A shore displacement curve from the Tromsø district, North Norway

MORTEN HALD AND TORE O. VORREN

Hald, M. & Vorren, T. O.: A shore displacement curve from the Tromsø district, North Norway. *Norsk Geologisk Tidsskrift,* Vol. 63, pp. 103–110. Oslo 1983. ISSN 0029-196X.

A shore displacement curve based on earlier and new data for the Lyfjorden area Kvaløya (Main shore line = 30 m a.s.l) is constructed. Stratigraphical studies show early Holocene terrestrial sediments (8350 ± 90 YBP) approximately 10 m below the altitude of the maximum Tapes shore level. The early Holocene regression rate was at least 1.25 m/100 yrs, whilst the following Tapes transgression rate was about 0.5 m/100 yrs.

M. Hald & T. O. Vorren, Department of Biology and Geology, University of Tromsø, P. O. Box 3085 Guleng, N-9001 Tromsø, Norway.

The aim of this study is to present new evidence for the early Holocene regression/transgression sequence and a tentative shore-level displacement curve for the Tromsø district.

The study area is located on Kvaløya (Fig. 1) at the embayment Lyfjorden which is in the outer part of Kaldfjorden. The bedrocks in the area are Precambrian gneisses. The Quaternary sediments in the area are mostly found below the marine limit. The area is situated distally to the Skarpnes (12,500–12,000 YBP) end moraine system.

Several authors have worked on the shore displacement problem in the Tromsø district: viz. Pettersen (1880, 1884), Helland (1989), Grønlie (1914, 1940, 1951), Hansen (1966) and Andersen (1968). Marthinussen (1960) presented an isobase map for the Main shore line where this area was included.

Raised shore lines

The most pronounced shore line in the area lies 30 m a.s.l. According to the isobases of Marthinussen (1960) and Andersen (1968), this must be the Main shore line. It is represented by bedrock terraces as well as accumulation terraces and beach ridges (Fig. 2).

At 15 m ± a.s.l. there is another level with pronounced shore features (Fig. 2). Shore notches/terraces lie slightly below the 15 m contour and beach ridges lie slightly above this level. Measurements of currently forming shore-lines have shown that beach ridges are formed higher than shore notches and, on average in northern Norway, 2 to 4 m above mean sea level (Rose & Synge 1979). Thus the shore features in question were probably formed at a mean sea level of 13 to 14 m. A section in a beach ridge belonging to this shore-line (Fig. 2) contained several clasts of black pumice. Frequent occurrence of pumice is restricted to shore levels belonging to, or younger than the Tapes complex (Marthinussen 1960, Binns 1972). Thus, both the pronounced morphology, the altitude, and the occurrence of pumice indicate that this shore line represents the maximum height of the Tapes transgression.

Below the Tapes level there is a continuous series of small beach ridges. Upvalley there are terraces of higher altitude than the Main shore line. Some of these may be of littoral origin. However, no detailed investigation of this has been made.

Stratigraphy

A section in a fluvial erosional scarp (Fig. 2) was investigated in detail. The lithostratigraphy shows three main units (Fig. 3).

The lower unit is a diamicton with an exposed thickness of 5 m. The sediment is rather massive, although lenses of sand occurred. The grain-size distribution (Fig. 3) shows a matrix of mud, in which are dispersed clasts of various sizes. There is a general tendency for an upward coarsening. Bivalves in life position were found throughout the whole section. In the lower part several shells of *Macoma calcarea* and a few shells of *Hiatella*

