Postglacial emergence along northern Nares Strait

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England, J. 1982. Postglacial emergence along northern Nares Strait. – In: Dawes, P. R. & Kerr, J. W. (eds), Nares Strait and the drift of Greenland: a conflict in plate tectonics. – Meddr Grønland, Geosci. 8: 65–75.

During the last glaciation much of northern Nares Strait remained an ice-free corridor separating the northeast Ellesmere Island and northwest Greenland ice sheets. The disproportionate size of these ice sheets resulted in the lithosphere being differentially loaded on either side of this prominent rift valley. Postglacial emergence in this area is analyzed in order to determine whether glacio-isostatic unloading engendered any abnormal displacement along the Nares Strait fault zone. Present data suggest that synchronous shorelines dated 6000, 7000 and 8000 BP rise from north to south across northeast Ellesmere Island and northern Nares Strait towards the Greenland ice sheet. This is considered to represent the glacio-isostatic dominance of the Greenland ice sheet during the last glaciation together with earlier postglacial emergence towards northernmost Ellesmere Island which lay beyond the influence of the Greenland ice sheet. This Greenland dominance indicates that northeast Ellesmere Island lay in the depression marginal to the Greenland ice sheet. This, in turn, requires a lithospheric flexural parameter extending in an undisrupted manner across the Nares Strait rift valley. Hence, on a regional scale, it appears that the lithosphere in this area has integrated the depressions from these separated ice sheets without any observable unconformities along Nares Strait. Although postglacial faulting has followed initial glacio-isostatic unloading in other areas the present data base does not have the resolution to document similar events along Nares Strait.

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Regional reconstructions of postglacial isobases have long been used for determining the distribution, magnitude and subsequent unloading of ice sheets from the last glaciation (cf. Andrews 1970, 1974). The relationship between former ice sheets and the vertical displacement of the lithosphere and asthenosphere is seen today in ongoing relative sea level adjustments and in negative free air gravity anomalies, both of which show that many areas are not in isostatic equilibrium (Walcott 1972a). In addition to postglacial isobases, postglacial emergence curves document the vertical displacement of specific sites through time following glacial unloading. Collectively this information has been increasingly used to develop geophysical models which attempt to duplicate and predict the rheological responses to different ice sheet histories (Broecker 1966, Brotchie & Silvester 1969, Walcott 1970, 1972b, Farrell & Clark 1976, Peltier 1976, Peltier & Andrews 1976, Clark et al. 1978, Quinlan in press). In most areas glacial unloading is thought to have produced a relatively gentle and continuous response in the lithosphere, resulting in a smooth net emergence of the land within and along the former ice sheet margin (Clark et al. 1978). In a few areas, however, glacial unloading was accompanied by faulting, most notably documented in Sweden (Lundqvist & Lagerbäck 1976, Lagerlund 1977, Mörner 1978). Postglacial faulting along Nares Strait has not yet

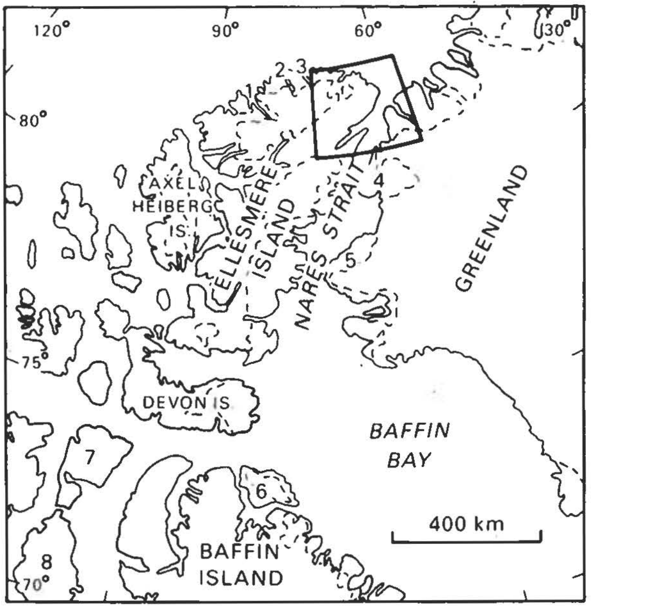

Fig. 1. Map of eastern Queen Elizabeth Islands and northwestern Greenland showing the location of the study area (inset) in the Nares Strait region. Main ice limits shown. 1 = Yelverton Inlet, 2 = M'Clintock Inlet, 3 = Ward Hunt Island, 4 = Washington Land, 5 = Inglefield Land, 6 = Bylot Island, 7 = Somerset Island, 8 = Boothia Peninsula.

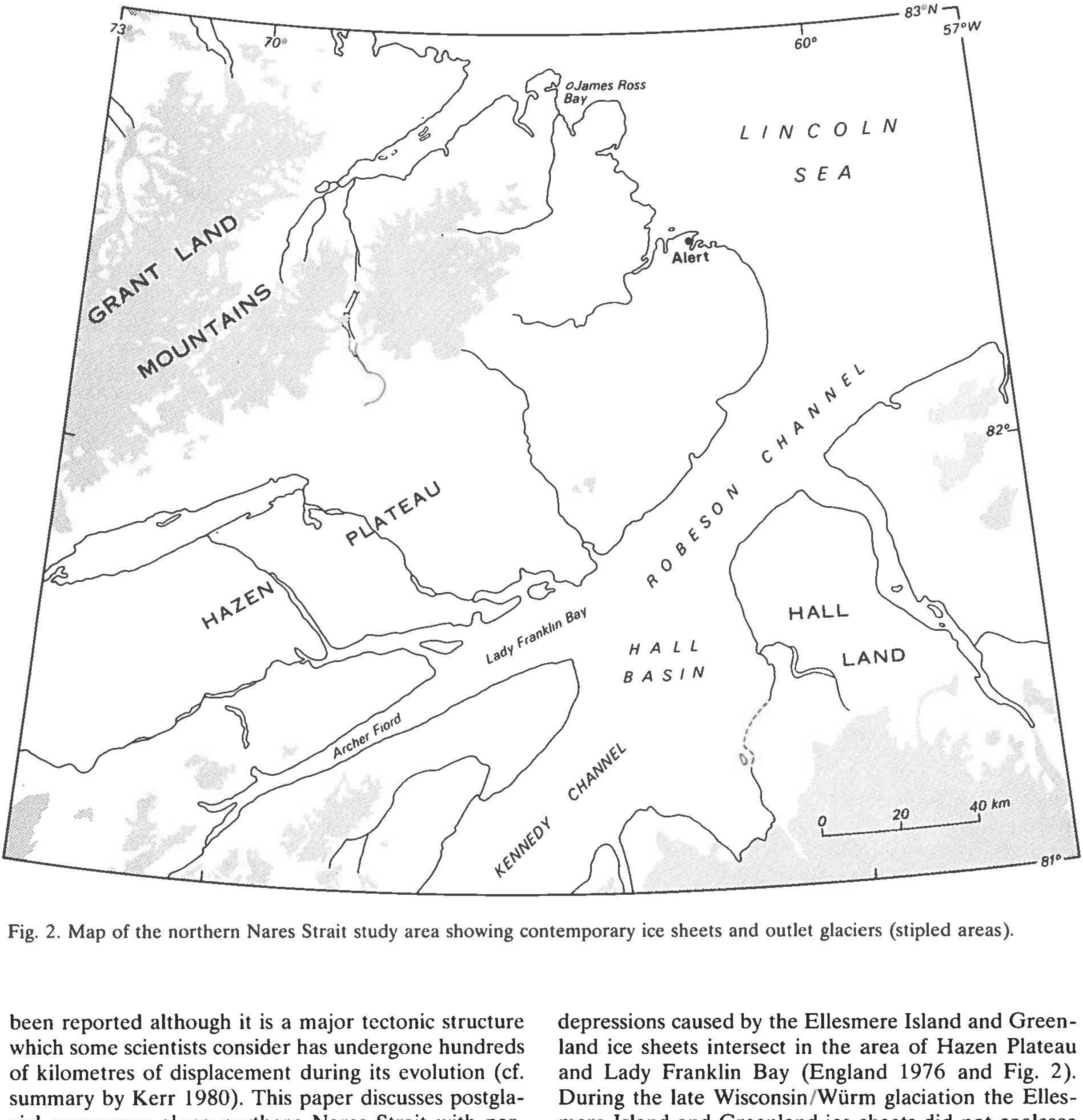

Fig. 2. Map of the northern Nares Strait study area showing contemporary ice sheets and outlet glaciers (stipled areas).

