larths and *Hyracotherium* sp. that are described from the Eocene of the Rocky Mountain area and of Europe.

The phylogeny of the equids has been carefully compiled from *Equus* to the Eocene perissodactyl *Hyracotherium*, but the phylogenetic link between the earliest populations of *Hyracotherium* and possible condylarth ancestors has not been found. In fact, the very abrupt Eocene appearance of *Hyracotherium*, even in those areas where Late Paleocene faunas are well known, is disconcerting. This is especially so if the northern origin of *Hyracotherium* is postulated. If, however, perissodactyls on the phylogenetic line leading to *Hyracotherium* evolved in a more southern region and then migrated to North Amerca and Europe, the abrupt stratigraphic appearance in these areas would be a logical consequence. Cf. *Hyracotherium* sp. from Baja California may well be the first discovery supporting such a hypothesis.

Regardless of the age assignment of the Punta Prieta assemblage, though Clarkforkian is at present preferred, the presence of these forms indicates access routes from the Rocky Mountain area to Baja California during early Tertiary time. If the Clarkforkian age assignment proves correct, then migrations along the route were in both directions; barylambdid pantodonts migrating southward while perissodactyls moved north. Occurrence of Early Tertiary notoungulates in South America, Wyoming, and Asia also suggests a north-south migratory route (*8*), but this may have been further east than the one suggested by the Punta Prieta assemblage.

Paleogeographic conditions conducive to north-south migrations are poorly understood. Some workers suggest a direct land connection from southwestern United States through northern Baja California, encompassing the Sierra San Pedro Martir, during the Paleocene and Eocene (*9*). This area would provide a convenient corridor between the Rocky Mountain region and Baja California at least for such seemingly pandemic forms as the barylambdids, *Hyracotherium*, and *Esthonyx*.

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## Baffin Island Refugia Older than 54,000 Years

Abstract. *Two radiocarbon determinations on marine shells from the east coast of Baffin Island give ages exceeding 50,000 years. These findings indicate the existence of unglaciated areas (refugia) between fiords occupied by outlet glaciers flowing toward Baffin Bay, from the central part of the Wisconsin ice sheet, over the Foxe Basin–Hudson Bay area.*

The east coast of Baffin Island is generally of steep and rocky fiords, with mountains higher than 1000 m within 10 to 20 km of the coast. A notable exception occurs near Clyde, where the terrain of an approximately 200-km length of the coast rises more gradually, extensive areas lying less than 200 m above sea level in a series of drift-covered forelands; a relatively minor rise in sea level would result in extensive landward displacement of the shore line.

One sample of shell was collected from a raised delta some 15 km inland from the present shore at Cape Aston. In many places the low-lying land slopes gently to the present shore, but elsewhere long stretches of cliffs, up to 40 m high, have been cut in the unconsolidated material. A second sample of shell was taken from such a cliff 17.5 km north-northeast of Clyde.

During the last glaciation the eastern part of Baffin Island was dominated by outlet glaciers flowing toward Baffin Bay along the major valleys and fiords (*1*). The extensive Cockburn moraine system, formed approximately 8000 years ago when the termini of the outlet glaciers lay in the middle parts of the fiords, has been described (*2*), but our knowledge of older glacial deposits is scant.

At the time of the last deglaciation the land was isostatically depressed, relative sea level near the head of the fiords standing more than 70 m higher than at present; the marine limit generally decreased toward the northeast to an altitude of approximately 20 m at the outer coast.

The Cape Aston shells were collected from a sandy part of a large delta at an altitude of 61.3 m; radiocarbon dating (Y-1703) showed an age exceeding 54,000 years (*3*). The sample consisted entirely of *Hiatella arctica* L. and *Mya truncata* L. (*4*); many paired bivalves were found, and few broken shells showed that they were *in situ*.

The delta front is approximately 10 km long and lies parallel with the present shore, while the apex is about 3 km farther to the west. The subaerial part of the delta surface, which is covered with many dry stream beds fanning from the apex, decreases in altitude from 88 m at the apex to 80 m at the rim, where a steep foreslope falls off to 45 m above sea level. Surface material grades from cobbles and small boulders at the apex to sands and gravels at the delta rim. However, boulders more than 2 m in diameter, the largest found on the delta, are scattered along its rim. This distribution pattern shows that the large boulders did not come from the higher parts of the delta; they are interpreted as ice-rafted deposits.