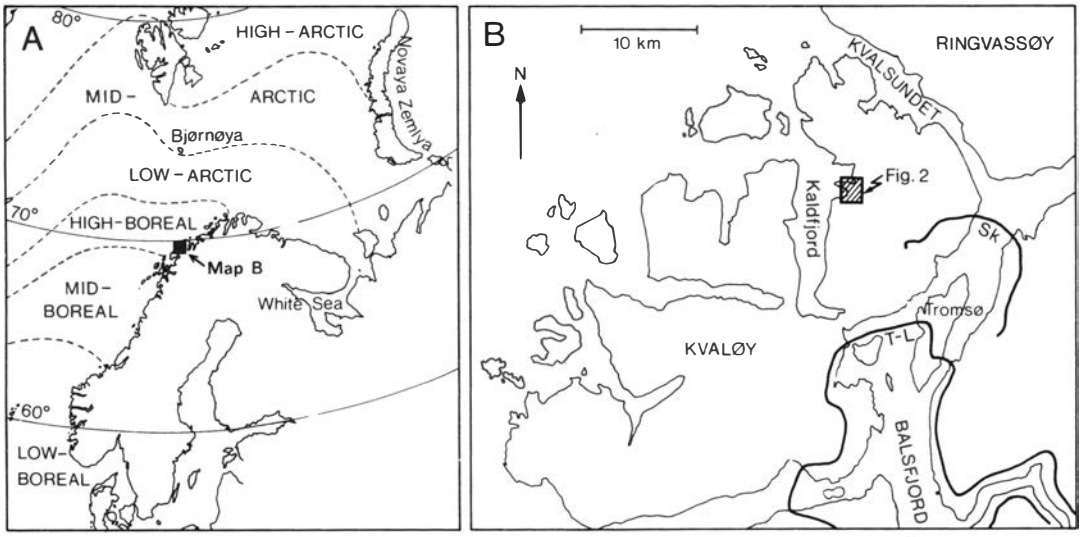

Fig. 1. Location maps. A: Keymap including the zoogeographical subdivision of the oceanic surface water after Feyling-Hanssen (1955). B: The ice margins of the Weichselian ice sheet during the Skarpnes event (Sk) (about 12,000–12,500 YBP) and Tromsø-Lyngen event (T–L) (about 11,000–10,000 YBP), after Andersen (1968). The investigated area (framed) is situated distally to these Late Weichselian ice margins.

arctica were found. Higher up *Mya truncata* is the most frequent bivalve. In addition some *Astarte elliptica* and *Chlamys islandica* also occurred. Some samples were analysed for foraminifera. There are only small changes between the lower and upper part. The fossil assemblage is typical of an arctic environment, namely dominated by *Elphidium excavatum* (57–77 %) and *Cassidulina reniforme* (12–30 %). Radiocarbon datings of shell from the lower *(M. calcarea)* and upper *(M. truncata)* part of the unit gave ages of 12,460 ± 190 YBP (T-4269) and 11,440 ± 170 YBP (T-4270), respectively.

The boundary with the middle unit is abrupt, indicating an unconformity. The middle unit comprises a twig-bearing sand layer with thickness mostly less than 10 cm (Fig. 3). The sand layer is discontinuous so that in some places the upper unit rests directly on the lower unit. The middle unit was not found downstream of the investigated section. The twigs (Fig. 4) in the sand layer were identified to *Betula pubescens* and *Salix* sp. Most of the twigs were compressed, less than one cm thick and broken into less than 5 cm long pieces. A radiocarbon date of the twigs gave 8,350 ± 90 YBP (T-4471).

The upper unit is a 5–6 m thick sequence of horizontally bedded sand and gravel. On the surface of this unit are broad, low amplitude (1–1/2 m) beach ridges.

Interpretation of the stratigraphy. – Finds of pelecypods in life position, the fossil assemblage and the lithology indicate that the lower unit was deposited in a glaciomarine environment. The lower dating shows that the area was deglaciated at latest 12,460 ± 90 YBP. The coarsening upward may indicate a general lowering of the relative sea level during the deposition of the lower unit.

The character of the boundary between the lower and the middle unit and the two radiocarbon dates, 11,440 ± 170 YBP and 8350 ± 90 YBP, indicate a hiatus of approximately 3000 years between these two units. We believe this hiatus is due to erosion during the early Holocene regression.

