SOME PROBLEMS IN THE TILL STRATIGRAPHY OF THE NORTHEASTERN PART OF SJAELLAND

A preliminary report

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Abstract. In the northeastern part of Sjælland, the general Quaternary stratigraphy that can be established is as follows: lower till, meltwater deposits, and an upper till. The lower till contains a foraminifera fauna of the *Portlandia arctica* Zone of the Skærumhede sequence, indicating a Weichselian age.

The value of the stone counts described by Ussing and Madsen (1897) is questioned.

Interpretations from aerial photographs, together with structural studies in the field, indicate an ice advance from the east. It seems probable that this ice deposited the upper till.

It is suggested that the Farum-Strø Bjerge-Ølstedt line is an old esker formed during the deglaciation of a former (Baltic ?) ice sheet, which was perhaps synchronous with the one which laid down the lower till in the northern part of the area.

In this paper the area for discussion is covered by the geological maps "Hillerød" and "Helsingør". The original mapping was carried out in the period 1888–93 by Rørdam (1893). For this area he established the following general stratigraphy for the Quaternary deposits: upper till, stratified deposits (meltwater sand) and lower till. Below this, the Danian limestone forms the subsurface. The stratigraphical division can still be accepted, with the exception of minor local modifications.

The absence of glacial striae forced Rørdam to use other methods in the search for the directions of glacial movements. This involved a close examination of the tills, especially in the cliffs on the northern coast. Here it was found that indicator boulders from Norway and the Swedish Kinne diabases were present where the lower till rose to the surface. Furthermore the lower till contained a significant amount of shell fragments, which represented a fauna much like the one described by Johnstrup (1882) from the disturbed Older Yoldia clay in Vendsyssel. Later on, the Older Yoldia clay was referred to the upper part of the Skærumhede sequence. The stratigraphical position of this sequence has been the subject of much discussion. The last description, based on the study of the foraminifera (Feyling-Hanssen *et al.*, 1971) has placed the sequence in the Eemian and at the beginning of the Weichselian.

A sample of the lower till at Hundested has been examined by A.-L. Lykke Andersen. She has determined the foraminifera in this sample as characteristic of the *Portlandia arctica* Zone (personal communication), which is the upper part of the Skærumhede sequence and of Weichselian age. The lower till in the northern part of the area is therefore probably of Weichselian age and was deposited by an ice sheet from the north, which supports the original assumptions of Rørdam (1893).

Structural evidence favours the same conclusion. The lower till at Hundested is fairly well layered. The layers are in some places folded, and the axes of the folds indicate that the glacial movements were directed towards the south-southwest (Fig. 1).

Both the stratified deposits and the upper till contain fragments of shells, but to a lesser extent. On the other hand, both deposits contain indicator boulders from the

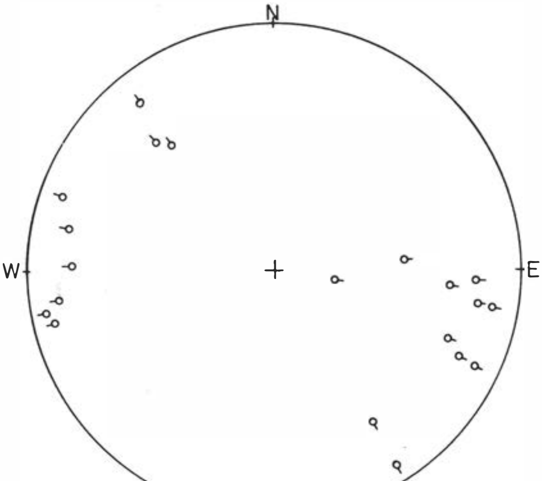

Fig. 1. Stereogram of the folds in the lower till at Hundested. Lower hemisphere.