been reported although it is a major tectonic structure which some scientists consider has undergone hundreds of kilometres of displacement during its evolution (cf. summary by Kerr 1980). This paper discusses postglacial emergence along northern Nares Strait with particular emphasis on the problems and potential of the present data base as it pertains to the general tectonics of the area (Figs 1 and 2).

Along northern Nares Strait, Ellesmere Island and Greenland attain their greatest proximity separated by only 24 to 40 km. In this area their contemporary ice sheet margins are only ~150 km apart (Fig. 3). Under normal lithospheric conditions ice sheets generate ice-marginal depressions of ~180 km beyond which is a low amplitude forebulge where crustal displacement is positive (Brotchie & Silvester 1969, Walcott 1970). Assuming a normal 'crust' under the Lincoln Sea (Trettin et al. 1972 and Fig. 2), the present marginal depressions caused by the Ellesmere Island and Greenland ice sheets intersect in the area of Hazen Plateau and Lady Franklin Bay (England 1976 and Fig. 2). During the late Wisconsin/Würm glaciation the Ellesmere Island and Greenland ice sheets did not coalesce along northern Nares Strait, and hence an ice-free corridor existed along this seaway (England 1976, 1978, England & Bradley 1978, England et al. 1978, 1981). Consequently, northern Nares Strait is an ideal area for investigating the glacio-isostatic interactions of two ice sheet systems which differentially loaded the lithosphere on either side of this prominent rift valley (Kerr 1967). Deglaciation of the areas bordering the ice-free corridor began ~8000 to 8400 BP based on evidence from the Ellesmere Island side. The problem of concern here is whether glacio-isostatic flexing of the crust engendered any abnormal movement along the northern Nares Strait rift valley following the last glaciation.

Previous results

Several authors have drawn regional isobases for the High Arctic that are shown to extend uniformly from northwest Greenland into the eastern Queen Elizabeth Islands (Andrews 1970, Walcott 1972a, England 1976, Weidick 1976). Although the absolute values and orientations of the isobases differ from study to study, no abrupt break, hinge line, or saddle has been suggested for the northern Nares Strait area. In addition, England (1976) drew isobases on the 7500 and 6000 BP shorelines along northeast Ellesmere Island that indicated a rise in these shorelines from northwest to southeast towards the present margin of the Greenland ice sheet. The gradients of these shorelines indicate: 1) the glacio-isostatic dominance during the last glaciation of the Greenland ice sheet to the southeast and 2) the lack of abrupt differential movement along either the Alert geomagnetic anomaly (Praus et al. 1971) or the Nares Strait rift valley (Kerr 1967). Finally, because the Greenland ice sheet did not cover northeast Ellesmere Island during the last glaciation, its glacio-isostatic dominance requires that northeast Ellesmere Island lay in the zone of depression marginal to the Greenland ice sheet. This in turn requires some type of lithospheric "flexural parameter" (Walcott 1970) which extended in an undisrupted manner across the Nares Strait rift valley.

England (1974) used a static geophysical model (modified from Brotchie & Silvester 1969) that simulated the isostatic effects of possible ice loads during the last glaciation as suggested by the geological data bordering northern Nares Strait. The model assumes a thin, elastic, spherical lithosphere overlying a viscous asthenosphere. The geological parameters which could be varied include the number of ice sheets, their locations, thicknesses, radii and rates of retreat (all of which are little known in detail). The geophysical parameters which could be varied include the lithosphere's radius of relative stiffness (similar to Walcott's flexural parameter) and the density of the asthenosphere. In the minimum ice load model, which assumed the aforementioned ice-free corridor, the northwest Greenland ice sheet was assigned a radius of ~500 km and a maximum thickness of 3200 m (compared to a radius of 400 km and a maximum thickness of 2500 m today, Weidick 1971). On the other hand, the Ellesmere Island ice caps were assigned a combined radius of ~180 km and a maximum thickness of 1500 m (compared to a combined radius of 120 km and a maximum thickness of 900 m today, Hattersley-Smith et al. 1969). Using a 'normal' flexural parameter of ~180 km and the restricted ice margins on northwest Greenland (Davies 1972, Weidick 1972) and northeast Ellesmere Island (England 1978) it was found that the predicted emergence from this model was in good agreement with the pattern and magnitude of the observed postglacial emergence. Although more sophisticated geophysical models are now available for predicting postglacial emergence (Clark 1977, Clark et al. 1978) the static depressions estimated by the Brotchie & Silvester model are still considered reasonable and they simply suggest that solutions based on a normal lithosphere in this area are presently consistent with the glacio-isostatic evidence. More recent evidence suggesting that northern Nares Strait is aseismic (Praus et al. 1971, Basham et al. 1977, Wetmiller & Forsyth, this volume) may also indicate a stable lithosphere whose large-scale activity is relatively uninfluenced by its numerous surface faults (cf. Kerr 1967, Trettin 1971).

Existing problems

The most outstanding problems for the analysis of glacio-isostatic adjustments along northern Nares Strait are those of: 1) limited control points; 2) the establishment of marine limits in the marginal depression and 3) the comparability of some radiocarbon age determinations. These problems must first be resolved before postglacial isobases can be accurately drawn and interpreted in terms of recent tectonic activity in the area. The present data base contains some inconsistencies which could be attributable to any of these problems and hence the question of whether or not there has been

Fig. 3. Visual satellite image (NOAA–6) of the Nares Strait region taken in late July, 1979. The disproportionate glacial loading presently bordering Nares Strait is clearly exhibited by the northwest Greenland ice sheet to the right and the smaller Ellesmere Island ice caps to the left. Top left ice field occurs on Axel Heiberg Island and lower left ice field occurs on Bylot Island bordering the 'North Water' polynya of northern Baffin Bay.

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Holocene faulting in northern Nares Strait cannot be definitely answered at this time.

Scarcity of data

The most obvious limitation to analyzing postglacial emergence along northern Nares Strait (north of 81° latitude) is the scarcity of control points, particularly on the Greenland side where only five ^{14}C dates are available, four of which come from Hall Land (Fig. 2; Weidick 1972, 1978). By comparison over one hundred ^{14}C dates are now available from the adjacent coast of Ellesmere Island. Due to this uneven distribution in the data base, a number of different isobase patterns can be drawn (Weidick 1976) and these can only be resolved by further field work.