The depositional environment of the middle unit is very important for interpreting the shore-level problem. The texture of the sand and the large amount and concentration of the twigs indicate that the middle unit has a littoral or fluvial origin. Due to the relatively unabraided nature of the twigs, rapid deposition by rivers seems most likely. As this unit was not found further downstream and no terrestrial deposits were re-

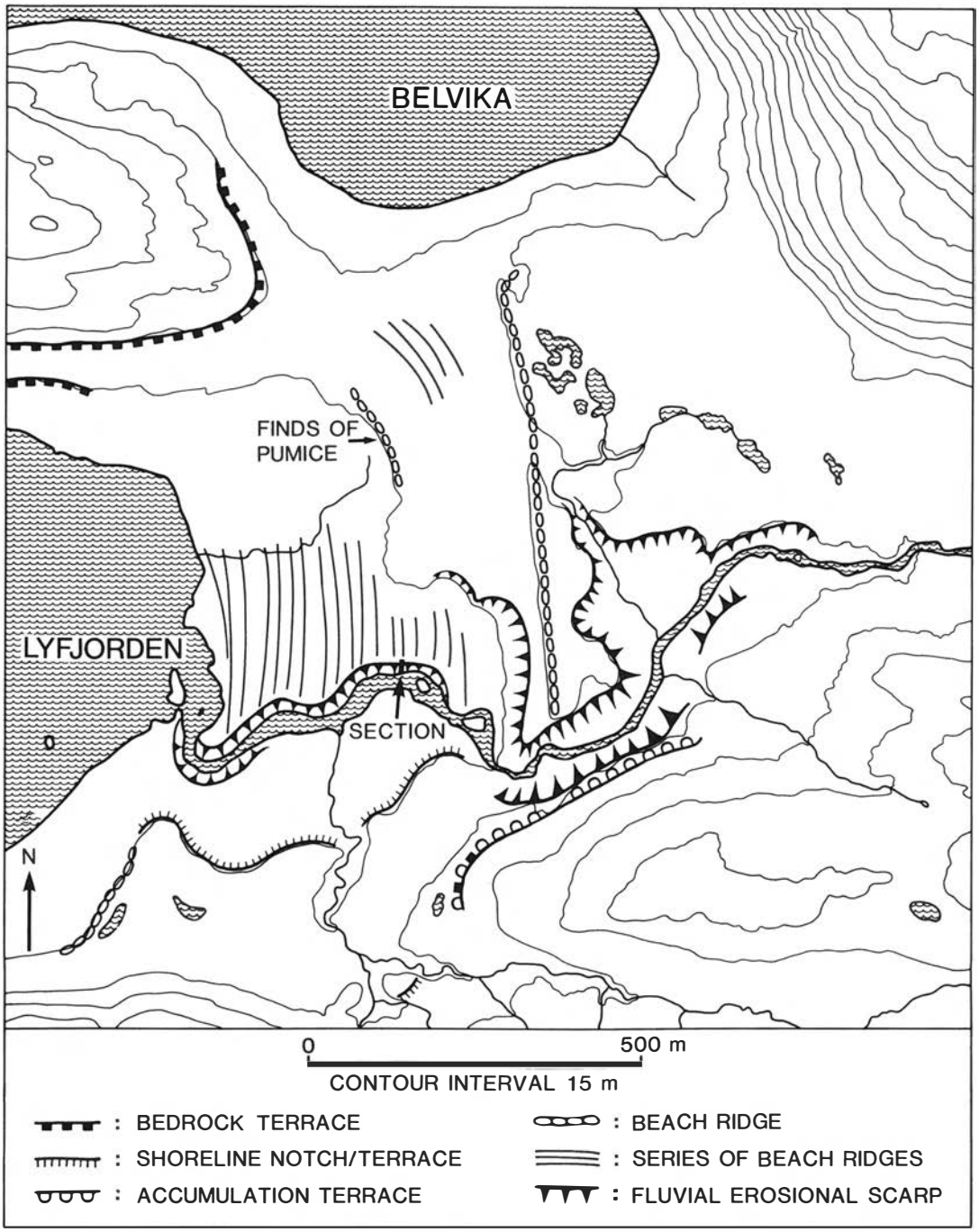

Fig. 2. Raised shore lines at the Lyfjord area. The maine shore line follows the 30 m contour and the maximum Tapes line follows the 15 m.

