GRØNLANDS GEOLOGISKE UNDERSØGELSE
RAPPORT Nr. 59

The Geological Survey of Greenland
Report No. 59

Radiocarbon dated shell samples from Nordre Strømfjord, West Greenland,

with comments on models of glacio-isostatic uplift

by

Michael Kelly

KØBENHAVN 1973

Grønlands Geologiske Undersøgelse

(The Geological Survey of Greenland)

Østervoldgade 10, DK-1350 Copenhagen K

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CORRECTION

KELLY, M. 1973 Radiocarbon dated shell samples from Nordre Strømfjord, West Greenland. Report No. 59.

1.	p. 14	line 2:	for fig. 4 read fig. 5
2.	p. 15	line 19:	for fig. 5b read fig. 4b
3.	p. 15	fig. 5:	the symbols a_t and a'_t should be transposed.

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Abstract

Shell-bearing marine sediments in the Nordre Strømfjord area belong to two lithofacies, calcareous sandy gravels and calcareous muddy sands, and to four biofacies comparable to modern communities and related to the sediment lithology: epifaunal benthic and infaunal benthic facies, a current reworked 'mixed' facies and a *Portlandia – Propeamussium* facies. Radiocarbon dates on nine samples provide a poorly defined model of the glacio-isostatic emergence of the region. The implications of such models and their physical validity are considered in the context of these and other data, and it is suggested that curves for uplift deceleration are a useful means of obtaining the exponential constant k.

CONTENTS

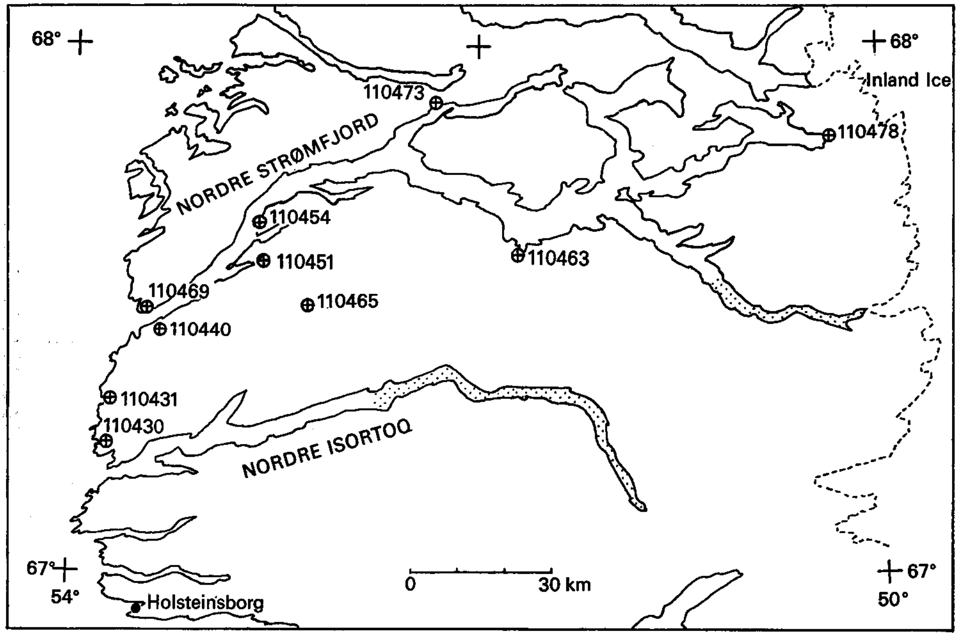

Fig. 1. Localities of marine shell samples.

INTRODUCTION

During the 1968 field season marine shell samples were collected from the Nordre Strømfjord – Nordre Isortoq region of central West Greenland (67°10′ – 68°00′ N) (fig. 1). A number of these have been radiocarbon dated in order to provide evidence about the glacio-isostatic uplift of the area; and also to help elucidate the biostratigraphy of the shell faunas. The radiocarbon analyses were made by H. Tauber of the National Museum, Copenhagen.

RADIOCARBON DATES AND ERRORS

The analytical results are given in tables 4 & 5 and in the appendix. Their reliability for both stratigraphic and isostatic modelling purposes depends upon a number of factors.

(1) the accuracy of the age given to the shells. Errors of this type are thought to be relatively unimportant for this material. The chance of too young a date due to isotopic exchange with young carbon is minimised by removal of the outer shell fraction before analysis. Too old a date due to the assimilation of old carbonate beyond the range normally associated with marine shells, which might be possible in fjords with a restricted water circulation, is discounted because of the essentially non-carbonate bedrock.

(2) the precision with which they date the deposition of the shells. This can be affected substantially by the reworking of older sediments, with the incorporation of old shells in young deposits.

