C_{14}-datings referring to shore lines, transgressions, and glacial substages in Northern Norway.

(A supplement to Papers of 1960 and 1961 by the Author).

By

M. Marthinussen

With 2 plates.

Contents.

Introduction.

The present paper gives essentially a brief account of some C_{14}-datings carried out by R. Nydal in the Radiocarbon dating laboratory in Trondheim. In the main it comprises a series of dating reports which soon will appear in Trondheim Natural Radiocarbon Measurements III, a reprint from Am. J. of Science, 1962, V. 4 (Radiocarbon Supplement). Some of the datings mentioned in the following have formerly been published by Nydal in 1960 (p. 86) and Marthinussen in 1960 (pp. 418 and 424).

The subjects dealt with here will to a certain extent be incorporated in a more comprehensive paper that will soon be ready for printing. As for the completion of the latter, more datings of material on hand as well as supplementary soil stratigraphic investigations are needed. Therefore a publication of a preliminary review of the obtained results was considered convenient.

The present paper includes a great many facts regarding shore lines, stratigraphic circumstances etc.; but because of the lacking data, the discussion of the problems will here be restricted to a brief report on the shore line displacements at Ramså (Andøy) and to the mention of certain main points concerning glacial substages as well as the appurtenant C_{14}-datings. Special reference is made to the chapters on observations, to the table (Pl. 1), and to the literature (including that in papers formerly published by the author).

The altitudes of the various finds and the shore levels have all been levelled and the basis of the height measurements has been the seaweed boundary (Fucus vesiculosus), see Marthinussen, 1960, Pl. 16 (the explanation).

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Driftwood series.

Driftwood occurs at the base of numerous peat bogs in the coastal areas, especially in Western Finnmark and in the Vesterålen – Lofoten Archipelago. The examination of a great many bogs at different levels above the present sea-shore seems to indicate that no driftwood (nor pumice accumulations) occurs above the so-called Tapes limit in these areas[1] (the Tapes I–IV shore lines described in the system of Marthinussen 1945 (Pl. I and II) and 1960 (Pl. 16)). The driftwood samples here reported have been collected mainly at altitudes closely corresponding to the Tapes I—IV lines and to the younger N_4 and N_2 lines, and the C_{14}-datings therefore approximately indicate the ages of these shore lines [2]. To avoid misunderstandings as regards the vertical distribution of driftwood in relation to the Tapes I—IV lines, it should be pointed out that in the outer coastal region the sequence (altitude-age) of the said lines is inverse to that in more central parts of the area concerned (Marthinussen, 1960, Pl. 16).

The driftwood occurrences in the various localities dealt with here are as follows [3]:

[1] See Marthinussen, 1945, p. 257 and 1960, p. 426.

[2] In some few cases samples of peat overlying the logs have been collected, but C_{14}-datings and pollen-analyses of this material have not yet been carried out.

[3] During printing two datings of driftwood from the Ramså region were received. They are marked out in Pl. 2.

Djupdalen, Finnmark (T-185 6350 ± 150).

Driftwood of *Pinus* (identified by O. A. Høeg) from Djupdalen, Ingøy, Måsøy, Finnmark. Found at the base of a peat bog, *8,9 m* above sea level. The thickness of the overlying layer of peat is 1,4 m. Comment: Assumed date about 4800 yrs. or older. An age of 4800 yrs. would correspond to the Tapes IV level (cp. T-126), at which the driftwood was found (cp. loc. Steinvika, Ingøy, Marthinussen 1960, Pl. 16). The dating, however, was made in an attempt to identify rather old drifts from levels below the Tapes IV line in the *outermost* districts, where a transport upwards may have taken place because of positive shore-level displacements. The result so far is satisfactory as it points to a shore line between 2 and 6 m, i. e. between Tapes I and II (See Marthinussen 1960, p. 424 (Table), p. 426 and loc. Steinvika, Ingøy, Pl. 16).

Nord-Mjele, Nordland (T-267 6250 ± 200).

Driftwood of *Picea* (identified by O. A. Høeg) from Nord-Mjele, Andøy, Nordland. Found at the base of a peat bog at altitudes of 5,0 to 5,3 m. The overlying layer of peat is 1,7 to 2,0 m thick. Comment: The altitude of the driftwood points to a shore level coinciding with the N_3 line as well as with the much older Tapes II line, (see Pl. 2 and Marthinussen, 1960, Pl. 16). The dating seems to indicate an approximate age of the latter. In contrast to the Djupdalen case reported above (cp. T-185) the driftwood here has somehow been prevented from following the continued positive shore-line displacement up to its maximum position at the Tapes IV level[1] (a shore-line diagram similar to that of Pl. 16, Marthinussen 1960, is being prepared).

Børfjordbotn, Finnmark (C I) (T-183 5500 ± 150).
Børfjordbotn, Finnmark (C II) (T-184 5700 ± 150).

The driftwood samples of *Picea* (identified by O. A. Høeg) are from Børfjordbotn, Sørøy, Finnmark. The logs were found at the base of peat bogs situated some 20 m apart and at altitudes of 10,5 to 11,0 m above sealevel (Marthinussen 1960, pp. 424 (Table) and 425). The peat layers overlying the driftwoods are 1,5 to 1,8 m thick. Comment: Assumed date some 4800 yrs. or older. In this locality the Tapes lines II, III and IV are

[1] This may be due to the development of peat layers (covering the driftwood) during a regression phase which succeeded the Tapes II shore-level maximum, see pp. 44 and 50.

at about the same level (as at the locality Børstrand, Marthinussen 1960, Pl. 16). The dating results, 5500 and 5700 yrs., most probably refer to the Tapes III line, as the age of the Tapes II line seems to be about 6250 yrs. (cp. T-267) and that of Tapes IV line about 4500–4800 yrs. according to the two datings, T-126 and T-266, mentioned below.

Oldervik, Finnmark (T-126 4820 ± 160).

Driftwood of *Picea* (identified by E. Mork) from Oldervik, Seiland, Finnmark. Found at the base of a bog peat, 15 m above sealevel, corresponding to a shore level of early Sub-Boreal time («the youngest Tapes level», Tapes IV, described in the system of Marthinussen 1945). Comment: Assumed date, about 4600 yrs., corresponds fairly well with the C_{14}-dating reported. See Nydal 1960, p. 86, and Marthinussen 1960, p. 424 and Pl. 16 (cp. a locality close to Stjernøyholmen).

Nøss, Nordland (T-266 4500 ± 150).

Driftwood of *Picea* (identified by O. A. Høeg) from Nøss, Andøy, Nordland. Found at an altitude of *7,4 m*, on a deposit of sand overlain by a layer of peat 1,0 m thick. The Tapes shore bar outwards is nearly 9 m a.s.l. Comment: The corresponding shore level seems to have been at 7,0 to 7,5 m a.s.l.., and coincides with the Tapes IV line, the age of which has earlier been fixed at c. 4800 yrs. (cp. T-126 above). It was believed that the dating result would either correspond to the age of the said line, or, possibly it might reveal older drifts (cp. T-185). The result obtained points to the former alternative. The dating, however, shows a divergence of about 300 yrs. as compared to the previous date of the Tapes IV line, which may indicate that the shore level represented by this line has been stable for a comparatively long time (a shore-line diagram similar to that in Pl. 16 (Marthinussen, 1960) is being prepared).

Saraberget, Finnmark (T-186 4100 ± 100).

Driftwood of *Larix* (identified by E. Mork) from Saraberget, Ingøy, Måsøy, Finnmark. Found at the base of a peat bog at an altitude of *6,5 m*. The overlying layer of peat is here 1,5 m thick. Comment: The altitude of 6,5 m corresponds to the N_4 line and the dating result indicates the age of this line (cp. Pl. 2). The assumed date, about 3800 yrs., agrees fairly well with the result obtained (See loc. Steinvika, Ingøy, Pl. 16 and p. 424 (table), Marthinussen 1960).

Lyngpollen, Finnmark (T-244 4100 ± 150).

Driftwood of *Larix* (identified by E. Mork) from Lyngpollen, Magerøy, Måsøy, Finnmark. Found at the base of a peat bog at an altitude of *7,8 m*. The thickness of the overlying layer of peat is 1,2 to 1,4 m. Comment: Assumed age: 4000—4500 yrs. The wood seems to have drifted ashore at a shore level corresponding to the N_4 line, and the dating in this case (4100 yrs) is in accordance with the result of T-186 (a shoreline diagram for this area, as yet unpublished, is similar to that of Pl. 16 in Marthinussen 1960).

Austbotn, Finnmark (T-243 2450 ± 100).

Driftwood of *Picea* (identified by O. A. Høeg) from Austbotn, Kobbefjord, Måsøy, Finnmark. Found at the base of a peat bog at an altitude of maximum *6,0 m*. The thickness of the overlying layer of peat is 1,2 m. Comment: Assumed date: 2500–3000 yrs. The altitude of nearly 6,0 m for the driftwood log corresponds at this locality to the N_2 line (Marthinussen 1945 (Pl. II) and 1960 (Pl. 16)), and the dating result indicates the age of the line (See the end of the comment for T-244).

Skallelv, Finnmark (T-245 850 ± 80).

