On the Late Weichselian and Flandrian shoreline displacement in Nærøy, Nord-Trøndelag, Norway

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Pollen analysis, diatom analysis, and radiocarbon dating have been carried out to trace the shoreline displacement in the Nærøy area of the county of Nord-Trøndelag, Norway. Radiocarbon dating (14 presented results) and pollen-analytical dating (9 presented results) are used as mutually independent methods. Discrepancies between various corresponding dating results are discussed, also with regard to possible sources of error linked to the radiocarbon method. The shoreline displacement curve, which is based on 9 dated marine/lacustrine boundaries, has a somewhat modified lapse, compared to curves from eastern Norway and the inland of Trøndelag. The shoreline displacement in Nærøy is, however, presumed to have been continuously regressive from late Younger Dryas up to the present, which is the time space covered by this investigation.

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The presented investigation forms part of a shoreline displacement project in Trøndelag, initiated by Prof. U. Hafsten in connection with the IGCP Project No. 61, 'Sea leve! movements during the last deglacial hemicycle'. Other studies concerning the Trøndelag project have been completed in Frosta (Kjemperud 1978, 1981 a, b), Bjugn (Kjemperud in press), and Frøya (Paus 1982). The Nærøy project is a continuation of a work presented for a cand. real. thesis at the University of Trondheim (Ramfjord 1979).

Some previous studies on the subject

The theory of a shoreline displacement in Norway was introduced by Keilhau in 1838. On the basis of studies of subfossile marine molluscs and vertebrates found far above present sea level, he estimated the post-Weichselian regression to be somewhere around 200 metres at certain localities. In the case of Trøndelag, Øyen (1908 and several later works) explored a huge amount of material from mollusc banks. Undås (1942) measured heights above present sea level concerning various terraces and traces of erosion, and from this material suggested directions of the isobases in the region.

Methods

Sediment cores from basins situated at various heights between the present sea level and the marine limit in the area have been investigated in order to localize the marine/lacustrine boundary, often being referred to as the isolation contact. In this paper, both terms are used. The sediments deposited immediately after the isolation of the basin from the sea are dated by means of pollen analysis and radiocarbon dating. In basins where it was difficult to discover the isolation contact, diatom analysis was kindly carried out by A. Kjemperud, in order to supply the pollen- and lithostratigraphical evidence (Table 2 and own section).

Field work

The choice of coring sites was mainly made by consulting a map published by Norges geografiske oppmåling, in the M 711 series, sheet 1724 IV, on a scale of 1:50 000. All cores were taken with a 'Russian sampler', which has a core shaped as a half-cylinder, where the diameter is 10 cm, and the length is 1 m. The thresholds were localized in all basins, and their height above present sea level measured, using both levelling and barometric heightening.
Laboratory work

Material for pollen analysis was usually sampled for every five centimetres in the cores, and acetylated as described in Fægri & Iversen (1975, p. 107). Since much of the analysed material was located around the marine/lacustrine boundaries, and thus was of a more or less minerogenous character, most of it had to be HF-treated. The analysis was carried out under a Leitz binocular microscope with phase contrast equipment, and normally the 40/0.65 objective was used.

Pollen diagrams

The calculation basis is given in each diagram. In the total diagram, the AP sum is listed for each stratum. The zone boundaries follow Mangerud et al. (1974). In addition, Hafsten's (1970) global system is used. Lithostratigraphically, the sediments are characterized by conventional symbols (Fægri & Gams 1937).

Radiocarbon dating

The dating was carried out at Laboratoriet for Radiologisk Datering, Norges tekniske høgskole, Universitetet i Trondheim. NaOH-soluble fractions (A), NaOH-insoluble fractions (B), and unfractionated material (C) have been dated. In Table 2, all dating results concerning the isolation of the various basins are presented. The $^{13}$C content was measured at the Karolinska Institutionen in Stockholm, Sweden.

Description of the investigated basins

In Table 1, the main features of the investigated basins and their environments are listed. The petrological data are based on Skarland (1974) in addition to own field observations. Blåvasstjønn, Gorrtjønn, and Lomtjønn have previously been studied as part of a vegetation-historical investigation in the area, and are more completely described in Ramfjord (1979).

