Distinguishing between tills of different geneses from Korsør Lystskov, Denmark

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Lithology and dynamics are described in a till from Korsør Lystskov, Denmark. Based on granulometric analyses, stone counts and studies of glaciodynamic structures, including fabric, the till complex is interpreted as consisting of a lodgement till overlain by ablation till, affected by a later overriding glacier.

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In Denmark, contrasting views on the mode of formation of Weichselian tills have been proposed, and several properties have been used in attempt to characterize different types of tills.

Primarily based on morphological investigations and visual inspection in the field, Marcussen (1973) describes widespread deposits consisting of flow till. In order to distinguish between flow till and lodgement till, Marcussen (1975) used four indications: the setting of the sediments, the orientation of the elongated particles, the degree of preconsolidation, and the morphological appearance of the till. Interpretations of the fabric analyses have been discussed by Krüger & Marcussen (1976). In addition to the properties mentioned above, Krüger (1979) discusses five structural and textural features indicating a subglacial deposition, namely: lenses of sorted material, smudges, small-scale deformations of till matrix and smudges by clasts, clasts consistently striated, and clasts with stoss- and lee sides.

One of the most convincing evidences of a subglacial origin of a till is the existence of shear induced glaciodynamic structures (Lawruschin 1971). Berthelsen (1979) in a paper demonstrates the occurrence of recumbent folds and boundinage structures formed by subglacial shear.

In the following, a sequence of tills from the Korsør Peninsula, Denmark, will be discussed with special reference to lithology and dynamics.

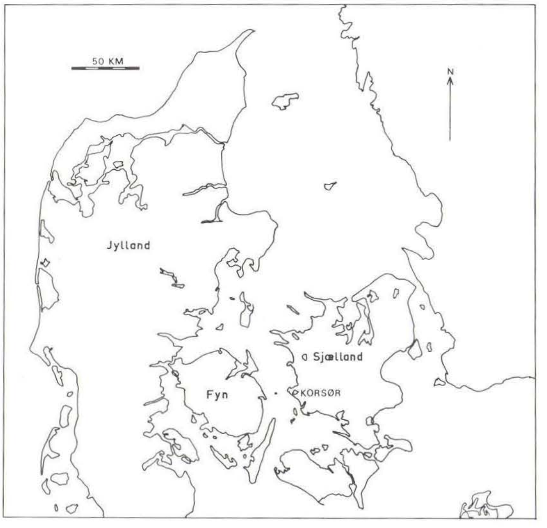

Fig. 1. Location map.

Observations

The section, located on the south coast of the Korsør Peninsula (fig. 1), has been described by Hansen & Nordmann (1950) as part of a terminal moraine landscape, and by Marcussen (1973) as a landscape consisting entirely of flow till formed by superimposed mudflows in a kame dominated region. Nielsen (1980) has described a lower till deposited by a glacier from a southern direction overlain by a till belonging to an advance from nearly the same direction.

The cliff consists mainly of till and till-like sediments (fig. 2), and can be divided into a lower till with a complex character, and an upper till not treated here.

Visually the lower till can be separated into three units. The lowermost part is a very stiff, homogeneous and compact silty till, usually with a uniform bluegray colour. Upwards through the unit the colour gets a little lighter, and smudges of chalk occur, in places with downpressed crystalline blocks. When slightly weathered, platy or jointed structures are developed. A close examination reveals that the individual plates have a thin coat of sand, often only one grain thick.

The transition to the middle unit of the lower till is gradual. The till becomes lighter and yellowish with a more sandy appearance. The till shows a faint layering due to differences in silt and clay content. There seems to be

