Danmarks geologiske Undersøgelse
V. Række. Nr. 5 (e.)

GUIDE
FOR THE EXCURSIONS IN DENMARK
1928

Danmarks geologiske Undersøgelse.
V. Række. Nr. 5.

Guide

for the

Excursions in Denmark

of the International Meeting of Geologists
in Copenhagen 1928.

Published by
Victor Madsen.

København.
I Kommission hos C. A. Reitzel's Forlag.
1928.

Danmarks geologiske Undersøgelse.

*The international Meeting
of Geologists
in Copenhagen 1928.*

Excursion A.

GUIDE

FOR THE EXCURSIONS IN DENMARK

BORNHOLM

KØBENHAVN
NIELSEN & LYDICHE (AXEL SIMMELKIÆR)
1928

Excursions prior to the Meeting.

Excursion A.

Bornholm.

17th—20th June 1928.

Under the guidance of Messrs. O. B. BØGGILD[1]), CHR. POULSEN and Miss K. CALLISEN.

Literature:

Summary of The Geology of Denmark. Published by VICTOR MADSEN. Danmarks geologiske Undersøgelse. V. Række. Nr. 4, pp. 14—47. V. MILTHERS: Bornholms Geologi. D. G. U. V. Række. Nr. 1. K. A. GRÖNWALL og V. MILTHERS: Beskrivelse til Geologisk Kort over Danmark (1:100 000). Kortbladet Bornholm. Résumé en français: Notice explicative de la feuille (géologique) de Bornholm. D. G. U. I. Række. Nr. 13. 1916.

Sunday, 17th June.

Departure from Copenhagen (Havnegade) by steamer to Rönne, on Bornholm, at 11 pm.

Monday, 18th June.

Arrival at **Rönne** about 7 am. From Rönne by automobile to Nilars Church (an old rotunda, built for purposes of defence in the first half of the 13th Century) and Aakirkeby.

---

[1]) Author of Guide for Excursion A.

From Aakirkeby on foot to the stream **Læsaa.** A little to the south of Aakirkeby is a slope, in which the granite,

Fig. 1. Geological map of Bornholm. (GRÖNWALL and MILTHERS).

which here is of the usual striated kind, rises rather steeply over the plain, the substratum of which is of Lower Cambrian Nexö Sandstone. The two are separated from each other by faults, of which there are two here, forming an acute angle with each other (see figs. 2 and 3) and between them is a terraced plateau with a substratum of arkose sandstone.

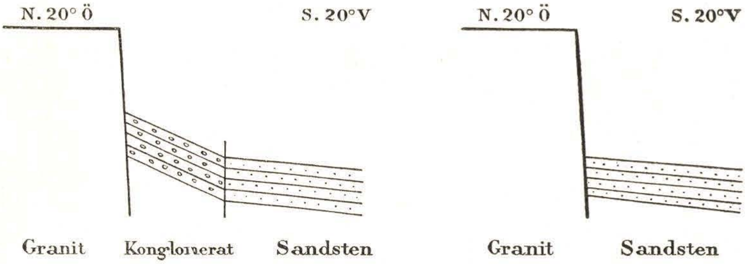


Fig. 2. Sketch profiles through the cliff south of Aakirkeby. (GRÖNWALL and MILTHERS).

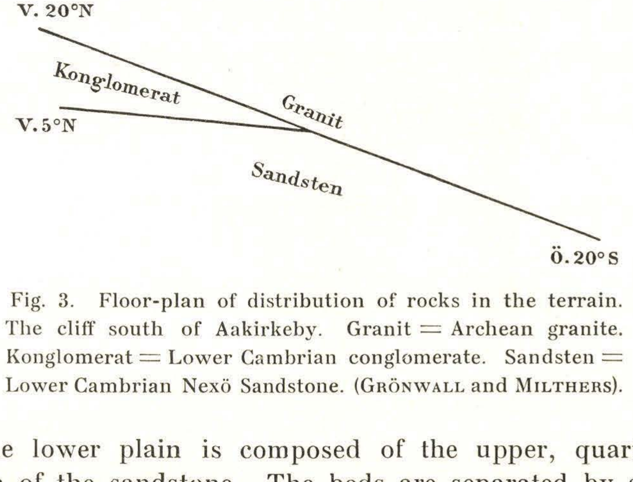


Fig. 3. Floor-plan of distribution of rocks in the terrain. The cliff south of Aakirkeby. Granit = Archean granite. Konglomerat = Lower Cambrian conglomerate. Sandsten = Lower Cambrian Nexö Sandstone. (GRÖNWALL and MILTHERS).

The lower plain is composed of the upper, quartzitic strata of the sandstone. The beds are separated by shale strata. Further to the west is a quarry in a similar sandstone, with numerous conical figures.

At the farm Vejrmöllegaard, near Læsaa are the Green Shales (Summary of The Geology of Denmark p. 25), which here contain a number of *Hyolithes*. On from here southwards along the stream, and we come to a low slope of Green Shales with a particularly large number of sandstone beds.

Rispebjerg Sandstone is to be seen at Kalby, and overlying it the Paradoxides Strata, consisting of Lower Alum Shale and, overlying them, anthraconite, Andrarum Limestone and Upper Alum Shale. Then comes a low slope, at the bottom of which can be seen Alum Shale with *Olenus* and, next, the profile mentioned in Summary of The Geology of Denmark p. 29 with Alum Shale with Orusia-, Eurycare- and Peltura zones and with anthraconite concretions. To the south the Alum Shale comes to an end at a fault against the Orthoceratite Limestone. A little to the south of this, at Vasagaard, is a high slope in Dicellograptus Shale (Summary of The Geology of Denmark p. 31) in which are

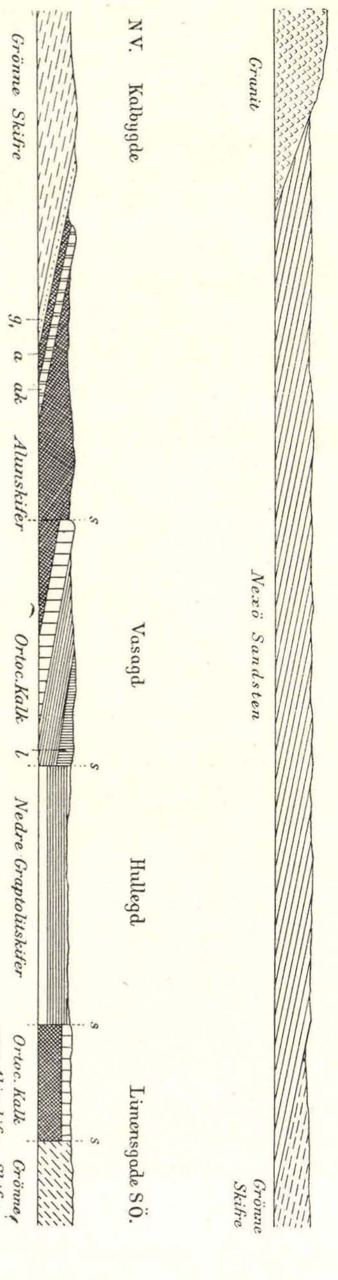
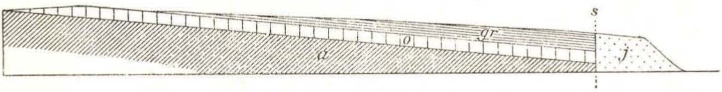


Fig. 4. Series along the Læsaa. Granit = Archean granite. Nexö Sandsten = Lower Cambrian Nexö Sandstone. Grønne Skifre = Lower Cambrian Green Shales. g_1 = Rispebjerg Sandstone (Lower Cambrian). a = Lower Alum Shale (Middle Cambrian). ak = Andrarum Limestone (Middle Cambrian). Alunskifer = Alum Shale (for the most part Upper Cambrian, the Olenus Stage). Ortoc. Kalk = Orthoceratite Limestone (Ordovician). Nedre Graptolitskifer = Dicellograptus Shale (Ordovician). l = Trinucleus Shale (Ordovician). s = Faults.

numerous graptolites of the genera *Diplo-*, *Climaco-*, *Dicello-* and *Dicranograptus* as well as *Discina Portlocki*. To the south of Vasagaard is a low slope in Trinucleus Shale. Further south, at Limensgade, is an old quarry in Dictyograptus Shale and, overlying it, Orthoceratite Limestone.

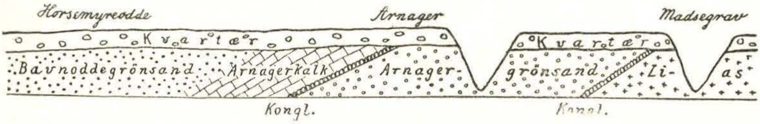
At the streamlet **Risebæk** (see fig. 5) furthest north in the bottom of the stream is Dictyograptus Shale and, over this, a large quarry in Orthoceratite Limestone with fine glacial



NNE Fig. 5. Series along the Risebæk. SSW
a = Alum Shale (Dictyograptus Shale, Ordovician). o = Orthoceratite Limestone (Ordovician). gr = Dicellograptus Shale (Ordovician). j = Rhæt-Lias deposits. s = fault.

striae and some fossils (*Megalaspis* etc.); above this Dicellograptus Shale which, towards the south, near the beach ends at a fault, south of which are Rhæt-Lias deposits (incoherent white sandstone and variegated, creeping clays).

By automobile to **Arnager,** where, at Madsegrav (see fig. 6) the Cenomanian Greensand with phosphorite nodules, resting discordantly upon Rhæt-Lias sand and clay, are to be seen (Summary of The Geology of Denmark p. 45).



W Fig. 6. Sketch profile of the cliff at Arnager. E
Bavnoddegrönsand = Senonian. Arnagerkalk = Turonian. Arnagergrönsand = Cenomanian. Kongl. = basal conglomerate. (Ravn).

A little to the west of Arnager, in a slope, the Turonian Arnager Limestone with numerous silica sponges, *Inoceramus, Scaphites* etc.

At **Bavnodde,** Lower Senonian Greensand with *Actinocamax westphalicus*.

At Klippegaard, Rönne Granite with numerous pegmatite veins.

At **Tornegaard** kaolin (Summary of The Geology of Denmark p. 19), also with pegmatite veins; here and there are also metamorphosed diabase dykes.

Tuesday, 19th June.

From Rönne by automobile to **Almindingen,** where the ground is formed of Striated Granite, not covered by Quartary deposits; the form of the surface is mostly due to the action of the ice. Tremendous fissure valleys, especially that to the south (Ekkodalen).

At **Listed** is the Svaneke Granite, some of it very crumbling, pierced by a thick diabase dyke (31 m) which shows the contrast between aphanitic structure at the boundary and grained in the middle. Both the granite and the diabase are penetrated by sandstone dykes (about 1 dm).

At **Aarsdale,** very crumbling granite with characteristic rounded forms and numerous pegmatite veins.

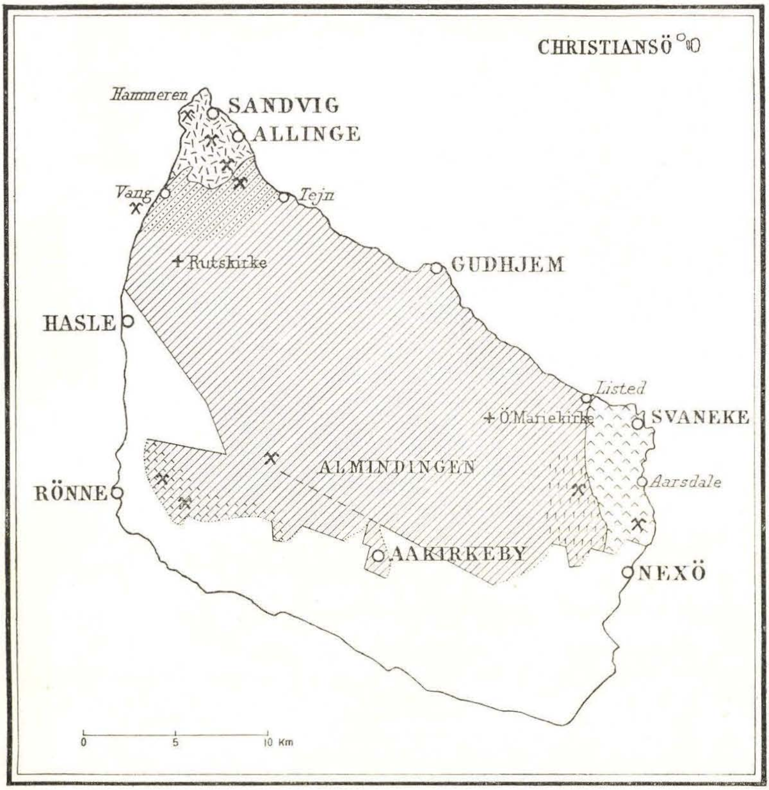
In the quarry of the Paradisbakker is the Paradisbakke Granite (Summary of The Geology of Denmark p. 16) in which are some thin (about 1 cm) sandstone dykes. On the excursion over the Paradisbakker the same granite, often with thick pegmatite veins; the granite is interspersed with numbers of tectonic fissure valleys, most of which are exactly parallel, mostly NE-SW, whereas a few run in a direction at right-angles to this.

In Frederiks Quarry, north of **Nexö,** is the middle section of Nexö Sandstone with kaolin cement and of reddish grey colour; false-bedding and ripple-marks are to be found.

Between the quarry and Nexö is a system of several parallel raised beach barriers deposited by the lateglacial Baltic ice-lake.

At Munkegaard, near the mouth of **Öleaa,** are Cyrtograptus Shale (Summary of The Geology of Denmark p. 32) belonging to Gothlandian and rich in fossils (*Monograptus priodon*, *Retiolites Geinitzianus*, more rarely *Cyrtograptus Lapworthi*, *Orthoceras* and spines of a *Ceratiocaris*). More to the north, by the stream, Rastrites Shale with more numerous limestone bands and numerous fossils (*Monograptus convolutus* etc.).

Further north are deposits of the Olenus Stage (Upper Cambrian), especially anthraconite with very numerous



Striated Granite.
Hammer Granite.
Vang Granite.
Svaneke Granite.
Rönne Granite.
Paradisbakke Granite.
Quarries of some importance.

Fig. 7. Distribution of the various granite varieties on Bornholm.

Orusia lenticularis and Alum Shale with *Agnostus pisiformis.* A little more to the north, in the bottom of the stream, Exsulans Limestone (the lowest zone of the Paradoxides Stage) and, overlying it in an old quarry, Lower Alum Shale, anthraconite and Andrarum Limestone, and at the top, Upper Alum Shale.

Wednesday, 20th June.