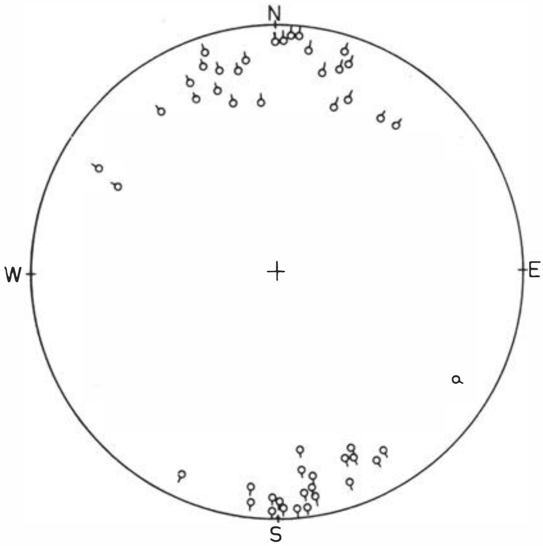

Fig. 2. Stereogram of the folds in the meltwater deposits and the upper till at Hundested. Lower hemisphere.

Dala region, from the Baltic area, and a considerable number from the Åland area. Unfortunately it is uncertain which deposit the Baltic indicator boulders especially belong to – the meltwater sand or the upper till.

Structural studies in the meltwater deposits and the layered upper till indicate that the upper till was laid down by an ice sheet from the east (Fig. 2). The statement of V. Milthers (1935) that the meltwater deposits at Hundested and Lynæs were covered by the upper till without any serious displacements having taken place, is not true. Examples of such disturbances are shown in Fig. 3.

With the intention of finding further evidence of the main directions of movement of the ice sheets which deposited the upper till, some stone counts were carried out according to the method described by Ussing and Madsen (1897). This should be an objective method of separating the different tills (cf. Madsen *et al.,* 1928) and should be a help in the search for the direction of transport.

The stone counts are worked out as follows. Adequate samples (normally 10 kg of air-dried till) are washed out. Pebbles bigger than 6 mm and smaller than a hen's egg are identified and counted, and the numbers of stones in each group are converted into percentages of the total number of stones. The percentage of flint divided by the percentage of igneous rocks and crystalline schists gives the so-called "stone count coefficient".

In the samples from Hundested and Lynæs, pebbles of flint are rare, compared with the normal situation on Sjælland, and this results in low coefficients for both of the tills (Table I). The lower till contains a little more flint than the upper, which is the opposite to what is stated by V. Milthers (1935). From the table it will be seen that the stone count coefficients differ very much from one part of the same sample to another and that the difference between the upper till and the lower till is very small. From this, it seems best not to use the method on a local scale.

The generally low content of flint pebbles in the tills does not support the view that the upper till was laid down by a Baltic ice sheet, as suggested by K. Milthers (1942). Milthers suggested that there had been 5–7 different ice advances in the area, on the basis of counts of indicator boulders, of which four were counts from the surface, 12 were counts on the coasts where the whole Quaternary sequence is often present, and the remainder (26) were counts carried out in the meltwater deposits, which in general were transported from the east and southeast towards the west and northwest.

To get further information about the ice sheet which deposited the upper till, aerial photographs (scale 1:25,000) were studied under a stereoscope, which exaggerates altitudes about 8–12 times. Even insignificant morphological features can be recognised in this way and also the change of soils at the surface. The resulting photogeological interpretation is shown in

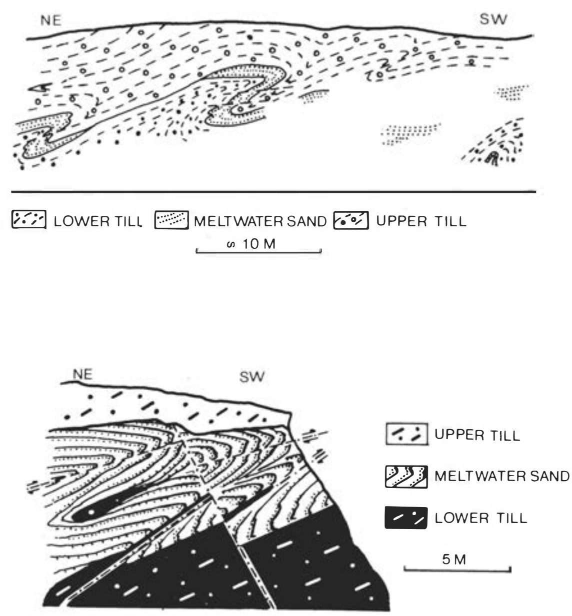

Fig. 3. Folding and thrusting in two sections of the coastal cliff at Hundested.