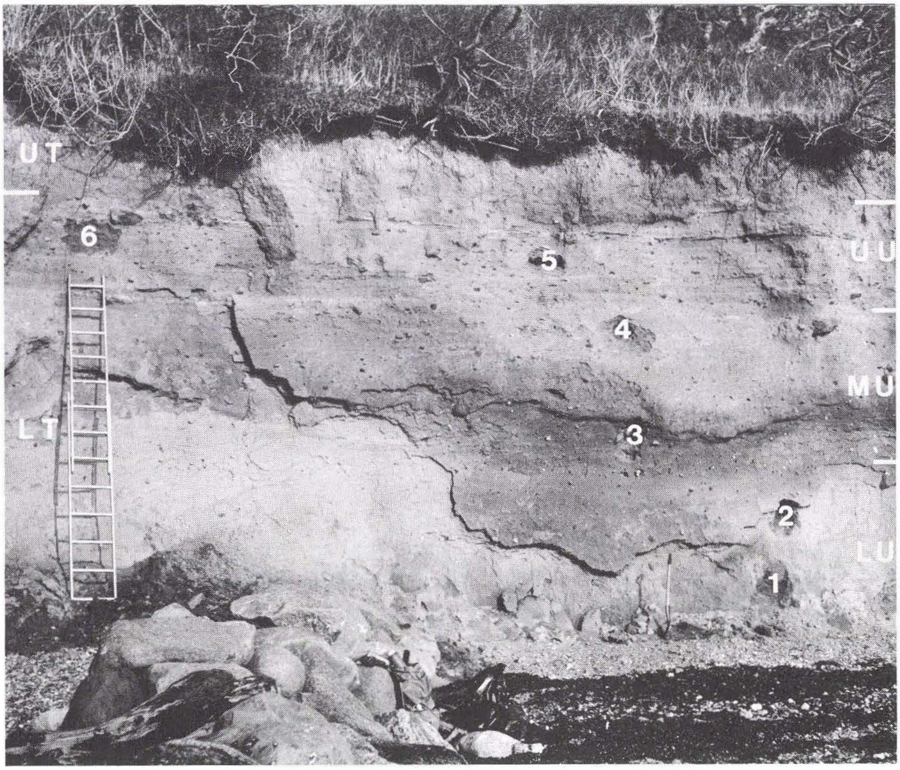

Fig. 2. The section at Korsør Lystskov showing a lower till (LT) divided into a lower unit (LU), a middle unit (MU) and an upper unit (UU), overlain by an upper till (UT). Numbers indicate sample sites referred to in the text.

little difference in the physical properties between this unit and the underlying one.

In places, the transition to the upper unit of the lower till is sharp. In windblown sections the sediments are seen to be clearly stratified and consist of sandy till with a differentiation between sandy and clayey layers. The sediments have a high content of sorted silt inclusions.

In order to investigate the causes of the visual differences in the lower till and make an attempt to explain the mode of formation, mechanical analyses, stone counts and fabric analyses were carried out at different sites in the till.

Mechanical analyses

Six samples from the lower till (fig. 2) were collected, and cumulative curves prepared in the laboratory (fig. 3). Using the grain size parameters of Folk

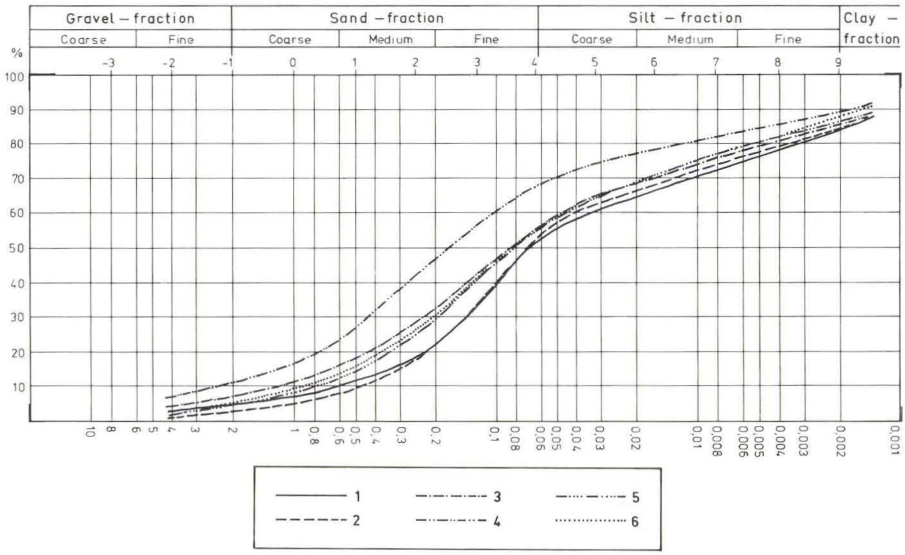

Fig. 3. Granulometric analyses: cumulative curves. For location of samples, see fig. 2.

& Ward (1957), values of mean size, standard deviation, skewness and kurtosis were computed (fig. 4). As the 95th percentiles are never attained, the last point determined by the hydrometer is extrapolated to 100 % at 14 Ø using a straight-line plot, a convention adopted from Folk & Ward (1957). The variation between the cumulative curves is very small with the exception of sample 4, which is clearly different and shows greater mean size and high standard deviation and kurtosis. K_G-values greater than 1.1 indicate that the central part of the curve is better sorted than the tails.

