AN OCCURRENCE OF PERIGLACIAL STRUCTURES AT LANGÅ, JYLLAND

By

LEIF CHRISTENSEN

Abstract

An occurrence of periglacial features, located 2 km east of Langå between Line C and Line D, the two outermost ice margins of the Würm glaciation in Jylland, is described. The features, which include soil polygons, involutions and other deformational structures were probably formed in Oldest Dryas Time. The deformational structures and involutions probably developed as the result of liquefaction and differential pressure distribution in water saturated, unconsolidated sediments beneath solifluction layers of variable thickness.

INTRODUCTION

While mapping Quarternary Deposits for the Geological Survey of Denmark during the summer of 1966 under the direction of Professor GUNNAR LARSEN, an occurrence of intensely disturbed structures in glacial and glaciofluvial material was found 2 km east of Langå (Fig. 1). This occurrence is situated between the Main Stationary Line (Line C) in central Jylland and the Eastern Jylland Stationary Line (Line D).

LOZINSKI (1909) was one of the first workers to use the term "periglacial". It has become a widely used term, which covers, 1) the ice free areas adjacent to Pleistocene ice sheets, 2) the climate which existed in these ice free areas, with strong winds, low temperatures and many fluctuations around the freezing point at certain seasons, and 3) the phenomena caused by such a climate (see also BRYAN, 1946).

Fossil periglacial phenomena have previously been found west of the Main Stationary Line in Central Jylland. The described phenomena consist of aeolian features (CAILLEUX, 1942) and congeliturbates, which include solifluction layers, soil polygons, stone stripes, ice wedges (ANDERSEN, 1963, NØRVANG, 1942, 1943, 1946 and RASMUSSEN, 1960) and polygonal patterns on aerial photographs (SVENSSON, 1963). The processes which were responsible for the formation of these phenomena took place during the Würm glaciation, when the ice was situated at the Main Stationary Line in central Jylland. Some processes, however, continued into late glacial time (NØRVANG, 1946) with the retreat of the ice to Line D in eastern Jylland

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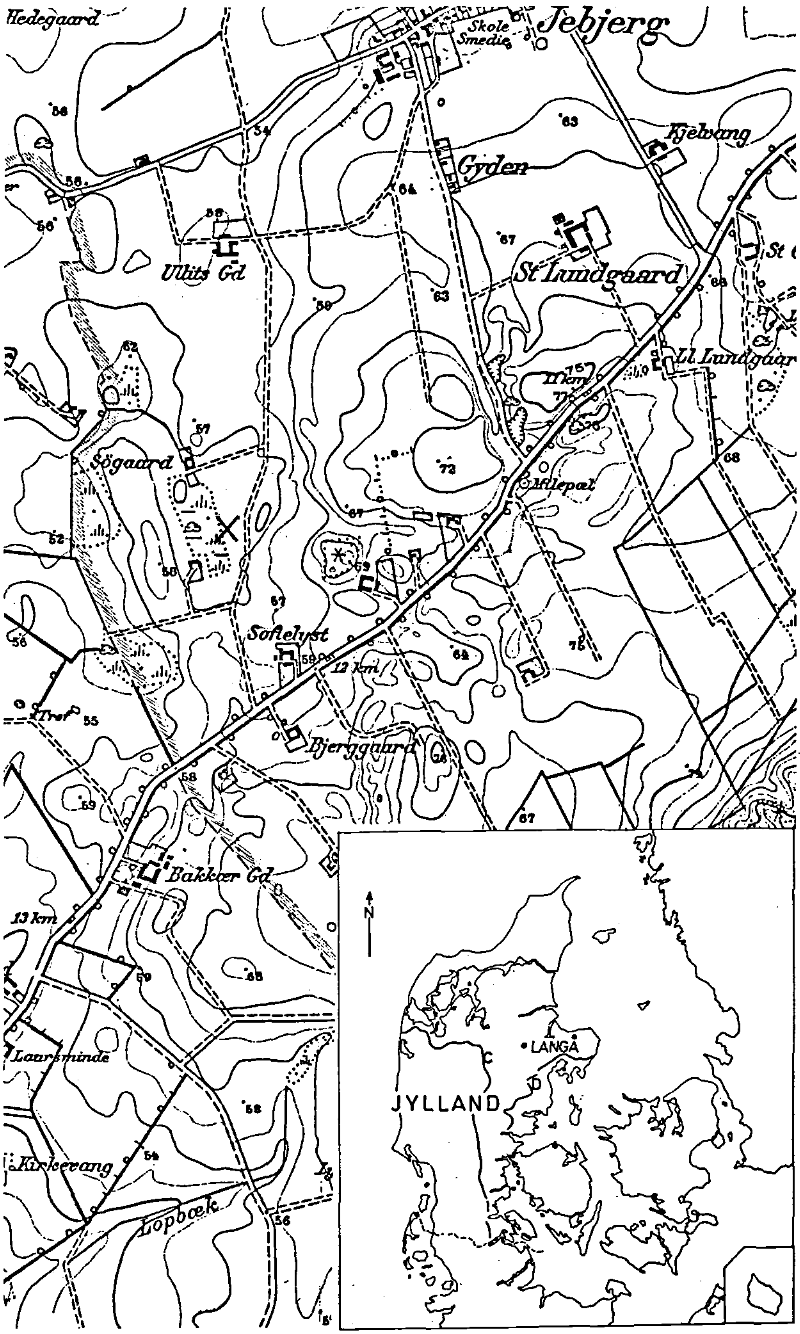
Fig. 1. Location of the Langå exposure. (Segment of M 2113 on the scale of 1 : 20.000. Copyright Geodetic Institute). × indicates locality. Key map shows position of Langå, lines C and D. (Modified from S. HANSEN and K. MILTHERS, in SORGENFREI and BERTHELSEN, 1954, p. 27).