Driftwood of *Larix* (identified by O. A. Høeg) from south of Skallelv, Nord-Varanger, Finnmark. The log was found at an altitude of *3,5 m*, partly covered by sand and overlain by a layer of peat 0,5 to 0,8 m thick. Comment: As the locality is strongly exposed to attack by the sea, the shore level corresponding to the altitude of the driftwood log seems to have been no more than 2,0 to 2,5 m above the present sea-shore. The youngest shore line recognized by the author, the N_1 line, is nearly twice as high at this place as the dated level (accord. to a diagram not yet published).[1] Because of the low altitude (and with due regard to the stratigraphic circumstances) the log was assumed to be quite young.

From the above it appears that the datings of the driftwood series were made in order to establish the approximate ages of the said younger shore lines and to discover drifts of logs older than the Tapes IV line in the outer coastal region.

The result of the tests seems reliable and logical.

[1] The N_1 line is here about 4,5 m a.s.l., see Marthinussen 1945, Pl. I (cp. a locality which in the diagram is about 1,3 cm to the left of No. 35).

Evidences of marine transgressions

The report of the driftwood series seems to tell of positive as well as of negative shore-line displacements in the outer coastal districts during the Tapes I-IV time, cp. the cases of Djupdalen (T-185) and of Nord-Mjele (T-267). In the following we are dealing with evidences of transgression phenomena consisting of occurrences of peat overlain by marine gravel or sand deposits.

Tomaselv, Finnmark (T-182 7750 ± 150)[1].

Peat from Tomaselv, Vadsø, Finnmark. Taken from the upper part of a layer of peat 8 cm thick at an altitude of 24,5 m. The peat, which occurs just inside the crest of the Tapes shore bar, is overlain by a layer of marine shore gravel 1 m thick and rests on slightly sea-washed gravel, primarily of glacial origin. Comment: The stratigraphy proves a marine transgression. The corresponding maximum shore level is represented by the above mentioned shore bar, at altitudes of 25,5 to 26,0 m, and coincides with Tapes I line (Marthinussen 1960, Pl. 16),[2] the age of which is assumed to be about 6600 yrs., see p. 50. As the said transgression undoubtedly is younger than the age found for the peat, a top layer of the peat must be presumed removed by marine abrasion (Marthinussen 1960, p. 424 and 1945, Pl. I (loc. No. 33)).

Ramså-profile I series, Nordland.

The dates represent ages of some peat samples from the deposits of the Ramså-profile I, Ramså, Andøy, Nordland.[3] The section of this profile, which overlies rock, ranges from altitude 0,1 to about 9,3 m a.s.l., and shows the following stratigraphic sequence from below upward: 0,1 m (a.s.l.): rock surface, 0,1 to 0,55 m: gravel, probably shore gravel, 0,55 to 0,80 m: coarse-grained sand and fine-grained gravel with a zone of vascular plant remnants (straw) in the lower part and with two very thin layers of peat near the top (T-271), 0,80 to 1,0 m: a zone of thin layers of alternate peat and sand, 1,00 to 1,20 m: a similar zone, but here the peat is far more dominating (T-294), 1,20 to 1,25 m: a thin

[1] A lately revised date, as to the previous one, see Marthinussen, 1960, p. 424 (inter al. the table).

[2] A diagram of this area, similar to that of Pl. 16, Marthinussen 1960, has not yet been published.

[3] At this place a corresponding section has previously been investigated by Holmboe, see Holmboe 1903, pp. 107–109.

layer of sand, 1,25 to 1,85 m: a layer of peat, in the middle and lower parts rich in wooden plant fragments (T-295 and T-270: samples from the base and the top of the layer respectively), 1,85 to 2,10 m: shore gravel (containing pebbles) that rests on the peat, 2,10 to about 9,30 m: marine sand deposits including the surface peat. The latter, about 0,3 to 0,8 m thick, consists of alternating zones of peat and eolian sand. This thick sand deposit must primarily be of marine origin, but in the uppermost part a redeposition as eolian sand may have taken place. The dated peat samples, especially marked out in Pl. 2, are as follows:

T-270	1,8 m a.s.l.	(c. 7,5 m below soil surface)		7400 ± 150
T-295	1,3 »	(» 8,0 » » » »)		9450 ± 250
T-294	1,05 »	(» 8,25 » » » »)		9900 ± 200
T-271	0,75 »	(» 8,55 » » » »)		10600 ± 250

Comment: The marine shore gravel at 1,85 to 2,10 m a.s.l. overlain by sand and resting on peat directly tells of a marine trangression. The maximum shore level of this transgression phase (here about 4 m a.s.l.) seems to be represented by the Tapes I line, the age of which is assumed to be about 6500–6600 yrs (cp. Sandegren 1931 and 1952). The age of the peat here concerned (T-270) is 7400 yrs. The difference of the ages pointed to (7400 and about 6500 yrs. respectively) must be explained in the same way as in the case of Tomaselv (T-182), see Marthinussen 1960, p. 424. The position (altitude))of this layer of peat (T-270) in relation to the continual shore-level displacement is seen from Pl. 2. In a subsequent chapter the other peat samples T-295, T-294 and T-271, are dealt with, and special attention is there paid to the sample T-271 (pp. 48–49).

As for a more detailed discussion of this profile, more datings as well as pollen-analyses of the peat are needed.

The above mentioned marine sand deposit culminates in an important shore bar at altitudes of 9,0 to 9,5 m[1]. The latter seems to correspond to the youngest Tapes transgression, the maximum sealevel of which is represented by the Tapes IV line, about 4500 to 4800 yrs. old, cp. T-126, T-266 and Marthinussen 1960, p. 425.

[1] The marked Tapes shore bars on Andøy have formerly been investigated by Reusch (1896 and 1903), Holmboe (1903), Holmsen (1924), Undås (1938), Grønlie 1940 and 1951 and lately also by E. Bergstrøm (unpubl., pers. comm.). The transgressive and complex character of these shore bars has been pointed to, especially by Holmsen (1924, pp. 80–83) and Holmboe (1903, pp. 106–109).

Ramså-profile II series, Nordland.

As the investigation of this profile has not yet been brought to an end, only a particular part of it is here dealt with.

Ramså-profile II, Nordland (T-296 6100 ± 150).

Peat from the deposits of the said profile, Ramså, Andøy, Nordland. Found at an altitude of 4,05 m in a thin layer of peat at the top of a deposit 1,15 m thick of mainly coarse-grained sand with some thin layers of peat, especially in the middle and lower parts of it. The layer of peat, at 4,05 m a.s.l., is overlain by a sand deposit of marine origin 1,2 m thick. Comment: The stratigraphy reveals a marine transgression. According to the dating result the latter obviously is of younger age than that of the Ramså-profile I series, previously pointed to. The peat in question probably coincides with a regression phase which followed the Tapes II transgression maximum, see Pl. 2. We do not know the minimum sealevel of this regression, but the shore level contemporaneous with the deposition of the peat may have been no more than 2,0 to 2,5 m above the present sealevel, probably lower. The succeeding transgression of the shore level, indicated by the sand deposit overlying the peat, reached a maximum position primarily corresponding to the Tapes III line, and finally to the Tapes IV line (Pl. 2), cp. T-183, T-184 and Marthinussen 1960, pp. 424—425.

The Main substage or the Tromsø-Lyngen substage

At the localities mentioned below there are big clay formations which contain shells of *Portlandia arctica*. Inside these formations (partly close by and partly at some distance) there are important end moraine systems which were assumed to have been deposited by glaciers of Younger Dryas age, at a time when also the fauna is believed to have been alive. The following datings support the probability hereof.

Saltenfjorden, Nordland (T-246 10550 ± 250).

Shells of *Portlandia arctica* from the brick-yard of Rønvik, Bodø, Nordland. Found at altitudes between about 7 and 10 m in the middle and upper part of a large deposit of blue clay, the thickness of which seems to be at least 7 to 8 m. The clay, including the upper part of it, is quite rich in *P. arctica*, and is overlain by ay Post-glacial shellbed (Holtedahl 1953, p. 714). Comment: Assumed date 10000—10500 yrs. The age obtained shows that the shells are contemporaneous with the Younger Dryas period. The corresponding shore line possibly lies a little *below*

the shore-level zone of the Main line, the altitude of which at this locality seems to be approximately 85 to 90 m a.s.l. (Pl. 1). The end moraines of the corresponding glacial substage in this district have not yet been localized with certainty. They must be situated somewhere east of the town of Bodø, presumably in the Skjerstadfjorden area (Holtedahl 1953, p. 710 and Fig. 317; Marthinussen 1961, Fig 17).

Djupvik, Troms (T-187 10350 ± 300)[1].

Shells of *Portlandia arctica* from Slottet, about 1 km north of Djupvik, Lyngen, Troms. Found at altitudes between 4,5 and 9,0 m a.s.l. in a clay deposit, the maximum thickness of which above the present sea-level is about 11 m. The clay is partly overlain by Post-glacial shellbeds. The locality is situated outside an important terminal moraine (at Spåkenes) belonging to the substage in question (Marthinussen 1960, p. 418). Comment: Assumed date 10000—10500 yrs. The date obtained probably indicates the minimum age of the said moraine and seems to coincide with the closing phase of the Younger Dryas period (p. 54). The contemporaneous shore level represented by the Main line, So (P_{12}), is at this locality 65—66 m a.s.l. (Holtedahl 1960, pp. 414—415; Marthinussen 1960 p. 418 (and Fig. 144) and 1961, Fig. 17; Nydal 1959, p. 77 and 1960, pp. 85—86).