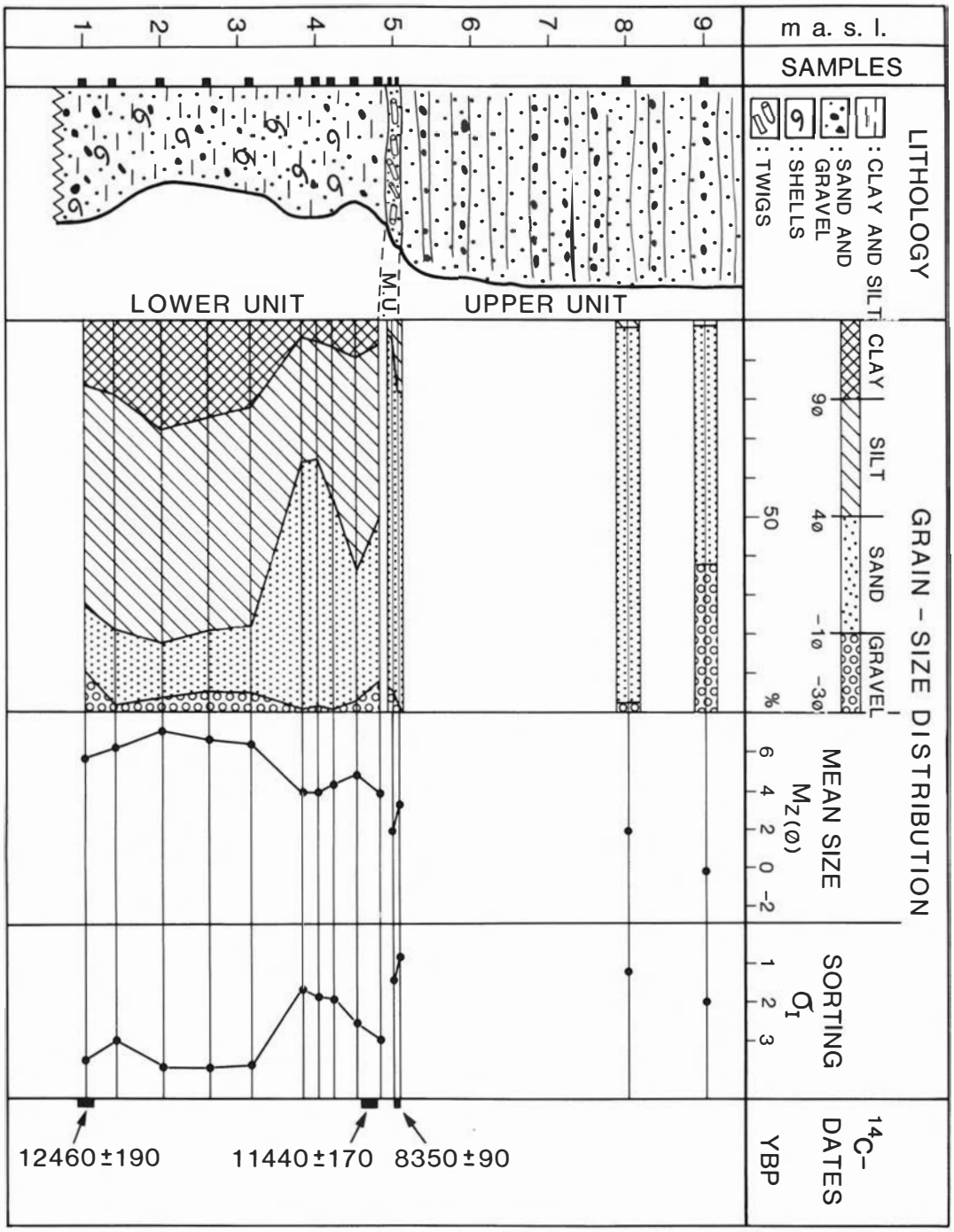

Fig. 3. Stratigraphy and lithology of the investigated section at Lyfjorden. For location, see Fig. 2.