Table 1. Stonecounts from the tills at Hundested and Lynæs.

Sample no.	Dry weight of sample, g	Weight of pebbles >6 mm as % of dry weight of sample	Stonecount coefficient >6 mm	4–6 mm	>4 mm
Upper tills					
1 *a*	6,800	3.5	0.01	0.04	0.03
1 *b*	8,500	1.8	0.07	0.05	0.06
1 +	15,300	2.5	0.04	0.05	0.04
2 *a*	7,800	1.9	0.01	0.00	0.01
2 *b*	8,200	1.2	0.06	0.08	0.07
2 +	16,000	1.6	0.04	0.04	0.04
3 *a*	9,000	0.7	0.09	0.06	0.07
3 *b*	9,800	1.3	0.07	0.01	0.04
3 +	18,800	1.0	0.08	0.03	0.05
6 *a*	9,100	0.7	0.06	0.07	0.06
6 *b*	9,300	1.5	0.04	0.02	0.03
6 +	18,400	1.1	0.05	0.04	0.05
9 *a*	10,000	1.5	0.09	0.07	0.09
9 *b*	8,200	0.7	0.10	0.06	0.07
9 +	18,200	1.1	0.10	0.06	0.08
Lower tills					
4 *a*	7,100	1.9	0.11	0.11	0.11
4 *b*	8,000	3.1	0.09	0.06	0.07
4 +	15,100	2.5	0.10	0.08	0.09
5 +	16,300	1.2	0.16	0.09	0.11
7 *a*	9,000	1.3	0.13	0.06	0.09
7 *b*	9,100	1.6	0.14	0.09	0.11
7 +	18,100	1.5	0.14	0.07	0.10
8 *a*	7,600	1.3	0.17	0.16	0.16
8 *b*	8,500	1.5	0.12	0.04	0.08
8 +	16,100	1.5	0.14	0.10	0.13
10 *a*	9,100	1.2	0.12	0.06	0.09
10 *b*	9,200	1.2	0.14	0.05	0.08
10 +	18,300	1.2	0.13	0.05	0.08

Fig. 4. The orientation symbols on this map represent in several places the strikes of sandy flakes, which differ from the orientations indicated by the elevated ridges.

The validity of the interpretation has been supported by structural studies in excavations scattered all over the area. There is a very high degree of agreement between the structural information and the photo-geological interpretation. Examples from the field studies are presented in Fig. 5.

On the basis of the photogeological interpretation and the structural evidence, we need only propose a single ice advance from the east to produce the mapped orientation elements, provided that some of the morphological elements were formed during an older ice advance.

The type of morphology which is indicated by the map (Fig. 4) is not a special one. Gripp (1964) has illustrated the same type from the front of the Usher Glacier on Spitzbergen.

The most intense structural modifications are found in areas where stratified deposits form the surface. In other localities the glaciotectonic influence has been proved, but there the structures have been masked by the upper till, and therefore they are not so noticeable on the aerial photographs. The upper till is supposed to have been removed or washed away from the areas where the stratified deposits are found at the surface.

The formation of some of the outstanding morphological elements, such as eskers and kames, is not connected with the last ice sheet. So long as these elements have not been mapped, the detailed history of glaciation and especially the deglaciation of the last ice sheet will not be discussed. Only a single hypothesis needs to be mentioned.