(3) the precision with which the samples can be related to a contemporaneous sea level. This is usually poor when dealing with:

(a) shells from deep water faunas deposited *in situ,*

(b) shells from shallow water faunas deposited in deep water.

Even when there is a morphological feature (e. g. delta surface defining a sea level overlaying a shell bearing horizon their vertical relationship may be obscured by the presence of a non-depositional or erosional hiatus.

The further interpretation of the samples will show that type 2 and 3 errors affect some of the data. Comments on these, for the individual samples are given in the appendix.

STRATIGRAPHY

Sediment lithology

The shell bearing sediments are principally of two broad lithological facies: calcareous sandy gravels or calcareous slightly gravelly muds, in the terminology of Folk (1968) (fig. 2).

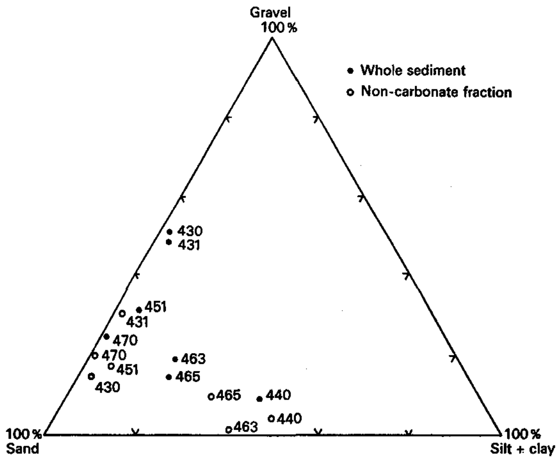

Fig. 2. Frequency of grain size classes in the shell bearing sediments. Only the last three digits of the GGU sample number are given.

Table 1. Percentage calcium carbonate contents

	110430	110431	110440	110451	110463	110465	110469/70	110473
% $CaCO_3$	58	38	30	18	21	28	25	41
% of this in > 2 mm fraction	78	79	87	90	79	84	54	90

Table 2. Weight percentages of constituents in carbonate fraction > 2 mm

	110430	110473	110469/70	110463	110478
Balanus spp.	57.7	89.3	43.6		2.2
Lamellibranchs:					
Hiatella	10.1	2.8	3.1		
Pecten	13.2		12.2	0.2	
Mya	1.3	0.3	26.7	96.1	89.3
Macoma	0.6		1.1	2.4	8.4
Others	0.1	0.1	1.3	0.8	0.1
Gasteropods		0.1	6.1		
Bryozoa	0.6	0.1			
Polychaetes	1.6	0.2			
Various + unidentified	14.8	7.1	5.9	0.5	0.0
Biofacies (see below)	A	A	C	B	B

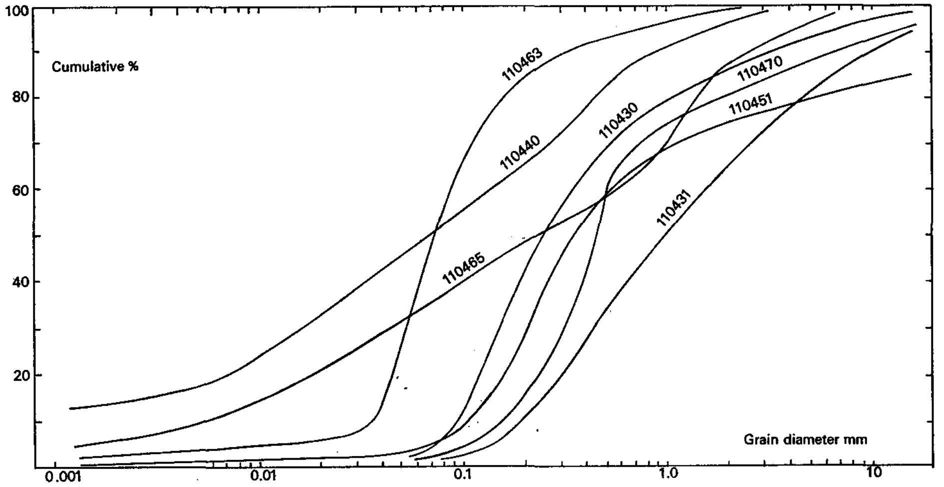

Fig. 3. Grain size distributions of the non-carbonate fractions of the shell bearing sediments.

In these the carbonate component forms between approximately 20–60 % of the sediment, with the major part of it, in most of them, being in the coarse sand and gravel fractions (table 1). The carbonate grains themselves are whole and broken skeletal fragments from a wide variety of organisms (table 2), though only cirripedes (*Balanus* spp.) and a few species of lamellibranchs contribute a significant amount to the sediment. Which of these is individually important depends on the biofacies to which the sediment belongs (see below). Because of the predominance of coarse carbonate grains the non-carbonate fraction of a sediment is finer grained than the whole sediment (fig. 2).