Hedegaard
Skole
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Sögaard
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Sofielyst
12 km
Bjerggaard
Bakkær Gd
13 km
Laursminde
Kirkevang
Lopbæk
LANGÅ
JYLLAND
N

(Fig. 1). The periglacial features in the Langå area probably formed under cold conditions prevailing in the area during the above mentioned retreat of the Würm ice, or while the ice was stagnating at Line D.

Periglacial features have also been found in Vendsyssel (ANDERSEN, 1961; NØRVANG, 1946), on the island Fur (GRY, 1964), in northern Sjælland (ANDERSEN, 1950; FLORIS, 1957), southern Sjælland (HANSEN, 1966), and in the westernmost part of Scania (JOHNSSON, 1956, 1957, 1962).

DESCRIPTION

The locality at Langå is a sand pit, 3 m deep and 19 m long, situated in a depression in the landscape (Fig. 1). In the north and northeast wall the uppermost 2 m of section are exposed. A representative section (Plate I) consists in ascending order of 25 to 70 cm of bedded, medium grained sand, 15 to 40 cm of gravelly sand (only developed between 6 to 17 m) and 15 to 25 cm of medium grained sand with clay-rich layers. The sand can be traced from 5.5 m and thins out at 11 m, appearing again at 13 m and folding around the gravelly sand at 17 m. Overlying the sand is a 75 to 120 cm till-like layer of sand with cobbles. The silt has been concentrated in the lowermost part of this layer by downwashing. A soil layer averaging about 25 cm in thickness caps the profile. The grain size distribution in a representative profile is depicted in Fig. 2.

The 75 to 120 cm thick till-like sand layer previously mentioned has the characteristics of two solifluction layers. For characteristics of solifluction layers see ANDERSON (1906), BESKOW (1930), and SØRENSEN (1935). In the lowermost part pebble and cobble rich areas can be seen between 0 til 2 m and 14.5 to 19 m. The pebbles and cobbles consist of frost shattered fragments in wedge-shaped groups which point upwards, resulting in indisinct festoonlike structures. Between 0–2 m somewhat elongated. These structures are the remnants of partially destroyed soil polygons. Uppermost in the profile, just below the soil cap, concentrations of large cobbles and boulders can be seen. In this upper solifluction layer a couple of wind polished stones (ventifacts) have been found. These cobbles and boulders constitute the margins of three soil polygons. Soil polygon 1 is located between 2.5 and 4.5 m (Plate 1 and Fig. 3), and polygons 2 and 3 intersect each other between 9.0 and 12.5 m (Fig. 4). The long flat stones which define the margins of the polygons have their flat surfaces parallel to the bottom and sides of the polygons. Most of the stones are frost-splintered flint fragments.