Special importance has been attached to the Farum-Strø Bjerge-Ølsted line. In the southeast the line has been described as two parallel tunnel valleys, and in the northwest the line is formed by the Strø Bjerge ridge,

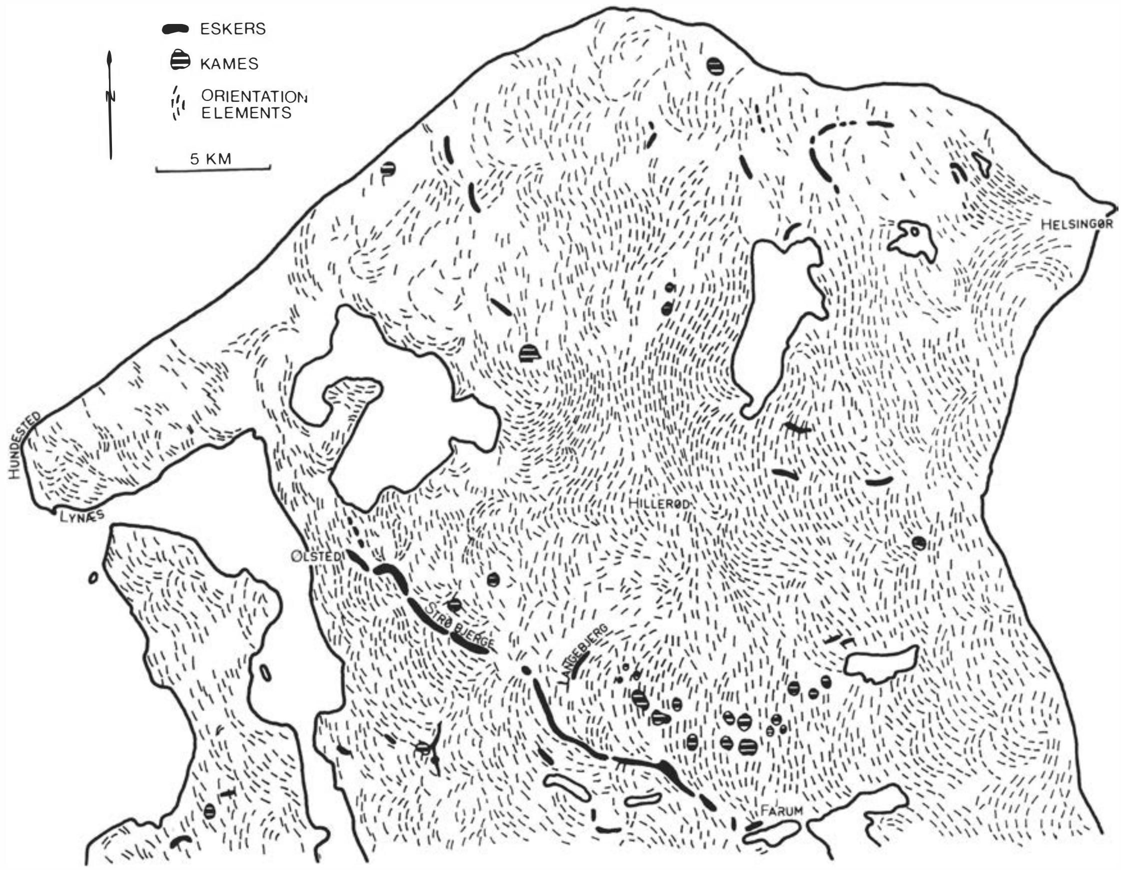

Fig. 4. Simplified morphological map of northeastern Sjælland. The orientation symbols have been drawn on the basis of a photogeological interpretation.

which has been described as an esker (V. Milthers, 1935, 1948).

Renewed examinations in the area from Farum to Ølsted give the impression that the ridge between the two tunnel valleys is formed by an esker, and the two so-called "tunnel valleys" are esker trenches and not tunnel valleys. Furthermore, it seems probable that the "esker" belongs to an older ice sheet than the one which formed the upper till. In the older ice sheet, we may find evidence of a Baltic one which may have been synchronous with the northern ice sheet in the Hundested region.