From Rönne by automobile across the granite terrain to **Salene,** at Gudhjem. From Salene along the beach to Helligdommen at Rö, on which excursion are to be seen various coast formations. Here is a low coast plain with a slope inside, formed by a previous, lower level of the land, and sometimes the rocks go right out into the sea, which has modelled a number of various forms which are, however, mostly governed by the directions of cleavage in the granite itself; the granite is everywhere of the striated kind. Particularly marked modelling is to be seen in the rocks of the Helligdommen where the numerous fissure systems, often with diabase dykes at the bottom of the fissures, produce deep indentations. Of single forms special attention is drawn to Lyseklippen and the deeply worn holes, the »Dry Oven« and the »Black Pot«. A little further north is Dynddalen, a very wide and deep fissure valley, the north side being quite vertical (Amtmandsstenen = the Sheriff's Stone).

Hammeren and Hammerhusklippe present a surface thoroughly worked by the inland ice, often with magnificent glacial striae. In Hammeren quarry is Hammer Granite (Summary of The Geology of Denmark p. 16); a few diabase dykes are to be seen. The beach below Hammershus is very markedly modelled, with the »Wet Oven« and the »Dry Oven«, the »Lions Heads«, etc.

At **Vang** is the Vang Granite with numerous pegmatite veins and aplite dykes; at the workshop here several other kinds of Bornholm rocks are also worked.

Jons Kapel (chapel) is formed of a beach rock which rises isolated out of the beach gravel and is pierced by a hole. Inside the rock is a deep cleft with vertical walls, at the bottom of which is a diabase dyke.

In **Bagaa** Brickworks pit (Hasle Klinker- og Chamottefabrikker) is mostly found Lias clay, which is either refractory (Chamotte clay) or semi-refractory with a wide interval of fusion (Klinker clay). The strata dip pronouncedly (about 20^0 to the south). The stratification is indicated by the occurrence of some black beds (either clay or thin coal layers). The clay contains many spherical pyrites concretions and a few large clay-ironstone concretions, in which well-preserved plant fossils (mostly ferns) are sometimes found.

Return to Rönne, whence departure for Copenhagen by steamer 11 pm.

Danmarks geologiske Undersøgelse.

The International Meeting of Geologists in Copenhagen 1928.

Excursion B.

GUIDE

FOR THE EXCURSIONS IN DENMARK

SOUTH SJÆLLAND AND THE ISLAND OF MÖEN

KÖBENHAVN
NIELSEN & LYDICHE (AXEL SIMMELKIÆR)
1928

Excursion B.

South Sjælland and the Island of Möen.

21st—24th June 1928.

Thursday, 21st June.

Guides: J. P. J. RAVN[1]), H. ØDUM and A. ROSENKRANTZ.

From Copenhagen by automobile through the moraine-flat landscape of East Sjælland, via Köge to **Rödvig,** the most southern point of Stevns peninsula (see map. fig. 1).

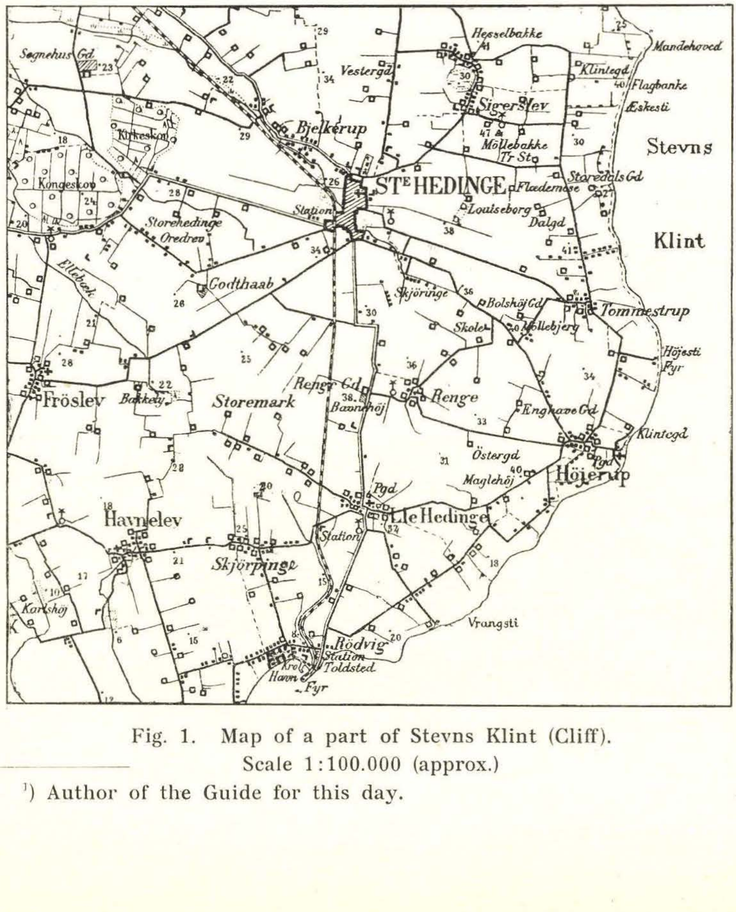


Fig. 1. Map of a part of Stevns Klint (Cliff).
Scale 1:100.000 (approx.)

[1]) Author of the Guide for this day.

The surface-form of the peninsula, an even moraine flat which very slightly rises towards the east to about 50 m above sea-level, directly reflects the regular structure of the Prequartary substratum as it appears in the cliff, about 15 km long, at which the peninsula terminates to the east.

From Rödvig on foot along the beach to the southern end of **Stevns Klint,** which here runs west-east. The first Prequartary deposit met with is the White Chalk (the very

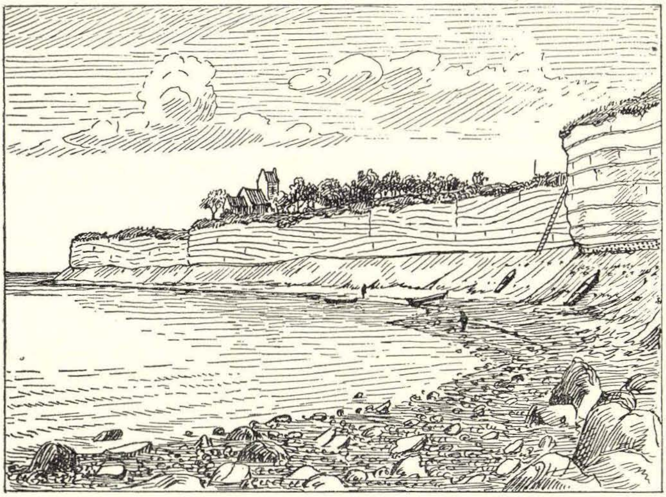


Fig. 2. Stevns Klint, with Höjerup Church.
On the extreme right is Limsten = Bryozoan Limestone (Danian) overlying Skrivekridt = White Chalk (Senonian), and, between them Cyclaster Limestone.

topmost Mucronata Chalk, the zone with *Scaphites constrictus*), quickly followed by the profile which is characteristic of the greater part of the cliff (see figs. 2—4, and Summary of The Geology of Denmark p. 55): lowest, White Chalk with layers of large flint nodules and also tabular flint secreted in cracks; overlying the White Chalk are strata which, in Summary of The Geology of Denmark, are placed under Danian, viz. a thin bed of Fish Clay deposited in shallow basins, very calcareous and often containing small, rounded fragments of White Chalk; it passes smoothly upwards into Cyclaster Limestone, a fragmented limestone which has hardened in a manner similar to the White Chalk lying between the fishclay-basins; over this hardened horizon lies the Bryozoan Limestone (Limsten), with its wavy, continuous beds of flint; then comes at the top of the cliff the moraine clay. At the boundary between the Bryozoan Limestone and the moraine clay there is, in places, a breccia of Bryozoan Limestone fragments, up to 1 m thick.

After having examined this part of the cliff a return

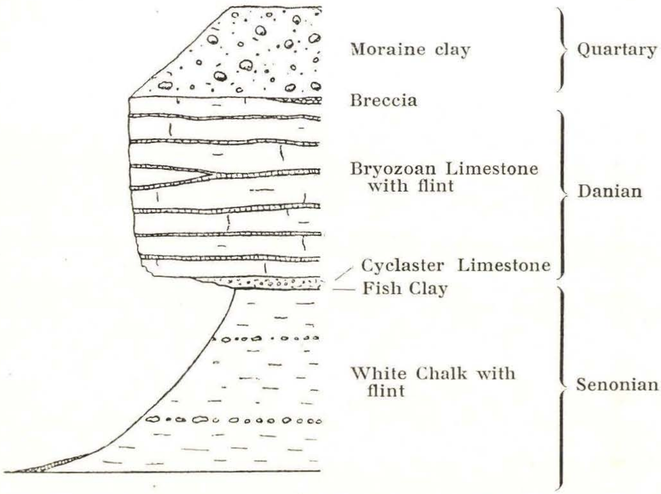


Fig. 3. Transverse section of Stevns Klint, right-angled on the shore.

will be made to the road, after which the party will drive a little within the edge of the cliff over the moraine flat to **Höjerup Church.** On the beach here are the masses of limestone and moraine clay which fell during the land-slide on March 16th, 1928; fragments of the chancel of the old church, pulled down in the slide, are also to be seen on the beach. From there one proceeds by the beach northwards to Stevns Lighthouse, one of the points where the cliff reaches its greatest height (41 m). On this stretch the profile is the usual one, but the boundary between Senonian and Danian is rather higher, and the Fish Clay basins and the thickness of the Fish Clay are on an average rather less than at Rödvig.

From Stevns Lighthouse to Store Hedinge and thence to **Faxe Hill,** where Denmark's biggest chalk quarry lies. From the highest point of the hill (76 m) there is a very wide view, including to Möens Klint. In the quarry are both Coral Limestone and Bryozoan Limestone, but these rocks vary very greatly, especially as to cohesion. They

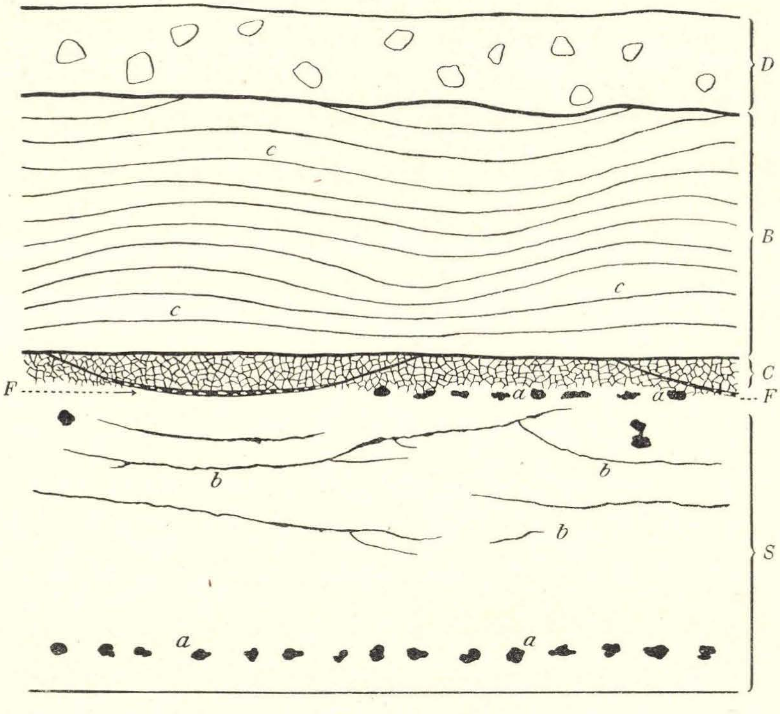


Fig. 4. Sketch profile of Stevns Klint.
S = White Chalk. F = Fish Clay. C = Hardened horizon (hardened White Chalk between the Fish-Clay basins and over these Cyclaster Limestone). B = Bryozoan Limestone. D = moraine clay. a = beds of flint nodules. b = tabular flint, secreted in cracks. c = continuous layers of flint.

both consist almost exclusively of animal shells, the interstices being infilled with calcareous ooze. Yet the aragonite shells are always dissolved; in only one or two places in the quarry does one find apparently aragonite shells preserved, but in reality they are metamorphosed: the aragonite of the shell has been replaced by calcite and its inner structure has disappeared entirely; on the other hand its sculpture is at times very well preserved. Regarding the stratigraphical position and the most important fossils, see Summary of The Geology of Denmark p. 60. It may be added here that when the surface of the limestone is laid bare of its overlying moraine clay, splendid glacial striae are frequently displayed, their direction varying greatly; their principal direction is ESE-WNW; but more scattered striae run SE-NW, SSE-NNW and NE-SW.

After visiting Faxe Quarry, proceed SE to Faxe Ladeplads (»place of loading«) where the night will be spent.

Friday, 22nd June.

Guide: V. HINTZE[1]).

In the morning there will be an opportunity of paying another short visit in the quarry of **Faxe.** At 10 am from Faxe along the main road to the south, along Præstö Fjord, past the little town of Præstö to Kallehave. From a geological point of view this part of the excursion proffers nothing of interest, whereas the drive itself, especially along Præstö Fjord, is very pretty and passes through a characteristic, fertile South Sjælland landscape.

After lunch, from Kallehave at 1.30, leaving Sjælland and passing over the narrow water Ulfsund to Koster, on the island of Möen, and on from there through a flat landscape to **Stege,** the only town on Möen (2,300 inhabitants). The harbour is formed of the outer part of Stege Nor (bay with a narrow inlet), a long stretch of water which has at one time undoubtedly divided Möen into two parts (see the maps figs. 5 and 6).

On leaving Stege on the eastern side the road runs by the old Mölleport (mill gate), the last remnant of the fortifications which formerly surrounded the town. With the bay constantly in view the route is through a comparatively even and slightly rugged, fertile moraine landscape

---

[1]) Author of the Guide for Möen.