The calcareous gravels have gravelly sand minerogenic fractions with grain size distributions skewed towards the coarse grains, and with a negligible content of silt and clay (fig. 3 & table 3). Their field contexts suggest an association with the relatively shallow, wave affected zone of rocky inlets and fjords where coarse grained tills and fluvial sediments are being reworked.

The calcareous muds are silty sands, whose minerogenic fractions are very poorly sorted, though with distributions skewed to the fine sizes (fig. 3 & table 3). At present such sediments occur in a marine environment from intertidal to relatively great depths, especially in areas receiving high discharges of suspended sediment from major glacial meltwater streams.

Table 3. Grain size distribution statistics for non-carbonate fractions
(Inclusive graphic statistics, after Folk, 1968)

	ø Mean	mm Mean	Standard Deviation	ø Skewness	ø Kurtosis
110430	+1.5	0.35	1.9	−0.4	1.2
110431	−0.2	1.15	2.1	−0.1	0.7
110440	+4.3	0.05	3.8	+0.25	1.1
110451	+0.1	0.90	2.8	−0.5	1.1
110463	+3.9	0.06	2.1	+0.1	2.1
110465	+2.5	0.18	3.5	+0.25	0.9
110469/70	+0.6	0.65	1.9	−0.5	1.4

Faunas

The samples can be divided into four categories, or biofacies, on the basis of the ecology of their major faunal components (table 4). These biofacies are:

A. Faunas dominated by epifaunal benthic organisms: essentially sessile, surface attached cirripedes, lamellibranchs and gasteropods (110430, 110431, 110465, 110473).
B. Faunas dominated by infaunal benthos: essentially burrowing lamellibranchs (110440, 110463, 110478).
C. Faunas with both infauna and epifauna from a wide range of habitats, typically including a large number of species (110451, 110469/70).

Table 4. Composition of faunas, with minimum number of individuals in fraction > 2 mm

GGU Sample No.	110430	110440	110465	110473	110451	110469/70	110431	110478	110463	110454
Date yr. B.P.	9090	8970	8660	7550	7340	7320	6820	6760	6500	(10000?)
Facies Type	A	B	A	A	C	C	A	B	B	D
Crustaceae										
Balanus balanus	28*	4*			4	40	70		1	
Balanus crenatus					1			1		
Balanus hammeri				120*						
Brachiopoda										
Hemithyris psittacea						1				
Lamellibranchiata										
Leda pernula		1								
Portlandia arctica										255
Crenella decussata					3	2				
Modiolaria laevigata				5						
Mytilus edulis			a*			1*	a*			
Propeamussium groenlandicum										69
Pecten islandicus	14			1	5	3				
Lima subauriculata				2		17				
Astarte montagui				4	17					
Axinopsis orbiculata						2	11			
Serripes groenlandicus					5	1		3		
Cardium ciliatum									1	
Macoma calcaria		5	r		3	5		17	17	
Hiatella arctica	70	1		24	29	10	50			
Mya truncata f. *typica*	3	3	r	2	57*	14	1	11*	45	
Mya truncata f. *ovata*									4	
Gasteropoda										
Chiton sp.				1						
Emarginula fissura				2						
Puncturella noachina				2		3				
Acmaea testudinalis				6		2				
Lepeta caeca				1						
Margarita sp.				1						
Moelleria costulata				2		2				
Alvania jeffreysi						1				
Marsenina glabra				1						
Buccinum sp.				1						
Bela cinerea				1		3				
Bela nobilis				1			1			
other spp.	+			3		4	3			
Echinodermata										
Strongylocentrotus droebachiensis	+			+	+	+				
Ophiura sp.										5
Bryozoa	a									
Polychaetes – serpulids	a			a						
Total sample wt. (kg)	2.1	–	–	1.6	0.7	2.0	2.3	–	2.1	–

Notes: The minimum number of individuals for lamellibranchs is the number of right or left valves, for cirripedes it is half the number of scutal plates; a – abundant, r – rare. No recorded sample weight indicates that shells were individually sorted in the field from very sparsely fossiliferous sediments.

*C^{14} dated samples.

D. A fauna including infauna and epifauna but containing a very limited number of species (110454).

Type A

The principal constituents of the fossil faunas are:

B. balanus	*M. edulis*	Gasteropoda
B. hammeri	*C. decussata*	Bryozoa
H. arctica	*L. subauriculata*	Serpulids
P. islandicus	*M. laevigatus*	

These are species which live attached to rock walls or on coarse sediment. In the modern arctic communities described from East Greenland by Ockelman (1958) these species occur either in the overlapping 'vegetation' and '*Hiatella*' zones, which extend down to 35 and 60 m respectively, or to the *Mytilus* intertidal zone.