Recognition of marine limits in zone of marginal depression

Relatively little attention has been given to the problems of marine sedimentation in the marginal depression of former ice sheets (England 1978). As suggested above, considerable areas along the northeast coast of Ellesmere Island remained ice-free during the last glaciation. Today, this polar desert landscape is characterized by numerous, small streams with little ability to erode and transport sediments since the annual water balance is close to zero (Bovis & Barry 1974). During the last glaciation these same streams provided so little sediment to the sea that the marine limit was not well recorded on the landscape in most places. In addition, many of these streams discharge into deep marine basins, such as Archer Fiord and Lady Franklin Bay (Fig. 2), that effectively dispersed these small sediment inputs. Consequently, many of these watersheds beyond the glacial limit produced small, submarine fan deltas that never aggraded to the marine limit. Marine fossils from these deltas, therefore, often relate to sea level positions considerably above these delta surfaces. An example of this occurs at site A, Fig. 4, where a ^{14}C date of 7910±145 BP (DIC–545) was obtained on marine shells from a non-graded fan delta which rises to 60 m a.s.l. in a small, ice-free watershed. In a larger watershed, twenty kilometres to the southwest (site B, Fig. 4), marine shells from a 90 m terrace provided a similar date (8200±260 BP, DIC–549). This suggests that the date of 7910±145 BP likely relates to a sea level position considerably higher than 60 m. Other examples could be cited where anomalously old dates were obtained from the foreset beds of relatively low deltas and these in turn are considered to represent inadequate sedimentation in certain sectors of the marginal depression rather than differential emergence or local tectonics. Finally, sedimentation in the marginal depression may not necessarily have coincided with initial glacial unloading but rather with climatically induced fluvial responses later in the Holocene. Hence strongly developed delta fans below the marine limit may be mistaken for the uppermost extent of the sea.

Radiometric problems

Another problem with the existing data base pertains to inconsistencies in radiocarbon age determinations provided by different laboratories. An initial date collected from the marine limit at site C, Fig. 4, was 7500±140 BP (St 4089, uncorrected date) and the ^{13}C correction increased the age determination to 7710±140 BP. Subsequent assessments, uncorrected for ^{13}C, from the same sample are 6845±70 BP (SI–4029) and 6790±410 BP (UQ–134, the large standard error is due to the small sample analyzed). A marine limit at the same elevation 12 km to the northwest (site D, Fig. 4) also dated 6860±70 BP (SI–3300) and these consistent dates on the same relative sea level are given precedence over the original determination (St 4089). Also an uncorrected date on marine shells from the surface of a 110 m terrace at Cape Baird (site E, Fig. 4) was 7025±150 BP (St 4099, 7565±150 BP, corrected for ^{13}C) and this contrasts with marine shells from the topset beds of the same terrace that dated 8380±150 BP (DIC–737, uncorrected) which is far more consistent with other dates on initial emergence in this area (England & Bradley 1978). For the most part these radiometric problems have now been eliminated by the recollection and dating of critical samples and they can likely be avoided by adequate pre-treatment of future analyses.

Recent data

Additional control points obtained since the initial construction of the local postglacial isobase maps (England 1976) warrant a re-evaluation of these data. However, these results remain provisional as many new field collections are presently submitted for ^{14}C analyses and a more detailed presentation is planned.

Initial emergence: Alert and James Ross Bay

Along the north coast of Ellesmere Island there are only a few ^{14}C dates available on shorelines at or near the marine limits. Most of these occur to the west of the study area (Fig. 4, see Fig. 1) such as Ward Hunt Island (Christie 1967, Lyons & Mielke 1973); M'Clintock Inlet (Christie 1967) and Yelverton Inlet (Blake 1972). Near Alert, which borders northernmost Nares Strait (Fig. 2), a marine limit at ~120 m a.s.l. dated 10100±210 BP (GSC–1815). Although this date is still an exception amongst >100 ^{14}C age determinations along the southern Hazen Plateau, ~110 km to the southwest (Fig. 2), it may indicate earlier emergence in the north as was originally suggested by Christie (1967) to explain the apparently higher marine limits there. In

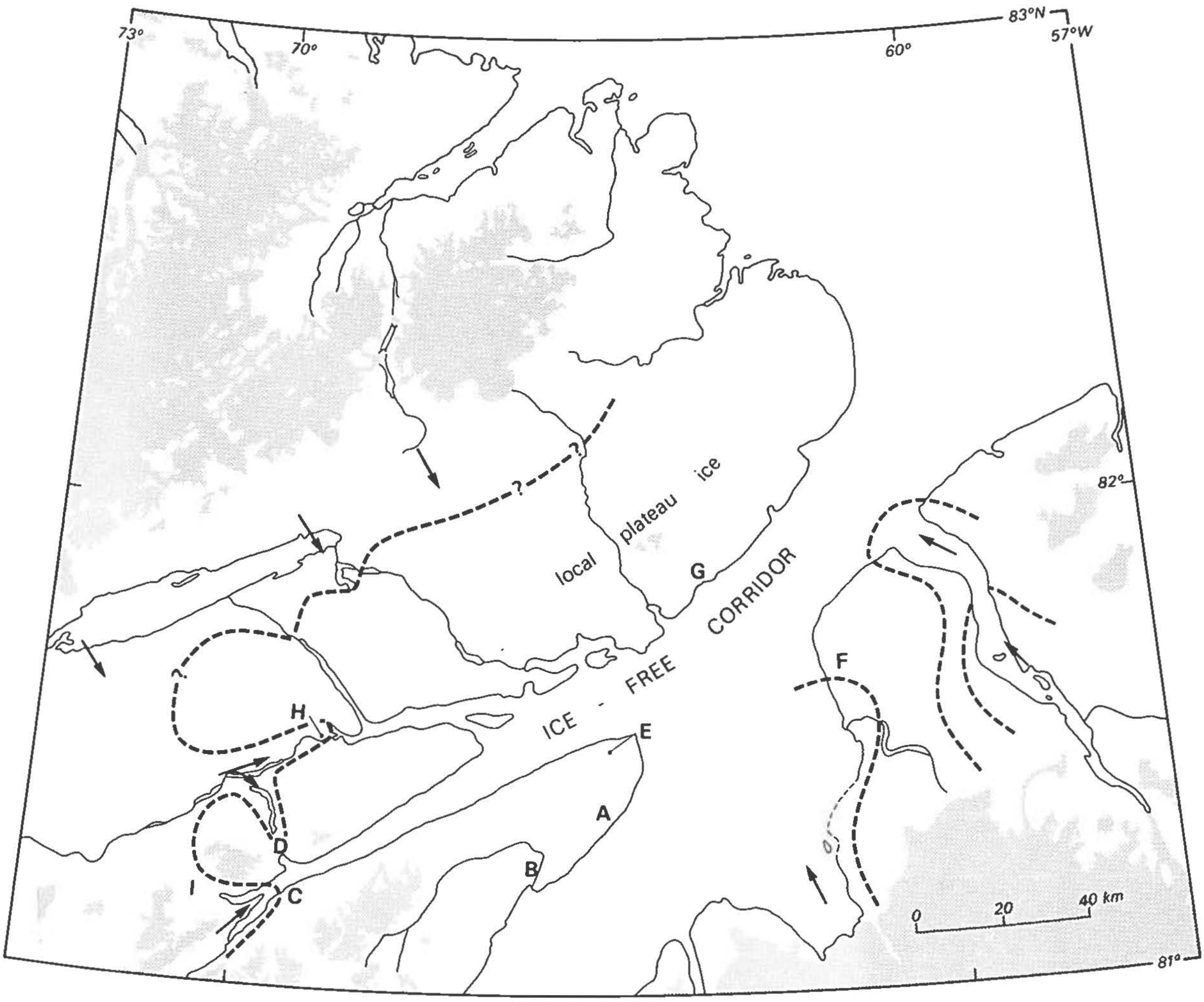

Fig. 4. Provisional limit of the last glaciation (dashed line) on northeast Ellesmere Island and northwest Greenland. These ice limits suggest that much of northern Nares Strait remained ice-free at this time. Site locations discussed in text are also shown. Arrows indicate former ice flow directions.

addition, a shell sample from the foreset beds of a 78 m delta inland from James Ross Bay (Fig. 2) recently dated 8280±300 BP (GSC–3002) and this occurs topographically below undated marine deposits at 90 m a.s.l. which must be older still.