Steinsdal, Helgeland (T-124 10300 ± 250).

Shells of *Portlandia arctica* from Steinsdal, Sømma, Helgeland. Found in «Yoldia clay», 8 to 10 m a.s.l. at a locality about 8 km in front of a terminal moraine system at Harangsfjord, probably belonging to the Main substage (the Tromsø-Lyngen substage) or the Ra substage respectively. Comment: The assumed date, about 10500 yrs, agrees fairly well with the C_{14}-dating. The latter approximately dates the said moraine system, which accordingly may be correlated with the marked substage mentioned above (pp. 55—56). The date probably refers to the minimum age of the substage and to the closing phase of the Younger Dryas period. The contemporaneous shore level, here about 122 m a.s.l., coincides with the Main line, S_0 (P_{12}). Ref.: Nydal 1960, p. 86, Holtedahl 1960, p. 415, and Marthinussen 1961, Fig 17.

The clay deposits (and their fauna) here dealt with correspond in a general way to the «Yoldia clay» of Brøgger's system in the South of

[1] A recently revised date, as to the previous one see Marthinussen 1960, p. 418 and Holtedahl 1960, p. 415.

Norway (Holtedahl 1960, p. 375) and were assumed to be of Younger Dryas age. The datings of the shells — from widely separated areas of Northern Norway – strikingly confirm this view.

Shell series of Older Dryas and of Allerød ages at Sandstrand

The locality is situated just outside a marked terminal moraine at the mouth of Astafjord, south-east of Harstad. This moraine, which by the author lately has been termed «the Outer Astafjord moraine[1]», was presumed to be somewhat older than the Younger Dryas period, because of certain traces of the sea (shore marks, shells, and fossil faunas of foraminifera) at altitudes *above* the assumed maximum shore level of the said period. The datings of shells seem to confirm this view.

Sandvatnet (I), Troms (T-269 12300 ± 250).

Shells of Macoma calcarea near the lake Sandvatnet, Sandstrand, Skånland, Troms. Found near the surface of a small deposit of sandy clay (or clayey sand) at an altitude of 69,0 m. Comment: The shells probably date the said «Outer Astafjord moraine», which consequently must be of Older Dryas age. It should here be mentioned that at Renså, about 5 km east of (and inside of) this moraine, there is another moraine ridge[2] apparently of Younger Dryas age in the standard chronological system (Nydal 1960, p. 86)[3]. The maximum shore level of Younger Dryas time at Sandstrand seems to be about 68 to 70 m a.s.l., and the shore-level zone of the Older Dryas period[4], the S_4-S_2 lines, probably lies between about 73,5 and about 80 m (Marthinussen 1960, Fig. 144 and Pl. 16, and 1961, p. 133). A shore-line diagram of this area, similar to that of Pl. 16 (Marthinussen1960), is as yet unpublished.

Sandvatnet (II), Troms (T-316 11700 ± 250).

Shells of *Mya truncata* (fragments only) near the lake Sandvatnet, Sandstrand, Skånland, Troms. Found imbedded in a layer of shore gravel

[1] This moraine seems to belong to the so-called Repparfjord substage (pp. 58–59).

[2] The moraine ridge is situated in front of a small (tributary) valley adjoining the Astafjord.

[3] Some time during the Main substage the frontal part of the Astafjord glacier may possibly have extended as far out in the fjord area as a km or two inside the said «Outer Astafjord moraine».

[4] In accordance with the *actual* positions of the corresponding shore levels, this zone seems approximately to range from the middle of the S_1–S_2 interval to well above the S_3 line, cp. also Pl. 16 (Marthinussen 1960).

25 cm thick at 73,2–73,4 m a.s.l. Comment: The age reported coincides with the Allerød period of the standard time-table, and the altitude of the shells seems to point to a corresponding shore level at about 73,0 to 73,5 m a.s.l. The S_1 line, assumed to be of Allerød age, is here about 71 to 72 m a.s.l., see the comment to T-269 and Pl. 1.

Sandstrand (III), Troms (T-214 11400 ± 250).

Shells of *Mya truncata* from the brick-yard of Sandstrand, Sandstrand Skånland, Troms. Found at an altitude of 30,5 m at the very base of a deposit of blue clay 5 to 8 m thick, which rests on sand and is overlain by thick layers of sand. The shells occur in the transition layer between the clay and the underlying sand. In the blue clay itself practically no shells are seen, except some extremely scarce and scattered species of *Portlandia arctica* (recently the skeleton of a whale, *Balaena mysticetus*, has been found in the clay at 32 to 35 m a.s.l.). Comment: The clay was assumed to correspond to the «Yoldia clay» of Brøgger's system and to be of Younger Dryas age. Consequently the shells from the said transition layer were assumed to be somewhat older. The correctness of this view seems proved by the dating in so far as the age of the shells coincides with the Allerød period of the general chronology. A climatic oscillation, probably corresponding to the transition Allerød-Younger Dryas time, seems to be reflected in the fossil faunas of foraminifera from the said transition layer and the overlying clay (identified by R. W. Feyling-Hanssen), which reveal subarctic and arctic climatic conditions respectively. Foraminifera from near the base of a banded clay at the lake Sandvatnet, altitude about 74 m, show arctic climatic conditions. According to the altitude this clay may possibly be of Older Dryas age.

Brief report on the shore-line displacements at Ramså (Andøy)

For a general view the numerous facts and results here presented have been put up in a table (Pl. 1). To demonstrate shore-level displacements in this part of Norway a curve which refers to the locality of Ramså (Andøy) has been drawn up. It is preliminary, however, because of the comparatively few datings at hand. From the previous chapters it appears that the curve is based on data partly from Ramså and partly from other localities of this area as well as from Finnmark and Troms. Material of fundamental importance for the construction hereof are the

shore-line diagrams of Finnmark, inter al. Pl. 16 (Marthinussen 1960)[1], and that of the Ofoten-Andøy area (unpublished). On the basis of these diagrams the various datings and altitudes referring to shore levels and transgressions from widely separated localities are used for building up the curve shown in Pl. 2..

The altitudes of shore lines and transgression limits etc. at Ramså, specified in the table (Pl. 1), are mainly deduced from the diagrams, but more sporadically also observed in the field.

Regarding the shore-line displacements for the last 13000 yrs· at Ramså, indicated in Pl. 2[2], the main features are as follows: A marked Late-glacial regression of the shore line seems to have been going on until some part of the Older Dryas period (cp. foot-note 3 below). During the Allerød age the mean rate of the regression was probably considerably slower than before. Of great interest in this connection is an observation by Grønlie, referring to the traces of a transgression at 12 m a.s.l. on Andøy (Grønlie 1924, p. 111). According to the height reported, this transgression must be of Late-glacial age. Without knowing the exact position of the locality in question (not mentioned in the paper referred to) nothing more definite can be said regarding the age[3]. The shore-line displacements during Younger Dryas time have not yet been fully ascertained. The two alternative curve sections (Pl. 2) representing this period, may both be characterized as preliminary and more or less hypothetic. Nevertheless, there is a possibility of a considerable shore-line oscillation, as indicated by one of the said curve sections, because of some known and comparatively reliable data. In this connection it is referred to the occurrence of peat at 0,75 m a.s.l. (and 10600 yrs old) and to the altitude of the Main line at Ramså, about 8,5 m a.s.l. The age

[1] The only complete diagram of this area as yet published by the author, cp. also Marthinussen, 1945, Pl. I and II.

[2] As to the «absolute» sealevel displacements (independent of the isostatic recovery of previously depressed areas) it is referred to some recent papers by Shepard and Suess (1956, pp. 1082–1083), Godwin, Suggate and Willis (1958, pp. 1518–1519) and by Fairbridge (1961, pp. 99–185). Of special interest is the last-mentioned paper (inter al. Fig. 15) as compared with the shore line movements at Ramså.

[3] The possibility therefore exists that at times during the Older Dryas and Allerød periods the shore-level movement (including eventual oscillations) may have been somewhat different from that expressed by the curve (Pl. 2). Thus, during Allerød time some fluctuation may have occurred, and as for the coincidence of the sealevel with the S_1 line this probably has been restricted to a comparatively short interval only (see p. 47 and Pl. 1).

of this line is probably about 10200–10300 yrs., cp. the table (Pl. 1) and Marthinussen 1960, Fig. 144. In the case considered, the peat must naturally be assumed to be of autochthonous origin. If not, the shore line movements during this period may possibly have been in the form of a slow regression, cp. the corresponding section of the curve (Pl. 2).

A shore level oscillation of Younger Dryas age also seems to have occurred in Iceland (cp. Thorarinsson, 1951, pp. 81–83 and Fig. 66.)[1] Reports from other areas, e. g. Ireland and the Great Belt area of Denmark, tell of Late-glacial shore levels (here to be considered) which were below the present sealevel. In Ireland this was the case during Younger Dryas time (cp. Donner, 1959, p. 21 and Stephens, 1958). As regards the Great Belt area it has been established that the shore line during Post-glacial (Boreal) time as well as some time during the Late-glacial period has been at least 25 m *below* the present one (Krog, 1960, p. 130). The said low Late-glacial shore level may possibly coincide with Younger Dryas time[2].