From exposure in numerous small valleys it is apparent that sand is the major material in the delta, in sharp contrast with the surface material. A stratum of silt and clay lies between 60 and 65 m above sea level near the rim, rising toward the apex and forming a distinct structural bench along the valley sides. Shells found in five different localities were all within or immediately adjacent to this stratum of finer sediments. The altitudes of the delta rim and of the marine molluscs show that the delta was formed in salt water at a time when relative sea level was approximately 80 m higher than today.

The delta was deposited in front of large channels, now occupied by notably underfit streams. These channels and the delta must have been formed during a glacial phase when an outlet glacier in McBeth Fiord blocked the normal drainage and channeled water along the ice margin farther north (Fig. 1). During glacial periods the land was isostatically depressed, causing the higher relative sea level. Both shell species are typical of Arctic environments; none of the indicators of warmer conditions, that occur in the postglacial deposits of the area, was found. These findings are consistent with a glacial rather than an interglacial orgin of the delta.

The silt layer is believed to have resulted from temporary interruption of the sand supply, caused by oscillations of the ice margin or by a transgression that brought the area under deeper water—into a relatively quiet environment.

The very high marine limit of 80 m at the delta, compared with about 20 m at the mouth of the fiords, is remarkable. It can hardly be explained by assumption of postglacial upwarping, but only by postulation of difference in age; thus the marine limit at the delta was formed during a major glaciation, when the land was greatly depressed, primarily by ice in and adjacent to the fiords; access by the sea was thus restricted to (topographically) protected parts of the outer coast. Retreat of the ice and isostatic recovery followed. It is not known how far the ice retreated; there may have been a slow, gradual retreat, but possibly there was extensive deglaciation, followed by a later readvance that obliterated older high shore features along the fiords.

The area adjacent to the fiord mouths did not become ice-free for the last time until relative sea level had fallen to approximately 20 m above the present; the date is unknown, but three radiocarbon ages of samples, believed to be of the oldest *in situ* marine fossils from the outer parts of Inugsuin Fiord and Clyde Inlet (*5*), are all younger than 8200 years. This finding may reflect a sampling problem, but it is possible that extensive outlet glaciers reached the mouths of the fiords between 8000 and 9000 years ago. Two shell samples collected in lateral moraines along the north sides of Clyde Inlet and McBeth Fiord, respectively, have been radiocarbon aged at 34,900 and more than 41,100 years (*6*). The moraines themselves must be younger than this, and the dates give the maximum age of the readvance to these ice-marginal positions. The great difference between these ages is remarkable and remains unexplained.

A continuous cliff, reaching more than 40 m in height, extends for some 25 km between Cape Christian and Kogalu River. The stratigraphy of the drift deposits is beautifully exposed (*7*). The material ranges from clay to large boulders, with sands predominating. Although the stratification is distinct, with essentially horizontal strata, there are noticeable contrasts between sections along the shore. At either end of the cliff the stratigraphy has several units and is very complex, whereas only clay overlying a sand unit occurs in the center.

Extensive till deposits in the area southeast of Kogalu River show that the Pleistocene ice sheets must have extended so far; lateral moraines at levels up to 300 m above sea level, on hills near the coast, confirm this extent. The marine limit lies at least 75 m above present sea level, but between Patricia Bay and Cape Christian a hummocky terrain, with many ponds below this level, is interpreted as dead-ice topography, thus suggesting that the ice was present at a later stage.

The Cape Christian sample was collected approximately 12 km northwest of the cape at 13.4 m above sea level; the cliff here is 21 m high and the stratigraphy is shown in Fig. 2.

A layer of fossiliferous sand with some stones lies at the bottom of the visible part of the section, which is cut entirely in drift; no bedrock is exposed. Above this sand lies an approximately 6-m-thick bed of rounded stones and coarse gravel; the stones rarely exceed 20 cm in diameter and are particularly concentrated in the upper part of the unit.