The individual death assemblages differ from the original life assemblages to the extent that there may have been dynamic (current) or passive (gravity fall) mixing of organisms from juxtaposed rock and sediment or from different depth zones. Differences between the samples can be due to differences in this degree of mixing as well as in the habitat diversity of their localities. The occasional occurrence of *Mya* indicates the presence of some infaunal benthos in suitable areas.

The sediment lithologies of the samples are compatible with the modern habitat requirements, belonging to the coarse lithofacies.

Type B

The species of the infaunal benthic facies include:

M. calcarea, M. truncata, S. groenlandicus, A. orbiculata, A. montagui, C. ciliatum.

These lamellibranchs are shallow or deep burrowers in muds or muddy sand; sediments which are indicative of relatively low energy environments. They are typical of the modern *Macoma calcarea* community, which Ellis (1960) recognises as being widespread and important in the arctic. In East Greenland Ockelman (1958) gives it a depth range of 5–50 m.

All three sediments of this facies contained shells in their life positions indicating a low degree of reworking. The death assemblages are consequently likely to compare closely with the living community. *Balanus* spp. occurred in two samples, representing an epifaunal benthic element, attached to erratic pebbles or to other benthos.

Type C

These faunas have the widest species diversity, and include infauna and epifauna from a broad range of habitats: epifaunal communities of rock walls, epifaunal communities of granular sediments, infaunal communities of cohesive sediments.

It is apparent that this facies represents the mixing by current activity of shells from these substrates, with a consequent lack of comparability between a death assemblage and a single life assemblage.

The sediments belong to the coarse lithofacies and are appropriate to a high energy environment.

Type D

This facies is represented by one sample of clayey silts whose fauna consists only of the infaunal *Portlandia arctica sensu stricto* and the epifaunal *Propeamussium groenlandicum* and *Ophiura* sp.

The modern East Greenland *P. arctica* community lives in depths up to 60 m in soft cohesive sediments, typically in areas with a high sedimentation rate and consequent turbidity. Both the lamellibranch species of the fossil fauna have high arctic distributions in West Greenland, which lie exclusively to the north of the fossil locality. Jensen (1942), who first described the fauna from this locality (see appendix), took the occurrence of *P. arctica* in central West Greenland as an indicator of a cold environment: colder than a later warm period which restricted its distribution, though not necessarily colder than at present.

Discussion

The data given in table 4 show that there is little evidence of a systematic succession of faunas in the area, the differences between the described facies faunas being related mostly to local environmental changes only. As discussed above, these differences are dictated by:

(a) a primary series of ecological controls which influence the distribution of different living communities, foremost amongst these being substrate, depth and turbidity.

(b) secondary control of waves and currents of the sediment transport system, including the process of gravity fall from rock faces.

It is the interplay between these two which determines the relationship between the death assemblages (thenatocoenoses) and the contributing life assemblages (biocoenoses).

Local successions of different faunas are possible because of the major changes in these controls which have taken place as isostatic uplift and retreat of the ice margin has proceeded, affecting depth, currents and sediment supply.

The question of the occurrence of a regional faunal succession due directly to climatic change and the immigration of new species can only be considered after taking the above into account. Laursen (1950) has proposed a scheme of shelly faunas for central West Greenland in which he uses the occurrence of certain indicator species as evidence for climatic change. Of these critical species the following occur in the Nordre Strømfjord faunas: *Portlandia arctica, Mytilus edulis, Pecten islandicus* and *Balanus hammeri.*

Although *Portlandia arctica* has some claim to be a cold water species, as mentioned above, its other fairly specific ecological requirements associated with the rapid deposition of silt may mean that the retreat of the ice margin will have had some influence on its distribution. Laursen assigned it to his early postglacial zones A & D. At Nordre Strømfjord, although not accurately dated it is possibly the earliest fauna studied dating from approximately 10,000 B. P., when the ice margin was undoubtedly close to the outer fjord region (see appendix for discussion of dating).

Mytilus edulis, which occurs throughout West Greenland today (to 76°N), is used by Laursen as one of the characteristic species of his zone E, marking the amelioration of the climate to conditions resembling today's. The oldest radiocarbon dates for this species from Nordre Strømfjord and elsewhere show that it has been present since relatively early in the postglacial:

K-1377	9070 B. P.	Holsteinsborg 66°56′N; 53°40′W (Weidick, 1972).
K-1553	8660 B. P.	Nordre Strømfjord 67°31′N; 52°52′W.
K-1037	8250 B. P.	Avatdleq 66°51′N; 53°40′W (Weidick, 1968).
K-1154	8210 B. P.	Frederikshåb 62°04′N; 49°20′W (Kelly, in Weidick, 1972).