The initial stage of the Post-glacial shore-level movements in this locality seems to have been a marked regression mainly coinciding with the successive development of the P_{11}-P_1 lines (Pl. 2 and Marthinussen 1960, Pl. 16). Also in parts of Southern Norway and Sweden a corresponding rapid rise of the land is traceable (Fægri 1944, Fig. 12, Hafsten 1960, figs. 151 and 152, Hessland 1943, Fig 62, Sandegren 1931, Fig. 36 and 1952, Fig. 46 etc.). The minimum level of this regression at Ramså, presumably at least 2-3 m below the present sealevel, was probably reached during the Boreal period (Pl. 2)[3]. During the interval between about 9900 and about 7500 yrs. B. P. the shore line seems all the time to have been below the present shore. This view is based on the altitudes and on the ages of some peat samples from the Ramså-profile I, i. e. T-294 (9900 yrs), T-295 (9450 yrs), and T-270 (7400 yrs), see pp. 42–43 and the table (Pl. 1). It should be added that pollen-analyses of the peat samples (by. K. Egede Larssen) are not contradictory to the shore

[1] This view seems later to have been somewhat modified, see Thorarinsson 1955, Fig. 4 and 1956, Fig. 6.

[2] The question, however, is whether marked shore line oscillations actually have occurred in the cases concerned.

[3] The transition Boreal-Atlantic time in Pl. 2 is based on investigations by K. Egede Larssen (unpublished).

line movements expressed in the curve section which represents the said time interval (Pl. 2)[1].

The following Post-glacial rise of the shore level coincides with the so-called Tapes transgression, the successive limits of which correspond to the Tapes I–IV lines (p. 38). During this long-lasting and mainly transgressive phase the positive shore line movements were interrupted by one main regression and probably also by a couple of minor ones. The two main transgression maxima, before and after the said regression, were reached in middle Atlantic and early Sub-Boreal time respectively (Pl 2).

More detailed, the events are as follows: During the rise of the shore level from the Boreal minimum position the peat layer at Ramså (T-270) was submerged (possibly about 7000 yrs. ago (Pl. 2)). Later, presumably 6500-6600 yrs. B. P. (Sandegren 1931 and 1952), the shore level reached a preliminary upper limit corresponding to the Tapes I line, in widespread areas a very marked shore line, the sealevel of which consequently must have remained stable for a comparatively long time. Then, at first probably interrupted by a slight regression, the shore level continued to rise to the maximum limit of the said middle Atlantic transgression phase. The transgression limit coincides with the Tapes II line, here about 6,2 m a.s.l., the age of which seems to be about 6250 yrs. B. P. according to datings of driftwood, p. 39 (T-267). The transgression phase here dealt with is, as previously pointed out, first followed by a marked regression and then by still another transgression phase (which was going on until early Sub-Boreal time). This view is based on the stratigraphy of the Ramså-profile II, see p.44 and the table (Pl. 1). Here a peat layer at 4,0 m a.s.l. and 6100 yrs. old overlain by a thick deposit of marine sand directly tells of an emergence of the land after the middle Atlantic maximum level as well as of a following marked submergence (p. 44). The shore line contemporaneous with the development of the peat (T-296) may have been no more than about 2 m above the present shore[2]. The minimum shore level during the emergence considered is unknown, but from the above it must be presumed that the said regression

[1] During this interval similar conditions seem to have existed in Scotland (Donner, 1959, Fig 5). To be noticed are also the other common main features as regards the shore level displacements in Scotland and the Ramså region, compare Pl. 2 with Fig. 5 of Donner (Donner, 1959).

[2] As regards the eventual existence of a basin with threshold at the critical altitude, no positive indication hereof has been registered.

phase represents a negative displacement of the shore line of at least 4 m (cp. Fægri 1944 a, Fig. 12).

The following transgression, the second main phase of the Post-glacial rise of the shore level, was limited upwards primarily by the Tapes III level (altitudes 7,0 to 7,5 m and age 5500–5700 yrs.), and finally by the Tapes IV level, about 4500—4800 yrs. old. The latter, which coincides with early Sub-Boreal time, represents the uppermost shore level during the last ten thousand years at this locality (8,0–8,2 m a.s.l.) as well as everywhere else in the outermost coastal regions. The shore line oscillation just pointed to also seems to be reflected in certain circumstances concerning the occurrence of driftwood at Nord-Mjele, p. 39 (T-267). At Skagen on Langøy, another locality in the Archipelago of Vesterålen, definite traces of corresponding regression and transgression phases have been observed by Grønlie (Grønlie 1924, p. 112). Also in Southern Fennoscandia direct proofs of such intermediate oscillation exist, inter al. provided by Fægri (Fægri 1944 a, pp. 42—45 and Fig. 12, Hafsten 1960, pp. 452–456), cp. also the Malmø curve of shore line displacements (Granlund and Lundqvist 1949, p. 319).

The maximum shore level of Sub-Boreal time (Tapes IV line) just mentioned, probably preceded by an insignificant shore-line oscillation (in the Tapes III-IV interval), was followed by a long-lasting and in the main a negative movement of the shore, which presumedly has been going on until the last centuries[1]. True, immediately before the time of the N_4 line (about 4000 yrs. old) a small emergence and a corresponding submergence of the land also seems to have taken place (Marthinussen 1960, p. 423). Thus, the Post-glacial shore-line oscillation (except for the first and last parts) in the outer coastal regions, e. g. at Ramså, possibly consists of five phases, viz. two main phases and three minor ones included in the former (Pl. 2). The corresponding shore level maxima, the Tapes I–IV and N_4 lines, were formerly by the author assumed to be the successive upper limits of actual transgressions because of pumice accumulations at these levels, and especially because of a find at Ingøy of peat overlain by a pumice layer at an altitude which coincides with the N_4 line (Marthinussen 1945, p. 239, and 1960, p. 423). In the areas con-

[1] The curve section of Pl. 2 which represents the last 4500–4800 yrs. is based on data concerning driftwood finds from Finnmark (and one find from Nöss, Andøy (T-266)). It shall be added that two datings of driftwood from the Ramså region, received during printing, have also been marked out in Pl. 2.

cerned the existence of several transgressions, presumedly caused by a successive and somewhat variable rise of the sealevel, seems to be a reality, reflected inter al. in the said upward transport of driftwood (p. 39) as in the deposition of thick masses of sand and fine-grained gravel, which in places build up the marked Tapes shore bars (p. 43 and Marthinussen 1960, p. 425). It is an essential question, however, whether a regression has actually occurred in all of these cases. This has not yet been fully ascertained, but at least after the Tapes II, Tapes IV, and N_4 maxima there is evidence of regressions. As for the Tapes I–II and III–IV intervals, we have no direct proof of negative shore level movements, but also here the possibility remains[1]. Regarding this extreme complexity of the Post-glacial (Tapes-Litorina) shore line oscillation[2] at Ramså (and possibly also elsewhere in the outermost coastal areas of Northern Norway), this has been traced also in other regions, e. g. in Denmark and in Southern Sweden. In Denmark evidences of four transgression phases during the Atlantic and Sub-Boreal times have been registered by Iversen (Iversen 1937 and 1943). In Southern Sweden three oscillations (and transgression maxima) during this time have been pointed out, e g. at Malmö and Öland (Granlund and Lundquist 1949, p. 319). Judging from the said paper (p. 319) the three maxima of the Litorina sea in Southern Sweden – LG I, LG II and LG III – seem in a general way to correspond to the transgression limits at Ramså as represented by the Tapes I, II and IV lines respectively. Also the relative altitudes of the three successive maxima at Malmö and at Ramså show fairly good accordance.

The actual rise of the shore level from the Boreal regression minimum to the Sub-Boreal transgression maximum (Tapes IV line) seems at Ramså to range between 10 and 12 m (Pl. 2). As in this peripheric district the isostatic uplift of the land during the said transgression period must be assumed to have been quite small, possibly about 2 m only, *the total eustatic* rise of the sealevel does not much differ from the value given

[1] A comparison of the Tapes I – N_4 oscillations (Pl. 2) with the corresponding «absolute» sealevel displacements as illustrated by Fairbridge (Fairbridge 1961, Fig. 15) seems to indicate a fairly good conformity. This would especially be the case if the curve section (Tapes I – N_4) had been slightly displaced within the range of the C_{14}-ages concerned.

[2] According to Fægri the complexity of the corresponding shore line movements at Bømlo and Jæren seems confined to two main phases (Hafsten 1960, Fig 151).

above[1]. Between 12 and 14 m would probably be about correct. According to Fægri the corresponding total sealevel rise at Bömlo is 8–9 m (Fægri 1944, p. 49). Assuming, like Fægri, that the trangression in question is mainly due to eustatic changes of level, the difference of the said total positive displacements in the two widely separated areas (12–14 m and 8–9 m respectively) is a result of a difference in the isostatic uplift, this component having been somewhat stronger at Bömlo than at Ramså. Consequently, the corresponding isostatic uplift at Bömlo may have been rather greater than estimated by Fægri (Fægri 1944, p. 49)[2]. Otherwise it appears that in both areas the second main transgression maximum reaches higher than the first one, cp. Pl. 2 with Fægri 1944, Fig. 12.

Also during the last 4000 yrs. some slight oscillations of the shore line may have occurred, but material which might give informations hereof has not yet been worked out. C_{14}-datings just received (not incorporated in this paper) seem to indicate oscillations before as well as after the time of the N_2 line, cp. Pl. 2[3].