Well developed involutions are present in the Langå section (Plate 1). In this paper "involutions" are defined as "deformed, involved and haphazardly interpenetrating masses of silt and sand originally arranged in horizontal position" (see SHARP, 1942, p. 115, and BUTRYM et al., 1964). JAHNS' (1956) breakdown of "involutions" into various types will be used in this paper. Broad pillar type involutions (height $<$ width) are developed in the lowermost sand bed (Plate I and Fig. 5). A few pillar involutions are present in the gravelly sand layer and are best displayed beneath soil polygon 3 where the overlying sand layer has been squeezed out. In the

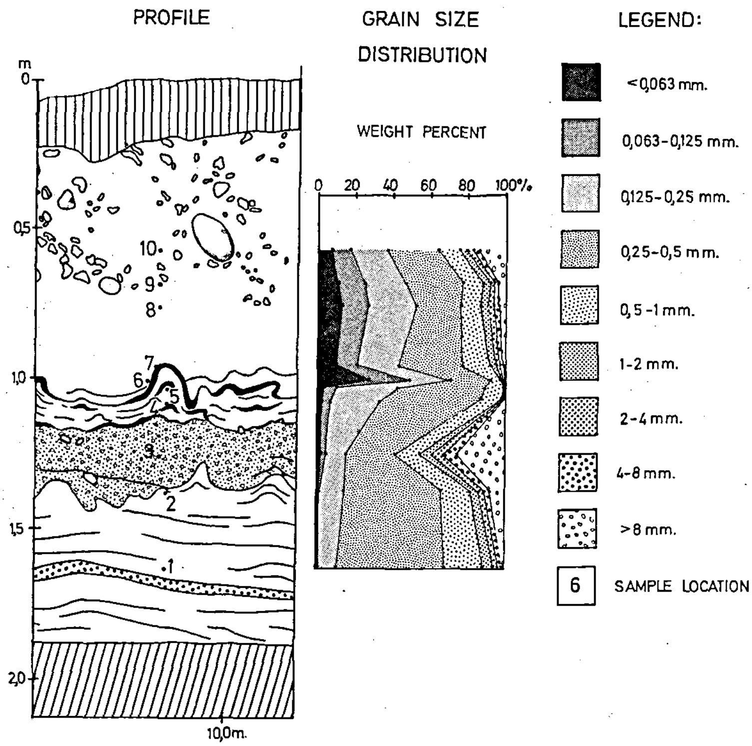

Fig. 2. Grain size distribution in vertical profile. Profile situated at 10.0 m position on Plate 1. For profile legend consult Plate 1.

latter sand layer slim pillar type involutions (height > width) are found. These are best developed outside polygons 2 and 3. Approaching soil polygon 1, between 4.5 and 5.5 m, involutions in all three sand layers mix to form a zone of amorphous involutions.

ORIGIN OF INVOLUTIONS

Different processes can result in the deformation of water saturated, unconsolidated sediments. The deformation may be penecontemporaneous or postdepositional. Structures caused by such different agents as ice pressure, permafrost and turbidity currents can be similar, and the origin of such structures, therefore, can be uncertain. In view of the apparent close relationship of the involutions and the soil polygons it can be concluded that the involutions at Langå are related to conditions resulting from Pleistocene glaciation.