Archer Fiord and Lady Franklin Bay

Compared to the aforementioned dates from the north coast of Ellesmere Island, the oldest available dates on initial postglacial emergence throughout Archer Fiord and Lady Franklin Bay, as well as along western Kennedy and Robeson Channels (Fig. 2), are ~8000 to 8400 BP (England 1978, England & Bradley 1978). Since similar dates on initial emergence extend inland from the northeast Ellesmere Island coast to the approximate margin of the last glaciation (a distance of ~75 km, Fig. 4), this zone of synchronous emergence (~8000 to 8400 BP) was interpreted to mark a former ice-marginal depression unloaded between the separated northeast Ellesmere Island and northwest Greenland ice sheets (England 1978). Any similar ice-free areas along the margin of the northwest Greenland ice sheet (which was presumably controlling this depression) also should have started emerging at the same time. This suggestion is indirectly supported by a date on marine shells from a terrace at 82 m a.s.l. from western Hall Land (site F, Fig. 4; 6100±300 BP, W–816; W. E. Davies in Rubin & Alexander 1960). This date indicates that the local marine limit, which is ~110 m a.s.l. (Weidick 1972), could be at least as young as ~8000 BP (England 1976).

Western Hall Land

More recently, Weidick (1978) has reported three additional ^{14}C dates from western Hall Land, two of which conflict with age assessment of W–816 (6100±300 BP). One of these dated samples (Weidick 1978: 121) was collected from "silt on top of a marine terrace at 80 m a.s.l." (9000±145 BP, I–9690) and the other came from "clayey silt under a veneer of shingles" at 85 m a.s.l. (9180±150 BP, I–9687). Weidick interprets these dates as part of a sea level regression following deglaciation that he estimates to have occurred at or before 9500 BP which would also date the local marine limit at 110 m a.s.l. If this interpretation is correct it seriously contradicts the isobases of this and previous studies (England 1976, Weidick 1976) as the estimated postglacial emergence since 6000 BP on western Hall Land is reduced to ~25 m (Weidick 1978) compared to values of 60–80 m (to be discussed). However, given this interpretation the 6000 BP shoreline on western Hall Land (provisionally 25 m a.s.l.) does not tilt up towards Washington Land (Weidick 1978) but rather towards the coast of Ellesmere Island where shorelines of the same age range from 60–80 m a.s.l. It is considered unlikely that the combined ice loads bordering northern Nares Strait, which are far larger on the Greenland side (Fig. 3), could produce such an abrupt reversal in the isobase gradients shown in Figs 5–7 unless postglacial faulting occurred.

An alternative interpretation of these ~9000 BP dates on western Hall Land, which would not contradict the present isobases, is also possible. I suggest that these older samples may record the transgression to the marine limit which in turn experienced an initial

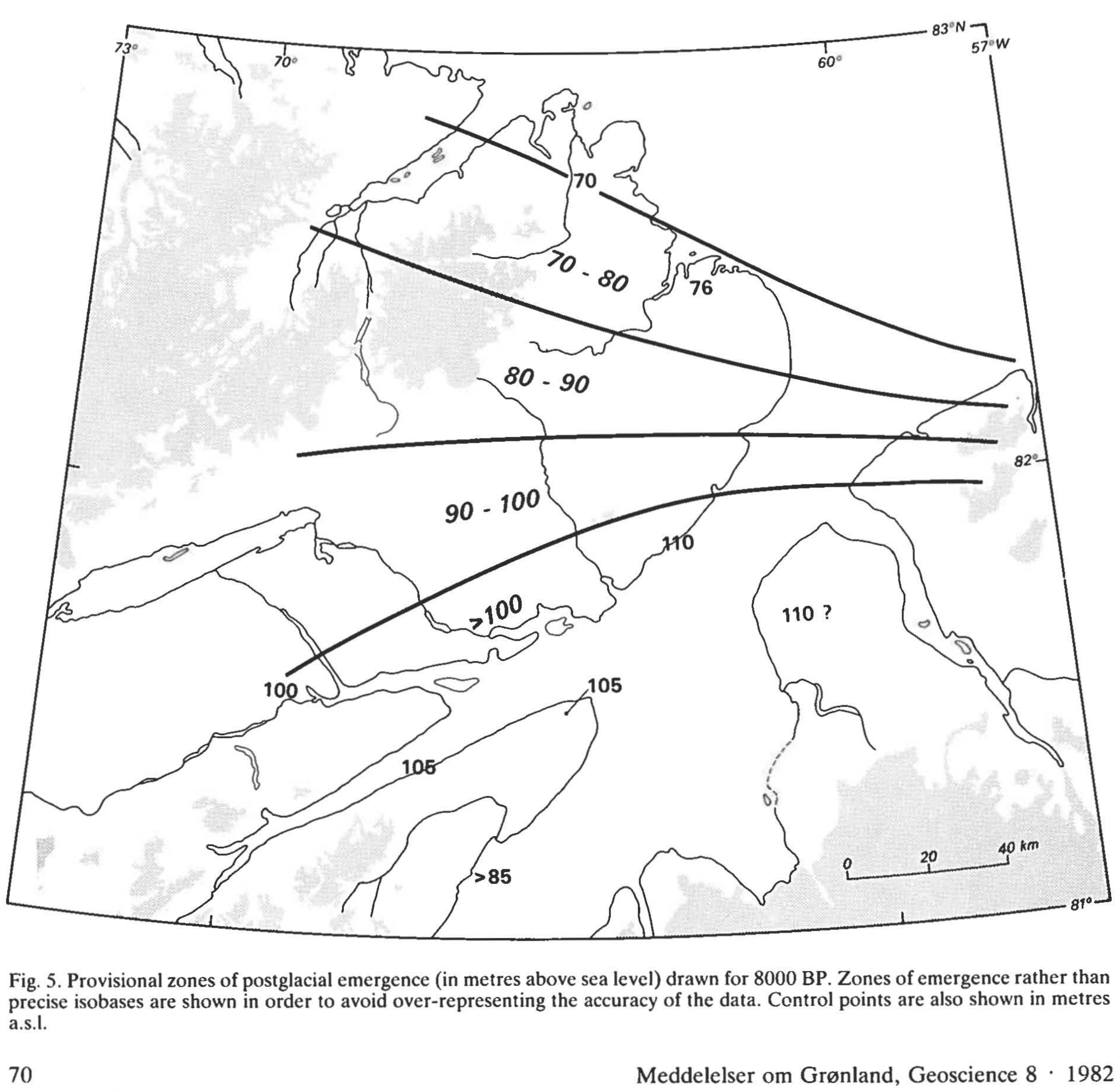

Fig. 5. Provisional zones of postglacial emergence (in metres above sea level) drawn for 8000 BP. Zones of emergence rather than precise isobases are shown in order to avoid over-representing the accuracy of the data. Control points are also shown in metres a.s.l.

emergence ~8000 to 8400 BP. This would also be compatible with a subsequent marine regression, following deglaciation, that deposited the 82 m shells dated at 6100±300 BP (W–816) in the same area. In this case it is of interest that directly across from this locality on western Hall Land, on the Ellesmere Island side of Robeson Channel, a marine limit at a similar elevation (115 m a.s.l.) is recently dated at 8050±120 BP (GSC–3041, site G, Fig. 4). Until the details of the raised marine stratigraphy on western Hall Land are determined (i.e. transgressive vs. regressive deposition) alternative interpretations of the postglacial isobases cannot be excluded (Weidick 1976). It is apparent, however, that within the ice-free corridor, which separated the northern Ellesmere Island and Greenland ice sheets during the last glaciation, there must be older marine deposits (ca. >9000 BP) which record the transgression to the marine limits dated 8000–8400 BP.