The shore level history for the last 13 000 yrs. at Ramså, indicated in Pl. 2, has naturally not yet been definitely established. Supplementary study of the stratigraphic profiles of this locality and datings of a great many peat, driftwood, and shell samples on hand are still needed. No radical changes are expected, however, from these investigations.

A few remarks on the described glacial substages and on the results of the C_{14} datings

Traces of several glacial stages during the last deglaciation period have been recognized in Northern Norway (Marthinussen 1960, pp. 417–418, and 1961 pp. 161–162 and 167–168). Of these the three, rat-

[1] This estimate is based on the supposition that the eustatic level of today is approximately equal to that of the Boreal period (cp. Fægri 1944, p. 49).

[2] It shall be added that the «absolute» rise of sealevel during the said Boreal – early Sub-Boreal time interval seems to have been at least 18 m according to Fairbridge (1961, Fig. 15). If correct, this sealevel rise exceeds by far those assumed by Fægri and by the present author, 8–9 and 12–14 m respectively. From the above-mentioned it can be concluded that the corresponding isostatic recovery of the regions concerned may have been rather greater than was originally supposed.

[3] As regards the «absolute» sealevel oscillations during this late period, see Fairbridge 1961, Fig. 15. Supplementary remarks: a comparison of the Post-glacial shore line displacements (Pl. 2) with the corresponding «absolute» sealevel movements (Fairbridge 1961, Fig. 15) gives to some extent an idea of the contemporaneous isostatic recovery at Ramså (which in a later paper will be commented on).

her marked late ones are in chronological order: the Outer (Yt.) Porsanger, the Repparfjord, and the Main substages (Marthinussen 1961 Fig. 19 and pp. 161 and 168). Only the two latter, for which C_{14} datings have been made, will be commented on in the present.

The most prominent system of end moraines in this part of Norway is that of the Main substage or Tromsø-Lyngen substage (cp. Marthinussen 1961, Fig. 17). The latter term was introduced by Grønlie, who, like Vogt and Tanner, assumed these moraines to be contemporaneous with the Ra substage in Southern Norway (Grønlie inter. al. 1940 pp.45, 46 and 51). The theory seems now verified through C_{14} datings of material from various places in Troms (and Nordland), collected by Andersen[1] and by the author. Andersen's results will not be discussed here. It should be noticed, however, that the age given for some of his samples exceeds that assumed for the moraines in these northern districts, which are actually contemporaneous with the Ra substage (Holtedahl 1960 pp. 414–415). Of the author's dated shell samples it is first of all the T-187, Djupvik, Lyngen (Pl. 1) which confirms the contemporaneity of these substages in Northern- and Southern Norway. The shells in this case are of *Portlandia arctica* (see p. 45) from a thick clay accumulation immediately outside a marked terminal moraine (at Spåkenes), deposited by the big Lyngen glacier[2]. It seems reasonable that this particular shell-bearing clay-zone was deposited while the glacier bordered on Spåkenes and not later[3]. The age arrived at, 10350 yrs., should thus correspond to some phase of this substage, presumably the closing one. The moraine of the Lyngen glacier at Spåkenes — in Grønlie's opinion a typical section of the Tromsø-Lyngen substage — is therefore from Younger Dryas time. The same is true for the Ra substage. Further, the marine limits at the distal and proximal slopes of this moraine, 66,0 and 63,5 to 64,0 m a.s.l. respectively, prove that a regression of the shore level was going on as the Lyngen glacier receded from this marginal zone. The former altitude corresponds to the Main line (S_0 (P_{12})), which in the form of rock terraces is distinctly recognized outside the

[1] Cp. Nydal 1959 and 1960.

[2] This moraine and especially the lateral end moraines inside (on the east side of the Lyngenfjord) reveal a complexity of the substage (see inter al. p. 58).

[3] Some observations from this area, inter al. concerning marine limits, seem to indicate that the ice-skrinkage, which followed the substage in question, possibly has been remarkably rapid.

moraine[1], but – as it might reasonably be expected – is absent in the fjord inside. The condition observed here is noticeable in several areas, possibly most distinctly seen on the south-eastern shore of the Porsangerfjord, where the rock terrace of the Main line ends close to the very distal part of the glacial deposits belonging to the Main substage. No traces of rock terraces are found in the fjord inside (Marthinussen 1961, Fig. 19).

As for the contemporaneous end moraine series in other districts of Northern Norway, only that of the southermost part of Nordland, i. e. in the Bindalsfjord area of Helgeland, will be mentioned. Here the auther in 1958 made some investigations on the Pleistocene geology, mainly in connection with the shore lines.[2] A few data are given in the following. First, the find at Steinsdal of *Portlandia arctica* (10300 yrs. old) will be recalled, cp. T-124 (p. 45 and Pl. 1). Shells of this species occur also at Sør-Horsfjord on the island of Austra, about 10 km south of Steinsdal[3]. The age of the Steinsdal find, as well as of that from the Lyngen area (T-187), corresponds to the closing phase of the Younger Dryas period. Marginal moraines to be considered here are found inter. al. at Harangsfjord (Gaupen), about 7 to 8 km south-east of (and inside) Steinsdal. This moraine system, which consists of two or three ridges, probably represents the Main substage (the Tromsø-Lyngen substage). The correlation is based mainly on the investigations of shore lines, especially of the Main line. In this area the line to great extent manifests itself by marked rock terraces[4], which here, like in Finnmark and Troms

[1] Due to the marked character, the Main line has long ago been noticed by several investigators, in Finnmark inter al. by Bravais (1840 and 1842), Chambers (1850) and Tanner (1906–1907, 1907 and 1930), cp. the «upper line» of Bravais and Chambers, and the I_E shore-line system as well as the f-line of Tanner.

[2] Earlier studies of shore lines in this area: Øyen 1896, Rekstad and Vogt 1900, pp. 66–71, Rekstad 1910, pp. 8–11 and 1917, pp. 70–72 and Grønlie 1940 and 1951).

[3] Due to the scarcity of material no C_{14} datings have been made.

[4] The tilt of this shore level is about 1,0 to 1,1 m per. km in the direction West 20–25° North, as based on numerous height measurements, inter. al. at Torghatten (113 to 114 m), at Skillbotn and Mardalsfjell (120 m), at Aarsetfjord (123,0 to 123,5 m), at Sør-Horsfjord (124,5 m), and at the Lysfjord moraine or the «Lysfjordmana» 128,5 to 129,0 m). The latter altitude, which corresponds to the Main line, most probably indicates the shore level during the deposition of this moraine (cp. Rekstad 1910, p. 10 and 1917 p. 71, Grønlie 1951, p. 38, and Svensson 1959, p. 206).

(pp. 54–55), seem present only outside the ice margin of the Main substage. According hereto, the corresponding Bindalsfjord glacier has probably occupied the entire inner fjord basin to the strait at Skauvik[1]. The position of the frontal part of this glacier corresponds to the Harangsfjord moraines (at Gaupen) and to a lateral glacial deposit high up in the mountain slope above Skauvik, to the south-west of the strait[2]. The said occurence of *Portlandia arctica* at Steinsdal probably reflects the climatic conditions during a late phase of this glacier stage. Corresponding ice margins have been traced south-west of Bindalsfjord, e. g. near the mouth of Lysfjord and in the area of Aarsetfjord – inner part of Kjella. Observations on moraine accumulations also support this view. To the south and west Lysfjord is encircled by end moraine ridges which extend to the very mouth of the fjord. To be mentioned are the previously described Lysfjord moraine, the «Lysfjordmana»[3], and a south-north directed lateral moraine ridge (at the eastern slope of Hegbærnesfjell) which is a direct continuation of the former. The corresponding Lysfjord glacier seems to have reached the mouth of the fjord[4]. In the other area – inter al. between Valen, near the head of Aarsetfjord, and Haalup, at Kjella – are some scarce glacial deposits, and east of Kjella, immediately north of the lake Lysfjordvatn, there are faint ridge-formed accumulations of morainic material. The glacial deposits of this area are assumed to coincide with the outer margin of an ice lobe which moved north by north-west and covered the innermost part of the Kjella fjord. At that time a small area between the moraines at Lysfjordvatn and the «Lysfjordmana» was ice-free, and also here the sea was in direct contact with the ice margins of the two glaciers, which is especially noticed on the «Lysfjordmana» side. Here it should be pointed out that the latter moraine (of the Lysfjord glacier) has certainly not been deposited by a glacier moving from south, as was assumed by

[1] The rock terrace of the Main line, not seen in this fjord area, occurs west of and closely outside the Skauvik promontory.

[2] Here the depth of the fjord is 350 to 400 m, whereas somewhat inside and outside it is 600 to 700 m and 450 to 500 m respectively.

[3] Cp. Rekstad and Vogt 1900 p. 63, Rekstad 1910 p. 16, and 1917 pp. 68–69, and Svensson 1959 inter al. pp. 205–207.

[4] Except a moraine at the Hegbærnes promontory also very faint traces of a submarine ridge seem here to occur, cp. Chart No. 224 of the Norwegian Coast. The Hegbærnes moraine may possibly partially be somewhat older than the stage described.

Rekstad (Rekstad 1910, p. 16 and 1917, pp. 68–69)[1]. The Lysfjord and Aarsetfjord – Kjella glaciers extended from the big Bindalsfjord glacier on the north and south side respectively of the Hildringsfjell – Heilhorn – Lillehorn mountain massif. The former glacier extended westward across the isthmus of Bindalseid and the latter south-westward, west, and finally north-westward through the depressions of Sørfjord and of Aarsand-Kjella.