Indications of isolation contacts

An accurate identification of the marine/lacustrine transitions is of vital importance for dating sealevel changes by aid of biostratigraphical methods. Table 2 gives a survey of the criteria used for marine/lacustrine boundary identification in each case. Frequently, the isolation contact is clearly manifested in the lithostratigraphy as a distinct transition clay/gyttja, especially during quick shorelevel regression. When it comes to marine/lacustrine boundary indications produced by pollen analysis, Dinophyceae cysts ("Hystrix") are regarded as reliable marine indicators. However, it has become clear that certain species in the group are less dependent on salinity than others. These exceptions include the discoveries above the isolation contact in Lomtjønn and Osavatn (B. Dale, pers. comm. 1981). Pollen from the genus Ruppia is another marine indicator, found in material from Gorrtjønn, and more numerously from Løypmotjønn. The latter discoveries gave a curve which was in good correlation with the local Dinophyceae curve (Fig. 9).
In the brackish part of the sedimentation, a blooming of *Pediastrum praecox* was registered in several basins. This species is commonly known from brackish environments. Generally, pollen diagrams from Trøndelag show an algae blooming of *Pediastrum* and *Botryococcus* species during and after a basin’s isolation from the sea, a fact that is emphasized by the present investigation. Such algae occurrences are mentioned by Kjemperud (1978, p. 59), who con-
nects them with the fact that newly isolated basins generally have a high pH (Renberg 1976). A temporary, eutrophic phase after the isolation may for Nærøy be explained by ion transport from marine sediments. As these sediments were covered by fresh material after the isolation, the ion transport ceased, and since the adjacent hard rocks of mainly Precambrian origin gave no ion contributions of any importance to the basin milieu, the alkaline conditions inherited from the marine phase changed into acid.

Pollen from vascular plants belonging to a shoreline vegetation is in general frequently recorded during and after isolation from the sea in the investigated Nærøy basins. The herb flora is in this newly isolated phase dominated by the Rosaceae, Cyperaceae, and Poaceae families, together with heliophilous contributors like Chenopodiaceae and Rumex. The total diagrams reflect a more open vegetation, with less trees and shrubs, around the isolation than later in the basin development (Figs. 2–10). In all basins except Osavatn (Fig. 10), Lomtjønn (Fig. 7), and Nedre Lisetjønn (Fig. 2), pollen from Hippophae rhamnoides occurs around the isolation phase. This shrub is not growing in the investigated area today, but is still occupying certain coastal habitats in Trøndelag (Hulten 1971, Skogen 1972). Hafsten (1966) introduces a correlation between great amounts of Hippophae pollen and quick shoreline regression. Gorrtjønn (Fig. 6) and Blåvasstjønn (Fig. 5) have the biggest Hippophae percentages in this investigation, in a period of maximal regression (Fig. 11). A marine over-representation of Pinus pollen (Fægri & Iversen 1975) is clearly manifested around the marine/lacustrine transition in the diagrams from Lomtjønn (Fig. 4) and Nedre Lisetjønn (Fig. 2).
Shoreline displacement in Nærøy

Table 2. List of the most important data used in localization of the marine/lacustrine boundaries in the cored material. Results from the diatom analyses concerning Blåvasstjønn, Gorrtjønn, and Lomtjønn can be found in Ramfjord (1979).