Postglacial emergence

Figs 5–7 show zones of postglacial emergence drawn along northern Nares Strait for 8000, 7000 and 6000 BP. All three diagrams show a progressive rise in synchronous shorelines from north to south across northeast Ellesmere Island towards northwest Greenland. If only the northern Ellesmere Island ice load is considered in relation to this differential emergence it is apparent that a radial expansion of the present day Grant Land Mountains ice cap (Figs 2 and 3) would result in a roughly uniform glacio-isostatic loading around its former margin, i.e. a similar amount of displacement both to the north and south of its centre. Consequently, the increasing postglacial emergence to the southeast (Figs 5–7) cannot be explained by a differential outflow from this central ice cap towards Nares Strait since the emergence on the southern Hazen Plateau would still

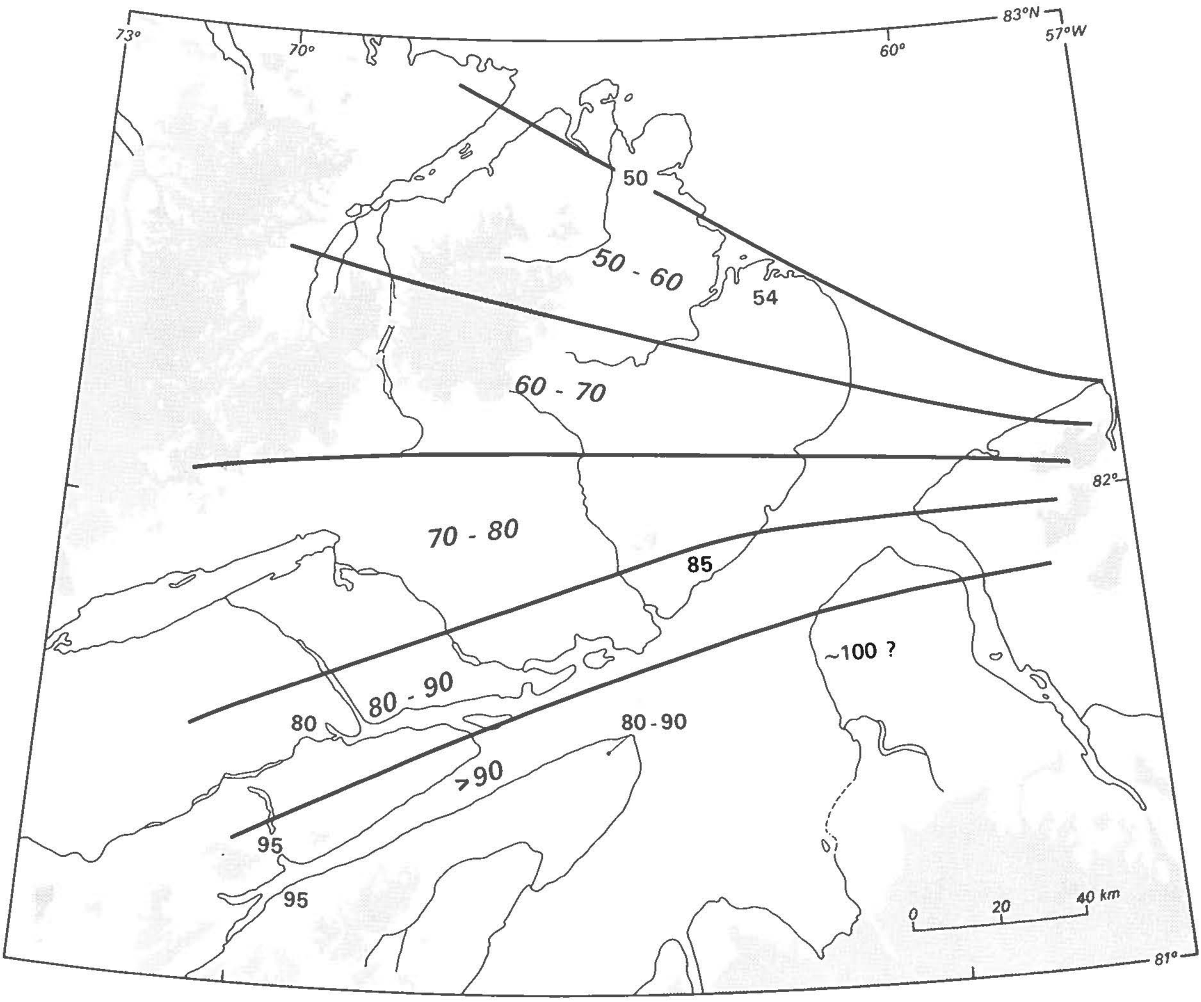

Fig. 6. Provisional zones of postglacial emergence drawn for 7000 BP. All elevations are in metres a.s.l.

