MORAINES IN THE HEMNEFJORD AREA, WESTERN NORWAY

By
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Abstract.

Four radiocarbon dates are used to date moraines in the inner Hemnefjord area. The radiometric ages of the moraines range from approximately 10,720 to 11,310 years B.P. and probably correlate with the Ra moraines in Southern Norway and the Tromsø—Lyngen and Skardmunken moraines in Northern Norway. Evidence suggests that by 11,300 years B.P. the Hemnefjord war partially open to the sea. The Hemne substage's ice either extended to the coast on both sides of an open fjord system, or local glaciers persisted in the outer fjord when the Hemne substage's ice was in the inner Hemnefjord.

Introduction.

The Hemnefjord area (63° 17′ N. lat., 9° 10′ E. long.) is situated at the southwestern boundary of Sør-Trøndelag, Norway (see Figure 1). The coastal mountains and off-shore islands, including Hitra and Frøya, of the area were extensively eroded by Pleistocene glaciers which exposed large areas of bedrock. The bedrock in the area was mapped by Ramberg (1966, 1968) and consists primarily of various types of gneiss and schist, amphibolite, occasional meta-diabase and dolerite, and rarely mylonite and marble. The Quaternary and Holocene deposits are generally restricted to the main valleys and low-lying areas. The deposits consist primarily of late-glacial and post-glacial marine clays, outwash sediments and morainal debris.

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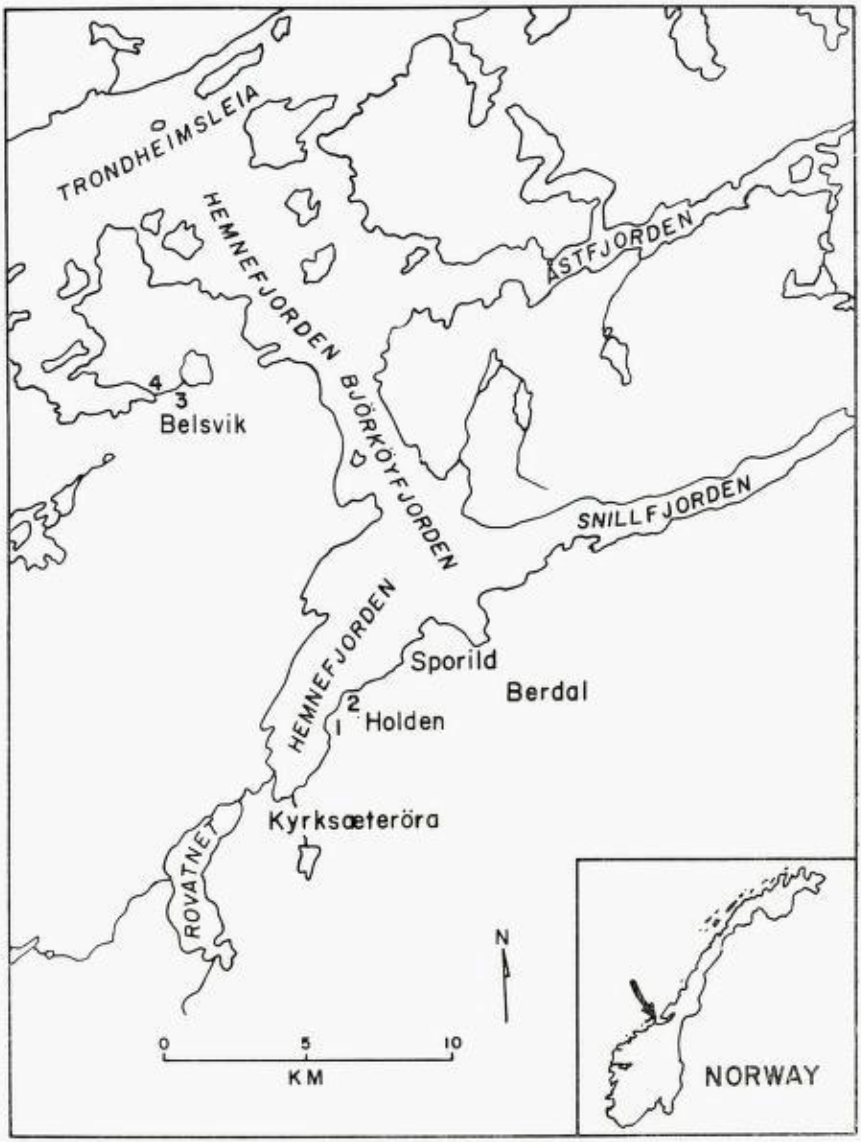

Figure 1. Map of the Hemnefjord area, West Norway. Numbers indicate dated shell localities. See Table 1.

Previous work.