The contemporaneity of the ice margins at Bindalsfiord, Lysfjord[2], and at Aarsetfjord — Kjella and their relation to the Main or Tromsø-Lyngen substage seem ascertained through the studies of the Main line and the marginal moraines. Of special interest here are the Main line rock terraces, which occur partly closely outside the strait of Bindalsfjord and partly on the western slope of Hegbærnesfjell, immediately outside the Lysfjord, as well as outside the inner part of the Kjella fjord. In this connection the *Portlandia arctica* find at Sør-Horsfjord, 2 to 4 km in front of the said moraine accumulations of this area, should be recalled[3].

For a more complete picture of the ice margins and marginal moraines of the region, belonging to the substage in question, it is referred to the investigations by Svensson, which to some extent support the author's results. A series of end moraines and other glacial deposits to be considered here, have been recognized by him (Svensson 1959, inter al. Fig. 72). According to position and character, they must belong to the same series as reported by the author. The most important moraine or moraine system is that on the eastern slope of the Heilhorn-Lillehorn massif, at an altitude of about 40 (–300 m, (Svensson 1957, figs 2 and 3, and 1959, Fig. 85). This, and other, belong to Svensson's Middagtind — Heilhorn stage, which surely must be correlated with the Tromsø-Lyngen or Main substage (as with the Tautra[4] and the Ra substages), especially because of the shore-line indications pointed to above (cp. Marthinussen, 1961, Fig. 17). The possibility of such correlation has also been discussed by

[1] The character of the material as well as the morphology of this moraine contradict an interpretation as that advanced by Rekstad.

[2] As a marginal moraine of the Lysfjord glacier, the «Lysfjordmana» is evidently included, cp. Svensson 1959, pp. 205–207, 223–233 and 235.

[3] Also an other shell find in this area should be mentioned, i. e. of *Macoma calcarea, Chlamys islandica* and *Mya truncata* embedded in sand and gravel near 100 m a.s.l. on the southern slope of the «Lysfjordmana» moraine. The samples have not yet been dated.

[4] See Holtedahl, 1928. Also in this area the Main line rock terraces seem to occur only outside the end moraines of the substage.

Svensson. Neither by the shore-line chronology nor by estimation of the climatic snow line and glaciation limit respectively, has he been able to reach a final conclusion (Svensson 1959 pp. 234—236), but on the basis of the characteristic prominence of the moraines in question he arrived at the same opinion as that expressed above (Svensson 1959 pp. 236—237 and 260).

The climatic and glacial conditions during the Main substage will also be recalled. The authors studies of moraines and drainage phenomena within the corresponding marginal zone, inter al. in western Finnmark, showed this glacial stage to be characterized by alternate active and passive phases, the former indicated by marked moraine ridges, inter al. push moraines, and the latter by dead-ice topography and especially by traces of a more or less intensive subglacial melt-water drainage (Marthinussen 1961 Pl. 2, Fig. 20, and pp. 157, 169). According to the observations from this region and from other parts of Finnmark the climate of Younger Dryas time seems to have been rather variable and of a more complex character than generally assumed.

As regards the said other glacial substage prior to the Main substage (Pl. 1) in these northern regions, it is referred mainly to the described Outer Astafjord moraine (p. 46) and to the moraines in the Repparfjord area of Finnmark. For the former dating of shells points to the Older Dryas age (T-269, Pl. 1). The Repparfjord moraines are a series of marked end moraines, the glacial substage of which has by the author been termed the Repparfjord substage (Marthinussen 1961). Studies of the ice-shrinkage that followed in the Repparfjord area, showed a period of intensive ice-melting between this substage and the later Main substage. The period was therefore assumed to correspond to Allerød time, and the Repparfjord substage consequently to Older Dryas time (Marthinussen 1961 pp. 133 and 165). True, the final proof hereof, which should naturally be directed to the purpose of showing the contemporaneity of the moraines in the said two areas, was still lacking. For this, however, the correlation of shore lines seemed of essential importance, in so far as the assumed chronological correspondence was verified by comparing the shore level zone of the Repparfjord substage (the S_4-S_2 lines, cp. Marthinussen 1960, Pl. 16, and 1961 inter al. p. 119) with the corresponding zone outside the Outer Astafjord moraine (p. 46). In relation to the Main line (S_0 (P_{12})), the conformity of the two zones is nearly complete. Consequently, the Outer Astafjord moraine and the end moraines of the Repparfjord area (see Marthinussen 1961, Pl. 1)

seem to represent the same glacial substage: *the Repparfjord substage*, the age of which coincides with the Older Dryas period. Corresponding end moraines and other glacial deposits have been recognized by the author in practically all parts of Finnmark[1] here considered, and to some extent also in Troms, whereas in Nordland no moraines have as yet with certainty been classified as belonging to this category.

From a general view of the regional extent of the marginal zones of the Repparfjord and Main substages[2] it appears that the distance between the two zones shows great variations from one area to the other. This must be thought due to the varied topography, e. g. with deep and shallow fjords alternating. The conditions pointed to are well illustrated in the areas of Altafjord and Porsangerfjord in Finnmark, the former being a deep fjord and the latter mostly a very shallow one (Marthinussen 1961, Fig. 19). The obvious explanation hereof is that the outlet glaciers from the ice cap during the Main substage, in contrast to those of the older substage, have locally not been large enough to compensate for the terminal loss of ice through the calving caused by the great depth of some fjord basins. In such cases the distance between the two marginal zones must naturally be comparatively wide. Conditions corresponding to those in Western Finnmark are also met with in Troms. In the Kvenangenfjord area, like in Altafjord, the two zones are far apart, as the end moraines of the Main substage are found near the head of the fjord and those of the older substage not far from its mouth. The position of the latter has been confirmed through data referring partly to observations by Undås (Undås 1938 pp. 111—115 and Fig. 16) and partly to the author's investigations in the adjacent area inside. In more southern districts of Troms, on the other hand, especially south of Lyngen, the two moraine zones are comparatively close to each other, in parts very close, which is seen inter al. in the previously described Astafjord area in the southernmost part of Troms (p. 46).

To this brief review of the regional extent of the ice margins it will be added a few remarks on the vertical extent or thickness of the corresponding ice masses. Informations hereof are based on the occurrence of lateral end moraines and other traces of the upper ice margin along the mountain slopes. The ice surface during the Main substage is in many districts roughly indicated by the altitudes of numerous lateral

[1] As regards Western Finnmark, see Marthinussen 1961, Fig. 19.

[2] It is here referred to the outer margins of the continental ice cap and its extensions respectively, and not to those of the local glaciers outside.

end moraines. As regards the older substage, similar traces of the ice margin — as indication of the ice thickness — are as yet known only in parts and extensive investigations are still needed. A few of the known data, mainly from the Repparfjord and the Stabbursdal area of Western Finnmark, will here be recalled. In the former area there are traces of the older substage and in the latter both of the older and the younger substage (Marthinussen 1961 Pl. 1 and 2). Pl. 1 to some extent gives a picture of the Repparfjord glacier, the surface of which gradually rose inwards and within the map area reached a maximum altitude of 500 to 550 m a.s.l. The second area, the Stabbursdal (Pl. 2), is to the east flanked by a high mountain massif which includes one of the highest peaks of Finnmark, the Cuokkarassa (1139 m a.s.l.) At an altitude of about 1000 m this peak is encircled by a marked moraine zone presumedly contemporaneous with the Repparfjord substage. A few km to the west of Coukkarassa there are distinct lateral end moraines about 650 to 700 m a.s.l., belonging to the Main substage. In view of the fact that the valley floor of Stabbursdal to the west is about 350 to 400 m a.s.l., the above data seem to suggest a thickness of the ice masses here during the older substage approximately twice that during the younger substage, namely 600 to 650 and 300 to 350 m respectively. This result regarding the relative thickness of the ice masses during the two stages — even though it does not hold everywhere within the former glacier domains of these northern districts — still it gives some indication of the conditions in general.

In the middle and southern part of Finnmark, mainly between 69 and 70° N. Lat., the surface of the ice cap during the Main substage reached to 650 to 700 m a.s.l. in the district some 10 km inside the heads of Porsangerfjord and Altafjord, and to about 1100 m in the southern part of «Finnmarksvidda». The corresponding altitudes for the Repparfjord substage were about 1000 m and 1400 to 1500 m respectively. The altitudes 650 to 700 m and 1000 m, in the outer area, have been directly observed, whereas those in the inner area, 1100 m and 1400 to 1500 m, have been tentatively calculated and estimated as based on the reasonable assumption of very slight rising gradients of the ice surfaces in a southernly direction, presumedly no more than 4 to 5 $^{0}/_{00}$ [1]. Conside-

[1] Cp. the gradients of the sloping surfaces of the Stabbursdal and Porsangerfjord glaciers (of the Main substage), 8 and 13,5 % respectively, Marthinussen 1961, pp. 134 and 166 (As for the corresponding gradients during the older substage, see the paper referred to p. 125).

ring that the existing medium heights for the underlying land surface in the two areas are about 350 to 400 m[1] and 500 m, the corresponding thicknesses of the ice cap were 300 to 350 m and 600 to 650 m (in the outer area), and about 600 m and 900 to 1000 m (in the southern part of «Finnmarksvidda») respectively.