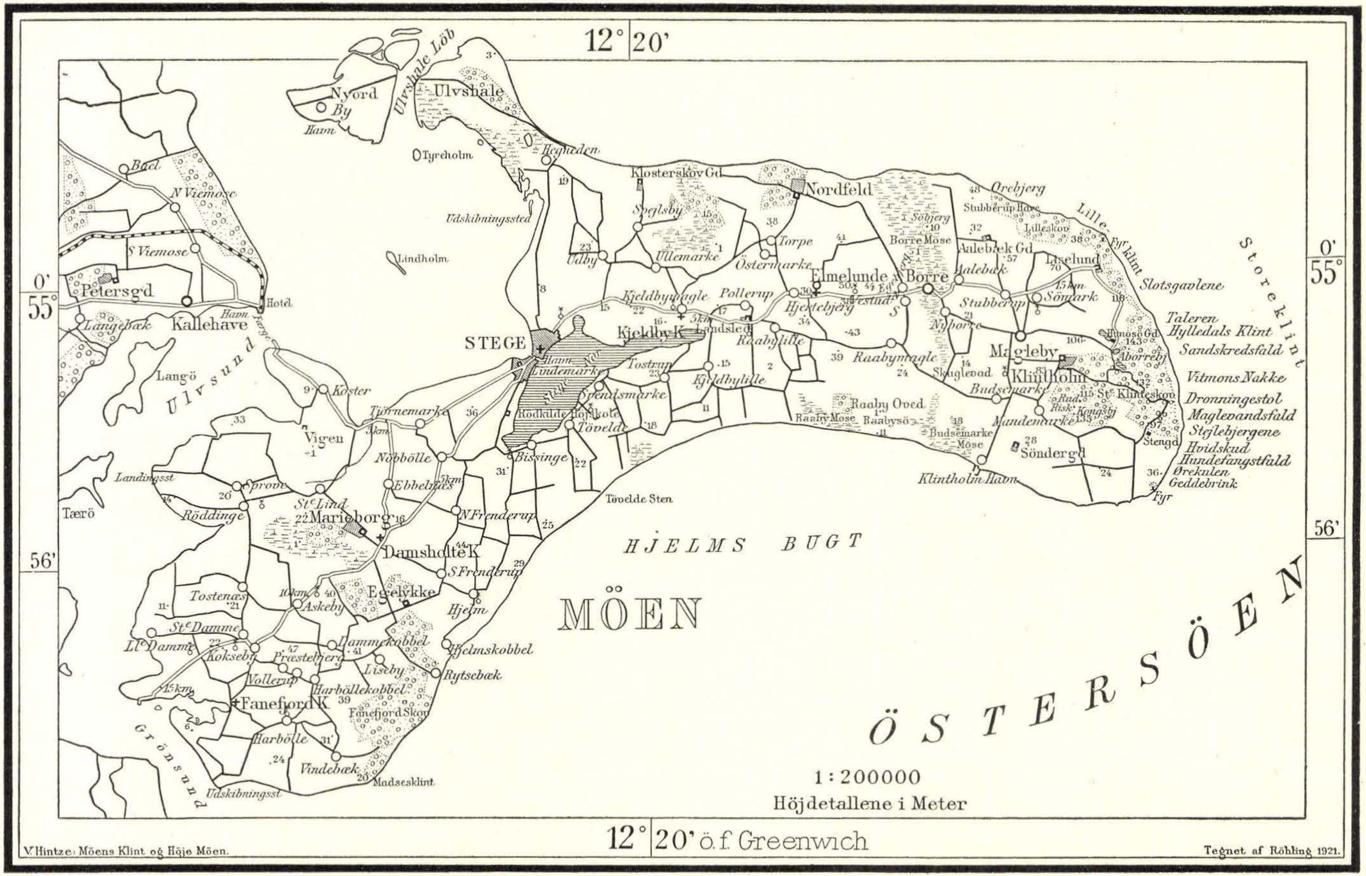


Fig. 5. Topographical map of Möen.

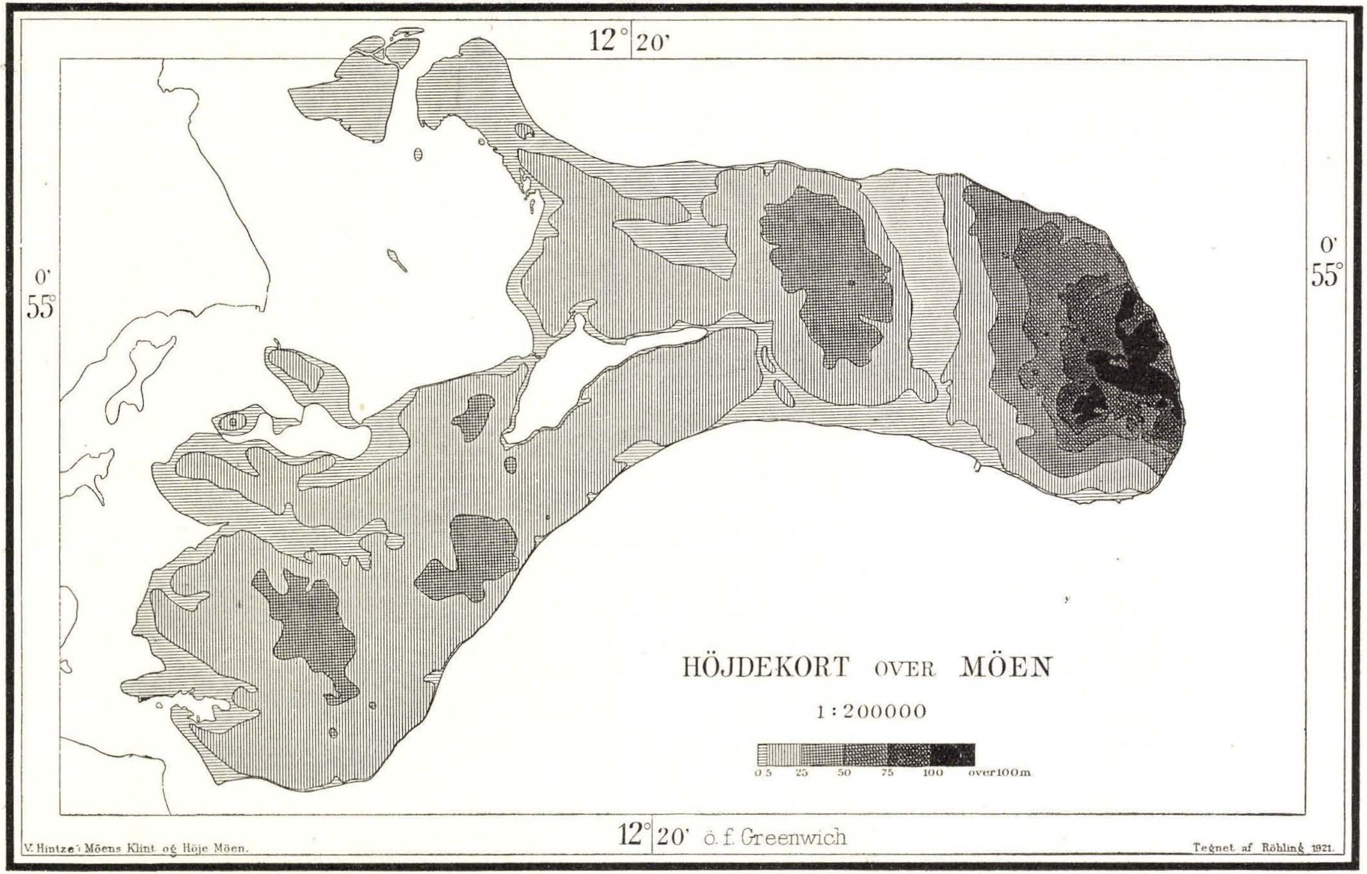


Fig. 6. Altitude map of Möen.

in the direction of Möens Klint. Past Kjeldby Church (Roman brick church with interesting mediæval frescoes) the road continues in almost the same manner until it rises steeply up towards the high Elmelunde Church (early Gothic) which, with its gleaming white walls, serves as a beacon.

The church itself stands at a height of 30 m, but a little more to the east the terrain rises to 50 m. From here there is a fine view over the great Borre depression to Höje Möen (fig. 7), where some of the thickly timbered hills describe their silhouettes sharply against the sky, and, in a very short time, we arrive down a long hill at the village of Borre, which for the most part is built upon the flat terrain which barely rises 1 m above the sea.

Only Borre Church (late Roman), which stands upon a small moraine clay islet, barely 2 m above the water level, rises above the surrounding stretch of bog and meadow. In the Middle Ages there was on this place a town (burned down by the warriors of Lubeck in 1510), to which ships could navigate from the north where, now there are fertile meadows. A presumption that at this spot a strait ran across the whole island has proved not to be in conformity with reality, even though there were considerable stretches of water to the south.

The road leads over the former Borrevig (vig = creek), from the far bank of which it now rises to greater and greater heights so that at Magleby (early Roman church), after a steady and uniform slope we have reached an elevation of rather more than 50 m. But from here on towards the east, out towards **Möens Klint** (Cliff) which borders this part of Möen, Höje Möen (the high Möen), the road up to Hunosögaard (excursion headquarters) passes heights of over 100 m and its continuation through the adjoining woods attains even greater heights, whilst the ridge in the woods rises to as much as 143 m, Aborrebjerg (perch mountain).

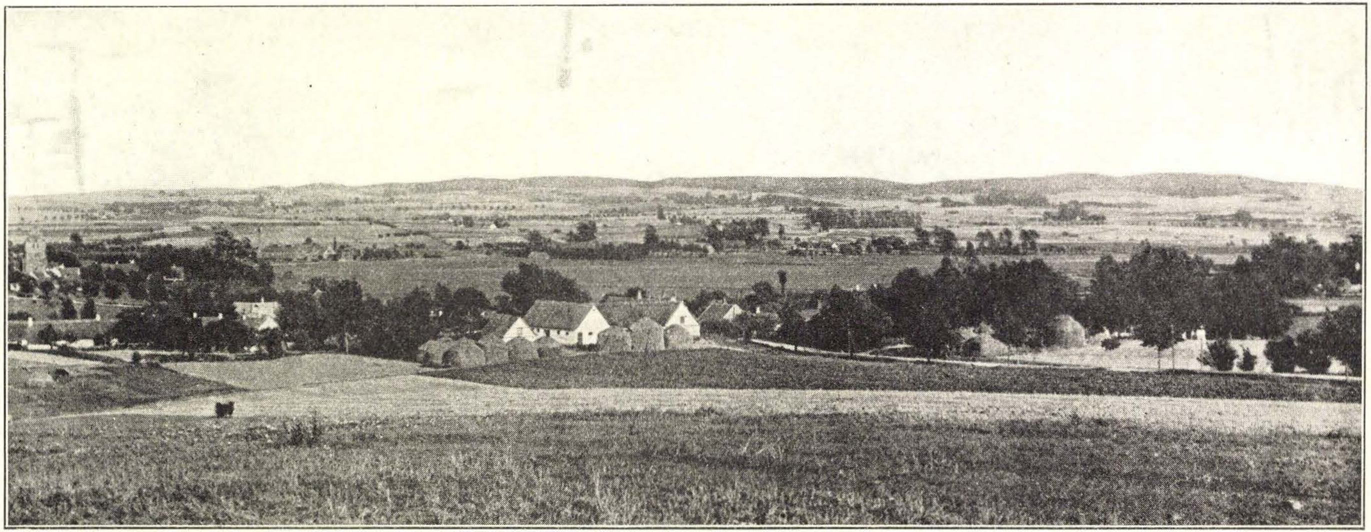


Fig. 7. View from height west of Borre depression, across the latter to High Möen. On the extreme right of the picture the big hills of Klinteskov, some of its timbered ridges standing out clearly against the sky.

Whereas the landscape west of Borre depression was a pronouncedly moraine clay landscape, it rather changes character on the stretch from the depression to Magleby, becoming more sandy in places, but on the whole retains its previous appearance. But at Magleby and onwards the picture changes, first to large, rather undulating forms stretching up towards the town, and then to sharper, more marked ridges and, in between them, deep valleys which, as a rule, are filled with bogs or lakes. The former even, uniform fertility is also replaced by very varying conditions, as meagre, poor soil here and there lies side by side with the richest and most fertile soil, and the White Chalk, which forms the substratum of the whole of Möen, but otherwise at considerable depths, is visible here and there in small pits in the hill sides. (In some places one may be inclined to think that the very roadways are the chalk beds themselves, but this chalk has merely been laid as road-improvement material).

This difference in the forms of terrain west and east of Borre depression is connected with the fact that to the west the surface is formed of undisturbed Ice Age deposits, lying on the whole just as the ice left them, whereas to the east (Höje Möen) they are, it is true, present in most places but no longer in undisturbed state. For, as the aim of this excursion to Höje Möen and Möens Klint is to show, the whole of this area has, in late and postglacial times, been exposed to violent disturbances.

Before we proceed to go into these matters more closely by means of personal inspection, we ought to see how conditions were before the great disturbances took place and created the present Höje Möen.

Here the chalk deposits consist exclusively of White Chalk (with *Belemnitella mucronata)* and the sedimentation of the chalk ceased even here before the deposition of the White Chalk series — as we know it in other places — had been brought to a close. Not the slightest trace is found either of more recent chalk (Danian) or Tertiary within the present Höje Möen region, and the conditions show that it has never been subjected to depositions either. For if the boundaries between the beds of the White Chalk, which are marked by layers of flint, are considered it will be found that the flint layers everywhere lie conformably with the upper plane of the chalk. In no place has the lower moraine — which directly overlies the White Chalk — attacked the latter, so that there cannot have been any younger deposits present at this spot.

The proof of this is that the lower moraine has not absorbed any of the rocks of the White Chalk, neither the White Chalk itself nor the flint which, under any circumstances, would still have been preserved in it. This peculiar circumstance, that the moraine which lies directly upon the White Chalk is practically bare of chalk content, can only be explained by the assumption that the lower moraine was not, at any rate to begin with, deposited by a permanent land ice, but by a floating ice — by which is not meant icebergs, but a continuous ice-sheet. The correctness of this can be proved, as between the White Chalk and the moraine there is almost everywhere a layer of gravel and stones which have »dripped« down from the underside of the floating ice; furthermore, at no place can it be seen that the ice has effected any erosion, as the flint layers in the upper stratum of the White Chalk are not broken anywhere. This shows that at the beginning of the Ice Age the surface of the White Chalk must have been extremely even and flat.

Over the lower moraine, which is so extraordinarily poor in flint (corresponding on every point with the moraine in Rügen) we find interglacial gravel, sand and clay deposits, likewise corresponding to the Rügen and East Prussian, and to some extent with a fossil content which forges a connection between these and the Eem deposits on Langeland and Als-Sundeved. The greater part of the series is marine; but the rock differences indicate rather considerable level changes during this period, in which the evidence of a single interglacial bog deposit even indicates dry land for a time. The whole series is deposited conformably with the lower moraine and with the stratum of the chalk.

The interglacial strata are on the whole overlain conformably by the upper moraine, which is much more sandy than the lower and, in contrast to the latter, is remarkable for a very high content of flint. In its upper portions it is in places substituted by glaciofluvial deposits.

The upper moraine also agrees in character with the Rügen moraine, but the latter is, in sharp contrast to that on Möen, unconformably deposited upon all the underlying strata which, on Rügen, were dislocated during the Interglacial Period — according to all more recent authors.