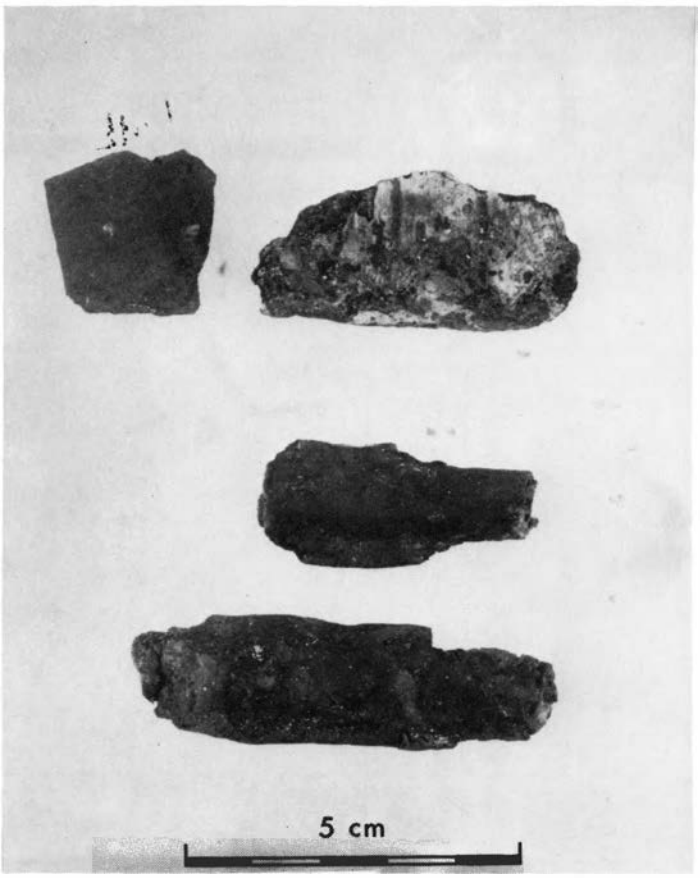

Fig. 4. Fossil twigs (*Betula pubescens* and *Salix* sp.) radiocarbon dated to 8350 ± 90 YBP from the Lyfjorden section.

corded below 5 m, it may be suggested that this altitude is close to the lowest sea level during the early Holocene regression. Thus the twigs give an age and elevation of the early Holocene sea-level lowstand in this area. The lithology of the upper unit and its connection with the beach ridges indicate that it is of littoral origin. This unit may have been deposited partly during the Holocene transgression (Tapes) and partly during the following regression.

Discussion

On Fig. 5 a shore displacement curve is constructed on the basis of:

1. An altitude of 30 m for the Main shore line, (S_0).
2. The equidistant shore-line diagram of Marthinussen (1960) for West Finnmark giving the heights of S_4, P_{11-1}, T I–IV and N_{4-2} shore lines.
3. Dating of the S_4-shore line to 12,000–12,500 YBP and a Younger Dryas age for the Main shore line (Marthinussen 1962, Andersen 1968).
4. Ages of the P_{11} to P_7-shore lines as indicated by Corner (1980), from Lyngen, northern Troms.
5. Ages of the Tapes I, II, III and IV, N_4 and N_2-shore lines as given by Marthinussen (1962), from Andøya.
6. The assumption that the P_1-level was formed immediately before the TI-level.
7. A slower emergence around the S_0-level, cf. Marthinussen (1962) and Hafsten (1981).