The earliest date for *Pecten islandicus* at Nordre Strømfjord is 9090 B. P. which is comparable with the earliest *Mytilus* date elsewhere. This date, in fact, is the oldest post-glacial date so far obtained on shells from West Greenland. Laursen considered that *Pecten* occurred in zone C though was most abundant in zone E.

Balanus hammeri which Laursen described as characterising zone B, though occurring in all subsequent zones, has one date of 7550 B. P., which cannot be given any significance.

It is apparent that the building up of a sequence of faunas from the isolated fossiliferous deposits in an area can only really be achieved successfully with the control of radiocarbon dating. Gradually as many faunas are dated, the range and time of immigration of species will be established from which deductions about the timing of climatic and other environmental changes can be made.

GLACIO-ISOSTATIC UPLIFT

Emergence curve

Table 5. Radiocarbon dates and altitudinal relationships of the samples

GGU Sample No.	110430	110440	110465	110473	110451	110469/70	110431	110478	110463
C^{14} Lab. No.	K-1549	K-1548	K-1553	K-1557	K-1552	K-1551	K-1550	K-1556	K-1558
Age yr. B. P.	9090 ±140	8970 ±140	8660 ±140	7550 ±130	7340 ±130	7320 ±130	6820 ±130	6760 ±130	6500 ±130
Height* m a. s. l.	50±3	93±3	72±5	18±1	3	5±0.5	30±3	42±3	8±0.5
Apparent† uplift (m)	73.5	115.5	92.5	32	16	18	40.5	52	17

* The height of the overlying sea level feature or the actual height of the sample, giving the minimum height of a contemporaneous sea level.
† The above plus the eustatic correction from Shepard (1963).

The data given in table 5 is plotted in fig. 4a in the conventional form for showing the 'emergence' of the area (as defined by Andrews, 1968), i. e. the net movement of sea level relative to a datum on the isostatically uplifted surface, in this case present sea level. It shows a surprisingly wide scatter of data, even between the six dates which should provide an emergence curve for the outer coastal region. This particular curve is probably given approximately by the three extreme dates for that area, as shown.

As mentioned earlier, the errors responsible for the spread are probably those affecting the precision with which the samples date a contemporaneous sea level, i. e. those due to the deep water effects and to reworking of older shells. One or more mechanisms can be invoked to explain the departures from the expected dates. These are dealt with individually in the appendix.

Discussion

Glacio-isostatic data is often refined by the application of mathematical models to it, for example, as Andrews (1970b) has done extensively with data from Arctic Canada, and also as Weidick (1972) and Washburn & Stuiver (1962) have done for Greenland. Although the Nordre Strømfjord data is not particularly suited to this because of its scatter it provides a worthwhile opportunity for discussing the use of these models.

The basis for all models of glacio-isostatic behaviour is the theory that deformation is by plastic flow (Haskell, 1937) and hence that displacement from the final equilibrium position produced by the addition or removal of a finite load decreases exponentially with time (fig. 4 and equation 1).