The greatly dislocated and piled-up White Chalk on Rügen opened many points of attack to the land ice during the deposition of the upper moraine. As a consequence thick chalk floes became embedded in it and these floes, which very decidedly characterise the features of Rügen, were during the advance from these areas to Möen transported by the ice. The chalk of course crumbled away during the transportation and only the flint which characterises the upper moraine remained in large quantities.

After what has been said in the foregoing it will be understood that the youngest moraine on Rügen forms the surface there. On Möen, where it was deposited conformably with the underlying Quartary deposits, it also formed the surface at first, so that the Möen high land at the end of the Ice Age was a chalk plateau, covered by all the deposits of the Quartary.

At this time the surface of the land was above the sea level, as is shown by bog holes in the upper moraine. Soon afterwards, however, began the disturbances which created the present Höje Möen, with its ridges and ravines, over which we will see that there is no continuous moraine cover as on Rügen.

Here we must restrict ourselves to saying that the great continuous, even and moraine-covered chalk bed was, through tensions in the earth's crust, split up into smaller floes which were so pushed out of their mutual positions

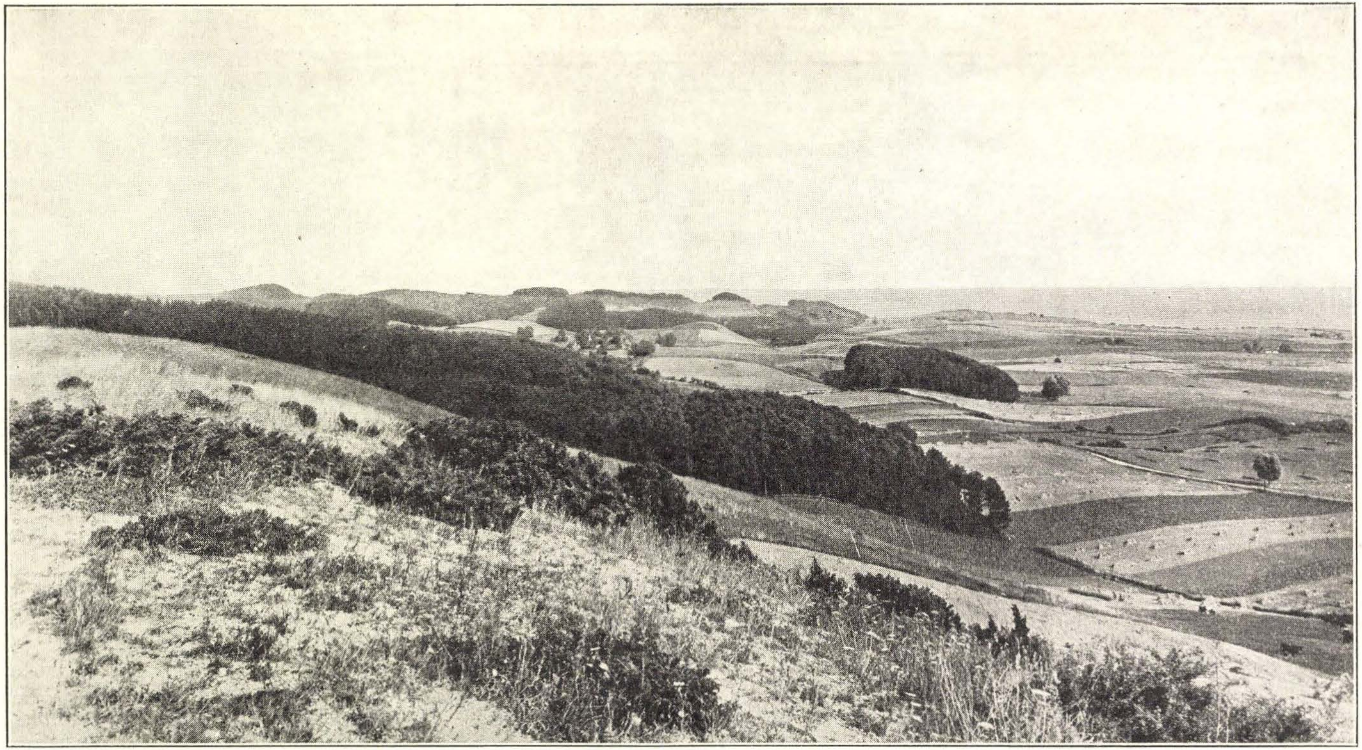


Fig. 8. View from Hövdbleg over the low country to the south, and the southern chalk cliffs whose contours can be seen on the left in the picture.

that one floe was overthrust upon the other. The once flat country was thereby changed from lowland to a very rugged high land, where only in the border zone is it possible to find even, low areas which might very well represent the former level condition.

In describing the road taken by the excursion it was mentioned that, by going straight out from Magleby, we would reach our headquarters, Hunosögaard. But instead of following that road we turn abruptly southwards at Magleby Church and along a slightly winding road through the village of Mandemarke south of Klinteskoven (the cliffwood), the hills of which rise on the left, whilst on the right there is a view over a low, to begin with rather rugged terrain to the Baltic. South of Hövdblege the party will leave the cars and proceed up the 120 m chalk hill which falls steeply away to the south. At the foot of the hill we have for the first time been able to see the White Chalk in a little chalk-pit. Apparently the top of Hövdblege is White Chalk too, but a closer examination shows that the chalk is mixed with a little Quartary material which permits the growth of *Juniperus communis*. As the name Hövdblege (The white bank at the edge of the wood) shows, it has formerly been timbered, and there is also evidence of this in numerous empty shells of *Helix nemoralis*, which do not thrive outside forest or thicket.

The view from Hövdbleg is splendid. The picture fig. 8 shows this view, which illustrates what was said on the other page that an even and low terrain passes into a very rugged highland, consisting of one chalk floe pushed up over the other. The low land is seen to the south, the high to the east, where the chalk cliffs form the boundary of Höje Möen towards the sea. Through the silhouette figures of the cliffs one dimly suspects that these are the thrusts of one floe over the other, and the hollows, which are seen between the single cliffs (and which we will learn to know as the steeply placed parts of the Quartary cover over the chalk, the so-called »falls«)

can be followed in the same directions some way into the country from the coast.

It will be seen — as the relief map[1]) also shows — that the direction of Hövdbleg is not the same as that of the coast-zone cliffs at this place. They each belong to systems with a different strike, where each system has arisen by continued pressures and the formation of »secondary« faults having the same direction, in those »primary floes«, in which the original, flat, Diluvial-covered chalk plateau became shattered by the tensions in the earth's crust referred to above. The cliffs of the coast zone at this spot thus belong to one primary floe, the Hövdbleg part to another, and between these runs the »primary fault line« which separates the floes and which on the whole follows the road that, from Bödkermose, continues southwards to the east of Busene Have.

We have mentioned that the original, extensive chalk surface was covered by Diluvial deposits. One should therefore expect that the south side and the top of Hövdblege, on which we still are, would be covered by such deposits. This is not the case however, and it might be thought that the theory that the chalk plateau had originally been uniformly and evenly covered with moraine must be wrong. In fact one might imagine on the contrary that the chalk had lain quite bare when the disturbances took place and that the Diluvial deposits, which from the vegetation we can judge must be present below Hövdblege and over the flat land, were not placed there until after the dislocations. By assuming that Hövdblege and the other high land had jutted up like a nunatak out of the ice, one would thus have an apparently plausible explanation of why the Diluvial deposits are missing from the top of Hövdblege; but gradually as we learn to know the terrain and the cliffs we will see that the dislocations are not intraglacial, as one might conclude from the theory of projecting nunataks, but that they are of postglacial age.

If one moves round a little on Hövdblege, and especially on its north side, where it is thrust up over other chalk

[1]) Will be distributed to the members of the excursion.

floes, one soon becomes convinced that ice can never have passed over this extremely rugged terrain, where there are not only pronounced valleys, but where these are in places further deepened by large, kettle-shaped hollows, the bottoms of some of which lie 39 m below the top of Hövdblege. At this spot the holes are always dry, despite the fact that they are run into from all sides, and this is not a phenomenon that is limited to this small part of Höje Möen, but is very generally spread. In contrast to the ordinary Danish use of the word »Hule« (cave), in the Möen dialect it is understood to mean a sinking of the terrain, i. e. more nearly corresponding to »Hul« (hole), and to this is often attached the word »Slumre«, which has nothing to do with sleep but means that the hole gulps down the water. It will be seen on the map that the name appears in many places within the cliff area.

These dry hollows have generally been called »subsidence hollows«, they having been thought to have appeared through elutriation and the subsequent collapse of the lime-charged substratum. As we shall see, this interpretation is erroneous, they having appeared either by floes, which have moved in rather different directions, having collided without being able to join closely together, or in the front edge of the advancing floe — which as we will repeatedly see may be regarded as a plane-iron — there has been a break which, at this spot between the otherwise closely packed flags, forms a fairly open connection with the underground and through which water can disappear without trace, only to appear elsewhere in the form of a spring[1]).

With this we leave the naked top of Hövdblege, to go out to the coast cliffs and there see whether, through them, we cannot get the theory that the high, naked hill was a nunatak either confirmed or dispersed. Today it is

---

[1]) It may in this connection also be observed that Höje Möen, owing to being built up for the most part of floes standing on edge and thickly interspersed with »subsidence holes« is so naturally drained that the surface water disappears practically where it falls, without forming watercourses.

not the intention to examine them from the sea side — this will be done the following day — but merely to study their surface along the cliff edge, of which there is a good opportunity by the most southerly cliffs, Söndre and Nordre Hundefangsklint.

This, however, requires some knowledge of them from the sea side, and therefore we must for the present obtain this knowledge from pictures of them. The picture fig. 9 shows a number of the south cliffs, all thrust over in directions from south and resting one upon the other, or ratheron the Diluvial cover of the northern cliff, seen like a sloping, dark stripe among the chalk cliffs where it partly fills up the intervals between them and forms the so-called »fall«.

Where the Diluvial of the falls has not been worn away to a greater or smaller extent as a result of the cliff being thrust over it from the south, it consists at the bottom of lower moraine, then interglacial deposits, and at the top upper moraine, on which the thrust has taken place. If no unconformable moraine, deposited after the dislocations, can be shown over the terrain, the date of the disturbances must consequently be placed to postglacial times, of which we shall receive decisive evidence from the bogs.

We now turn to a consideration of the most southerly cliff, Söndre Hundefangsklint, shown in fig. 10 and 11, and see that this, on the top of which we now stand, seen from the coast is covered with moraine in the left side of the picture (fig. 10), but that the Diluvial deposit thins off towards the top of the cliff, to disappear entirely to the north of it, (fig. 11) as here not only the Diluvial is missing but also a part of the uppermost stratum of the chalk. This, however, can only be seen out by the very edge of the cliff. We shall soon revert to the cause of this.

Corresponding features are present in the next cliff to the north, Fig. 12, Nordre Hundefangsklint; there Diluvial coverings are lacking at the top and north end but are present at the south end, where, following the southern slope of the curved cliff, they sink down to the coast and form the Hundefangs Fall (fig. 13). But in the upper part of

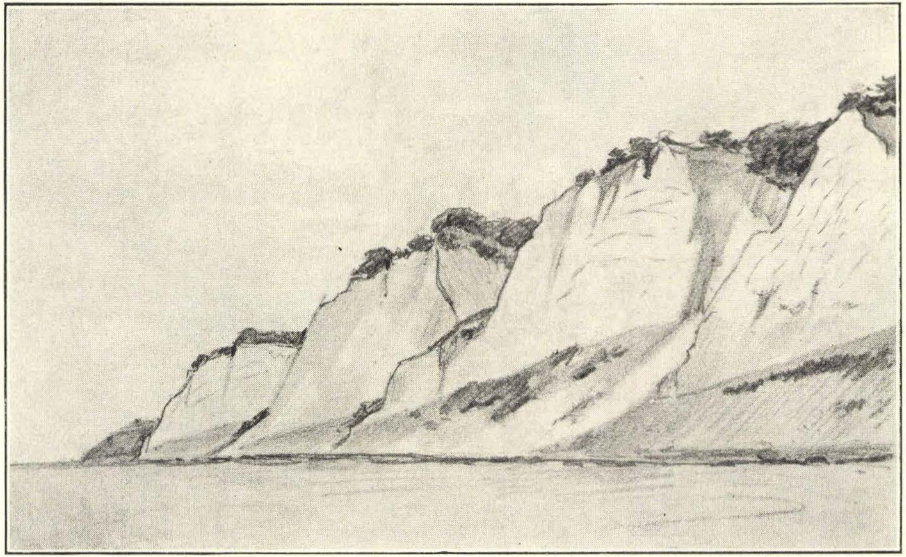


Fig. 9. View of some of the southern chalk cliffs, stretching from Söndre Hundefangsklint in the south, on the extreme left of the picture, to Store Stejlebjerg on the right. All the cliffs have been overthrust from the south so that they still rest upon the Diluvium of the more northern cliff — shown on the drawing as dark, oblique streaks between the chalk cliffs.

this we see that, across the various Diluvial strata of the fall (both the moraines with intermediate Interglacial) stretch foreign elements, among them chalk gravel, which usually, and it is to be hoped on this excursion too, can be shown to have been carried from the now naked chalk surface of the cliff and over the fall. At the top of the left side of fig. 13 can be seen a white chalk streak, which however has now presumably been replaced by others.

Thus both these cliffs (and also the following) show the same phenomenon as Hövdbleg, that the foremost part of the floes is very much abraded and, having learned to know the features at the coast cliffs, the theory of nunataks must be abandoned. The cause of the abrasion is quite a different one and rather strange, as we shall now see.

It has been stated that the whole of the Höje Möen region was originally a flat and extensive, moraine-covered chalk plateau, which was split up into floes which were thrust one over the other. But now the position is that the underside of one cliff, i. e. deep strata in the White Chalk, rests upon the moraine stratum of the northern, neighbouring cliff, so that to enable this to have happened there must have been a lifting of the southern cliff corresponding to the thickness of chalk floe plus Diluvium, which means about 80 m. As volcanic action has not been contributory to the dislocations, this can only be explained by the fact that the foremost end of the southern cliff has been pressed through the upper part, especially the Diluvial, of the northern cliff, before it could succeed in being thrust on over it. This, however, has abraded the fore end of the cliff and the material has been carried back over the more or less thickly moraine-covered part lying behind.