In general, the differences between the curves in the fraction finer than 4 Ø are very small. All samples are positive- to very positive-skewed (Folk & Ward 1957): i.e. they have a tail of fines.

The mean weight percentages per 1.0 Ø interval are shown in fig. 5. Using this delineation the dominant fractions become more obvious.

Sample no.	1	2	3	4	5	6
Mean Size	4.86	4.90	4.66	3.40	4.43	4.30
Standard Deviation	3.81	3.62	3.87	4.07	3.78	3.77
Skewness	0.35	0.38	0.33	0.28	0.34	0.28
Kurtosis	1.09	1.05	1.13	1.33	1.14	1.10

Fig. 4. Textural parameters.

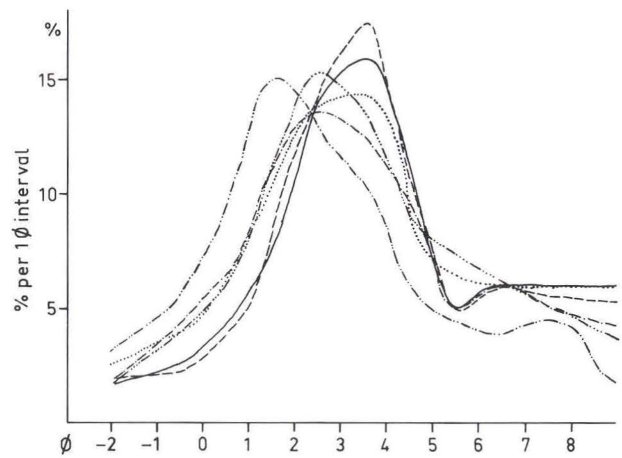

Fig. 5. Mean weight percentages per 1.0 Ø interval.

Stone counts

Petrographic variation of pebbles in the section could support an idea of a multiple till complex as indicated by the visual differences. However, the stone counts showed in fig. 6 and fig. 7 seem strongly to contradict such an idea. Fig. 6, which shows the composition of the exotic elements, reveals little differences between the individual samples. It is interesting to notice, however, that when using the relations between crystalline rocks, local sediments and exotic sediments (fig. 7) a vague trend seems to emerge. The con-

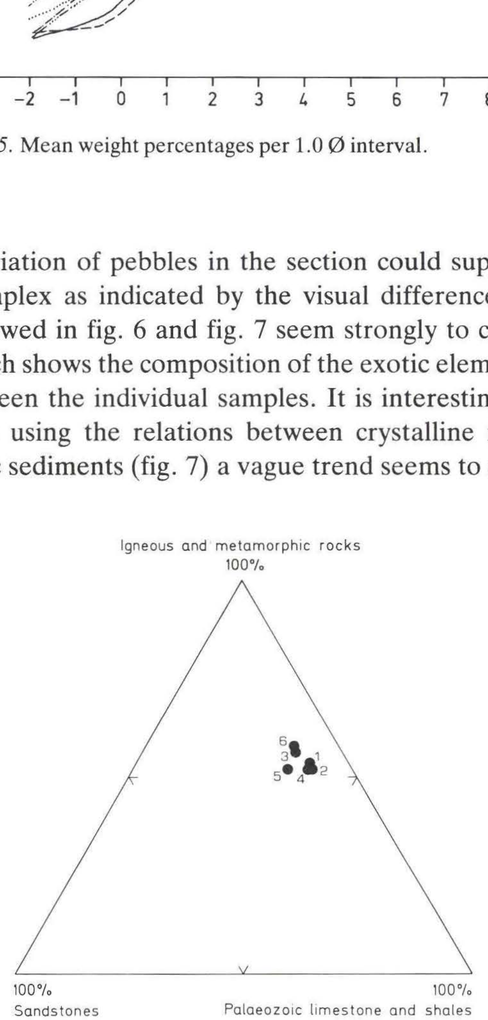

Fig. 6. Triangular diagram showing stone count data (>4 mm) from the lower till.

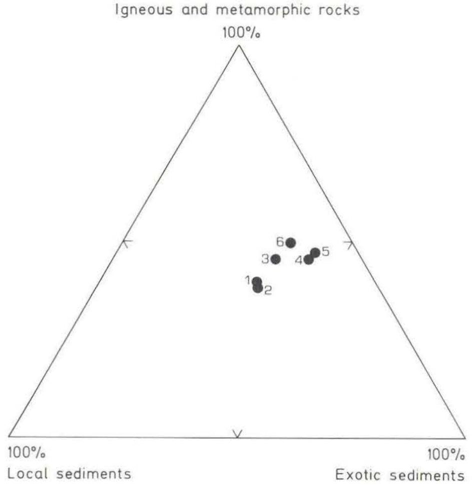

Fig. 7. Stone counts showing the proportion between local and exotic elements (>4 mm). Local sediments: Cretaceous limestone and flint. Exotic sediments: Paleozoic limestone + shale + sandstone.

tent of local sediments, being nearly constant in sample 1 and 2, starts to decrease during sample 3, 4 and 5, but ends up with a slight increase in sample 6.

