulder beaches extended to approximately 265 feet (80 m), and altimetry in 1976 confirmed that their result is of the right order of magnitude. All that can be stated at present is that when the 7900 year-old pelecypods were living, relative sea level was certainly above 23.5 m (the elevation of the boulder beaches immediately above the collection site), and it could well have been above 30 m.

As to the "old" marine fauna, both of the species dated live at varying depths. Pilsbry (1916) states that *Balanus balanus* occurs as deep as 165 m, and Bousfield (1960) gives a value of 180 m. In the vicinity of Saunders Ø and Wolstenholme Fjord *Balanus balanus* has been dredged from several sites between 30 and 40 m depth (Vibe, 1950). For *Chlamys islandicus* the range is given as up to 150 m by Odhner (1915) and up to 356 m by Ockelmann (1958). In view of the severity of the storm waves which pound the coasts of the Carey Islands at present, it seems reasonable to assume that the level of the sea could easily have been 10 m or several tens of metres higher, relative to the land, when the delicate scallops and the barnacles were the dominant elements in the marine fauna.

During the collecting on Isbjørneø no significant break, such as might be represented by a till or by a unit devoid of marine fauna, was observed in the section, although extensive digging could not be undertaken because of the danger of boulders rolling down from above. In terms of the general grouping of radiocarbon age determinations (i.e., Holocene and "old"), however, the section is similar to those studied earlier on Saunders Ø, Coburg Island, and at Cape Storm on Ellesmere Island (Blake, 1976). Hence, it is perhaps not unreasonable to postulate that the *Chlamys islandicus* unit on Nordvestø corresponds to a gravel unit on Saunders Ø in which fragments of *Mytilus edulis* are >40 000 years old (GSC-2143; Blake, 1976) and in which fragments of *Chlamys islandicus* are also present. Likewise, on Coburg Island, fragments of *C. islandicus* occur with *Hiatella arctica* shells >40 000 years old (GSC-1062), beneath a *Mytilus*-bearing unit for which an age determination of >38 000 years (GSC-1425; Blake, 1973) was obtained.

Peat Deposits

Following their visit to Nordvestø in 1965, Bendix-Almgreen *et al.*, (1976) reported that "very thick (4 feet or more) peat deposits of the palsa type were found at several places near the edge of the summit". Thick deposits of peat were observed by the writer on top of Dark Head, Isbjørneø in 1974 (Blake, 1975), and peat mounds elsewhere on that island were discovered in 1976.

Coring with a SIPRE-type auger (equipped with tungsten carbide cutters; core diameter, 7.6 cm) was carried out at two localities on Nordvestø in 1976. One site, in the central part of the island, is located in the upper reaches of the same valley shown in Figure 90.7; the other site is at an elevation of approximately 140 m on the edge of the plateau, overlooking the north coast of the island (Figs. 90.8 and 90.9). At the north coast site, one mound was cored to 258 cm below the surface, at which depth an object (presumably either bedrock or a boulder) was encountered of sufficient hardness that the cutters started to chip. Core recovery was 100 per cent, and the increment at 253 to 258 cm depth gave an age of 6300 ± 80 years (GSC 2368; Table 90.1). Dating of the top of the frozen peat (only the top 15 cm was thawed) is planned as part of a more detailed treatment of this interesting site. In addition to its unusual location, the moss species constituting the basal dated peat, as well as the rest of the core, is *Aplodon wormskioldii;* this is a species commonly restricted to growing on carcasses or excrement (G.R. Brassard, pers. comm., 1976; cf. also Holmen, 1960; Brassard, 1971; Kuc, 1973).

Figure 90. 8. View southeast at peat mounds and coring site (black arrow) on the plateau rim along the north coast of Nordvestø. Erratics plus striated boulders of locally-derived diabase were common on the edge of the plateau at the position indicated by the open arrow. August 9, 1976 (GSC-203107F).

Figure 90. 9. Detail of the coring site shown in Figure 8 (view northwest). The basal peat here, at a depth of 253 to 258 cm, is 6300 ± 80 years old (GSC-2368; Table 90. 1). August 7, 1976 (GSC-203107G).

Acknowledgments

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