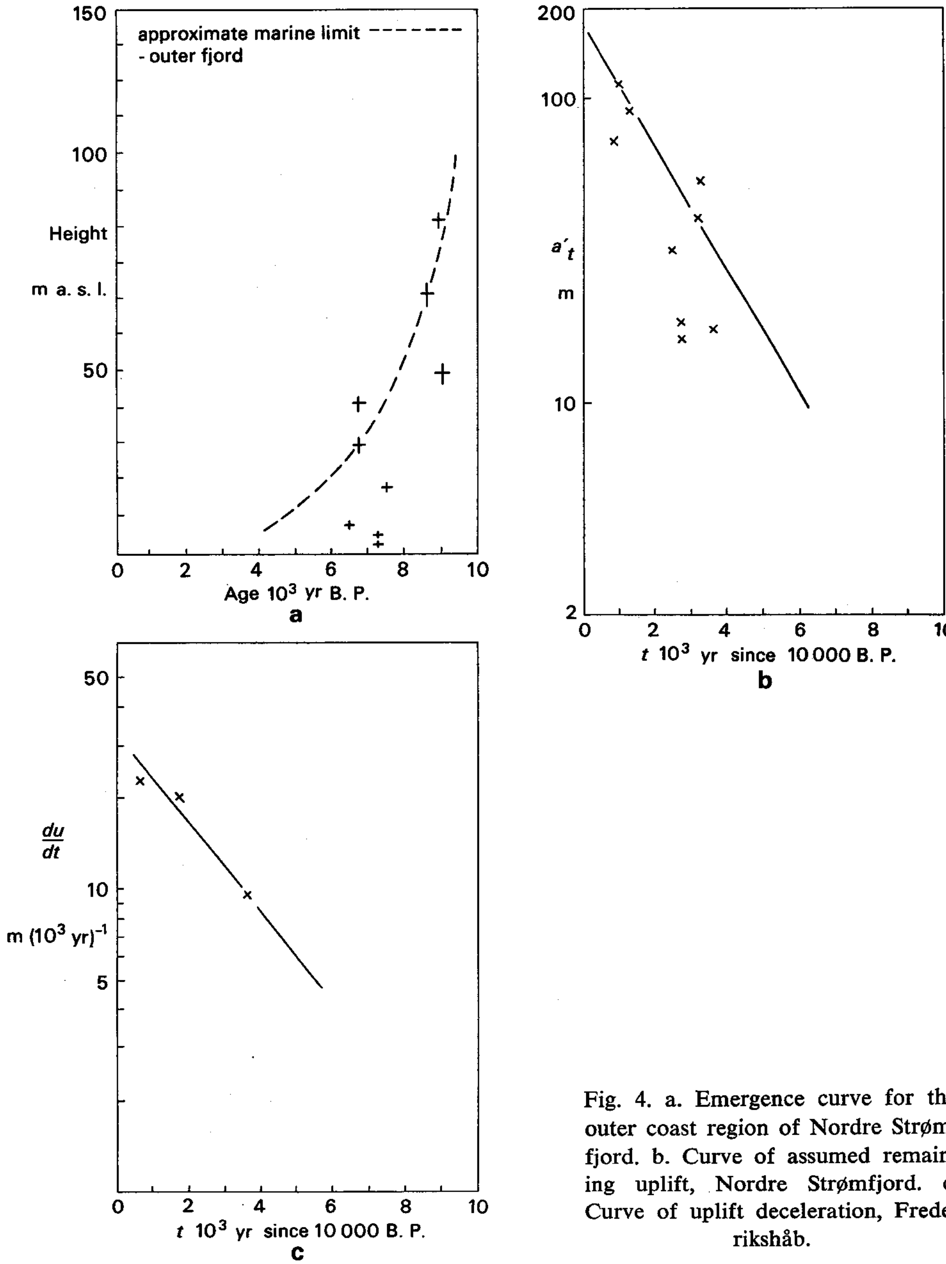

Fig. 4. a. Emergence curve for the outer coast region of Nordre Strømfjord. b. Curve of assumed remaining uplift, Nordre Strømfjord. c. Curve of uplift deceleration, Frederikshåb.

$$a_t = a_0 e^{-kt} \quad (1)$$

where a_t, in a post-glacial context, is the amount of uplift remaining to be achieved at time t after uplift began. In particular, it is the height to which a shoreline feature formed at a sea level at time t will be raised above that original sea level datum at the end of displacement ($t \rightarrow \infty$), i. e. after correcting for eustatic and other crustal movements.

An alternative expression is:

$$u_t = a_0 - a_t = a_0 (1 - e^{-kt}) \quad (2)$$

where u_t is the uplift accomplished by time t. Again in this context, it would be the height at which a shoreline feature formed at t would lie below a reference level formed at t_0 if there had not been any eustatic change in sea level, i. e. a correction has to be applied. The marine limit or any lower level can be arbitrarily nominated as the reference level if its time of formation is designated as t_0.

These concepts can be used in the following ways:

(a) The simplest is by the construction of semi-log plots of functions of the type of equation 1. However this can be applied rigorously only when uplift is complete, or when it is thought that future uplift can be estimated satisfactorily (Gutenberg, 1941). The majority of graphed functions of this type probably do not satisfy these conditions (e. g. fig. 5b; Andrews, 1966; Washburn & Stuiver, 1962; Weidick, 1972 and can only be drawn as straight lines because of the unavoidable inaccuracies of the data since, if uplift is incomplete, they should be curved lines.

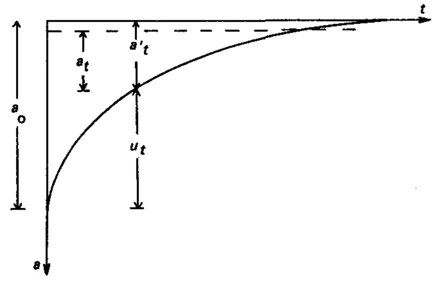

Fig. 5. Reference model of isostatic uplift.

Where a straight line is obtained from measurements relative to present sea level (corrected for eustatic changes) in such an area, it is a'_t that is being plotted rather than a_t, i. e. a is underestimated. Consequently the gradient of the line will be K rather than k, with $K > k$. This is the basis for Gutenberg's (1941) and Andrews' (1968) demonstration that K values decrease with time, i. e. $K \rightarrow k$ as $a'_t \rightarrow a_0$.

The value of K in fig. 4b is $0.43 \times 10^{-3}\mathrm{yr}^{-1}$. It should be noted that Andrews' K values for Arctic Canada (1968, 1970b) appear to be an order of magnitude too small, and should be 0.34 to $0.56 \times 10^{-3}\mathrm{yr}^{-1}$.