Till fabric

Five till fabric analyses have been carried out in the lower till (fig. 8). The measurements, 50 points per diagram, are plotted on equal-area net and contoured after the method described by Kalsbeek (1963).

The diagrams from the lower unit (fig. 8, 1&2) show an a-lineation with plunge in the southern direction. There is some resemblance to the mixed types described by Lindsay (1970). The fabric from the middle unit is more inconsistent with two maxima, one in the northeastern and one in the southwestern direction. In the upper unit the majority of the pebbles are lying with their long-axes subhorizontal. However, diagram 5 has a maximum in the southeastern direction while No. 6 shows a faint symmetry with a weaker maximum.

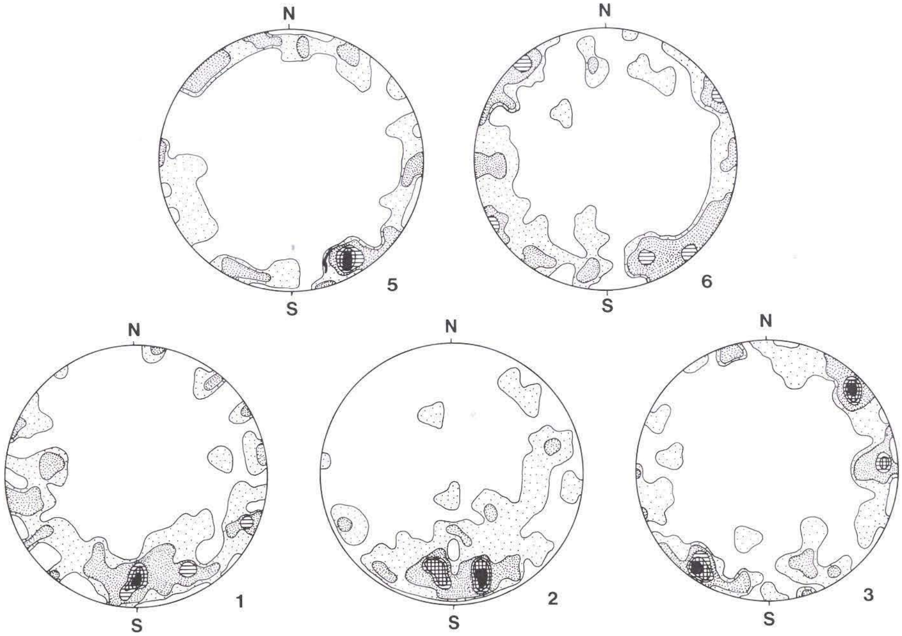

Fig. 8. Till fabric diagrams from the lower till. 50 measurements per sample are plotted on equal-area net (lower hemisphere) and contoured after a method described by Kalsbeek (1963). Contours: 3, 6, 8, 10 points per 1 % area. For location see fig. 2.

Discussion

Several hypotheses for the origin of the lower till can be considered:

(1) a multiple till complex as indicated by the visual differences,
(2) a true flow till complex as suggested by Marcussen (1973), or
(3) a lodgement till overlain by ablation till affected by a later overriding glacier.

The stone counts and grain size distribution are not in agreement with hypothesis 1. The petrology and grain size in Danish tills are very variable, and different tills often show approximately the same characteristics, but the variation in this till, however, is too small to justify an idea of different tills. According to Bahnson (1973) the lithology must display specific variations.

There appears to be no support for hypothesis 2. The lower part of the section bears all the characteristics of a lodgement till. The sediment is stiff and homogeneous with a well developed subhorizontal jointing representing earlier shear planes (Boulton 1970).