We have already said that this took place at the Hundefangs Fall, where it is easy to prove the truth of it, whereas the corresponding portion of Söndre Hundefangsklint is difficult of access. Nordre Hundefangsklint also shows that this abrasion cannot have taken place after the cliffs had received their present position and shape, and here one also looks in vain for a force which could

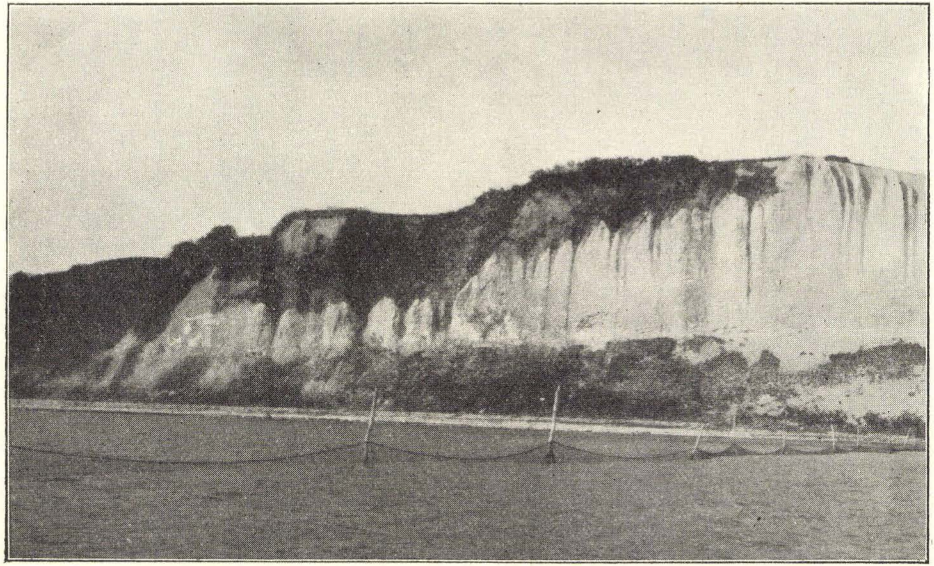


Fig. 10. The most southerly part of Söndre Hundefangsklint, where the Diluvium farthest to the left stretches right down to the beach whereas the remainder, gradually decreasing in thickness, covers the chalk in the other part of the cliff. On the extreme right is the naked chalk, with no covering whatever.

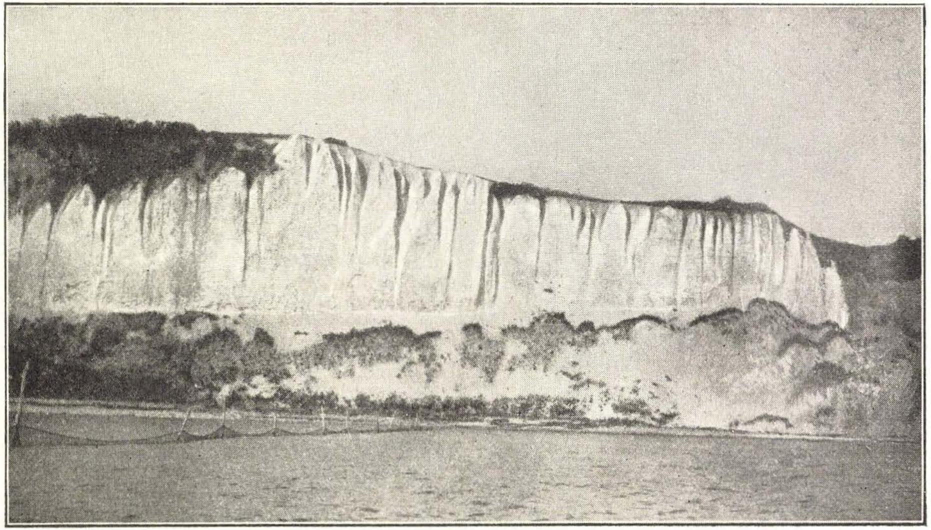


Fig. 11. The northern part of Söndre Hundefangsklint, with gradually thinning Quartary on the left of the picture and very abraded chalk on the right, whereby the surface has dipped to the north whereas the remainder of the cliff dips to the south. Figs. 10 and 13 to some extent overlap.

have made the abrasion. For the thought of ice-planing is out of the question, as it is only the northern end of the cliff that is abraded, and this lies protected by the higher cliff to the north, which is still the case within the whole region that has been thrust over from the south. Within the areas that are thrust over from the north the contrary is the case; there it is the southern ends that are bare, and there, too, they lie in shelter from any planing by ice which here would have had to be contrary to that at the southern cliffs. But the question is clearly and distinctly settled by the fact that the chalk masses in the top of the arch of Nordre Hundefangsklint are broken (fig. 11), and wedge-shaped cracks run down into the chalk. And, seen from the sea, one can observe that these cracks are empty and not infilled with foreign matter, which definitely shows that the abrasion has taken place before the cracks were formed.

It remains to mention the reason why it is only possible to observe the naked, uncovered chalk close to the edge of the cliff. The consistence of the mixed and kneaded material brought about by the abrasion is very incoherent, as we have an opportunity of observing for instance over the Hundefangs Fall, where in over the cliff it is of a nature like Loess. The wind is most powerful just at the cliff edge and, when heavy gales are blowing in dry periods, the earth is swept in from there over the country, where sometimes the drifting dust is of great inconvenience to the farmers.

After a close examination of the southern cliffs, we continue on foot northwards along the edge of the cliff, observing the regular hills and dales passed on the way. Having come into the wood Klinteskov a visit might be paid to the well-known tourist attractions: Graaryg, with vertical moraine remains on its south side, »Tragten« (the funnel) with sloping erosion planes, the Sommerspir area with peculiar arabesque-like figures on the south side under the spire. This vertical wall is an old, originally hori-

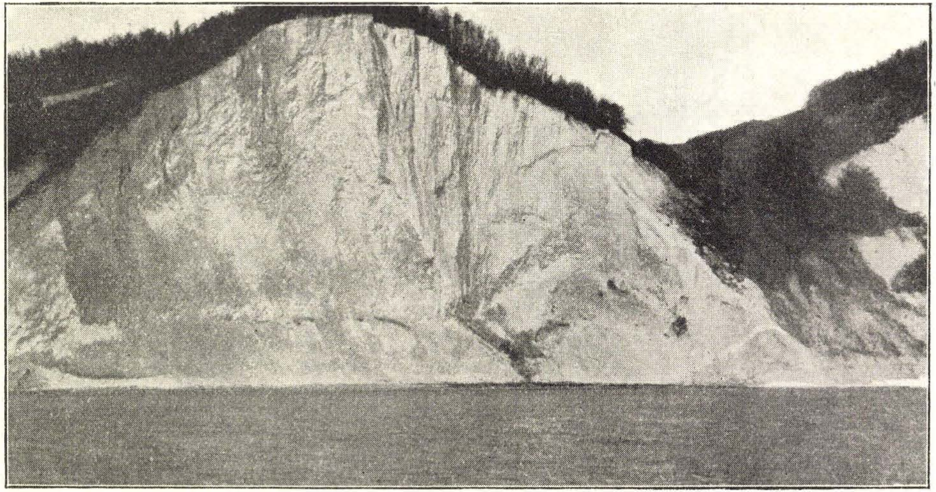


Fig. 12. The very arched chalk layers of Nordre Hundefangsklint, which are exposed at the surface without any Quartary covering. This covering, however, is to be seen in the southern part of the cliff (left edge of the picture), where it stretches down over the sloping cliff side and forms the Hundefangsfald. In the top of the cliff are to be seen some open fissures, the result of the arching of the cliff. They have no infilling whatever, as was proved by the fact that in the middle of May (1928) a number of jackdaws had nested in them in the interior of the cliff, which was then just like a fowling cliff.

zontal chalk surface, from which most of the moraine has crumbled away, leaving the erosion marks of small streams under the land ice visible as arabesques.

Through the characteristic valley »Nellerenden«, which is a continuation of a fall in the cliff and runs between high ridges, to Stengaarden, whence either afoot or by car to the headquarters, Hunosögaard. The road from Stengaarden to the place by the restaurant in the wood follows a primary fault line. On the way are also typical »subsidence holes«, and the features everywhere show that the terrain forms, with only that smoothing which the erosion of the air gives, have their original shapes and no ice-sheet has attempted to erase them.

Saturday, 23rd June.

Guide: V. HINTZE.

After breakfast, leave Hunosögaard by the same road along which the excursion arrived the previous evening, but this time going further on to the lighthouse close to the southeast point of the island, where the cars will be left. Proceeding along the edge of the even and comparatively low cliff (20 m) we walk northwards to Ørekulen, by an easy descent to the beach, which is fairly wide here and stony. Ørekulen forms the boundary between Gedebrink and Söndre Hundefangsklint. Above the sea-level the former consists exclusively of Diluvial deposits which are covered by grass vegetation; in the latter the chalk appears at the beach just north of Ørekulen and soon rises, together with its Quartary cover, up to 57 m; but as stated in the Guide for yesterday, the north end of the cliff is so abraded that even the chalk is to some extent removed. As long as the cliff is covered by Quartary we are able to observe that the flint beds, which mark the stratification of the chalk, lie like dark stripes conformably with the surface of the chalk and the underside of the Quartary; within the abraded part, however, we see the upper flint layer disappearing more and more,

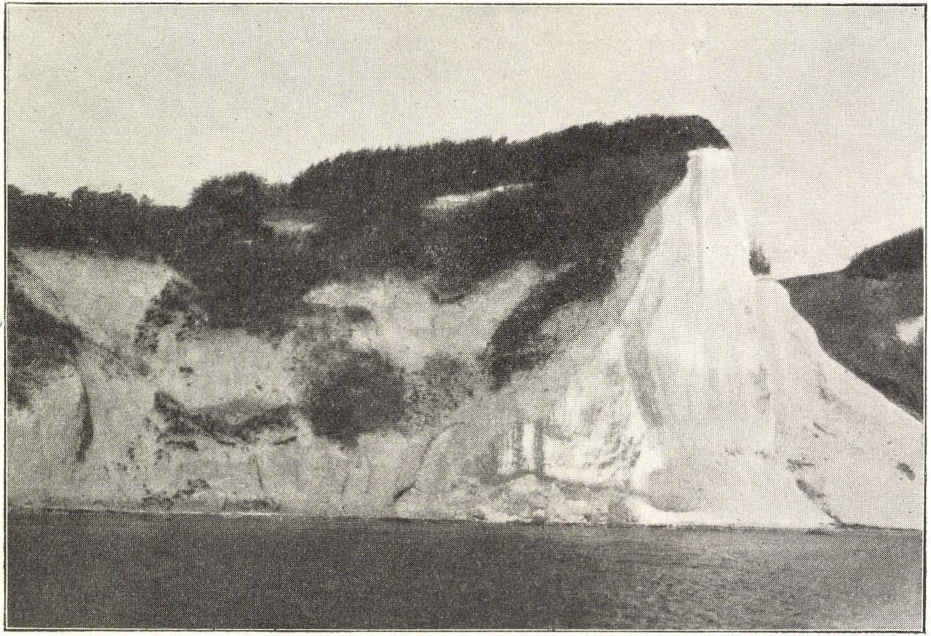


Fig. 13. The Hundefangsfald, photographed in 1925. At the top of the fall was the light streak seen in the middle of the picture, consisting of chalk fragments planed off the parts lying to the north. Now, in 1928, there have been big slides at the fall with the result that the Diluvium has to a great extent slipped out and exposed a high, vertical wall in the upper part of the fall, consisting exclusively of abraded material from the northern cliff.

showing that most of the abrasion has taken place at the north end of the cliff.

Whereas in the upper part of the cliff the chalk wall is vertical, at the foot of the cliff it passes into a sloping plane, apparently a talus. The talus gravel is, however, only a comparatively thin layer — although in places it is a metre thick — covering a sloping flat of solid chalk. It is the result of weathering and retreating. We call it the »the sloping flat«, and where it is more or less covered by chalk gravel mixed with nourishing substances, there may be some vegetation. This is particularly the case at the north end; but if we examine it more closely we will find that solid moraine-clay forms here the sloping flat which, inclining gradually, rises up over the shore line and on which the underside of the chalk-masses of the cliff rest.

Thus we have here the thrust plane between the chalk masses of Söndre Hundefangsklint and the Quartary cover of the cliff to the north of this, and we can directly trace the clay as being in connection with the clay masses which, north of the endwall of the chalk, fill the cleft (the fall) between this and Nordre Hundefangsklint. The fall itself, Hundefangsfaldet, is filled up by all the Quartary deposits which we meet with on Höje Möen. Farthest to the north, close up against the north cliff, we find the grey-blue lower moraine clay which is characterised by an almost total absence of flints. To the south of this we meet with marine fossiliferous sand and thin clay beds which, little by little, pass into thick deposits of stoneless clay, in colour very closely resembling the grey-blue lower moraine clay. In accession to this, we find towards the south the upper moraine clay, which is more yellowish-grey, rather sandy and with an extremely large content of flints.

It is this upper moraine clay which we see continuing in under the chalk-masses of the south cliff, which thus clearly proves itself to have been thrust over the upper moraine clay. It is not, however, upon its original surface that the chalk lies. Through the thrusting the chalk floe has been a good deal abraded on its underside, particularly at its foremost end which has travelled the longest distance (this is shown by the fact that the flint beds here do not follow the other stratification but dip forward towards the fore end of the cliff); and furthermore, in a similar manner the underlying clay, the moraine-clay, has been abraded so much that the chalk has forced its way comparatively deeply into it. Thus in front of the north wall of the cliff we see the clay-masses lying much higher than they do under the chalk cliff itself; only a small portion of this clay, however, is unaltered moraine clay, most of it being transformations of it.

It is easily comprehensible that if by the thrusting of two floes one over the other some of the mass is ground away, the loose material thus formed will be pressed forward like a rampart in front of the floe which is in motion. The longer the distance traversed the greater the heap of material must be, for the latter can only escape at the sides of the floe. In this respect one may regard the floe that is being thrust over as a plane which passes over the underlayer. To retain the simile it is natural to call this loose material »shavings«, a term which might just as well have been substituted with »tectonic moraine«, but which has purposely been avoided in order not to give an impression of the effects of ice. But just as happens to the iron of a plane when in use, when it chips or flakes, so with the »planing chalk floe«. We have already indicated something of the sort when referring to the »subsidence holes« at Hövdbleg, that they might be due to such chips in the edge of the floe which, of course, must have been subjected to great strain during its work.

If we observe the north end of the chalk wall of Söndre Hundefangsklint it will be seen that there are two small chalk pilasters, where the flint beds have quite another direction than in the main mass of the cliff itself, from which they are in fact separated by a slight interval. These chalk blocks are parts of the edge of the plane which have chipped off and, had the advance continued a little further, they would have been overturned, crushed and ground to pieces, mixed in with the other »shavings« material, whose high flint percentage, higher than that of the upper moraine clay, we can thus readily understand.