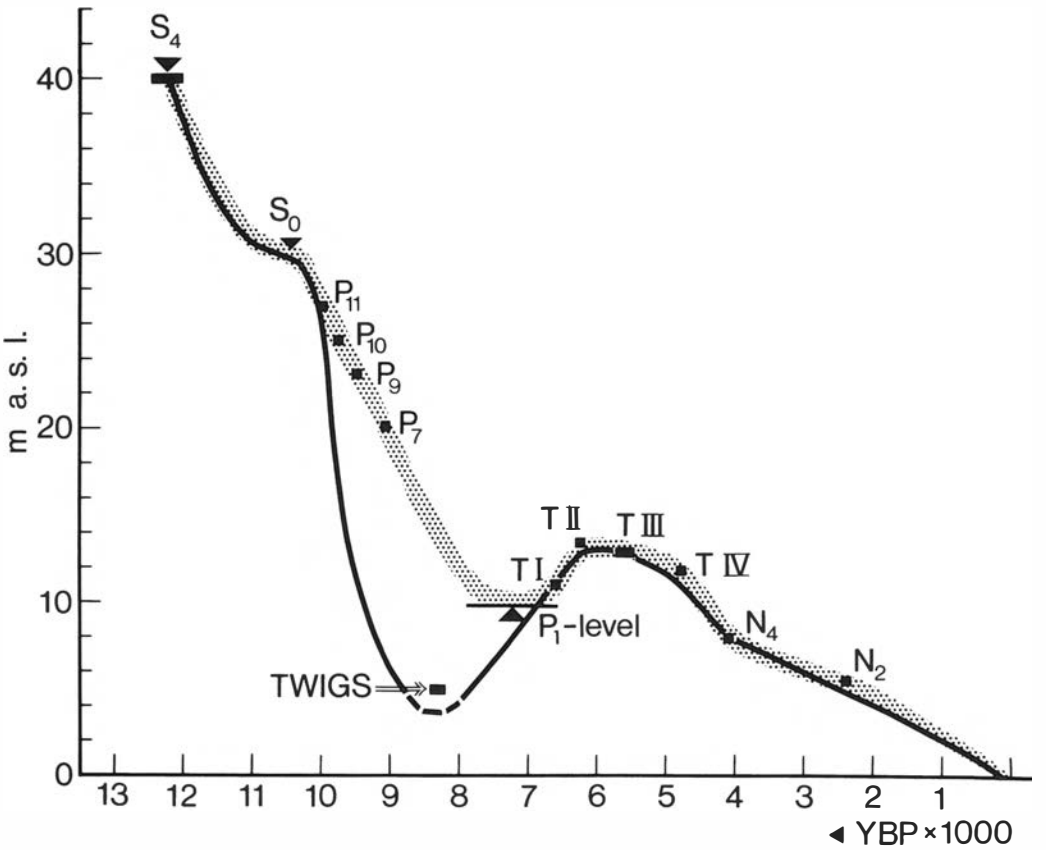

Fig. 5. Grey line: Shore displacement curve for the Lyfjorden area relying on data from Marthinussen (1960, 1962) Andersen (1968) and Corner (1980), see text for further explanation. Solid line: Updated shore displacement curve based on the grey curve and the new finds in Lyfjorden.

Referring to point 5, a date of 5790 ± 90 YBP (T-3035) (Vorren, unpubl.) from Nord-Kvaløya is of interest. This date is of *Arctica islandica* sampled from a shore ridge corresponding in altitude to the Tapes III or IV. The age corresponds very well indeed with the age of Tapes III given by Marthinussen (1962), i.e. 5700–5900 YBP.

The 'theoretical' curve (grey line, Fig. 5) does not agree with the data from Lyfjorden on one major aspect, namely the magnitude of the early Holocene regression/transgression sequence. The magnitude indicated by the Lyfjorden data is far larger than indicated by the 'theoretical' curve. On the other hand, the magnitude of the regression (solid line, Fig. 5) corresponds with those constructed from sites with a similar isobase position in southern Norway (Hafsten 1981).