Some information can be drawn from the granulometric analyses (fig. 4). The sediment is fine-grained and poorly sorted with a standard deviation

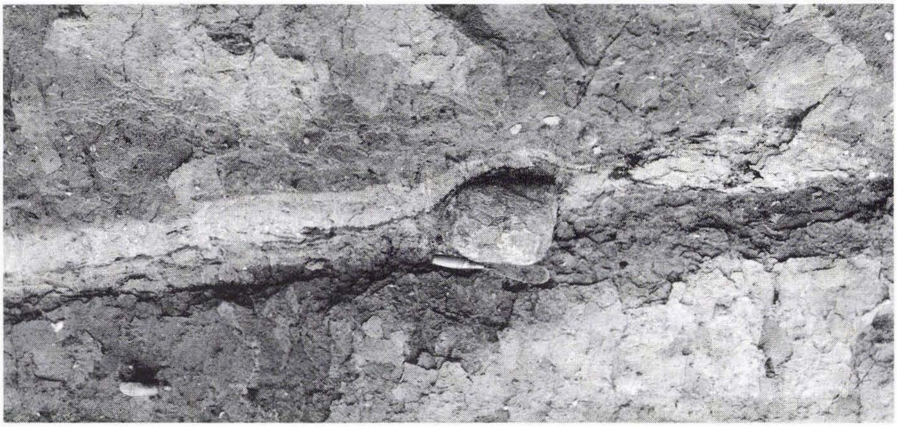

Fig. 9. Small-scale deformation of till and chalk-floe by clast. Note the stoss- and lee sides. Glacier movement from right to left.

around 3.70. The curves are very positive-skewed, indicating a tail of fines. They also show a distinct mode in the fine sand/silt range (fig. 5), a circumstance which seems to be typical for tractional debris in recent glaciers (Boulton 1978). Further support for a subglacial origin is the sporadic occurrence of small-scale deformations of till by clasts (fig. 9), indicating a lodgement of individual particles (Krüger 1979). In agreement with this, the till fabric shows a clear a-lineation with plunge in the upglacier direction (fig. 8, 1&2). Based on the data presented, it is proposed that the lower part of the section is a lodgement till, and not a flow till as suggested by Marcussen (1973).

The data from the middle unit of the lower till are more inconsistent. Concerning the exotic elements (fig. 6) little difference exists between this unit and the underlying one. There is, however, a clear decrease in the content of local sediments (fig. 7), in particular Cretaceous limestone. This decrease coinsides with a colour change from bluegray to yellowish and an increase in grain size (fig. 3). In proportion to the lower unit, the distinct mode has moved upwards in grain size (fig. 5), but the deficiency in the fraction 3–5 Ø is greater than in the clay-fraction. According to Drake (1971) this could reflect the possibility of the small grains being washed out in an ablation till. The idea of the middle unit being an ablation till or a basal melt out till in the sense of Dreimanis (1976) is partly supported by the till fabric (fig. 8,3). The diagram shows a marked decrease in plunge, and the clear a-lineation has been replaced by an incipient b-lineation indicating a compressive flow. The fabric is interpreted as a relic and an englacial fabric.

The upper unit of the lower till shows some resemblance to the lower unit. The distinct mode in the fine sand/silt range is reestablished (fig. 5), and values for standard deviation and kurtosis are about the same. In proportion to the middle unit, mean size has decreased. A closer inspection of the stratification earlier mentioned, reveals large amounts of secondary chalk precipitated along subhorizontal planes. The inclusions of sorted silt are often slightly torpedo-shaped (Berthelsen 1978) with their long-axes parallel to the planes. There are no signs of primary sedimentary structures.

Investigations outside the section (Nielsen 1980) show that the upper till has been deposited by a glacier advancing from a southern direction. The till fabric in the lower till seems to reflect this movement. One diagram (fig. 8, 6) shows considerable variations with a symmetry around a line from the north to the south, while another (fig. 8, 5) has a clear maximum indicating a movement from the south. Consequently the upper unit is interpreted as the reactivated part of the ablation till, intensively sheared during the overriding of a later glacier from a southern direction. The decreasing mean size could be a product of crushing during the renewed shearing.

Conclusion

The lower till from Korsør Lystskov is interpreted as a lodgement till overlain by an ablation till, the upper part affected by a later overriding glacier. Evidences that the lower unit is a lodgement till are: strong a-lineation with upglacier plunge, subhorizontal jointing, deformation of till by clasts often showing stoss- and lee sides (Krüger 1979), lack of washing, and a distinct mode in the fine sand/silt fraction. Evidences that the middle unit is an ablation till are: inconsistent fabric, mechanical analyses show signs of washing and weathering. The present author interprets the upper unit as the upper part of the ablation till intensively sheared during a later advance based on: subhorizontal extensive stratification, decreasing grain size and fabric.

It is stressed that the observations presented here provide no support for a flow till hypothesis. However, more work on different tills must be done to get better knowledge of their characteristics and modes of formation.

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