In many cases it is difficult to decide directly whether one has to deal with an upper moraine or with shavings. Here at the spot where we are at present there is, however, a good opportunity of ascertaining the difference; for by means of determining the proportion between flints and eruptives it would be found that, for the upper moraine lying below the chalk mass, the percentage is 1.4, whereas just outside the chalk wall it would be 2.52. Having regard to the manner in which the shavings have been produced, it will be clear that these may consist of a mixture of a little of everything and that as a rule they may be remarkable in that they contain small fragments of chalk in very large quantities. This latter feature in particular may under most conditions be regarded as a sign of »shavings«, which are of great practical as well as theoretical interest.

As a rule these can easily be proved by means of the metre-bore in places where they cannot be observed directly. In the cliff-profile itself it can be done very easily. But when it is remembered that the cliff-profile is merely an accidental section through the ridges of which Höje Möen is formed, it must be clear that the shavings cannot be restricted to the cliff itself but must be equally present further inland.

We saw that the shavings have been piled up at the fore end of the overthrusting cliff, and therefore the ascertaining of the shavings at the foot of the ridges further inland by means of the metre-bore gives us a means of establishing their direction of movement as they are shown on the accompanying relief map of a part of Höje Möen.

Of late years the beach below Möens Cliff has become extremely narrow, in fact in places it is entirely absent. At high water or with an east wind it may therefore be impossible to proceed along certain stretches and, if this misfortune should occur to the excursion, it will be necessary to return the same way as we came and thereafter to study the cliff at the places where it is possible to approach it.

Conditions will, it is hoped, permit of passing round Nordre Hundefangsklint in order to see its finely arched chalk and flint masses and see that this cliff, like the other cliffs, rests upon Quartary deposits. In the fall to the north of it, Fruerstuefaldet (Gyneceum-fall), are thick masses of extremely incoherent material thrust together, for the most part consisting of chalk — i. e. the shavings-heap of the cliff — pressed up against the next cliff, Hvidskud. In this cliff are several secondary overthrusts in the chalk masses themselves, produced by the pressure of the neighbouring cliff.

It is hoped that at this spot it will be possible to go out in boats so that there will be an opportunity of seeing from the sea the magnificent, almost vertical, profile in Stejlefald (Steep Fall), below which there is no beach at all. The profile consists of chalk, lower moraine clay, interglacial clay and sand, upper moraine clay, over which the chalk masses of the southern cliff are thrust. Up at the top of the cliff are very stony masses, shavings, which for the most part consist of glaciofluvial material which in places compensates the uppermost layer of the upper moraine.

On by boat past the cliffs to the north, their peculiarities being very prominent when viewed from the sea. Thus the Sommerspir (Summer Spire) section will be observed, where the flint layers stand vertically in the lower part of the cliff, whereas the Sommerspir itself, an isolated cone of chalk and a remnant of an overthrust mass of chalk, exhibits the flint layers in a horizontal position.

Opposite Maglevandsfald (Big Water Fall) we will try to get in upon the narrow beach. This is the north end of the southern cliff area, that with which we have so far been dealing, where all the cliffs have been thrust up from the south (fig. 9). Here we are for the first time faced by overthrusts from the opposite direction, coming from the north (fig. 14), and just by the beach the collision of the two systems can be shown. The thrust from the north can be traced below the high bottom of the Maglevand valley and along under the 128 m high chalk-massif Dronningestolen (Queen's Chair).

The Dronningestolen is not a massif in the proper sense of the word, as it is built up of chalk floe over chalk floe, all of which have been overthrust from the north, i. e. in the opposite direction to the movement of the south cliffs. Seen from the sea one might get the impression that an unconformable moraine stretches above the various floes of the Dronningestol section. Had we an opportunity of going further into this we would find that the overlying layer does consist of moraine in places where it forms the termination of an overthrust chalk floe, but that the cover which stretches over all the floes is of Aeolian nature and consists of material which, owing to strong wind pressure upon the vertical cliff wall, has been carried up over it. Thus for the great part it is mould, clay and sand mixed with numerous small, sharp-edged pieces of chalk which, by their form, are distinguished from the rounded form of the shavings.

As the map shows, all the following cliffs belong to a system from the north, but with some change in the directions. On this stretch notice should be taken of the wide, Quartary-filled falls which separate the various chalk sections and which for the most part have been left bare by slides, whereas formerly they bore a luxuriant beech vegetation.

At Sandskredsfald (Sand-slide Fall) the chalk disappears and the stretch north of it as far as Nylandsnakke consists of naked bluffs of sand and clay and also of tree-grown slopes. Although it has not yet been possible to prove it definitely, it may be said that the chalk does not escape observation here by lying below the sea-level, but that the slopes and bluffs before us are Quartary deposits resting upon a chalk floe thrust up from the east and thus belonging to a third system with which we have so far not made any acquaintance.

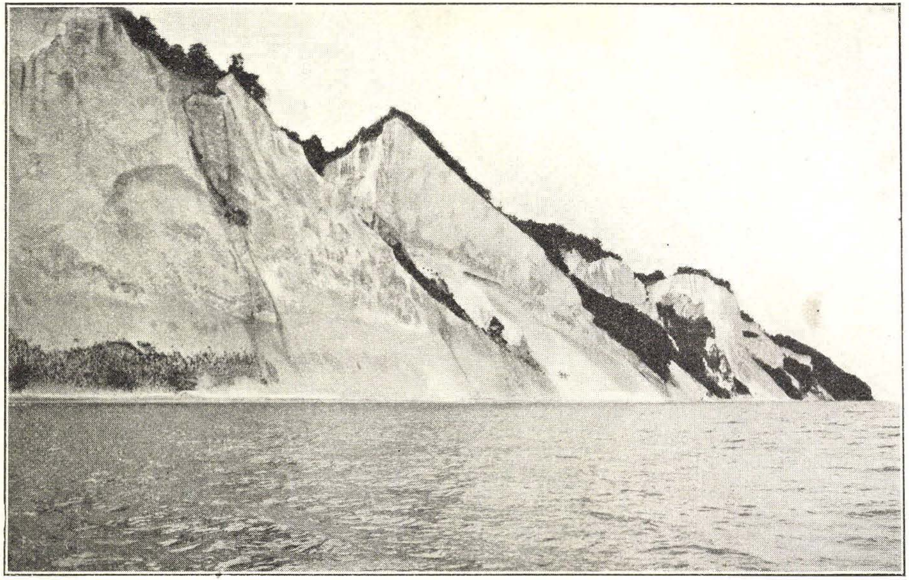


Fig. 14. On the left of the picture is Forchhammers Pynt, forming the north end of the Dronningstolen, and thereafter the cliffs to the north of it, all of which — in contrast to what is shown by fig. 9 — overthrust from the north, the point of collision between the two overthrust-directions being at Maglevandsfald. This will be clearly seen on the excursion as there have recently — while this Guide has been in the press — been great changes here.

At Nylundsnakke and Hyldedalsklinter (Elder-dale Cliffs) the chalk again becomes visible up to great heights, belonging to a system which originates from the south-east. In direct connection with this we come to the handsome Talerklinter (Speaker Cliffs) consisting of floes thrust up from the north but with other directions than those hitherto seen. At Jydelejeslugt, north of which we see the imposing chalk masses of the Slotsgavle, we go ashore and continue through the ravine up to the top of the cliff and, through pretty hill country (the map gives the necessary information of the overthrust directions of these), we arrive through the Jydeleje district to Hunosögaard, where lunch awaits us.

It is difficult to draw up any fixed programme for the afternoon, as everything greatly depends upon how the forenoon programme has been carried through. Thus the excursion may either go through Jydeleje to the beach in order to learn to know the sections of the northern cliffs, or follow a part of the cliff-stretch along its top edge and thereafter turn inwards through the very rugged terrain of the woods, so that there will be an opportunity for the excursion to see for itself the agreement between the fault lines and direction lines of the terrain and those of the relief map. There will also be an opportunity of observing accumulations of shavings along the fore ends of the ridges as well as the abrading of the surfaces of the floes at their foremost edges, as a consequence of which the naked chalk sometimes is visible on the one side of the hills whereas the other side bears a thick cover of the deposits of the Ice Age.

The treatment meted out to the ridges when the overthrusts took place has also left other traces on their surfaces. The planing-off has had the effect that there are only very few, or no large stones on the surfaces of the fronts of the ridges, whereas in many places there are large numbers of them on the back, where they lie untouched, cemented into the moraine clay. The big boulders are, however, mostly to be found in the shavings at the foot of the ridges; only in few places, however, are they still preserved in their entirety as they have mostly been utilised for building the stone fences in the woods or as building stones.

In the terrain here and there »subsidence holes«, large and small, will be seen; as already observed, »chips in the plane« have prevented complete continuity everywhere between the ridges during the overthrustings. These round or elongated, deep hollows, which stretch down into the Quartary deposits (some of which are gravel and sand deposits) lying between the floes present particularly favourable opportunities for the surface water to disappear into the depths below, so that the holes can remain quite dry, even though they may drain very wide areas, as for instance is the case as regards the »subsidence hole« »Kælderen« (the Cellar). As has already been stated, the water has every possibility of getting away through the ravines between the ridges, and this is the reason why Höje Möen, despite the very rugged terrain, does not contain a single natural watercourse except those fed by springs.

The »subsidence holes« are connected with fault lines and have, besides through »chips in the plane«, also appeared in cuttings between these fault lines; such »subsidence holes« are as a rule much bigger than the former kind. Vildmandsti-Hule (Wild-Man's Path Cave) may be mentioned as an example. If in addition they are particularly deep so that there is easy access to the underground, they sometimes act as indicators of rainy and bad weather to come; when the barometer falls heavily and quickly — so that the fall has not yet reached the deeper strata — such quantities of moist air are emitted that it shows above the top of the woods like a column of smoke. This phenomenon is particularly attached to that part of the forest that is known as »Bjergene« (the Mountains) and, in this area, especially so to the big »subsidence hole« »Køkkenet« (the Kitchen), although it has not been possible to definitely trace it to this hole. Among the people it is said that »it is smoking in the mountains«, and this is taken to be a weather sign.

At times the open connection with the underground may be choked up. In such cases the »subsidence hole«, as long as this lasts, becomes a lake. This may happen even in dry periods, as is the case for instance with »Staklesö«, in the Jydeleje district. If this choking lasts, the lake may become a bog, and there are many of this kind here and there in the terrain. These bogs, whose basins were first made by the dislocations, naturally retain in the peat only the remains of the plants which were growing on the spot at the time, or after, the disturbances took place. The cliff profiles have shown that the overthrusts are of postglacial age, but we have not by this means been able to arrive at a more definite date. Now the bogs offer us an opportunity, as we find that the oldest strata in them originate from the time of the Pine-Forest or from the Oak Mixed Forest (boreal and early atlantic time); from this, however, we do not derive any certainty that the disturbances are not older, as conditions may have been that the formation of the bogs commenced later than the completion of the terrain disturbances.

Besides this type of bog there is another, which has already been present as such before the time of the cliff disturbances, and thus with its peat layers has been involved in the overthrusting of the fioes. The moor specialist, Dr. Knud Jessen, has kindly undertaken an investigation of a large number of the bogs and, by means of borings, shown that the contents of some of these bogs extend right down to lateglacial times. By laying boring-sections across these bogs it appeared that at the top they consisted of normally deposited, undisturbed peat formations from the time of the Pine Forest or from the Oak Mixed Forest, but that under these there were sloping lateglacial strata, the stratigraphical position of which showed that they must have been deposited at the time when the Möen area was a smooth chalk plateau and that they were only brought out of their normal positions later on. Dr. Jessen therefore is of the opinion that the movements — which perhaps may be placed in connection with the formation of the cliff — may on this basis be placed to the Lateglacial Period.

It may be added to Dr. JESSEN's pronouncement that the conditions in the cliff-section, where it can be seen that the chalk floes are thrust over the upper moraine, show that the dislocations cannot be of glacial age. The regular stratigraphical position in the postglacial bogs shows that the dislocations must be older than the oldest deposits in these bogs (Fir Period) and thus the time of the dislocations in the Möen highland is limited to the Lateglacial Period.

This conclusion was in decided contrast to what I believed was possible to determine from the cliff profiles themselves, where in several places I had an opportunity of discovering large beech trunks which were buried under chalk floes in no way due to later falls, but overthrust or folded portions which in late oak mixed forest times had buried the straight, well-grown trunks and, by means of the moisture of the earth, had preserved them perfectly until the present day. These observations have, however, proved to be correct, as in several places in the cliff-forest, Øster Vandsvalebanke (Waterswallow Hill) og Fattigbanke (Poor Hill), it has been possible to prove that much later movements of the earth's crust have taken place. At the first-named place the conditions are particularly clear. When the ridge was subjected to the thrust from the north, large masses of shavings accumulated at its south end, principally composed of chalk. Over both the chalk mass and the shavings there have later been deposited fairly thick layers of mould, the deposition of which must have extended through long periods from lateglacial times, from which the shavings date, and onwards. A closer examination at this spot has shown, however, that besides these old shavings there are some that are much younger, originating from a movement of such recent date that the younger shavings have been thrust over the mould deposit, whose low content of fossils points to the period of the foliferous forest. It is thus clear that, apart from the older and violent thrusts in lateglacial time, much more recent but less vigorous thrusts took place.

The result of these dislocations was that the terrain, from being flat and passable, was changed into the extremely rugged terrain we now know, with high ridges and deep ravines, except that then they were much more sharply outlined than now where wind and weather have rounded them through the ages. Here and there in the woods on this peculiar terrain we find a number of tumuli which, at any rate those examined, prove to belong to the Bronze or the Iron Age. Stone Age tumuli have not been discovered here, so that we may conclude from this that Neolithic Stone Age people have not lived at this place, a circumstance which may naturally be placed in connection with the difficult terrain and without doubt also with the superstition which must have been attached to the great natural events.

On the other hand we find, here and there outside the rugged Höje Möen terrain, tumuli of the Neolithic Stone Age as well as of the Bronze and Iron Ages all mixed up together. Just east of Sömarke and on Sydlandet close to Bandhöjgaard, standing like far advanced outposts in front of the other Stone Age tumuli, are fine cairns, both standing on the outer slopes of the very rugged area, over which the Stone Age people were able to move about easily.

After dinner at Hunosögaard one ought to go up to one of the high points which offer a good view over the country, in order to see the many Midsummer bonfires which will certainly be lighted everywhere.

Sunday, 24th June.

Guides: V. HINTZE[1]) and KNUD JESSEN[2]).

Before leaving Hunosögaard by car for Sværdborg, the forenoon may be spent more in accordance with the individual wishes of the members of the excursion, either collecting fossils in the chalk, studying the terrain forms in the various places, or devoting the time more to the aesthetics of the chalk cliff itself.

---

[1]) Author of the Guide for Möen.

[2]) Author of the Guide for Sværdborg.

From Hunosögaard over Koster, Kallehave and Vordingborg to Sværdborg.