The Strø Bjerge ridge at the northwestern end of the line is not an esker but represents an original glacial lake and is built up of characteristic lake sediments such as varved clay. Only at the base of these lake sediments can typical esker sediments be found, and these are laid down directly on the Danian limestone. These 25–35 m of gravels (mainly below the groundwater table) form two or three parallel gravel ridges, which can be seen in the very big excavation in the western part of Strø Bjerge. This may be the prolongation of the till-covered "esker" in the southeast.

According to the soil map by Rørdam (1893), the (upper) till covers the eastern part of Sjælland as far as the eastern end of Strø Bjerge. This is in accordance with the observation that all the excavations in the line from Farum to Strø Bjerge are covered by till which arrived from the east. Both the structural features, the glacial striae on single stones found in the till and the presence of Silurian shales containing graptolites, which are known from Skåne (the southern part of Sweden), support the view that the covering till in this part of the area arrived from the east and obscured the picture of the old and very long "esker".

At Strø Bjerge, the sediments of a glacial lake were deposited or – if they belong to the former ice sheet – were preserved from glacial erosion. In contrast to the situation in Strø Bjerge, the Langebjerg esker, 4 km east of Strø Bjerge, was been greatly disturbed by the westward-moving ice.

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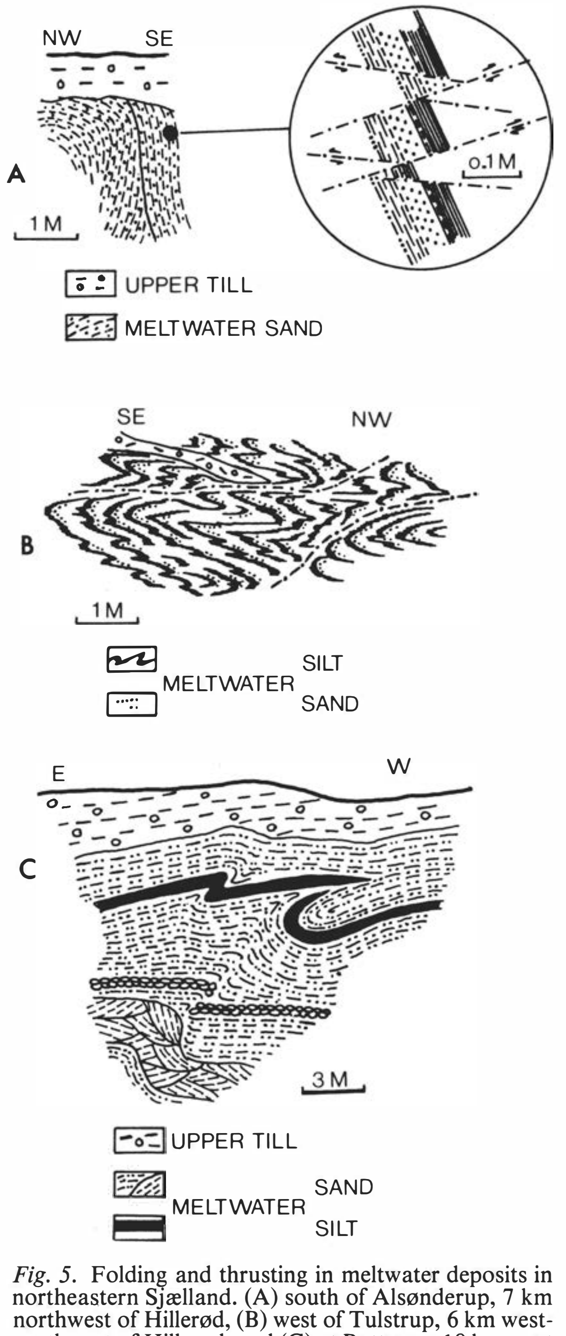

Fig. 5. Folding and thrusting in meltwater deposits in northeastern Sjælland. (A) south of Alsønderup, 7 km northwest of Hillerød, (B) west of Tulstrup, 6 km west-northwest of Hillerød, and (C) at Bøtterup, 10 km west of Helsingør.