As seen above, the Repparfjord substage has in Finnmark been represented by an extensive and heavy ice cap, which – except in the extreme western part bordering on Troms — has covered nearly all land inside the marginal zone, including the highest mountains (Marthinussen, 1961, p. 125)[2]. Outside this ice cap a more or less ice-free[3] coastal zone existed in Finnmark as well as in Troms (and Nordland). The transversal extent of this zone, reaching to the outermost projections of the land mass, has been comparatively small, between about 30 and 80 km. For comparison it should be mentioned that the distance between a moraine series near Gøteborg, corresponding to the Repparfjord substage, and the outer limit of the Würm ice-sheet near Limfjord (in Denmark) is about 250 km. Although otherwise incomparable because of eventual difference in the conditions in these widely separated areas, the facts reported above nevertheless indicate that the outer ice margin in northernmost Norway during the last glacial maximum (the Würm), probably extended far outside the coast line bordering on the Arctic sea (cp. Marthinussen 1960 p. 421, and 1961 pp. 161 and 167—168).

Referring to the above it is of interest to notice that this rather marked glacial event (the Repparfjord substage) took place only 12 000 to 12 500 yrs. ago, a fairly late date as compared to the preceding long-lasting phase of the last glaciation epoch (the Würm-Wisconsin glaciation), which probably commenced more than 60 000 yrs. ago. During this long phase, at some time characterized by the undoubtedly most unfavourable climatic conditions of the last ice age, the accumulation of ice has obviously by far exceeded that during the Repparfjord substage, and must periodically have been of such dimensions that all land in Finnmark (and probably also all of Northern Norway except the outermost part of the Lofoten Archipelago) has been entirely covered by ice. The time of this event, naturally uncertain, may possibly correspond to that of the maximum extent of the ice-sheet on the Continent, which

[1] The figures 350 to 400 m do not hold for the area near the Altafjord.

[2] The Cuokkarassa and possibly also one or two other peaks in central Finnmark reached above the ice surface.

[3] Cp. the occurrence of some local glaciers.

occurred in early «Main Würm» (about 20 000 to 24 000 yrs. ago). Or it may have happened much earlier, e. g. at the time of the maximum extent of the ice in England, which coincided with the maximum of «Older Würm», about 50 000 yrs. ago (cp. Coope, Shotton, and Strachan 1961 p. 382 and Table 1).

As regards Finnmark, the above view on a total glaciation is, as will be stated elsewhere, supported by the author's observations on the degree of weathering, the occurrence of erratics, glacial striae etc. as well as by study of the shore lines. The assumption of ice-free refuges during the last, and also earlier, glaciations in this part of Norway, especially maintained by botanists (Nordhagen and Dahl), is in the author's opinion highly improbable.

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SAMMENDRAG

C_{14}-dateringer som angår strandlinjer, transgresjoner og brerandstadier i Nord-Norge.

Denne publikasjon er en foreløpig meddelelse som i det vesentlige dreier seg om en serie C_{14}-dateringer utført av R. Nydal ved Laboratoriet for Radiologisk Datering i Trondheim. Dateringene synes å gi viktige opplysninger om alderen av bl. a. visse strandlinjer og av et par brerandstadier, henholdsvis Repparfjordstadiet og Hovedtrinnet eller Tromsø-Lyngen stadiet. Det daterte materiale, av drivved, torv og skjell, er med hensyn til funnforhold, høyde og alder etc. nærmere omtalt i flere avsnitt (s. 38–47). Resultatene er videre sammenstillet i en tabell (Pl. 1). Drøftingen av resultatene er her sterkt begrenset og omfatter hovedsakelig en kort utredning angående strandforskyvningen ved Ramså på Andøy (s. 47–53) samt visse heterogene og fragmentariske bemerkninger vedrørende de anførte brerandstadier (s. 53–62). Nevnte strandforskyvning er illustrert ved en kurve (Pl. 2), som er konstruert ved hjelp av data dels fra Ramså og dels fra en rekke andre lokaliteter. Sammenstillingen av de ulike data i Pl. 2 er basert på en serie strandlinjediagrammer fra forskjellige strøk av Finnmark og Troms/Nordland (jfr. bl. a. Marthinussen, 1960, Pl. 16). Tilsammen gir plansjene 1 og 2 en konsentrert oversikt over en del resultater fremkommet ved undersøkelser av stratigrafiske profiler, strandlinjer og brerandstadier, og ved radiologiske dateringer. Fremstillingen her er ellers et supplement til et par tidligere publikasjoner (Marthinussen, 1960 og 1961).

Hva strandforskyvningskurven fra Ramså angår (Pl. 2) er denne i visse henseender av foreløpig karakter. Foruten enkelte supplerende

studier av profiler ved Ramså gjenstår det her også en serie C_{14}-dateringer av prøver av torv, skjell og drivved. Undersøkelser av torvprøvenes innhold av pollen og diatomeer er naturligvis av betydning for mer pålitelige slutninger vedrørende nivåforandringenes gang. Når slike undersøkelser kan bli utført og i hvilken utstrekning materialet egner seg dertil, er ennå uvisst. De påtenkte studier og dateringer vil formodentlig ikke medføre vesentlige endringer i det foreliggende resultat, men de antas å ville kunne verifisere visse forhold som ennå er usikre, og ellers komplettere bildet av strandforskyvningene ved Ramså ytterligere. I senglacial tid, før Yngre Dryas tid, har strandens negative bevegelse muligens ikke vært så regelmessig som kurven (Pl. 2) gir inntrykk av. Det er iallfall muligheter for at visse oscillasjoner kan ha forekommet (s. 48). I en særstilling står den antydede markerte svingning av stranden under Yngre Dryas perioden, en svingning som forøvrig ennå ikke er helt fastslått (s. 48–49). Hva de postglaciale forandringer angår er hovedtransgresjonsfasens komplekse karakter først og fremst verd å merke seg (s. 51). Det er forøvrig interessant å kunne konstatere at strandens bevegelser her (se Pl. 2) utviser trekk som generelt såvel som også mer spesielt —iallfall i visse henseender — synes å ha likhetspunkter med tilsvarende fenomener i andre områder i og utenfor Fennoskandia, f. eks. i Sørvest-Norge, Sør-Sverige, Danmark, Island, Skottland og Irland (se bl. a. s. 49 og 50). Sammenlikningen viser også innbyrdes divergerende utviklingsforløp, som imidlertid i de fleste tilfelle må antas å være relative, betinget av ulike isostatiske forhold.

Omtalen av brerandstadiene, Hovedtrinnet (Tromsø-Lyngen stadiet) og Repparfjordstadiet, er temmelig fragmentarisk og angår hovedsakelig områder hvor det foreligger C_{14} datert materiale som har tilknytning til brerandavsetninger av vedkommende kategorier, f. eks. Bindalsfjord-, Astafjord- og Lyngenfjordområdene. Ellers er det bl. a. referert til tidligere undersøkelser av de nevnte stadier, først og fremst i Vest-Finnmark, jfr. Repparfjord — Stabbursdalområdet (Marthinussen, 1961).

Hovedtrinnets (the Main substage) eller Tromsø-Lyngenstadiets samtidighet med Ra-stadiet synes nå å være verifisert, bl. a. ved hjelp av C_{14}-datert materiale fra en skjellforekomst umiddelbart utenfor Lyngenmorenen (ved Spåkenes). Ellers er den regionale korrelasjon av hithørende brerandavsetninger i Nord-Norge bare mer unntagelsesvis basert på C_{14}-dateringer. Til gjengjeld gir randmorenenes morfologiske karakter og særlig utbredelsen av Hovedlinjens bergterasser ofte verdifulle opplysninger om isens maksimale utstrekning under vedkommende sta-

dium (se s. 54–55 og Marthinussen, 1961, Fig. 17). Hovedtrinnets morenesystem utviser i mange områder en utpreget kompleks karakter, som gjenspeiler suksessive aktive og passive brefaser betinget av tilsvarende variasjoner i Yngre Dryas-tidens klima (s. 58).