In **Sværdborg** Bog[1]) the National Museum has excavated an extensive Epipaleolithic culture-layer which, together with the contemporary culture-layers in Maglemose (ɔ: the Big Bog) at Mullerup, north of Slagelse and in Holmegaard's Bog north of Næstved, provide the most important evidence of the earliest actual settlement of a hunting and fishing population in Denmark.

This Mullerup or Maglemose Culture, in contrast to the Campignien Culture of the kitchen middens, is characterised by the large number of implements of bone and antler (harpoon heads, axe-heads) in comparison with the flint implements which are not so numerously represented, although the microlithic technique is highly developed. Pottery is unknown. The dog is the only domestic animal.

The settlement in Sværdborg Bog lies a few hundred metres from the southeastern side of the bog. The section of the strata of the bog at the spot was:

A. 0—0.15 m. Soil.

B. 0.15—0.62 m. Dark-brown alder-peat. Trunks, branches, stumps and other remains of *Alnus glutinosa* were common. In the lowest part of the stratum were scattered remains of *Phragmites communis*.

C. 0.62—0.75 m. Dark-brown, greatly humified Caricetum peat, in which were found numerous remains of *Cladium mariscus* and *Phragmites communis*, also *Coronaria flos cuculi*, etc. The culture-layer was found in this horizon.

D. 0.75—0.78 m. Light-grey snail mud. Numerous shells of *Bithynia tentaculata*, *Valvata cristata*, *Planorbis stroemi* and of *Planorbis corneus*, the oldest find so far made in Denmark

---

[1]) K. Friis Johansen avec la collaboration de Knud Jessen et de Herluf Winge: Une station du plus ancien âge de la pierre dans la tourbière de Sværdborg. Mém. de la Soc. Roy. des Antqu. du Nord. 1918—1919. Copenhague.

	of this southern species. Branches of *Pinus silvestris,* etc.
E. 0.78—0.81 m.	Brownish-green elastic mud with seeds of water plants, i. a. of *Najas marina,* the oldest find so far made of this thermophile species in Denmark.
	In places the snail mud sometimes underlies the brown mud.
F.	Glaciofluvial sand with large stones.

The section shows that we are in the border-zone of the former lake, the deepest parts of which were to the west, north and northeast of the settlement. The latter was placed on a low, meadow-like stretch which extended in the form of a tongue into the lake towards the northwest. As has been stated, the culture-layer was found in stratum C, the Caricetum peat, the composition of which shows that the settlement has been flooded by the highwater of the lake in winter. The culture layer is from a summer settlement here, as in the case of that in Holme gaard's Bog.

With regard to determining the geological date of the settlement the culture-layer's content of remains of forest trees is the deciding factor. In 44 fields of a metre square, wood and charcoal were distributed as follows: *Pinus* was found in 32 of them (68 per cent), *Corylus* in 6 (13 per cent), *Alnus* in 4 (9 per cent), *Betula* in 3 (6 per cent), *Ulmus* in 2 (4 per cent), and, finally, indeterminable remains — undoubtedly mostly *Alnus* — in 4 fields. That *Pinus* formed a principal constituent of the forest which covered the surrounding hills is also shown by the pollen spectra from the culture layer:

Analysed samples from	No.	*Salix*	*Betula*	*Pinus*	*Alnus*	*Quercus* + *Ulmus* + *Tilia*	*Corylus*	*Quercus* + *Ulmus* + *Tilia*: *Pinus*
Middle of culture-layer . . .	1	1	31	44	14	11	22	0.26
Lower edge of culture-layer	2	1	56	39	1	3	9	0.10

Such »Mullerup spectra«, in which the proportion oak mixed forest: fir has values lying between 0.1 and 0.5, have also been found in the other Sjælland Mullerup Culture-layers. By the help of pollen analyses it is therefore possible to follow the Mullerup horizon through other East-Danish bogs. They show that the Mullerup deposits are older than the submarine bogs in the Sound, that is to say older than the formation of the Sound, and they make it probable that the forest floor with fir stumps at depths up to 40 m in the Baltic are almost contemporary with the Mullerup Culture-layers.

The Epipaleolithic Culture-layers of the Mullerup period thus belong to the Continental Period, or, classified according to the forest periods, they belong to the latest part of the Fir Period, when the species of the oak mixed forest were beginning to make their appearance.

The many bones which were found in the culture deposit were of urus, elk, stag, roe-deer, wild boar and many other animals. The mud-tortoise *(Emys orbicularis)* is also found in it. The presence of this animal here in company with *Planorbis corneus* and *Najas marina* makes it probable that the summer temperature at that time was at least as high as in Denmark nowadays.

The urus, the elk, the wild boar and the mud-tortoise are now extinct in Denmark.

From Sværdborg direct to Copenhagen.

Danmarks geologiske Undersøgelse.

The International Meeting of Geologists in Copenhagen 1928.

Excursion C.

GUIDE

FOR THE EXCURSIONS IN DENMARK

NORTHWEST SJÆLLAND, FYN, LANGELAND AND JYLLAND

KÖBENHAVN
NIELSEN & LYDICHE (AXEL SIMMELKIÆR)
1928

The Excursion after the Meeting.

Excursion C.

Northwest Sjælland, Fyn, Langeland and Jylland.

29th June—9th July 1928.

Friday, 29th June.

Guide: V. Milthers.

From Copenhagen via Roskilde and Holbæk to **Odsherred.**

The prominent marginal moraine bows which border the indentations of the Isefjord to the west, mark a stationary line of the edge of the inland ice during its retreat from the northwest part of Sjælland. From the central depression of Isefjord the inland ice, which came from the east, pushed out tongues in all the branches of the fjord towards the west: Nyköbing Bugt, Sidingefjord, Lammefjord and adjoining lowland south of Lammefjord. Each of these small central depressions is surrounded by a rugged ridge with a stretch of marginal moraine hills before it (see map[1]) and fig. 1). In front of these lie more or less well-developed sandy plains (heath plains).

With the continuation of the melting of the inland ice away from the moraine flat south of Lammefjord, there appeared peculiar forms of hat-shaped hills with inclined beds of sand and gravel, overlain by the moraine clay of the moraine flat.

---

[1]) Generalstabens Kort over Danmark (General Staff map of Denmark), 1:160,000 i Farvetryk med Højdekurver (in colours with contours). Sheet 19. Also see: D. G. U. I. Række. Nr. 8. Description of the geological map-sheets Sejrö, Nykjöbing, Kalundborg and Holbæk. (Text in Danish, Résumé en français) 1900.

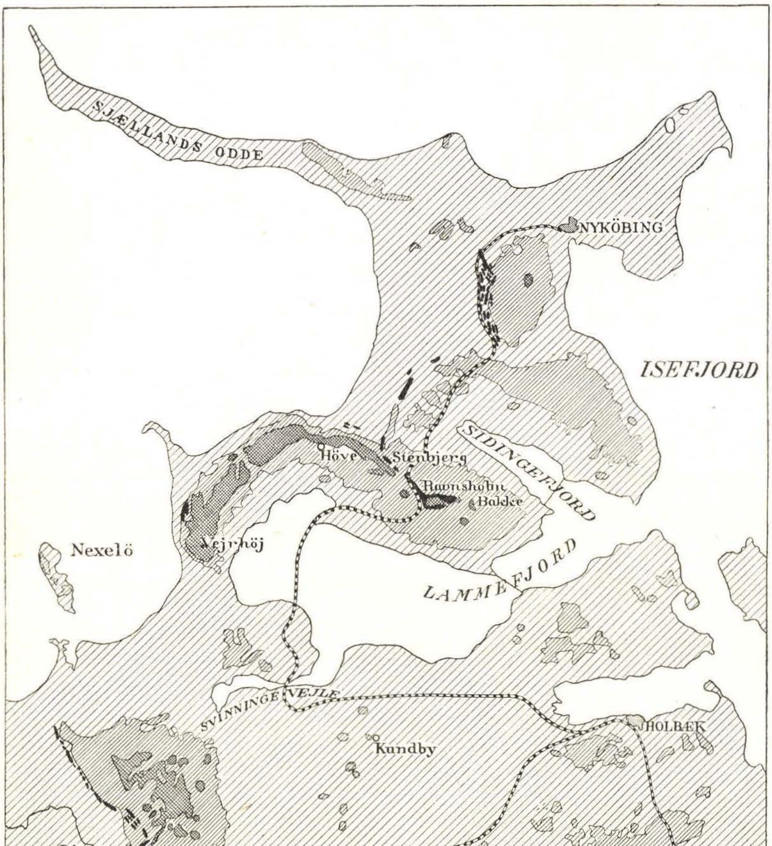
In the postglacial Continental Period, when the whole region lay above the sea-level, peat deposits were formed in the deeper parts of the present sea area along the coast and also of the now reclaimed Lammefjord. The upheaval of the land in the Continental Period was succeeded by the submergence in the Litorina Period to greater depths than the present level of the country. This caused not only the indentations of the present Isefjord and Cattegat, but the Odsherred area was for the most part restricted to the moraine bows and ridges referred to, besides some smaller islands and islets in the most northerly part of the area. To the south this ragged peninsula was only connected with the mainland by a very narrow ridge west of Lammefjord (east of Dragsholm).

From Holbæk the route today — over the peninsula between Holbæk Fjord and **Lammefjord** — follows the boundary between the hilly landscape on Tudse Næs and the moraine flat south of the reclaimed Lammefjord, which it passes over the embankment, constructed before reclamation, out towards Isefjord.

After having passed a part of the ground-moraine landscape between the two central depressions: Lammefjord and Sidingefjord, we arrive at the interlobate moraine of the corresponding ice-lobes south of Sneglerup, which can be followed for three or four kilometres to the northwest; on towards the northwest, via Stenbjerg to **Höve,** the route follows the big ridge of the Vejrhöj moraine bow, which divides the central depression Lammefjord from the sea-covered heath plain in Sejrö Bugt lying in front of the moraine bow. From Maglehöj, $1^1/_2$ km east of Höve, and from Esterhöj at Höve, there are instructive views over the moraine bow and the surrounding landscape.

From Höve to Asnæs over the ground-moraine landscape towards the central depression.

From Asnæs to Faarevejle again over the reclaimed Lammefjord, with occurrences of shell deposits from the period of the Litorina (Tapes) submergence, with *Ostrea, Tapes, Cardium, Mytilus, Litorina* etc.



0—30 m 30—60 m above 60 m Marginal moraines

Fig. 1. Contour-map of Northwest Sjælland. Scale: about 1:350.000.

On from Faarevejle to **Vejrhöj** (121 m), from where there is a view over the southern end of the moraine bow and the marginal moraine ridges, »Bjergene«, in front of it. From here there is also a view over the more westerly, fragmentary moraine bow to which Ordrup Næs and Nexelø belong.

From Vejrhöj, to the southeast beyond the moraine flat south of Lammefjord. East of the manor-farm Dragsholm is the narrow portage which, in the Litorina Period, connected Odsherred peninsula with the land to the south. A little further south we pass the entrance to an innermost, dried-up cove of Lammefjord, Svinningevejle, which, like Lammefjord, is rich in mollusc shells of the Litorina Period.

In the district between Kundby and Stifts Bjergby the route passes a large number of the hat-shaped hills with vertical beds of sand and gravel. The gravel beds are overlain by moraine clay; several of the hills between Kundby and Bjergby present crag-and-tail phenomena, stretching NE—SW, and one hill, Drusebjerg, east of Svinninge Gaard, has a drumlin form stretching E—W.

West of Jyderup is a hilly ground-moraine landscape which forms the continuation of the moraine bows north of Lammefjord; on its west side are fine marginal moraines at Davrup and at **Bjergsted.** The marginal moraine stretches towards the NW, towards Alleshave, and towards the SE, past Holmstrup and Bromölle and onwards to the east, north about the great bog Aamose; its westerly side is passed at the end of the day on the way from Jyderup to Slagelse and Korsör[1]). Just before coming to Korsör there are some transverse hills formed during the Langeland Advance, or what De Geer calls the Gothiglacial Phase. In Korsör the excursion boards the steamferry which brings us over the Great Belt to Nyborg.

The Great Belt only became a sea through the Litorina submergence about 7000 years ago. Before that it was a valley, through which ran a river, one of the outlets of the freshwater Ancylus Sea of that time in the Baltic basin. South Denmark then lay about 40 m higher than it does now. In the deep channel of the Great Belt there

---

[1]) If time permit there will be paid a visit to the brickworks' pit at Ruds Vedby (ice-lake clay and Dryas Clay with Alleröd mud).

are hollows. About midway between Korsör and Sprogö the ferry passes over one of these, which is about 58 m deep.

The Island of Sprogö, which can be seen from the ferry, is a transverse hill in the Langeland or Gothiglacial ice-edge line which, on Sprogö turns off in a southerly direction and reaches the west coast of Langeland via the Island of Vresen and the shoals south of it (see Summary of The Geology of Denmark p. 118 and the map Plate II).

The ferry passes close by the south end of Knudshoved peninsula and continues NW through Nyborg Fjord to Nyborg.

Knudshoved peninsula, which bounds Nyborg Fjord on the east, consists along the east shore of a system of big raised beaches from the Litorina Period; their maximum height is 3.2 m. Inside these beaches are low shore plains. Some islands of moraine clay, of which that farthest to the SE, Knudshoved, forms the most easterly projection of the peninsula, have supplied some of the material for the formation of these beaches. Along by the south shore of the peninsula from Knudshoved runs a low raised beach which forms the south-west corner of the peninsula, turning in a northerly direction and thus forming a small bay, Slipshavn. From the west coast of Nyborg Fjord Holckenhavn Fjord runs into the land.

The excursion will spend the night in **Nyborg.**

Saturday, 30th June.

Guides: Victor Madsen and V. Nordmann.

The highroad from Nyborg to Kerteminde runs over a moraine flat, passing several transverse hills[1]) of which the largest is Skalkebjerg, 380 m long, 300 m broad and rising 44 m above sea-level and 20 m above the terrain.

[1]) Se D. G. U. I. Række. Nr. 9. Victor Madsen: Beskrivelse til det geologiske Kortblad Nyborg. Avec résumé en français: Notice explicative de la feuille (géologique) de Nyborg. 1902.

After having passed the streamlet Kavslund Aa, the road runs close to the coast. A halt will be made at **Lundsgaards Klint,** which is ordinarily called simply »Klinten« (the Cliff). In it the middle subdivision of the Selandian, the Middle Paleocene Kerteminde Clay, appears on a stretch of a kilometre from 650 m NE of the NE edge of the forest Storskov to 350 m SE of the edge. It rises to a height of 10.7 m above sea-level and is overlain by moraine clay up to 11.9 m thick. In some places the moraine clay is separated from the Kerteminde Clay by relatively thick beds of glaciofluvial sand and gravel.