Overlying this gravel is a 6-m-thick stratum of sand, in the middle of which is an exceptional concentration of shells. In one sample, aged more than 50,000 years (Y-1702) (*2*) and collected from this part of the section, *Serrepis groenlandicus* (Brugiere), *M. truncata*

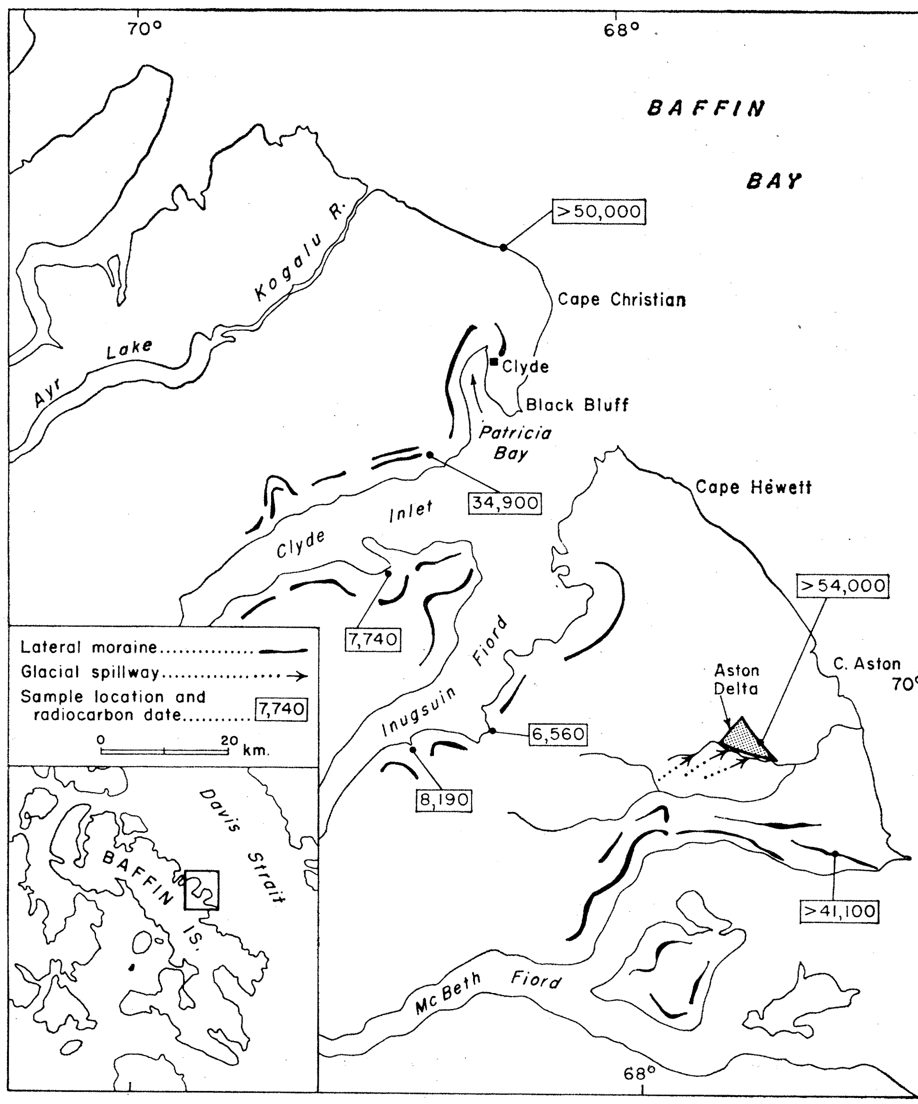


Fig. 1. Main lateral moraines and sources of dated samples.

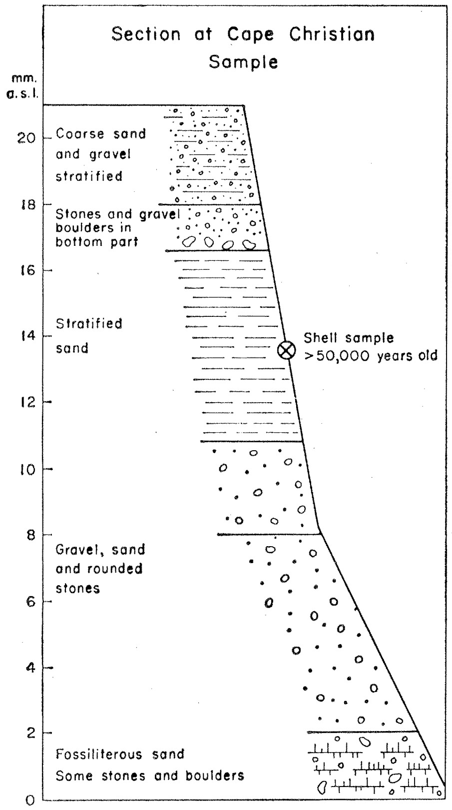


Fig. 2. Stratigraphy of cliffs near Cape Christian.