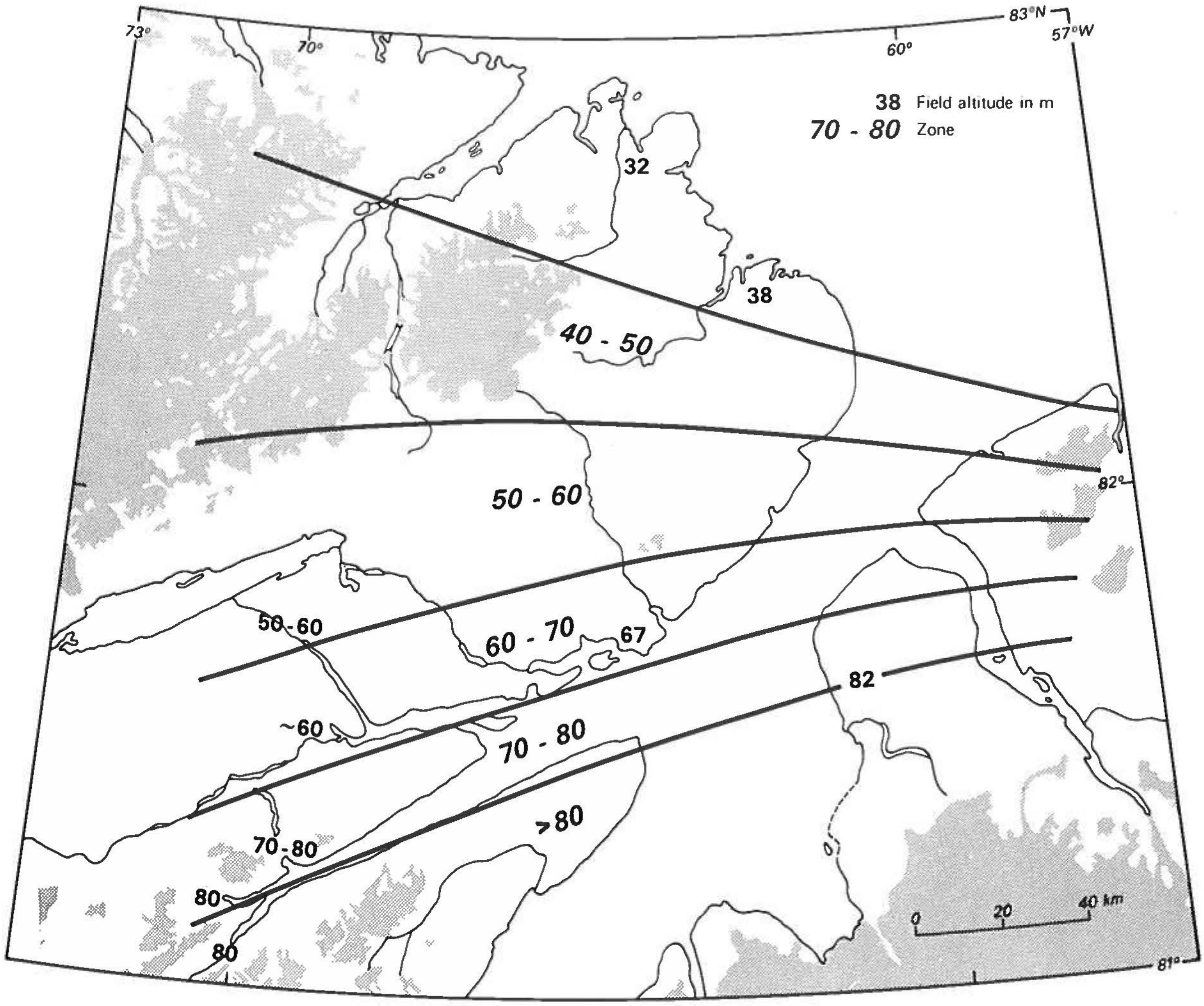

Fig. 7. Provisional zones of postglacial emergence drawn for 6000 BP. All elevations are in metres a.s.l.

have to be inclined toward the former ice source (i.e. to the north). On the other hand ice recession earlier along the northern margin than along the southern margin of this former ice cap might partly explain this differential emergence (cf. Christie 1967 and the ~10,000 BP Alert date, this paper). However, since postglacial emergence attains its maximum values along the approximate southeast margin of the last ice sheet on northeast Ellesmere Island (Figs 4 and 5), and since these sites also occur within a few tens of kilometres of the proposed Greenland ice sheet terminus in Hall Basin (Weidick 1972), it is proposed that the marginal depression from the Greenland ice also contributed to this southward rise of synchronous shorelines. Given the much greater size of the Greenland ice sheet, it is logical that the postglacial emergence on northeast Ellesmere Island is dominated by it (England 1976). The similarity in the generalized emergence in all three diagrams (Figs 5–7) reinforces this interpretation. It is apparent that the gradient of the isobases (Figs 5–7) becomes much less steep on northeast Ellesmere Island (away from northern Nares Strait) and this may suggest a more uniform glacio-isostatic loading in this area during the last glaciation.

The above hypothesis would argue that although there was a common ice sheet over a large part of northern Ellesmere Island, initial postglacial emergence along its southeastern flank (i.e. along the southern Hazen Plateau) was controlled by the recession of the northwest Greenland ice sheet (England 1976, England & Bradley 1978). On the other hand, the fjord systems along the northernmost coast of Ellesmere Island are presently >200 km from the Greenland ice sheet and hence their initial emergence would more likely record the independent recession of this local ice load which may not correspond to the initial emergence reported in the Archer Fiord–Lady Franklin Bay area to the southeast (Greenland induced, ~8000 to 8400 BP). Consequently, the view of earlier ice recession on northernmost Ellesmere Island (Christie 1967) combined with the glacio-isostatic dominance of the Greenland ice sheet along northern Nares Strait (England 1974, 1976), may best explain the differential emergence shown in the Figs 5–7. This pattern of differential emergence is similar, both in its orientation and slope, to the previously constructed isobase maps for northeast Ellesmere Island (England 1976).

Discussion

On a regional scale it is presently maintained that the glacio-isostatic deformation of the lithosphere and asthenosphere by the northern Ellesmere Island and Greenland ice sheets has been integrated coherently without recognizable unconformities produced by structural weaknesses along the Nares Strait rift valley. Also on a regional scale, epicentral solutions for Arctic earthquakes generally suggest that Nares Strait is noticeably aseismic although the most detailed records only post-date 1962 (Praus et al. 1971, Basham et al. 1977, Wetmiller & Forsyth 1978). In addition, Niblett & Whitham (1970) found no heat flow anomalies on northern Ellesmere Island which also suggests a normal lithospheric thickness. Finally, although large-scale stability for this area is suggested by the geophysical and geological evidence (Kerr 1967, Dawes 1979, Wetmiller & Forsyth, this volume) it is also apparent that numerous faults and graben cross-cut the Phanerozoic sediments throughout the field area under discussion (Christie 1964, 1974, Trettin 1971). Along the continental shelf of eastern Canada, from western Baffin Bay to Nova Scotia, faults that have been mapped by seismic studies generally extend to depths of ~10 km (Beh 1975, Smith 1975, Keen & Hyndman 1979). If the faults adjacent to and including northern Nares Strait are similar in depth (~10 km) then they may be exerting only minor effects on the large-scale lithospheric response to former ice loads in the area.

In comparison to this perspective of regional stability, however, some small-scale anomalies in postglacial emergence could still occur along such faults where elastic stresses might be differentially released, particularly during the rapid phase of initial emergence (Mörner 1978). Basham et al. (1977) and Wetmiller & Forsyth (1978) have suggested that contemporary seismicity in the Baffin Island – Foxe Basin area and along the Boothia Uplift, respectively, may be the product of stresses triggered by glacio-isostatic unloading. In eastern Canada, Stein et al. (1979) have estimated that postglacial crustal flexure could attain stresses of 100 to 150 bars which they suggest is adequate to reactivate pre-existing faults. In southwestern Sweden, a vertical displacement of up to 100 m has been reported along some faults since the Late Weichselian based on till-stratigraphic studies (Lagerlund 1977). Most dramatically, in northern Sweden, the 150 km long Pärve Fault has been demonstrated to be of late-glacial age having a vertical displacement of ~10 m (Lundqvist & Lagerbäck 1976). Adams (1981) has discussed the effects of postglacial faulting in eastern Canada, however all the offset movements noted so far are small (<10 m and generally <2 m). Finally, postglacial offset has also been discussed for portions of the Denali Fault system in south-central Alaska (Lanphere 1978) and the possibility of postglacial tectonics has been raised for the Puget Sound Lowland, Washington State (Thorson 1979).

In Arctic Canada no direct evidence has been presented demonstrating the effects of recent tectonics on the pattern of postglacial emergence although several areas are seismically active (Basham et al. 1977). However, recent work by Dyke (1979) on northern Boothia Peninsula, mainland Canada, has suggested very rapid rates of initial emergence (>30 m/100 years compared with generally reported rates of <10 m/100 years; Andrews 1970, Blake 1975). Although instantaneous effects such as ice-water gravitational attraction and elastic rebound of the crust might partly explain this initial emergence (>30 m/100 years) it is also possible that the reactivation of faults also took place along the seismically active Boothia Uplift (A. S. Dyke, pers. comm. 1980).