<table>
<thead>
<tr>
<th>BASIN</th>
<th>INDICATIONS OF MARINE/LACUSTRINE BOUNDARY</th>
<th>Pollen analysis</th>
<th>Diatom analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Lisetj.</td>
<td>Diffuse</td>
<td>End of Dinophyceae curve</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decline in Pediasma praecox curve. Rise of Botryococcus curve</td>
<td></td>
</tr>
<tr>
<td>Kvennhusv.</td>
<td>Clear</td>
<td>Decline in P. praecox curve</td>
<td></td>
</tr>
<tr>
<td>Lomstjønn</td>
<td>&quot;</td>
<td>End of Dinophyceae curve</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decline in P. praecox curve</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rise of Botryococcus curve</td>
<td></td>
</tr>
<tr>
<td>Blåvasstj.</td>
<td>&quot;</td>
<td>End of Dinophyceae occurrence</td>
<td>X</td>
</tr>
<tr>
<td>Gorrtjønn</td>
<td>&quot;</td>
<td>End of Ruppia occurrence</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decline in P. praecox curve</td>
<td></td>
</tr>
<tr>
<td>Lomtjønn</td>
<td>&quot;</td>
<td>End of continuous Dinophyceae curve</td>
<td>X</td>
</tr>
<tr>
<td>Strandav.</td>
<td>&quot;</td>
<td>Decline in Pediasma praecox, rise of Botryococcus</td>
<td></td>
</tr>
<tr>
<td>Løyprmotj.</td>
<td>Diffuse</td>
<td>End of Dinophyceae and Ruppia curves</td>
<td>X</td>
</tr>
<tr>
<td>Osavatn</td>
<td>&quot;</td>
<td>End of continuous Dinophyceae curve</td>
<td>X</td>
</tr>
</tbody>
</table>

The recorded arboreal pollen gives no further indications of isolation contacts.

Diatom analysis

Samples for diatom analysis were taken for every third centimetre in the material around the lithostratigraphical transition clay/gyttja in five of the investigated basins (Table 2). These qualitative analyses were of great value concerning the identification of the isolation contacts in Blåvasstjønn and Gorrtjønn. The cored material showed a very distinct lithostratigraphical transition in both basins. Analyses from the clay gave good indications of a marine milieu, with halophilous diatoms as Dimerogramma minor, Amphora proteus, Trachyneis aspera, and Plagiogramma staurophorum. The brackish phases are very short. Only 2 cm above the clay/gyttja transition, the diatom flora consisted of freshwater species as Tabellaria fenestrata and Navicula radiosa, in addition to several indifferent types. In the other three basins where diatom analyses were done, the analyses did not contribute decisively to the identification of marine/lacustrine boundaries. Nedre Lisetjønn, Lomtjønn, and Osavatn all had long zones with indifferent and fresh/brackish diatom flora, and other biostratigraphical indications had to be used (Table 2).

Datings from the marine/lacustrine boundaries

Radiocarbon datings as well as biostratigraphical methods have been used in all basins. An at-
Table 3. Conventional radiocarbon dates from the marine/lacustrine boundaries in Nærøy. $\delta^{13}$C-values are listed beneath the dates. MASCA values (Ralph et al. 1973) are given in years BC and AD, and radiocarbon dates in years before present (1950).

<table>
<thead>
<tr>
<th>BASIN</th>
<th>Elev. m. Lab. no.</th>
<th>Soluble fraction (A)</th>
<th>Insoluble fraction (B)</th>
<th>Not fractionated (C)</th>
<th>Calibrated age (MASCA)</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Lisetjønn</td>
<td>123 T-3844</td>
<td>$10340 \pm 250 - 27\sigma_7$</td>
<td>$9230 \pm 130 - 27\sigma_7$</td>
<td>$8450 \pm 80 - 32\sigma_7$</td>
<td>Gyttja/Clay</td>
<td>Gyttja</td>
</tr>
<tr>
<td>Kvennhusvatn</td>
<td>111 T-3843</td>
<td>$9230 \pm 130 - 30,7$</td>
<td>$8630 \pm 150 - 28,7$</td>
<td>$8450 \pm 80 - 32,1$</td>
<td>Gyttja</td>
<td>&quot;</td>
</tr>
<tr>
<td>Lomstjønn</td>
<td>103 T-3807</td>
<td>$8450 \pm 80 - 32,1$</td>
<td>$8360 \pm 240 - 31,6$</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Blåvasstjønn</td>
<td>92 T-2844</td>
<td>$8950 \pm 260 - 27,7$</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Gorrtjønn</td>
<td>66 T-2847</td>
<td>$8680 \pm 150 - 27\sigma_7$</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Lomtjønn</td>
<td>52 T-3738</td>
<td>$6180 \pm 90 - 32\sigma_5$</td>
<td>$6380 \pm 90 - 31\sigma_6$</td>
<td>$5135 \pm 115$ (A-fract.)</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Strandavatn</td>
<td>48 T-3805II</td>
<td>$7080 \pm 110 - 31\sigma_0$</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Løypmotjønn</td>
<td>10 T-3806</td>
<td>$3750 \pm 110 - 27,7$</td>
<td>$3440 \pm 140 - 32,2$</td>
<td>$2295 \pm 185$ (A-fract.)</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Osavatn</td>
<td>7 T-3845</td>
<td>$1570 \pm 185 - 31,0$</td>
<td>$1540 \pm 185 - 31,0$</td>
<td>$AD405 \pm 185$ (A-fract.)</td>
<td>Gyttja/Clay</td>
<td>Gyttja</td>
</tr>
</tbody>
</table>