The involutions at Langå might have been formed by (1) ice pressure,

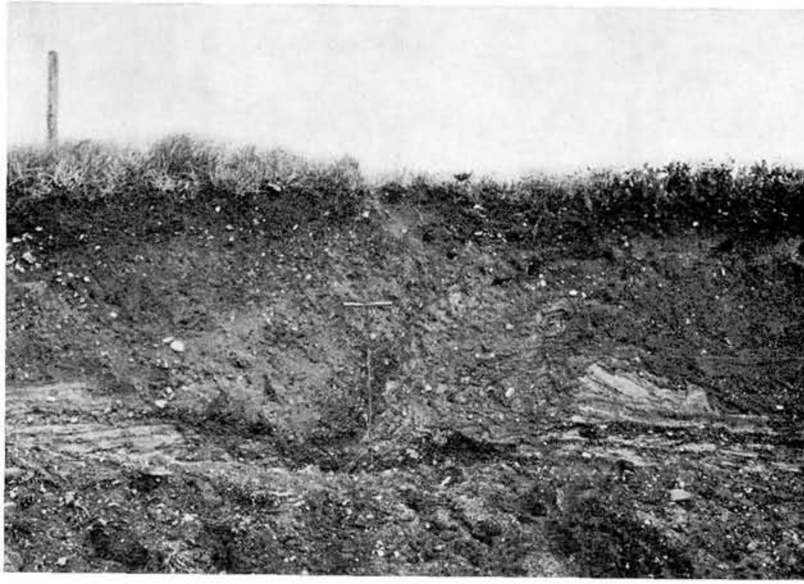

Fig. 3. Soil polygon 1 located between 2.5 and 4.5 metres on Plate 1. The long flat stones which define the margins of the polygon have their surfaces parallel to the bottom and sides of the polygon.

Fig. 4. Intersection between soil polygons 2 and 3 which is located between 9.0 and 12.5 m on Plate 1. Pencil indicates scale.

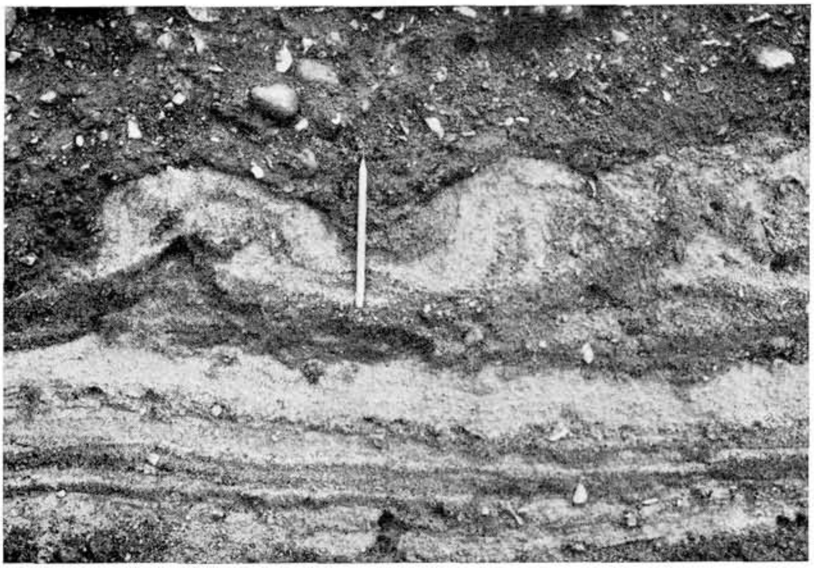

Fig. 5. Closeup view of broad pillar involutions in lowermost sand layer located at 13.0 m on Plate. Pencil indicates scale.

(2) load casting, or (3) by squeezing of watersaturated material between a frozen crust and the underlying permafrost.

If the involutions formed due to pressure exerted by moving ice then one would expect to find the involutions displaying linear trends indicating the direction of the ice movement. In view of the absence of any such linear trends it is considered unlikely that the involutions at Langå could have originated in this manner.

The involutions described are very similar to "load cast structures" from flysch, greywacke and molasse deposits and to some experimentally produced structures (KUENEN, DŹUŁYŃSKI 1953, 1958; and WALTON, 1963, 1965; and DŹUŁYŃSKI and SMITH, 1963). KUENEN (1953) has stated that "load casts" can be formed under permafrost conditions long after the deposition of the sediments.