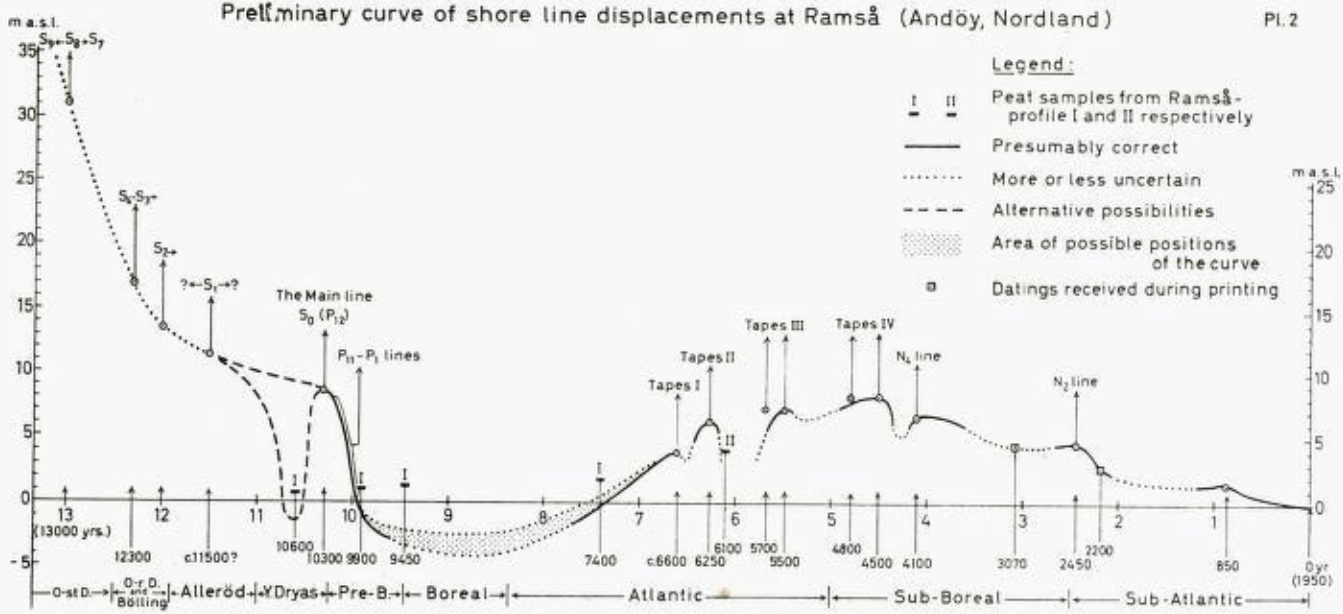
Hva Repparfjordstadiet angår må her først og fremst nevnes de brerandavsetninger som forekommer i Astafjord- og Repparfjordområdene. Ifølge C_{14}-datering synes den såkalte Ytre Astafjordmorene å tilhøre Eldre Dryas-perioden (s. 46). En korrelasjon basert på strandlinjesystemer synes ellers å vise at et hovedmorenesystem i Repparfjordområdet, som representerer Repparfjordstadiet, også tilhører nevnte periode (s. 58). Den regionale utstrekning av det korresponderende bredekke er påvist i vidstrakte områder her nord. For Finnmarks, spesielt Vest-Finnmarks, vedkommende er såvel isens utstrekning som dens vertikale mektighet noe nærmere presisert (s. 59–61 og Marthinussen, 1961, Fig. 19). Bortsett fra en kystsone av varierende bredde var da praktisk talt hele den innenforliggende landmasse dekket av en mektig iskappe. Med dette som utgangspunkt berøres så kort diverse grunner for antagelsen av en total nedising iallfall av Finnmark under en eller annen tidligere periode av siste istid.

Table of C_{14}-datings referring to shore lines, transgressions and glacial substages etc.[1]

Ref. Nos. Rad. Dat. Lab. in Trondheim Norway	Locality	Material	Species and (or) genera	Altitude of the finds a.s.l. (m)	Age of the material B.P.	Corresponding climatic periods, assumed	Glacial substages
T-269	Sandvatnet (I) Troms	Shells	*Macoma calcarea*	69,0	12300 ± 250	Older Dryas (partly Bølling?)	The Repparfjord substage (Finnmark)[2]
T-316	Sandvatnet (II) Troms	»	*Mya truncata*	73,2–73,4	11700 ± 250	Allerød (*Betula* phase)	
T-214	Sandstrand (III) Troms	» (from transition layer between sand and overlying «Yoldia clay»)	»	30,5	11400 ± 250	Allerød (*Pinus* phase)	
T-271	Ramsåprofile I series Andøy, Nordland	Peat[3] (from a very thin layer)		0,75	10600 ± 250	Younger Dryas	The Main substage[2] or the Tromsø-Lyngen substage
T-246	Rønvik, Bodø, Nordland	Shells (from «Yoldia clay»)	*Portlandia arctica*	c. 7,0–10,0	10550 ± 250	»	»
T-187	Djupvik, Lyngen, Troms	»	»	c. 4,5–9,0	10350 ± 300	»	»
T-124	Steinsdal, Helgeland, Nordland	»	»	c. 8,0–10,0	10300 ± 250	»	»
T-294	Ramsåprofile I series Andøy, Nordland	Peat (from a zone of thin altern. peat and sand layers)		1,05	9900 ± 200	Pre-Boreal	
T-295	»	Peat (from the base of a layer of peat 60 cm thick)		1,3	9450 ± 250	Transition Pre-Boreal–Boreal time?	
T-182	Tomaselv, Vadsø, Finnmark	Peat (overlain by a shore bar)		24,5	7750 ± 150	Atlantic	
T-270	Ramsåprofile I series Andøy, Nordland	Peat (overlain by marine shore gravel and sand)		1,8–1,85	7400 ± 150	»	
T-185	Djupdalen, Ingøy, Finnmark	Driftwood	*Pinus*	8,9	6350 ± 150	»	
T-267	Nord-Mjele, Andøy, Nordland	»	*Picea*	5,0–5,3	6250 ± 200	»	
T-296	Ramsåprofile II series Andøy, Nordland	Peat (from thin layers overlain) by a marine sand deposit)		4,1	6100 ± 150	»	
T-184	Børfjordbotn (G. II) Sørøy, Finnmark	Driftwood	*Picea*	10,5–11,0	5700 ± 150	»	
T-183	Børfjordbotn (G. I) Sørøy, Finnmark	»	»	»	5500 ± 150	»	
T-126	Oldervik, Seiland, Finnmark	»	»	15,0	4820 ± 160	Sub-Boreal	
T-266	Nøss, Andøy, Nordland	»	»	7,4	4500 ± 150	»	
T-186	Saraberget, Ingøy, Finnmark	»	Larix	6,5	4100 ± 100	»	
T-244	Lyngpollen, Magerøy, Finnmark	»	»	7,8	4100 ± 150	»	
T-243	Austbotn, Kobbefjord Finnmark	»	*Picea*	6,0 (max.)	2450 ± 100	Transition Sub-Boreal-Sub-Atlantic time?	
T-245	Skallelv, Nord-Varanger Finnmark	»	*Larix*	c. 3,5	850 ± 80	Sub-Atlantic	

[1] Cp. Marthinussen, 1960, Pl. 16. – [2] See Marthinussen, 1961. – [3] Cp. pp. 42–43 and 48–49.

Terminal moraines	Corresp. shore-levels or shore-level zones (and transgression limits).	Altitudes of shore levels or shore-level zones at the localities of finds. m a.s.l.	Approx. ages of shore levels or shore-level zones B P.	Altitudes of shore lines at Ramså. m.a.s l.
The Outer Astafjord moraine	S_1-S_2 shore-level zone (see p. 48).	Between c. 80 and c. 73,5	12350–11900 ?	S_1-S_3 = c. 18,0 – 15,5 and S_2 = c. 13,5
	S_1 level and a part of the interval S_2-S_2 (see p. 48).	Between c. 73,5 and c. 70,5	11900–11000 ?	c. 12,0–10,0
In the Andøy area moraines deposited by small local glaciers represent the substage	Shore level probably considerably lower than the Main line, S_0 (P_{12})? (at the locality of find)	At least c. 1,0 m *below* the present sealevel.	c. 10600	At least c. 1,0 m *below* the present sealevel
Probably the end moraines situated in the Skjerstadfjord area.	Shore level probably a little *below* the shore-level zone of the Main line (at the locality of find), cp. p. 45.	85–90 the shore-level zone of the Main line.	10550	?
The Lyngen (Spåkenes) end moraine.	The Main line	65,0–66,0	10300–10200	c. 8,5
End moraines of the Bindalsfjord area, inter al. at Harangsfjord.	The Main line	About 122,0	10300–10200	c. 8,5
	Probably a little *lower* than the present sealevel (at the locality of find)	1,0–1,5 m *below* the present sealevel (?)	9900	÷ 1,0 ?
	Certainly *lower* than the present sealevel (at the locality of find).	Possibly c. 2,0–4,0 m *below* the present sealevel	9450	÷ 3,0 ?
	The subsequent transgression limit = Tapes I line	25,0	c. 6500–6600	3,5–4,0
	The subsequent transgression limit = Tapes I line	3,5–4,0	c. 6500–6600	3,5–4,0
	Tapes I–II (found at Tapes IV level = 8,2 m)	Between c. 2,0 and c. 6,0	6350	between 3,7 and 6,2
	Tapes II line	4,5–4,8	6250	6,2
	Shore level between c. 3,0 m and the present sealevel (at the locality of find).	1,0–3,0 ?	6100	1,0–3,0 ?
	Tapes III line	11,0–11,5	5500–5700	7,0–7,5
	Tapes III line	11,0–11,5	5500–5700	7,0–7,5
	Tapes IV line	15,0	4800–4500	8,1
	Tapes IV line	7,0–7,5	4800–4500	8,1
	N_4 line	c. 6,5	4100–3900 ?	6,4
	N_4 line	7,0–7,5	4100–3900 ?	6,4
	N_2 line	5,0–5,2	2450	4,7
	Half the altitude of the N_1 line (at the locality of find)	2,0–2,5	850	c. 1,5


Preliminary curve of shore line displacements at Ramså (Andöy, Nordland)
Pl. 2
m a.s.l.
Legend:
Peat samples from Ramså-profile I and II respectively
Presumably correct
More or less uncertain
Alternative possibilities
Area of possible positions of the curve
Datings received during printing
The Main line
Tapes I
Tapes II
Tapes III
Tapes IV
Boreal
Atlantic
Sub-Boreal
Sub-Atlantic