There is no detailed work on the Quaternary deposits of the Hemnefjord area, although extensive work on the marine shorelines was done by Undås (1942) and the positions of various moraines in the Hemnefjord area were described (Undås, 1935). Although no absolute dates were available Undås suggested several alternative positions for the moraines in the Hemnefjord area correlative with the Ra moraines of Southern Norway:

1. based on strandline studies and the size of the moraines, there are Ra-Salpausselkä moraines in the inner Hemnefjord (Undås, 1935).
2. based on «... a reliable marine limit and surf limit ... the Ra-moraine lies outside Krokstadaune [inner Snillfjord]. The moraine may there be situated either in Hemnefjord or at the mouths of the tributary valleys, where there are great local moraines (Undås, 1942).»
3. based on the marine limit, the distal edge of the Ra-moraine lies outside (seaward) of the islands in Møre and Trøndelag (Undås, 1963).

Undås (1942) investigated the shorelines and terraces in the Hemnefjord area, while Øyen (1910, 1914) studied the marine molluskan faunas from the clays in the Trondheimsfjord region which included Hemnefjord. Rekstad (1922) in a summary of the isostatic adjustment of the Scandinavian peninsula, indicated an adjustment of about 100 m on South-Central Hitra and greater than 125 m in the inner Hemnefjord area (Figure 1).

Present work.

The present work was begun in 1965 for the expressed purpose of dating the moraines in the Hemnefjord area. A reconnaissance study of the surficial geology was completed in 1968. In general, the moraines shown on Holtedahl and Andersen's glacial map of Norway (Andersen, 1965, p. 94–95) are correctly located. It is suggested that the Hemne moraines [Kyrksæterøra (Hemne), the outer moraines at Holden, Sporild and Berdal] of the inner Hemnefjord were deposited during the Hemne substage, and that (1) either local glaciers present in the outer Hemnefjord area formed local moraines, or (2) that Hemne substage glaciers extended to the outer coast, but the Hemnefjord was open to the sea. The Hemne moraines usually consist of two parallel ridges, the outer of which is large

Table 1:

Radiocarbon dated shells from the Hemnefjord area, Sør-Trøndelag, Norway. Shells were dated by the Radiological Dating Laboratory, Norwegian Institute of Technology (NTH), Trondheim, Norway.

Loc. No. and NTH Lab. No.	*Loc.*	*Field Alt.*	*Species*	*C-14 age yrs. B.P.*
Loc. 1 T-551	Ice-contact delta c. 1 km south of Holden, Sør-Trøndelag.	21 m	*Pecten islandicus* (Müller) *Astarte elliptica* (Brown) *Cyprina* sp. cf. *c. islandica* (Linné) *Saxicava* sp. cf. *s. arctica* (Linné)	11,310 ± 140
Loc. 2 T-552	Ice-contact delta c. 1 km north of Holden, Sør-Trøndelag, near smelting plant.	20 m	*Pecten islandicus* (Müller) *Astarte elliptica* (Brown) *Macoma calcarea* (Chemnitz) *Acmaea* sp. cf. *A. testudinalis* (Müller)	11,300 ± 150
Loc. 3 T-553	Ice-contact deposit Belsvik, ½ km west of southwest corner of Heimvatn.	46 m	*Mya truncata* Linné *Pecten islandicus* (Müller) *Astarte elliptica* (Brown) *Macoma calcarea* (Chemnitz) *Saxicava* sp. cf. S. *arctica* (Linné) *Liocyma* sp. cf. *L. fluctuosa* (Gould)	10,720 ± 110
Loc. 4 T-554	Glacial-marine clay near Belsvik. 1 km west of the southwest corner of Heimvatn.	15 m	*Pecten islandicus* (Müller) *Mya truncata* Linné *Mytilus edulis* Linné *Macoma* sp. cf. M. *calcarea* (Chemnitz) *Astarte* sp. cf. *A. elliptica* (Brown)	11,250 ± 180

and distinct. There were no absolute dates on the age of any moraines in the Hemnefjord area until 1965-66 when several shell localities were found that related to moraine sequences. In particular, *in situ* shells were found in ice-front delta deposits which are in contact with and directly in front of a moraine 1 km south of Holden, at Holla, and near the smelting plant at Holden (Table 1). At Holla, the delta beds abut the distal side of the moraine and are disected by a post-glacial river where the shells are exposed (see Figure 2). At Holden, the shell-bearing beds were exposed during construction of the smelting plant. Additional shell material was found at Belsvik in near-ice deposits and in glacial-marine clays (Table 1).

The marine shell material was dated by the Radiological Dating Laboratory of the Norwegian Institute of Technology (NTH), Trondheim, Norway, using a radiocarbon half-life of 5570 years. The equipment and counting techniques used by the laboratory are described by Nydal and Sigmond (1957), Nydal (1959, 1962, 1968), and Nydal and others (1964). The localities, species, altitudes and dates are summarized in Table 1. Plotted altitudes are field altitudes taken with Paulin aneroid and are not corrected for eustatic rise in sea level. Accuracy for altitudes between 5 and 25 m is estimated to be ± 1 m, and above 25 m, ± 2 m.