The involutions at Langå are mainly confined to a zone near the interface between two sedimentary layers having somewhat different mechanical properties, e. g. between the sand with clay-rich layers and the sand layer with cobbles (Plate 1 and Fig. 2). This suggests that the sedimentary layers have attempted to reestablish an equilibrium which somehow was disturbed. Because the involutions "intrude" solifluction layers and are vertically oriented rather than inclined, they must have been formed sometime after the solifluction layers had come to rest in the depression in the landscape. Furthermore none of the involutions described, showed a flattening of its upper part which could be ascribed to contact with an overlying frozen layer. Therefore it seems unlikely that the involutions developed by squeezing of watersaturated, unconsolidated material in autumn between a frozen crust and the underlying permafrost. WILLIAMS (1960) has stated that in loosely packed silt material loading alone can result in liquefaction. Because the solifluction layer was probably thickest in the area of the soil polygons (see Plate 1, polygon 1, and BESEKOW, 1930) the underlying liquefacted sediments would tend to be displaced away from beneath the polygons. Therefore, the disequilibrium may have been caused by variations in the thickness of the solifluction layer. Such variations in thickness and the resulting differential load distribution might have produced the involutions in the underlying, unconsolidated sediments.

The involutions must have been formed after the squeezing out and folding by liquefaction, as the involutions are arranged vertically and do not themselves appear to be deformed. Polish workers (RZECHOWSKI, 1961, and BUTRYM et al., 1964) in their studies of Quaternary deposits have also invoked the above "load cast mechanism" to explain similar structures.

TIME OF FORMATION OF STRUCTURES

NØRVANG (1946) states that permafrost conditions must have existed in those areas where soil polygons and ice wedges have been found. The presence of soil polygons at the Langå locality suggests that permafrost conditions existed there during the retreat of the ice from Line C to Line D.

By the end of the Oldest Dryas Time the ice had retreated so far away from central Jylland (HANSEN, 1965) that it is highly unlikely that permafrost conditions existed in the Langå area. The proximity of the ice margin Line D suggests that the structures were formed sometime between the retreat from Line C to Line D, or while the ice was stagnating at Line D. Vegetation studies suggest that the climate had a sub-arctic character in Oldest Dryas Time (IVERSEN, 1954). The temperature in the warmest month of the year was slightly below 10°C, while the winter temperature was a little below ÷ 8°C (HANSEN, 1965).

The periglacial features in the Langå area are not as well developed as those in Jylland west of Line C described by NØRVANG (1946). This might indicate that the Langå features were formed during a relatively shorter period of time.

SUMMARY AND CONCLUSIONS

In Oldest Dryas Time probably permafrost conditions existed in the Langå area while the ice border was lying 20–30 km to the east at Line D in eastern Jylland. Thawing of the uppermost few metres of till during summertime led to the development of a solifluction layer which moved downslope and was deposited on water saturated, unconsolidated sediments in a depression in the landscape. Soil polygons were formed in the solifluction layer and were later partly destroyed by the superposition of a younger solifluction layer, in which new soil polygons later developed. Liquefaction

of the underlying water saturated, unconsolidated sediments led to the squeezing out and folding together of sedimentary layers. Later involutions developed in the sediments probably as the result of a differential load distribution arising from variations in thickness of the overlying solifluction layers.

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DANSK SAMMENDRAG

Der beskrives en forekomst af periglaciale strukturer, beliggende 2 km øst for Langå mellem Würm nedisningens to yderste isrande i Jylland, hovedopholdslinien og den østjydske israndslinie. Strukturerne, som omfatter stenpolygoner, involutioner og andre deformationsstrukturer, opstod sandsynligvis ved forskellig trykfordeling i vandmættede, ukonsoliderede sedimenter under flydejordslag af forskellig lagmægtighed. Strukturerne antages at være dannet i ældste Dryastid.

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PLATE I

CROSS SECTION OF PERIGLACIAL STRUCTURES AT LANGÅ

VERTICAL AND HORIZONTAL SCALES EQUAL

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