Assuming an age of 10,350 YBP for the Main shore line (Corner 1980), the shore-level displacement rate was at least 1,25 m/100 yr, during the early Holocene regression. The following transgression to the Tapes maximum was at a rate of about 0.5 m/100 yr. A paleogeographic reconstruction of the Lyfjord area during four different postglacial time intervals is given in Fig. 6.

Conclusions

The present data show that:

- The Lyfjord area was deglaciated at the latest 12,500 years ago.
- A glaciomarine sedimentary environment prevailed at least until 11,400 YBP, probably until 10,000 YBP.

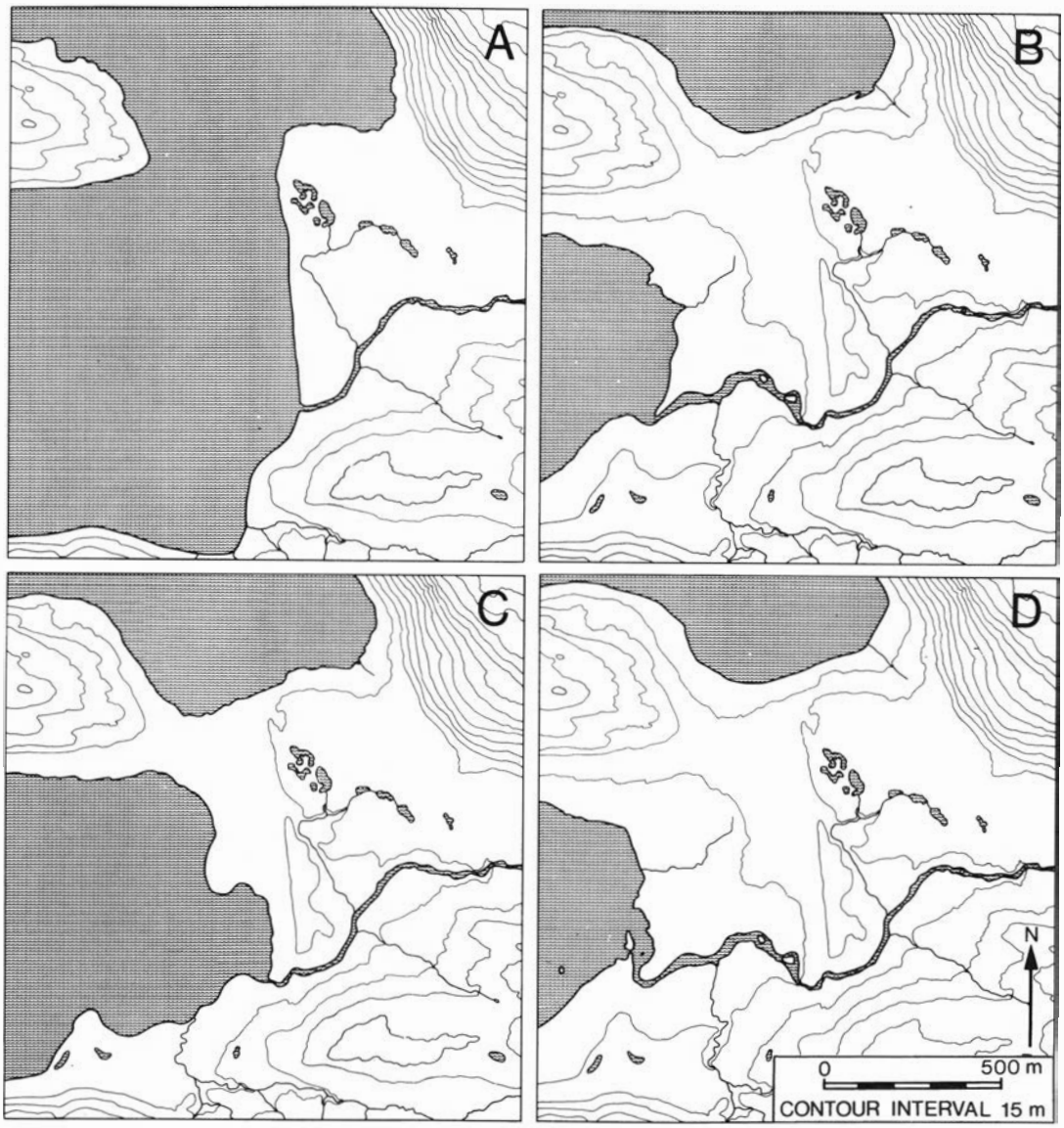

Fig. 6. Paleogeographic maps for the Lyfjorden area. A: Younger Dryas; shore line 30 m above present sea level. B: Boreal; (ca 8,350 YBP), shore line ca. 5 m above the present. C: Atlantic; shore line at the maximum of the Tapes transgression, ca. 13–14 m above the present. D: Present. Contour interval is 15 m.

- The early Holocene regression was rather rapid; at least a 1.25 m/100 yrs shore displacement occurred.
- The following Tapes transgression, which was approximately 10 m in vertical extent in the study area, was slower, about 0.5 m/100 yrs.

Acknowledgements. The work was financed by the University of Tromsø. We thank K.-D. Vorren for identifying the twigs, H. Falkseth for making the drawings, M. Berntsen for assisting the field work, the Laboratory for Radiologic Dating, Trondheim, for doing the radiocarbon datings and G. D. Corner for critically reading the manuscript.

References

Andersen, B. G. 1968: Glacial geology of western Troms, North Norway. *Nor. geol. unders. 256,* 160 pp.

Binns, R. 1972: Composition and derivation of pumice on postglacial strandlines in northern Europe and western Arctic. *Geol. Soc. Am. Bull. 83,* 2303-2324.