Temt has been made to transfer the pollen zone boundaries to an absolute scale by means of other radiocarbon dates from the Trøndelag area.

**Radiocarbon dating results**

The total number (14) of radiocarbon dates from marine/lacustrine boundaries in Nærøy are listed in Table 3.

Where both fractions are dated, the general impression is that the NaOH-soluble fraction gives the highest age (except for Lomtjønn). The fractional differences are biggest for the oldest sediments, with around 1100 years for the mean values in Nedre Lisetjønn, and 600 years in Kvennhusvatn. The data from the soluble fractions are considered to be the most reliable, and the insoluble ones to be too young. These conclusions have been drawn from the theory that penetrating roots from the limnic vegetation have contaminated the insoluble material, and thus distorted the dating results from these fractions (Kaland, Krzywinski & Stabell 1982). In addition, the dates from the soluble fractions, especially for Blåvasstjønn and Gorrtjønn, are in better accordance with the pollen-analytical dates than the insoluble ones. The so-called ‘hard water effect’, which complicates the interpretation of radiocarbon dating results from several areas, is irrelevant in this connection, considering the lack of carbonaceous rocks in Nærøy.

**Pollen stratigraphy**

In general, the pollen analysis shows (Figs. 2–10) a similar tendency around the isolation phase in all basins, with a total diagram reflecting a development from a relatively scattered, sparse vegetation towards a more forested phase.

*Nedre Lisetjønn* (123 m a. s. l., Fig. 2), the highest situated basin on the shoreline displacement curve, was during the isolation neighboured by an Arctic/Alpine flora, characterized
by heliophilous shrubs and herbs. Dominating pollen types such as *Salix* spp., *Betula* spp. (mostly *B. nana*, according to diameter measurements), *Juniperus*, *Artemisia*, and *Rumex* give a clear biostratigraphical dating of a Younger Dryas isolation, in good correlation with the radiocarbon dated soluble fraction (Table 3).

*Kvennhusvatn* (111 m a. s. l., Fig. 3) shows a similar vegetational development in the isolation phase, with the exception of the *Betula* spp. domination over *Salix* spp. and *Juniperus* in the pollen deposition. The pollen analysis here indicates that the *Betula* spp. group includes an increasing part of tree-forming types in addition to...
**B. nana**, compared to the preceding diagram. Together with the low *Pinus* percentages throughout the diagram, and an almost total lack of *Corylus*, this gives a pollen-analytical dating of Preboreal in the isolation phase. The soluble radiocarbon date supports this indication (Table 3).

**Lomstjønn** (103 m a. s. l., Fig. 4). The lowest zone, which covers the isolation phase, has much in common with the corresponding zone in Kvennhusvatn. The area adjacent to Lomstjønn had by the isolation time a typical Preboreal vegetation, with *Betula*, *Juniperus*, and *Salix* as dominating arboral elements, and low *Pinus* and *Corylus* shares. The herb flora mostly consisted of species from the *Artemisia* and *Rumex* genera and the Cyperaceae and Poaceae families. In spite of this quite convincing biostratigraphical indication of Preboreal, the radiocarbon date shows middle or even late Boreal for both fractions. This is obviously too young compared to what should be expected from this basin, considering the other dating results from Nærøy. This is visualized in Fig. 11, where the marked radiocarbon date for Lomstjønn lies outside the constructed curve pattern, even with two standard deviations.