On northeast Ellesmere Island the present data base does not have the resolution to decipher small-scale, fault-related anomalies in the local isobases. The one possible exception occurs between Simmonds Bay and the Dodge River (sites D and H, respectively, Fig. 4) along the southwestern margin of the Hazen Plateau. These two sites are only 25 km apart yet the 95 m marine limit at Simmonds Bay dated 6860±70 BP (SI–3300) whereas the 105 m marine limit in Dodge River dated 8130±200 BP (GSC–1775). In both cases significant errors in either the stratigraphy or the ^{14}C dating can be excluded due to repeated and consistent results in all of these analyses. Since the average rate of initial emergence previously estimated in this area is ~3 m/100 years (England 1976) it is apparent that the dated shoreline at Simmonds Bay (~1200 radiocarbon years younger than the Dodge River shoreline) is abnormally high for its age. This Simmonds Bay anomaly does not exist in isolation but rather it is consistent with similarly high, young shorelines at the fjord head, 15 km to the southwest (site I, Fig. 4). There, the marine limit at ~85 m a.s.l. dated 6430±150 BP (GSC–1614). This contrast between Simmonds Bay and Dodge River may suggest that some postglacial faulting has contributed to this differential emergence since both sites were similarly occupied by late Wisconsin ice. Alternatively, initial postglacial emergence in this intervening period (ca. 8200 to 6900 BP) was abnormally slow (<1 m/100 years). In conclusion, although the reactivation of faults by glacio-isostatic stresses cannot be excluded these effects are presently considered to be minimal and beyond detection by the available field data bordering northern Nares Strait.

Finally, if the postglacial isobases do cross from northwestern Greenland to northeast Ellesmere Island (Figs 5–7) then they must eventually close themselves and return to Greenland across southern Nares Strait (cf. England 1976). The precise configuration of these isobases is not presently known although Blake (1975) does show a northeast–southwest orientation for his 5000 BP isolines which extend across central Devon and southeast Ellesmere Islands in the direction of southern Nares Strait and Inglefield Land, northwest Greenland. England (1976) indicated that the highest isobase values (for 7500 and 6000 BP) on northeast Ellesmere Island also cross back to Greenland in the area of Inglefield Land. Although these two isobase patterns (Blake 1975, England 1976) show somewhat different orientations they are not necessarily mutually exclusive since the absolute values (for any given sea level) differ considerably between northeast and southwest Ellesmere Island. For example, the 6000 BP shoreline is displaced up to 60–80 m a.s.l. on northeast Ellesmere Island whereas on southwestern Ellesmere Island it declines to ca. 30–35 m a.s.l. (Blake 1975). Hence, although the actual isolines for 6000 BP vary in magnitude and orientation between these two areas they may still represent the overall isobase pattern which converges upon and crosses southern Nares Strait.

One complicating factor in reconstructing the postglacial isobases in southern Nares Strait pertains to the differential buildup of ice during the late Holocene (Koerner 1977). Southern Nares Strait borders the important moisture source of the North Water polynya (in northern Baffin Bay) and as a result adjacent glaciers on both northwest Greenland and southeast Ellesmere Island are favoured by greater accumulation (Mock 1968, Koerner 1977). Hence, the buildup of greater ice thicknesses in this area during the late Holocene may have suppressed postglacial emergence such that the isobases in northern Nares Strait have higher maximum values than their counterparts to the south. England (1976) alluded to this problem in southern Nares Strait since the maximum values for postglacial emergence on Inglefield Land appeared too low compared to those on northeast Ellesmere Island. Nichols (1969) has also suggested a late postglacial advance of the Greenland ice sheet on Inglefield Land which may account for this lower emergence. Therefore, if some asymmetry occurs in the postglacial emergence between northern and southern Nares Strait it is more likely the result of the glacio-climatic regime than postglacial faulting (which has not yet been documented).

Acknowledgements

Logistical support for this study was provided by the Polar Continental Shelf Project, Department of Energy, Mines and Resources, Ottawa. The research was also supported by grants from the Boreal Institute for Northern Studies, University of Alberta, and from the National Science and Engineering Research Council of Canada. Radiocarbon dates were provided by Dr. Robert Stuckenrath, Smithsonian Institute, Maryland, and by Dr. Weston Blake Jr., Geological Survey of Canada. Dr. A. S. Dyke, Geological Survey of Canada, provided a conscientious review on an earlier draft of the manuscript and Dr. Richard Lambert, Department of Geology, University of Alberta, helpfully discussed a number of points on the tectonics of Nares Strait.

References

Adams, J. 1981. Postglacial faulting in eastern Canada. – Atomic Energy of Canada Ltd., Technical Record Series, Ottawa.

Andrews, J. T. 1970. A geomorphic study of post-glacial uplift with particular reference to Arctic Canada. – Inst. Br. Geogr. Spec. Publ. 2: 157 pp.

Andrews, J. T. 1974. Glacio-isostasy. – Benchmark papers in geology 10: 491 pp. – Dowden, Hutchinson and Ross Inc., Stroudsburg, Pennsylvania.

Basham, P. W., Forsyth, D. A. & Wetmiller, R. J. 1977. The seismicity of northern Canada. – Can. J. Earth Sci. 14: 1646–1667.

Beh, R. L. 1975. Evolution and geology of western Baffin Bay and Davis Strait, Canada. – In: Yorath, C. J., Parker, E. R. & Glass, D. J. (eds), Canada's continental margins and offshore petroleum exploration. – Mem. Can. Soc. Petrol. Geol. 4: 453–476.

Blake, W. 1972. Climatic implications of radiocarbon-dated driftwood in the Queen Elizabeth Islands, Arctic Canada. – In: Vasari, Y., Hyvärinen, H. & Hicks, S. (eds), Climatic changes in Arctic areas during the last ten-thousand years. – Acta Univ. Oulu, Ser. A(3), Geol. 1: 77–104.

Blake, W. 1975. Radiocarbon age determinations and postglacial emergence at Cape Storm, southern Ellesmere Island, Arctic Canada. – Geogr. Annlr. Ser. A: 1–71.

Bovis, M. J. & Barry, R. G. 1974. A climatological analysis of north polar desert areas. – In: Smiley, T. L. & Zumberge, J. H. (eds), Polar deserts and modern man: 23–31. – The University of Arizona Press, Tucson, Arizona.

Broecker, W. S. 1966. Glacial rebound and the deformation of the shorelines of proglacial lakes. – J. geophys. Res. 71: 4777–4783.

Brotchie, J. F. & Silvester, R. 1969. On crustal flexure. – J. geophys. Res. 74: 5240–5252.

Christie, R. L. 1964. Geological reconnaissance of northeastern Ellesmere Island, District of Franklin. – Mem. geol. Surv. Can. 331: 79 pp.

Christie, R. L. 1967. Reconnaissance of the surficial geology of northeastern Ellesmere Island, Arctic Archipelago. – Bull. geol. Surv. Can. 138: 50 pp.

Christie, R. L. 1974. Northeastern Ellesmere Island: Lake Hazen and Judge Daly Promontory. – Pap. geol. Surv. Can. 74–1A: 297–299.

Clark, J. A. 1977. An inverse problem in glacial geology: the reconstruction of glacial thinning in Glacier Bay, Alaska between A. D. 1910 and 1960 from relative sea-level data. – J. Glaciol. 18: 481–503.