L., and *H. arctica* L. were identified (*3*). Many paired bivalves were found in upright positions and the shells were undoubtedly *in situ*.

The sand is overlain by a 1-m-thick gravel bed similar to the one below the sand. The stones and boulders in this stratum decrease in size and increase in roundness upward. The layer is again overlain by a layer of coarse sand and fine gravel.

The bottom stratum, with shell fragments and high clay content, is interpreted as a marine deposit that has been plowed up and redeposited by an advancing glacier. That the dominating sand layer is a marine deposit is shown by the molluscs, and the low sorting coefficient (*So*, 1.33) and the low skewness (*8*) ($Sk_I$, 0.22) indicate that the sand is a littoral deposit. The sand also contains more rounded and subrounded grains than any other part of the section. The coarse strata above and below the sand are both interpreted as glacial deposits, and may be either till or glaciofluvial in origin. The lower parts of both strata, with less sorted material, resemble till, while the upper parts, which are better rounded and sorted, appear to be glaciofluvial. The upper gravel stratum may be a lag deposit that was left after a more extensive deposit had been washed away; if it is of glaciofluvial origin, its coarse texture indicates that it was deposited near base level. The highest sand and gravel is interpreted as a littoral deposit formed partly by deposition of ice-rafted material as the sea regressed over the area for the last time.

Thus there is evidence of two glacial advances, one of which occurred more than 50,000 years ago, as shown by the age of the overlying sand. The lateral deposits along Patricia Bay and Clyde Inlet show that ice flowed north from the mouth of the inlet, and the decreasing complexity of the stratigraphy of the cliffs immediately northwest of the locality described reflects the extent of this northward flow.

A most intriguing implication of the very great age of the Cape Aston sample is the possible existence of ice-free areas along the east coast during glacial maxima. The Cape Christian sample confirms the great age of the other sample and shows that these very old sediments occur in more than one isolated locality. Especially in Scandinavia (*9*), but also in North America (*10*), attention has been given to distribution of plants, insects, and animals, and the evidence strongly suggests that the present distribution pattern is explained by migration from refugia where the organisms survived glaciation.

The Aston delta shows no evidence of having been overrun by ice after its formation, and the same thus applies to the higher hills nearby, which are above the marine limit and would therefore have provided refugia for plants and animals. The evidence suggests the presence of ice-free areas for longer than 54,000 years, but by analogy one may assume that similar conditions existed earlier in the Pleistocene. In the discussion of refugia, attention has been focused on (i) nunatak refugia (on the high coastal mountains) and (ii) on foreland refugia (on the low coastal areas and possibly coastal banks). The refugia near Cape Aston would be of the second type.

In spite of the long period of subaerial weathering, a low knob at the apex of the Aston delta was not covered by mountain-top detritus (*11*). Although extensively weathered, the structure of the underlying bedrock was clearly visible and the surface resembled that of the "middle zone" in the Torngat Mountains of northern Labrador, thus indicating that the "upper trimline" in that area is older than 50,000 years (*12*).

The two samples gave the oldest radiocarbon ages obtained in arctic Canada, although a number of samples have proved older than 40,000, years; one cannot yet correlate the described deposits with any other features in the area or in southern Canada. The cliff sequence north of Cape Christian should yield a chronology reaching far back into the late Pleistocene.

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## Nickel Orthouronate: High-Pressure Synthesis

Abstract. *The compound $NiUO_4$ has been synthesized at high pressure and temperature. No material of this composition is known to be synthesized at ambient pressure. The $NiUO_4$ structure is of the orthorhombic body-centered $MgUO_4$ type; cell dimensions:* $a_1$, *6.415 Å;* $a_2$, *6.435 Å; and* $a_3$, *6.835 Å.*

When mixtures in proper proportions of MgO and $U_3O_8$ were fired in air at 1000° to 1200°C, the orthouranate $MgUO_4$ was formed. In mixtures of NiO and $U_3O_8$ fired at temperatures