**Blåvasstjønn** (92 m a. s. l., Fig. 5). In this basin, the surroundings during the isolation phase were dominated by *Betula*, *Pinus*, *Hippophae*, and...
Fig. 6. Pollen diagram from Gorrtjønn, Nærøy, Nord-Trøndelag, c. 66 m a.s.l.

Fig. 7. Pollen diagram from Lomtjønn, Nærøy, Nord-Trøndelag, c. 52 m a.s.l.
Corylus. The increasing share of Pinus pollen compared to the preceding diagrams, together with presence of Corylus and absence of Alnus, indicate a Boreal isolation. The corresponding radiocarbon date shows early Boreal, with relatively wide standard deviations (Table 3).

Gorrtjønn (66 m a. s. l., Fig. 6). High Pinus, Betula, and Hippophae pollen amounts occur around the isolation of this basin, together with a noticeable appearance of Corylus. This indicates Boreal age. The Alnus expansion gives a good basis for absolute dating control in this basin, since the expansion happened relatively synchronously around 8000 yrs. BP (Lundquist 1969, Tallantire 1974). It is situated around the chronozone Boreal/Atlantic, as defined by Mangrud et al. (1974). By Gorrtjønn, the expansion takes place closely above the isolation contact, which is radiocarbon dated to middle Boreal (Table 3). Material from both Blåvasstjønn and Gorrtjønn is radiocarbon dated with regard to the rise of Alnus (Figs. 5 and 6, cf. Ramfjord 1979, 52-54).

Lomtjønn (52 m a. s. l., Fig. 7). A luxuriant forest of birch, pine, and alder in addition to considerable occurrences of hazel has characterized the surrounding landscape at the time of isolation. This corresponds well with the general impression of the climatically favourable, warm Atlantic time in most pollen diagrams from Trøndelag. However, Lomtjønn proved to have a somewhat special lithostratigraphy, with a telmatic phase right above the isolation, forming a peat layer consisting mostly of Fontinalis sp. This telmatic phase may indicate fluctuations in water-level in the basin right after the isolation, giving uneven sedimentation and an uncertain radiocarbon date (cf. Fig. 11). The radiocarbon date (soluble fraction) for this basin still lies within Atlantic (Table 3).

Strandavatn (48 m a. s. l., Fig. 8). High Alnus percentages throughout the diagram in addition to QM findings in all strata (mostly Ulmus pollen) indicate a warm climate, which points towards Atlantic. The radiocarbon date agrees, giving early Atlantic.

Løypmotjønn (18 m a. s. l., Fig. 9). Here, it is difficult to establish an accurate pollen-analytical date of the isolation phase. Around the marine/lacustrine boundary there is a slight descent in the Alnus curve, possibly reflecting a climatic worsening. The Subboreal was in general a period with relatively high mean summer temperatures, but with low humidity and a trend towards colder weather conditions. In Trøndelag, Subboreal usually is manifested by a descent in Alnus and warmth-demanding elements such as QM and Corylus. The radiocarbon date shows middle Subboreal, and the calibrated date early Subboreal (Table 3).

Osavatn (7 m a. s. l., Fig. 10). The distinct Picea curve in the diagram is the most important tool concerning pollen-analytical dating of the isolation phase in this basin. Presence of spruce pollen in such amounts is generally accepted as indication of Subatlantic in Trøndelag. Radiocarbon dates dealing with Picea immigration history in
Fig. 9. Pollen diagram from Løypmotjønn, Nærøy, Nord-Trøndelag, c. 18 m a. s. l.

Fennoscandia have been compiled by Moe (1970), and Tallantire (1972 a, b), and in Trøndelag by Hafsten (Hafsten, Henningsmoen & Høeg 1979). In the Nærøy district, the radiocarbon dates from the start of continuous Picea curves assemble around 2500 yrs. BP, cf. Blåvassstjønn and Gorrtjønn (Figs. 5 and 6), and compilation in Ramfjord (1979, Fig. 18). During the isolation of Osavatn, the Picea curve exceeds 30% of the arboreal pollen sum, which indicates that spruce was well established in the area by that time. A pollen-analytical dating of middle Subatlantic should thus be reasonable in this case. The radiocarbon and calibrated dates coincide well with this supposition (Table 3).