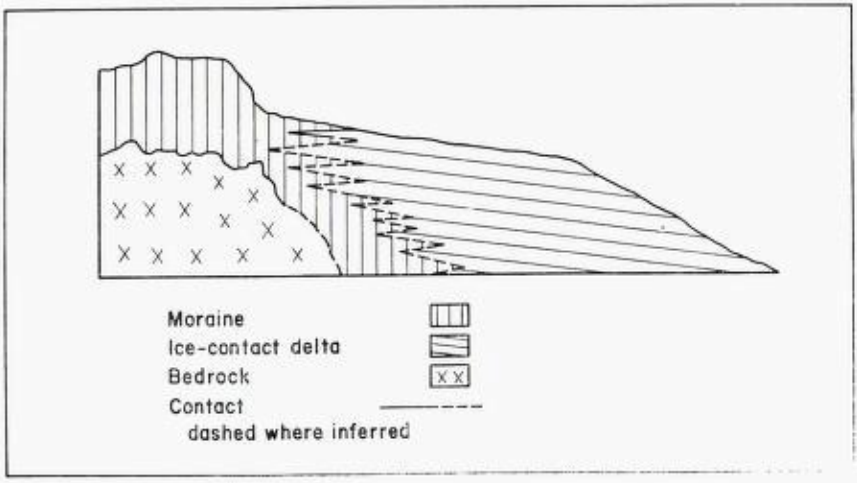

Figure 2. Diagramatic cross-section illustrating the relationship between the moraine and ice-contact delta deposits in which in situ *shell material was found and dated. See Table 1.*

Correlation and Conclusions.

Holtedahl (1928) investigated the ice-front and moraine deposits in the Trondheimsfjord district and noted two glacial substages, the Ørlandet substage and the Tautra substage. In the Trondheimsfjord district these are an outer and inner moraine system respectively. Andersen (1965)suggested that the Tautra substage probably corresponded to the Ra-Salpausselkä substage. Similarly, in the Hemnefjord area there are two distinct moraine systems. It seems likely that the inner moraine system, the Hemne moraines, correlates with the Tautra moraine system and that Andersen's suggestion is correct.

The following conclusions are presented: (1) the marine shell material in the Hemnefjord area is suggestive of a cold (arctic and boreal waters) sea and was probably deposited in front of retreating ice. (2) The marine character of the fossils at Holden, indicates that Hemnefjord–Bjørkøyfjord–Hemnefjord was at least partially open to the sea by about 11,300 B.P. (3) At least 21 m of emergence occurred since 11,300 B.P. It is tentatively suggested that emergence is related almost entirely to isostatic adjustment due to glacial unloading. Emergence probably began prior to 11,300 B.P. for three reasons: higher sea levels are indicated by delta and beach deposits to altitudes of 136 m; undated shell material is found at altitudes up to 88 m; and, some adjustment probably occurred as the ice thinned prior to encroachment of the sea upvalley. (4) Based on the positions and radiometric dates of shell material near Belsvik, it is suggested that either local glaciers persisted in the outer fjord area during the Hemne substage, or that the fjord was open to the sea with ice extending nearly to the sea on both sides of the fjord during the Hemne substage. (5) The Ra moraines in Southern Norway and the Tromsø–Lyngen and Skardmunken moraines of Northern Norway (Andersen, 1965, 1968; Holmes and Andersen, 1964) are large, distinctive moraines. The radiometric ages of the Ra moraines range from approximately 10,000 to 11,200 years B.P., of the two phases (Younger *Dryas* and Older *Dryas*) of the Tromsø–Lyngen moraines from approximately 10,200 to 11,700 years B.P., and of the Skardmunken moraines from approximately 10,390 to 11,500 years B.P. (Andersen, 1965, 1968; Holmes and Andersen, 1964). Considering these dates two interpretations of the Hemne moraines are possible. (A) If the Hemne substage's ice extended nearly to the sea (see 4 above), the radiometric dates of the Hemne moraines range from approximately

10,720 to 11,300 years B.P. and the moraines are correlative with the Ra, Tromsø—Lyngen, and Skardmunken moraines. (B) If local glaciers existed in the outer fjord during the Hemne substage, then the Hemne moraines are late Allerød age (approximately 11,300 years B.P.) and were deposited between the two phases of the Tromsø—Lyngen substage in the north, and before the Ra substage in the south. Therefore, any moraines in the Hemnefjord area correlative with the Ra substage must lie to the east of the Hemne moraines. Further investigations are in progress to clarify the issue.

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