Values obtained for K have been used to predict curves from incomplete data (Andrews, 1968) and for regional comparisons of isostatic behaviour. The error involved in using K rather than k is a function of both the amount of uplift still to be achieved ($a_t - a'_t$) as a proportion of the total uplift possible, and also the distribution of the data.

That the start of uplift also cannot be defined is less important since equation 1 holds whatever value of a_t is taken as a_0 (or a'_0), the only effect being that a curve parallel to the true curve will then be obtained. This is convenient since evidence for early, predeglaciation uplift during ice thinning is unobtainable. Sea level evidence is only available after the first incursion of the sea into an area, i. e. as represented by the marine limit, which in many cases can be, as Andrews (1966) has pointed out, at the moment of deglaciation.

(b) Models based on the proportional change of uplift accomplished in equal time intervals also have been used, e. g. by Schofield (1964) and especially by Andrews (1968, 1970a).

For time units of 1000 years the uplift in the first unit ($u_1, t = 1$) is given by a modified version of equation 2.

$$u_1 = a_0(1 - e^{-k}) \qquad (3)$$

The proportional response for longer time intervals is then given by the ratio:

$$u_t/u_1 = (1 - e^{-kt})/(1 - e^{-k})$$

or

$$u_t = u_1(1 - e^{-kt})/(1 - e^{-k}) \qquad (4)$$

Andrews (1970a) utilised an equation of the form:

$$U'_p = A\ (1 - i_t)/(1 - i) \qquad (5)$$

where $U'_p = u_t$ *and* $u_1 = A$ according to his definitions, and hence, $i = e^{-k}$. *Since* it includes the term k it should suffer the limitations outlined above. However Andrews (1967) initially derived i empirically from uplift curves (u_t versus t) combined from many sites; obtaining $i = 0.677$. If we calculate k from this it gives $0.39 \times 10^{-3}\mathrm{yr}^{-1}$. As Andrews has been able to show that equation 5 gives predicted results close to those observed it suggests that this value of k has some validity for Arctic Canada.

(c) The most direct way of utilising the measurable uplift accomplished (u_t) is to differentiate equation 2:

$$\mathrm{d}u_t/\mathrm{d}t = a_0ke^{-kt}$$

This is a function describing the deceleration of the rate of uplift from which k can be calculated by plotting:

$$\log du_t/dt = -kt \log e + \log (a_0 k) \quad (7)$$

i. e. the method is free of errors arising from unassessed future uplift. However it can only be used for reliable data. Application to the emergence curve for Nordre Strømfjord is not justified for this reason. However fig. 4c illustrates the method for data from Frederikshåb, (Kelly, in Weidick 1972), from which the four most reliable dates have been selected (K-1149, K-1151, K-1153, K-1152). The value for k given by the diagram is about $0.35 \times 10^{-3}yr^{-1}$, compared with $0.51 \times 10^{-3}yr^{-1}$ for K, calculated from a plot of a'_t versus t.

In theory if the data was accurate enough to give a correct k value this could be used to calculate the remaining future uplift, e. g. from equation 2. Any two dated horizons can be used, the older one providing an arbitrary a_0 horizon, the younger defining u_t and t relative to a_0; a calculated value for a_0 compared with the measured then gives the future uplift according to the model. From the Frederikshåb data a figure of 15 m is obtained, though this can be regarded only as very approximate.

CONCLUSION

Of the various response models discussed the uplift deceleration model has certain advantages, in particular avoiding the physical inaccuracy of the 'apparent uplift remaining' model.

All models however, and hence the equations which describe them, are susceptible to two major limitations. The first of these is the accuracy of the observational data, particularly in the definition of a sea level contemporaneous with a date. Shell fauna data are particularly prone to this because of the factors, described earlier, which contribute to the occurrence of biofacies. The least equivocal information is probably provided by marine regression horizons in sediments from rock basins which are now freshwater lakes. In attempting to provide definitive models, and also to test the validity of the basic concepts, the latter source of information may have to be used more.

Secondly, all models are affected by the eustatic correction applied. Since this is itself a controversial subject with a large number of eustatic models currently available (Mörner, 1971) there must necessarily be an element of uncertainty about the validity of any equations obtained for isostatic phenomena. For the sake of ease of camparison with Andrews' data the same eustatic model has been used (Shepard, 1963). It should be noted that this is different to that used by Weidick (1972).

Acknowledgements

The writer is indebted to Dr. R. Banks of the Department of Environmental Sciences, University of Lancaster for discussions on isostasy; and to Dr. A. Weidick of the Geological Survey of Greenland for his interest and support.

APPENDIX

Post-glacial C^{14} dates from Egedesminde District: samples collected and submitted for analysis by M. Kelly, 1968. For localities see fig. 1.