Younger Dryas ice marginal deposits

Rekstad (1895) describes an approximately 30 m high moraine south of Salsvatn, situated south of the investigated area, and outside the map (Fig. 10).
This moraine is mentioned as a part of the regional Younger Dryas end moraine in a later work by Sollid & Sørbel (1975). The authors emphasize that the complex topography, with several bays and fjords, prevents a total reconstruction of the shape of the ice front. It is clear, however, that the Younger Dryas marginal ice front crosses Buøya, passes Kolvereid and Ramfjord, and is refound in the glacio-fluvial deposits at Dypvik (Fig. 1). From this, it seems very likely that several of the sites used for sampling in the shoreline investigation are situated distally to the Younger Dryas end moraine. This consideration is supported by the Younger Dryas deposits found at Nedre Lisetjønn. Another high-situated basin outside the assumed position of the marginal ice front (Fig. 1) is Kvennhusvatn, but here the registered accumulation of organic material starts in Flandrian (Fig. 3).

Shoreline displacement in Nærøy

The shoreline displacement curve (Fig. 11) is based on data listed in Table 3. Dates from the NaOH-soluble fraction have been used for all basins except Osavatn, where dating was carried out on non-fractionated material. For the younger dates, the curve follows the calibrated values for variations in the $^{14}$C content in the atmosphere (Ralph et al. 1973). The uncertainty of the dates is marked as one standard deviation ($\pm$ 1 $\sigma$).

Shoreline displacement curves from outer coastal parts of western Norway differ in appearance from curves from eastern parts of the country. Although the Nærøy curve has features in common with the 'western type', it lies closer to the curves established from Trøndelag and eastern Norway, with no traceable transgression phase. It will thus be compared with curves from Frosta, Trøndelag (Kjemperud 1981), and Vestfold, eastern Norway (Heningsmoen 1979). These two curves are established from areas situated proximal to the Younger Dryas ice marginal deposits. In Table 4, the most important displacement data for all three curves can be surveyed.

Compensation for different isostatic recovery at the investigated sites

Undås (1942, fig. 22) asserted that the isobases of 'Ra-time' (Younger Dryas) and 'Tapes time' are parallel in Trøndelag, and lie between N 30°E and N 35°E. This is supported by later observations (Sollid & Kjenstad 1980). The shoreline gradients have been calculated to 1.5 m/km for Younger Dryas, and to 0.4 m/km for Tapes time on the basis of observations made by Undås (1942, fig. 20). An even, hyperbolic curve of shoreline gradient changes from Younger Dryas to the present was then tentatively drawn from this material. The curve was used when eliminating the vertical difference in isostatic uplift between the various investigated basins, taking into consideration their perpendicular distance to an isobase line (N 33°E) drawn through Lomstjønn. The biggest correction came for
Nedre Lisetjønn, with +7 m. In addition, it is noticeable that Stranda vatn and Lomstjønn came out with the same level in the shoreline displacement curve after the correction.

The marine limit in Nærøy

In this investigation, the marine limit has not been exactly determined, but it is localized between 123 and 135 m in the areas distal to the Younger Dryas ice marginal deposits. Øvre Lisetjønn (135 m a. s. l.), lying 500 m east of Nedre Lisetjønn, had no signs of marine influx in the analysed sediments. Since the investigated area includes the Younger Dryas ice marginal deposits, the marine limit of the area in general will be a little lower for the inner parts, proximal to the line formed by these deposits (cf. Fig. 1). However, uncertainties in the exact localization of the glacier front in younger Dryas, due to the varied topography, complicate the establishment of a marine limit gradient within the investigated area. Geomorphological investigations indicate the marine limit close to the Younger Dryas ice marginal deposits to be c. 125 m (Holtedahl reports 124 m for the Dypvik district).