Corner, G. D. 1980: Preboreal deglaciation chronology and marine limits of the Lyngen-Storfjord area, Troms, North Norway. *Boreas 9,* 239–249.

Feyling-Hanssen, R.W. 1955: Stratigraphy of marine Late – Pleistocene of Billefjorden, Vestspitsbergen. *Nor. Polarinst. Skr. 107,* 226 pp.

Grønlie, O. T. 1914: Kvartærgeologiske undersøkelser i Tromsø Amt. II. Strandlinjer i amtet. *Tromsø Museums Aarsh., 35–36,* 221–240.

Grønlie, O. T. 1940: On the traces of the ice ages in Nordland, Troms and the south-western part of Finnmark in northern Norway. *Nor. Geol. Tidsskr. 20,* 1–70.

Grønlie, O. T. 1951: On the rise of sea and land and the forming of strandflate on the west coast of Fennoscandia. *Nor. Geol. Tidsskr. 29,* 26–63.

Hafsten, U. 1981: Late and post-Weichselian shore level changes in South Norway traced by biostratigraphical methods. In: *Sea level variation, last fifteen thousand years, magnitude and causes.* Proc. vol. IGCP Proj. 61, meeting in Columbia South Carolina, U.S.A. April, 1981.

Hansen, H. P. 1966: *Sein-og postglaciale havnivåer i Nord-Troms.* Unpubl. thesis. Department of Geogr., Univ. of Oslo.

Helland, A. 1889: Tromsø Amt I. Geologi. Norges Land og folk. Kristiania, 592 pp.

Marthinussen, M. 1960: Coast and fjord area of Finnmark. In: Holtedahl, O. (ed.), Geology of Norway. *Nor. geol. unders. 208,* 416–429.

Marthinussen, M. 1962: C_{14}-datings referring to shore lines, transgressions, and glacial substages in northern Norway. *Nor. geol. unders. 215,* 37–67.

Pettersen, K. 1880: Terrasser og gamle strandlinjer. *Tromsø Museums Aarsh. 3,* 1–52.

Pettersen, K. 1884. Det nordlige Norge under den glaciale og postglaciale tid. *Tromsø Museums Aarsh. 7,* 1–46.

Rose, H. & Synge, F. M. 1979: Glaciation and shoreline development between Nydal and Haukdal, south Varangerfjorden, north Norway. *Quastiones Geographicae 5,* 125–151.