K-1548 — 8970±140 B. P.
GGU 110440 — 7020 B. C.

Qáqarôq in Nordre Strømfjord, 67°21'N, 53°36'W.

Shells of *Balanus balanus* in marine silts at 93±3 m a. s. l. Date gives an acceptable age for a sea level in the outer region of minimum height of 93 m a. s. l.

K-1549 — 9090±140 B. P.
GGU 110430 — 7140 B. C.

Nísip kûa in Nordre Isortoq, 67°14'N, 53°47'W.

Shells of *Balanus balanus,* excavated from a surface pit in 20 cm thick shell gravel resting on silt, at 50±3 m a. s. l. Date unacceptable for height suggesting a contemporaneous sea level *c.* 50 m higher. Shells were possibly reworked from older deposits or were deposited in deep water, up to 50 m. Context suggests a combination of both.

K-1550 — 6820±130 B. P.
GGU 110431 — 4870 B. C.

Tatsip atâ, inlet between Nordre Isortoq and Nordre Strømfjord, 67°19'N, 53°49'W.

Shells of *Mytilus edulis* from 20 cm thick fossiliferous layer in marine sands. Sample height 28±3 m a. s. l., 2 m below terrace top. Date acceptable for sea level in outer region of minimum height of 30±3 m a. s. l.

K-1551 — 7320±130 B. P.
GGU 110469/70 — 5730 B. C.

Depothavn, Nordre Strømfjord, 67°30'N, 53°39'W.

Shells of *Mytilus edulis,* from top 1 m of 5 m fossiliferous sands and gravels; overlain by 3 m of fine, possibly aeolian sands. Sample height 4–5 m a. s. l. Date unacceptable, suggesting contemporaneous sea level *c.* 35 m higher. Shells possibly deposited in water of that depth, also likelihood of minor reworking.

K-1552 7340±130 B. P.
GGU 110451 5390 B. C.

Eqalugarssuit in Nordre Strømfjord, 67°35′N, 53°06′W.

Shells of *Mya truncata* from sands at 2 m a. s. l., 1 m below a terrace surface. Date unacceptable for a sea level at 3 m a. s. l. suggesting one *c.* 40 m higher. Shells possibly deposited in water of that depth, also likelihood of minor reworking.

K-1553 8660±140 B. P.
GGU 110465 6710 B. C.

Kigssaviarssuit narssât, inland between Nordre Isortoq and Nordre Strømfjord, 67°31′N, 52°52′W.

Shells of *Mytilus edulis* in fine sands and silts at 72±5 m a. s. l. Date gives an acceptable age for sea level of outer region of minimum height of 72±5 m a. s. l.

K-1554 Undated
GGU 110454 (*c.* 10,000 B. P.?)

Marrânguit, Nordre Strømfjord, 67°40′N, 53°05′W.

Shells of *Portlandia arctica* in marine silts at 62 m a. s. l. Samples not radiocarbon dated because shells could not be separated from internal silt casts.

The fossiliferous exposure is on a spur in small valley cut into the silts. At its head similar sediments extend up to 116 m a. s. l. and it is possible, though not certain, that the fossiliferous horizon lies below this level. If so a minimum age can be estimated from the emergence curve, fig. 4a, as about 10,000 (± 500) B. P.

Shells were first collected from this locality by O. Bendixen and described by Jensen (1942). The name of the locality was given by them as Lersletten in Depot Bugt.

K-1556 6760±130 B. P.
GGU 110478 4810 B. C.

Ugssuit, Nordre Strømfjord, 67°51′N, 50°16′W.

Shells of *Mya truncata* from poorly fossiliferous silts between 25–35 m a. s. l., below a graded terrace surface at 42±3 m a. s. l. Date gives an acceptable age for a sea level in inner region of minimum height of 42±3 m a. s. l. Also provides a minimum age for adjacent moraine system.

K-1557 7550±130 B. P.
GGU 110473 5600 B. C.

Itivdlerssuaq in Amitsuarssuk, 67°54′N, 52°12′W.

Shells of *Balanus hammeri* from shell gravels at 11±1 m a. s. l. unconformably overlying till and overlain by fossiliferous sands and boulder gravels, cut by a terrace surface at 18±1 m a. s. l. Date unacceptable for sea level at 18 m suggesting one *c.* 30 m higher. Shells probably deposited in water of that depth. Date gives a minimum age for deglaciation of area.

K-1558	6500±130 B. P.
GGU 110463	4550 B. C.

Sêrsínilik in Nordre Strømfjord, 67°37′N, 51°53′W.

Shells of *Mya truncata* at 6 m a. s. l. Sample from 8 m section in sands occupying a channel in marine silts. Date unacceptable for sea level at 8 m, suggesting one *c.* 15 m higher. Shells probably living in water of that depth.

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