Generally, the marine limit in Trøndelag is very likely to have a continuously sinking gradient from the inland towards the coast, by other means from the glaciation centre towards the Younger Dryas ice marginal deposits. In Nærøy, the marine limit in the area proximal to these deposits was probably formed during the Younger Dryas.

Younger Dryas shoreline displacement

In the investigated parts of this chronozone, only about 2% of the registered shorelevel regression took place, and thus the curve has a flattened shape in this phase (Fig. 11). Such a lapse of the curve in later Younger Dryas/early Preboreal is previously known from investigations in western Norway, as Bømlo (Fægri 1944), and Yrkje (Anundsen 1978). It seems obvious that eustatic changes during this time are more clearly manifested at such “western” localities, which lie on low isobases, and possess a modest isostatic movement compared to Nærøy, where the investigated basins are grouped around the Younger Dryas ice marginal deposits. Still, the Nærøy curve has a development similar to the mentioned curves from western Norway in the investigated parts of Younger Dryas, in contrast to the Frosta curve (Table 4), which falls steeply in this part of the chronozone. This is mainly due to stronger isostasy (Kjemperud 1981 a, fig. 9), since Frosta is situated at the 180 m isobase and Nærøy at the 120 m isobase (Sollid & Kjenstad 1980). Difference in the time of ice withdrawal between Nærøy and Frosta is another interpretation. Kjemperud (1981 a, p. 11) indicates a glacier retreat beyond Frosta during younger Dryas, considering that his research area is situated proximal to the local Younger Dryas ice marginal deposits (The Tautra-Tangen line, cf. Sollid & Sørbel 1975).
lar steep fall is also observed in Vestfold and Frosta (Table 4), but in these curves, the Preboreal had a much larger regression than the Boreal, with more than double the vertical distance. In Nærøy, the difference in displacement between the two chronozones is rather small, with a slight overweight for the Preboreal. The steepest part of this curve is 'postponed' from Preboreal to the transition Preboreal/Boreal, seen in comparision to the two other curves.

Atlantic

Two dates from Nærøy form the basis for drawing the curve in this chronozone. The MASCA age for Lomtjønn is nearly identical with the radiocarbon age for Strandavatn (Table 3), but a difference in radiocarbon age of more than 900 years for these two basins at the same level indicates a temporary standstill in the shoreline regression, or at least a very slow movement. Such a standstill is also indicated in works from Frøya (Påus 1982), and Bjugn (Kjemperud in press). As for Nærøy, the number of dated marine/lacustrine contacts is too small in this phase to give information of a possible transgressive movement similar to those known from the western parts of Norway (Fægri 1940, 1944, and others) There is, however, reason to believe that the Nærøy curve also in this case differs from the 'eastern' curves in Table 4, where there is no sign of transgressions or sea level standstills in the Atlantic.

Subboreal and Subatlantic

The form of the three curves (Table 4) corresponds well for the last 5–6000 years up to present time, i.e. after 'Tapes time'.

The recent shoreline regression in the area is not investigated, but Kvale (1966) has determined the annual regression for Trondheim to 3.1 mm, approximately at the 180 m isobase. It is therefore assumed that the recent sea level sinking movement is between 0.15 and 0.25 m pr. century in the Nærøy area.

An isostatic model for the area

The local crustal recovery from the ice depression has been calculated (Fig. 12), and an isostatic curve tentatively drawn on the basis of 5 dates from the shoreline displacement curve, using Shepard’s (1963) eustatic curve. His curve is smooth and even, and was originally thought to possess universal applicability. Later research has indicated that eustasy is affected by several factors working in different directions. Mörner (1976) emphasized the importance of geoidal changes, and introduced a wave-formed curve. The local isostatic curve for Nærøy probably is a wave-formed one, but it is very likely to show the same trend as Shepard’s curve, which is internationally well-known (Flint 1971, Eronen 1974, and others).

The isostatic curve for Nærøy has an exponential form, similar to the Frosta isostatic curve (Kjemperud 1981 a, fig. 9), though the latter has a steeper lapse in the Late Weichselian and early Flandrian, presumably as a result of stronger ice depression.

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