Clark, J. A., Farrell, W. E. & Peltier, W. R. 1978. Global changes in postglacial sea level: a numerical calculation. – Quaternary Res. 9: 265–287.

Davies, W. E. 1972. Landscape of northern Greenland. – Spec. Rep. Cold Reg. Res. & Engng. Lab. 164: 67 pp. – Hanover, New Hampshire.

Dawes, P. R. 1979. Precambrian and Palaeozoic development of northern Greenland. – Norsk Polarinst. Skr. 167: 321–324.

Dyke, A. S. 1979. Radiocarbon-dated Holocene emergence of Somerset Island, central Canadian Arctic. – Pap. geol. Surv. Can. 79–1B: 307–318.
England, J. 1974. The glacial geology of the Archer Fiord/Lady Franklin Bay area, northeastern Ellesmere Island, N. W. T., Canada. – Unpubl. Ph. D. thesis, Univ. of Colorado, Boulder, U.S.A.: 234 pp.
England, J. 1976. Postglacial isobases and uplift curves from the Canadian and Greenland High Arctic. – Arct. Alp. Res. 8: 61–78.
England, J. 1978. The glacial geology of northeastern Ellesmere Island, N. W. T., Canada. – Can. J. Earth Sci. 15: 603–617.
England, J. & Bradley, R. S. 1978. Past glacial activity in the Canadian High Arctic. – Science 200: 265–270.
England, J., Bradley, R. S. & Miller, G. H. 1978. Former ice shelves in the Canadian High Arctic. – J. Glaciol. 20: 393–404.
England, J., Bradley, R. S. & Stuckenrath, R. 1981. Multiple glaciations and marine transgressions along western Kennedy Channel, N. W. T., Canada. – Boreas 10: 71–89.
Farrell, W. E. & Clark, J. A. 1976. On postglacial sea level. – Geophys. J. Roy. astr. Soc. 46: 647–667.
Hattersley-Smith, G., Fuzesy, A. & Evans, S. 1969. Glacial depths in northern Ellesmere Island: airborne radio echo sounding in 1966. – Defence Res. Board, Canada, DREO Tech. Note 69–6: 23 pp.
Keen, C. E. & Hyndman, R. D. 1979. Geophysical review of the continental margins of eastern and western Canada. – Can. J. Earth Sci. 16: 712–747.
Kerr, J. W. 1967. Nares submarine rift valley and the relative rotation of north Greenland. – Bull. Can. Petrol. Geol. 15: 483–520.
Kerr, J. W. 1980. Did Greenland drift along Nares Strait? – Bull. Can. Petrol. Geol. 28: 279–289.
Koerner, R. M. 1977. Ice thickness measurements and their implications with respect to past and present ice volumes in the Canadian High Arctic ice caps. – Can. J. Earth Sci. 14: 2697–2705.
Lagerlund, E. 1977. Till studies and neotectonics in northwest Skåne, south Sweden. – Boreas 6: 159–166.
Lanphere, M. A. 1978. Displacement history of the Denali fault system, Alaska and Canada. – Can. J. Earth Sci. 15: 817–822.
Lundqvist, J. & Lagerbäck, R. 1976. The Pärve Fault: a late-glacial fault in the Precambrian of Swedish Lapland. Geol. Fören. Stockh. Förh. 98: 45–51.
Lyons, J. B. & Mielke, J. E. 1973. Holocene history of a part of northernmost Ellesmere Island. – Arctic 26: 314–323.
Mock, S. J. 1968. Snow accumulation studies on the Thule peninsula, Greenland. – J. Glaciol. 7: 59–76.
Mörner, N.-A. 1978. Faulting, fracturing, and seismicity as functions of glacio-isostasy in Fennoscandia. – Geology 6: 41–45.
Niblett, E. R. & Whitham, K. 1970. Multidisciplinary studies in the Canadian Arctic. – J. Geomag. and Geoelect. 22: 91–111.
Nichols, R. L. 1969. Geomorphology of Inglefield Land, North Greenland. – Meddr Grønland 188(1): 109 pp.
Peltier, W. R. 1976. Glacial isostatic adjustment II: the inverse problem. – Geophys. J. Roy. astr. Soc. 46: 669–706.
Peltier, W. R. & Andrews, J. T. 1976. Glacio-isostatic adjustments – I. The forward problem. – Geophys. J. Roy. astr. Soc. 46: 605–646.
Praus, O., DeLaurier, J. M. & Law, L. K. 1971. The extension of the Alert geomagnetic anomaly through northern Ellesmere Island, Canada. – Can. J. Earth Sci. 8: 50–64.
Quinlan, G. in press. A comparison of observed and theoretical Holocene relative sea level in Atlantic Canada. – Can. J. Earth Sci.
Rubin, M. & Alexander, C. 1960. U. S. Geological Survey radiocarbon dates V. – Am. J. Sci. Radiocarbon Suppl. 2: 129–185.
Smith, H. A. 1975. Geology of the West Sable structure. – In: Yorath, C. J., Parker, E. R. & Glass, D. J. (eds), Canada's continental margins and offshore petroleum exploration. – Mem. Can. Soc. Petrol. Geol. 4: 133–153.
Stein, S., Sleep, N. H., Geller, R. J., Wang, S.-C. & Kroeger, G. C. 1979. Earthquakes along the passive margin of eastern Canada. – Geophys. Res. Lett. 6: 537–540.
Thorson, R. M. 1979. Isostatic effects of the last glaciation in the Puget Sound Lowland, Washington. – Unpubl. Ph.D. thesis, Univ. of Washington, Seattle, U.S.A.: 173 pp.
Trettin, H. P. 1971. Geology of lower Paleozoic formations, Hazen Plateau and southern Grant Land Mountains, Ellesmere Island, Arctic Archipelago. – Bull. geol. Surv. Can 203: 134 pp.
Trettin, H. P., Frisch, T. O., Sobczak, L. W., Weber, J. R., Niblett, E. R., Law, L. K., DeLaurier, J. M. & Whitham, K. 1972. The Innuitian Province. – In: Price, R. A. & Douglas, R. J. W. (eds), Variations in tectonic styles in Canada. – Spec. Pap. geol. Ass. Can. 11: 83–179.
Walcott, R. I. 1970. Isostatic response to loading of the crust in Canada. – Can. J. Earth Sci. 7: 716–727.
Walcott, R. I. 1972a. Late Quaternary vertical movements in eastern North America: quantitative evidence of glacio-isostatic rebound. – Rev. Geophys. Space Phys. 10: 849–884.
Walcott, R. I. 1972b. Past sea levels, eustasy and deformation of the earth. – Quaternary Res. 2: 1–14.
Weidick, A. 1971. Quaternary map of Greenland, 1:2 500 000. – Geol. Surv. Greenland, Copenhagen.
Weidick, A. 1972. Holocene shore-lines and glacial stages in Greenland – an attempt at correlation. – Rapp. Grønlands geol. Unders. 41: 39 pp.
Weidick, A. 1976. Glaciations of northern Greenland – new evidence. – Polarforschung 46: 26–33.
Weidick, A. 1978. Comments on radiocarbon dates from northern Greenland made during 1977. – Rapp. Grønlands geol. Unders. 90: 124–128.
Wetmiller, R. J. & Forsyth, D. A. 1978. Seismicity of the Arctic, 1908–1975. – In: Sweeney, J. F. (ed.), Arctic geophysical review. – Publ. Earth Physics Branch 45(4): 15–24.
Wetmiller, R. J. & Forsyth, D. A. 1982. Review of seismicity and other geophysical data near Nares Strait. – This volume.