The Kerteminde Clay (see Summary of The Geology of Denmark p. 70) is a grey marl, almost devoid of sand, with a lime content of about 50 per cent. It contains subordinate, hornstony beds, for instance in the lower part of the cliff at Lundsgaard. Very often one meets with Foraminifera shells and sponge spicules as well as diatoms; the shells of the latter have been turned into pyrites. Bigger fossils are rare. The most important are *Lima testis* GRÖNW. (= *L. Geinitzi* v. HAG) and *Pecten sericeus*. In the Kerteminde Clay at Rugaard, in Jylland, there have also been found *Discohelix Pingelii* and *Fusus cimbricus*. The fossils are most easily found in the pebbles of the hornstony beds.

From Lundsgaards Klint on to Kerteminde. Just before reaching the town the road passes over the »Fedet«, which is formed of raised beaches attaining a height of about 2 m, after which Kerteminde Fjord is passed over a bridge.

From Kerteminde by the high road to Odense. The surface is of moraine clay, but very soon the terrain forms reveal that we are at a stationary line of an ice-edge (the boundary in this district of the Belt Advance). Here we make a halt for the purpose of ascending the Loddenhöj (58 m) which is famed for its view, and from which a good survey of the terrain forms can be obtained: the stationary line of the ice-edge appears, surrounding the bay **Kertinge Nor** which occupies its central depression. A halt will be made at Munkebo to see the traces of a subglacial stream's mouth. In this is a small feeding esker, in continuation of which a small heath plain, deposited by the glacier stream, stretches to the 251 ha Virö embankment which, prior to 1874, was a part of Odense Fjord.

A little way in front of the streamlet Gelsaa we arrive upon the largest heath plain on Fyn, deposited outside the ice-edge during the Belt Advance; here it has a breadth of about 5 km and extends to the west to Odense Aa. The heath plain was, for the most part, formed by the meltwater which streamed out from the ice-edge between the bogs Brabæk Mose and Urupdam, where there is a feeding esker, the Urup Aas, $1^1/_2$ km long but now almost dug away. (Time will not permit of a visit to this, however). The heath plain here, between Davinde, Vejrup Gaard, Birkinde, Bremer Skov and Röjrup, occupies a total area of about 16 sq. km. From this area the heath plain stretches NW to Odense Fjord in the form of several long, narrow sand stretches between long, narrow, low moraine clay ridges, but they again unite in the vicinity of Odense Fjord, where they are passed by the excursion. When this district was geologically mapped about thirty years ago, parts of the heath plain still lay uncultivated, covered with heather.

Two kilometres N of Aasum we leave the heath plain and enter a moraine flat. Between Marslev and Langeskov we pass the joint area of the heath plain previously mentioned, after which the road again runs over a moraine flat to Nyborg.

After lunch, to the south over a uniform moraine clay terrain by the high road to Hesselager, where a halt will be made to see the largest erratic boulder in Denmark, the **Damesten.** It consists of light, reddish-grey granite. On approaching it from the SW, it does not appear to be very large, as it only rises $1^1/_2$ m above the surrounding terrain. Seen from the opposite side, however, an impression is gained of its astonishing size, as it forms one side of a big excavation which was made in the beginning of the 1840's at the command of King CHRISTIAN VIII. The excavation has been carried down rather below the depth at which the stone has its greatest breadth; the lowest point of the stone was not reached. Between the bottom of the excavation and the top of the stone the measurement is 9.8 m. The circumference at the widest part is 45.8 m. The stone lies in moraine clay. Its upper part has the shape of a roche moutonnée with pronounced up-stream and down-stream sides. There are glacial striae especially on its NNE side. The direction of the striae on the back of the stone is S 83^0—44^0 E, average S 63^0 E.

Continuing from Hesselager, still over a uniform moraine clay terrain, to the once ice-dammed lake at **Stenstrup.**

The gently undulating plain surrounding the village Stenstrup, 11 km NW of Svendborg, is about 7 km long from W to E and about 5 km from N to S. To the NE, E and S it is surrounded by hills, whilst to the W and NW it slopes down towards the lower country round the river Hundstrup Aa and the tributaries of Odense Aa. The surface consists of stoneless, horizontally stratified clay, which is extensively used in the brick-making industry and which by its content of land and freshwater plants and shells of freshwater molluscs shows that it must have been deposited in a lake. As, however, the territory of this lake is now lacking a natural boundary to the W and NW, and as it has been impossible for the lake to exist and for the clay to have been deposited without such a boundary, it must have been the inland ice that once constituted the western and northwestern shores of the lake. The plain is highest in the wider, eastern part, 57—72 m above sea-level, whilst its surface in the narrower, western part lies only 53—61 m above sea-level. In the years from 1900 to 1903 several of the brickworks' pits in the eastern part displayed the following section: At the bottom, stratified, freshwater clay and thin layers of sand resting on moraine clay and containing in its upper parts remains of arctic plants and molluscs; on top of that up to 0.4 m of rich layers of freshwater mud and calcareous mud, appearing in the form of flat, inverted arches and containing subarctic plants and temperate molluscs, and, on top of that again, freshwater clay containing arctic plants. Exactly similar conditions were found in 1922 along the streamlet Hörup Aa in the low, western part of the lake. These mud and calcareous deposits, with remains of more thermophile plants and animals, must on the whole be contemporaneous with the other deposits of similar nature which have been found in several places in Denmark, Holstein and Scania and which were formed during the lateglacial oscillation of climate which is called the Alleröd Oscillation (see Summary of The Geology of Denmark pp. 121 and 133).

The development of this ice-dammed lake has proceeded in the following manner: When the inland ice at the close of the Last Glacial Period melted away from South Fyn and the high hills to the east and south of Stenstrup became free of ice, there was formed between these and the retreating tongue of ice, which covered the low country towards the NW, an ice-dammed lake, on the bottom of which unfossiliferous varved clay was deposited. During its retreat NW and W the edge of the ice-tongue has probably made a halt along a line from the village Rödme over a small hill, named Lerbjerg, and the village Stenstrup to the north of Hundtofte, which partly marks the boundary between the higher, easterly, and the lower, westerly part of the old lake bottom, and partly is marked by a number of lateglacial sand areas resting upon the freshwater clay (see fig. 2).

Gradually the ice also evacuated the low westerly part; varved clay was likewise deposited there, and, when at last owing to the melting away of the ice the water was given a free outlet, small bodies of water remained in the hollows of the surface of the old lake bottom and in these an ever-increasingly rich fauna of more temperate molluscs made their home, whilst mud and calcareous beds were deposited.

A deterioration of the climate and a fall in the temperature involved that the subarctic vegetation which had made its way into the environs of the basins, and whose remains are to be found in the gytje, again disappeared and made room for the reimmigrated arctic plant community which, later on, during the new rise of the temperature, had to give way to the advancing postglacial flora.

During these changing temperatures, series up to 2.4 m thick of thin sand and clay strata were deposited, formed of washed-out material from the environs of the small lakes. It was not until far into the Postglacial Period that these sheets of water finally dried up.

From Stenstrup Station the excursionists walk to Egebjerg Brickworks, where, in the section in the new clay-pit which has been excavated in the bottom of the old pit, the uppermost layer consists of Alleröd Mud and, below it, Lower Dryas Clay and ice-lake clay; the Upper Dryas Clay, which formed the bottom of the old pit and rested upon the mud bed, has been almost entirely dug away.

Then on to Juelsbjerg Brickworks where, in the southeast corner of the pit, between Upper and Lower Dryas Clay, there is Alleröd Mud and, under it, very calcareous clay beds. From there to the clay-pit of the New Stenstrup Brickworks, where one can see the ice-lake clay proper with layers of sand and gravel near the bottom, almost directly over the underlying moraine.

Walk from there to Lerbjerg, close to the aforementioned boundary line between the higher and the lower part of the lake bottom. From the top of the bank there is a good view over the former glacial lake and its surroundings. At the village of Rödme the party will rejoin the cars and drive first eastwards along the shore of the old lake to the Odense—Svendborg highway, then turn southwards to Svendborg. If time permits, there will be an opportunity of studying a section in lateglacial lake-sand near to Kirkeby Station.

On to **Svendborg,** where the night will be spent.

Sunday, 1st July.

Guides: VICTOR MADSEN and V. NORDMANN.

From Svendborg by steamer to **Rudköbing,** on the island of Langeland. Thence by road southwards to the village of

Fig. 2. Map of the western part of the ice-dammed lake at Stenstrup.
× × × × Its boundaries; ·—·—·—· Stationary line during the retreat of the ice westwards. Equidistance 2 m.

Humble, through a peculiar landscape characterised by fairly regular, domed, and more or less isolated transverse hills. Where there are gravel-pits in these hills, it can be seen that the core consists of glaciofluvial sand and gravel in inclined layers, which more closely approach the vertical the nearer one approaches the middle of the hill; those in the middle are practically vertical. These hills, which form a belt through the whole of Langeland, are an ice-edge phenomenon related to the limit of the Langeland Advance of the last inland ice during the melting period (Line F on the map Pl. II in Summary of The Geology of Denmark).

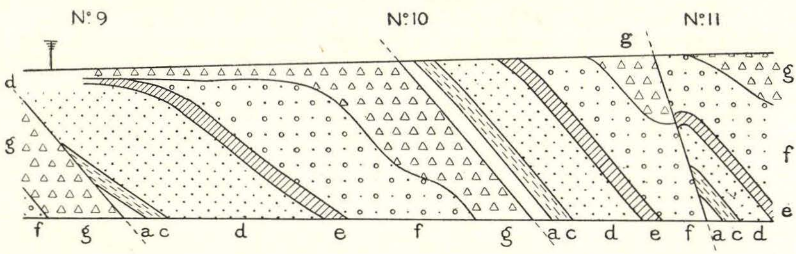


Fig. 3. Sketch section of Ristinge Klint between the localities No. 9 and No. 11. The height is exaggerated in proportion to the length. The thrusts are shown by stippled lines above and below the drawing.

At Humble we turn westwards and, at Ristinge, arrive at the foot of the evenly arched Ristinge Banke, which is flat on the top and whose limit towards the south is the wellknown **Ristinge Klint,** 25 m high. In this cliff we find the same phenomena as are to be seen in several of our other cliffs (Möens Klint, Rögle Klint and Lönstrup Klint), viz. a complex of floes thrust over one another (Fig. 3). In Ristinge Klint all the floes consist of Quartary rocks and on the whole the floes are thrust up in the same direction, the strike on an average being N 53° E and the dip 47° to E 53° S (maximum strike N 75° E and minimum N 39° E; maximum dip 70°, minimum dip 26°); thus the thrusting force, whether due to the pressure of the inland ice or to tectonic disturbances in the wider sense, has come almost from the south-east.

The normal series of the originally horizontally deposited strata is as follows (see fig. 4):

a. The oldest known deposit is an extremely rich, stoneless clay without fossils; it is called the »shiny clay« on account of its polished slickensides. The clay is sometimes blue-grey, sometimes red, and greatly resembles the Eocene Plastic Clay, which doubtless has in fact supplied the principal material. The shiny clay, however, differs from the Tertiary clay in its mechanical composition. It must therefore be regarded as a Quartary deposit. Over this lie

b. stratified sand and gravel with small pebbles of flint and Scandinavian eruptives. This is a freshwater deposit with shells of the genera *Bythinia, Valvata, Pisidium, Unio* and *Anodonta*. The sand is overlain by

c. the marine Eem deposits (the Cyprina Clay), which again can be divided into three horizons connected by smooth transitions, viz:

1. (lowest) Brackish-water mud with shells of *Syndesmya (Lutricularia) ovata* and thin-shelled *Cardium edule, Mytilus edulis* and *Hydrobia ulvae*.
2. The Mytilus horizon, rather more argillaceous, with a shallow-water fauna, containing among others smaller specimens of *Tapes senescens (Tapes aureus var. eemiensis);* in several places two conspicuous shell-layers which principally consist of shells of this kind, may be seen.
3. The Cyprina ho-

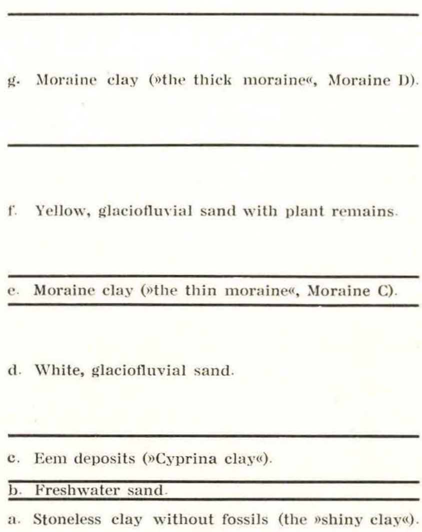


Fig. 4. Sketch of the original series of deposits in Ristinge Klint.

rizon, which is composed of fairly pure clay and contains a fauna from rather deeper water, with large specimens of *Tapes senescens*, *Cyprina islandica*, *Cardium echinatum*, *Ostrea*, large *Corbula gibba*, and many others.

Over this marine series follows:

d. white, glaciofluvial sand; as in some places in its lower part this contains marine shells of the fauna of the Eem deposits, it is not impossible that this lower part of the white sand is in reality marine and corresponds to the Tapes Sand over the Cyprina Clay in Stensigmose (Broager) and to the fossiliferous sand over the Eem Clay in West Slesvig. Over the white sand is

e. a bank of moraine clay, on an average 1 m thick, in which only Baltic boulders have been found. The stone-count coefficient is 0.68 with a mean error of 0.064, and therefore it is placed to Moraine C, the oldest of the moraines of the Last Glacial Period (see Summary of The Geology of Denmark pp. 109 and 120). This moraine is overlain by

f. a considerable deposit of yellow, glaciofluvial sand in which remains of plants have here and there been found; these plant-remains are, however, not primarily embedded. This sand deposit is covered by

g. a deposit of moraine clay of considerable thickness. A few Norwegian boulders besides Baltic boulders have been taken in it. The stone-count coefficient is 1.20 with a mean error of 0.119, and consequently the moraine has been placed to the East Jylland Advance (Moraine D) during the melting period of the last inland ice (see Summary of The Geology of Denmark pp. 114 and 120).

The whole of this series, which originally lay horizontally, has as mentioned above later on been broken into several (at least 25) pieces which have been thrust over one another in such a manner that as a rule each floe contains the whole series in the original order. The shiny clay has formed the lubrication. During the movement the ends of the different beds have been worn to a wedge-shape and, as a rule, the overthrusting has been so radical that more or fewer of the lower sections rest in turn upon the surface of the thick moraine in the next floe to the west. Locality No. 11 (see fig. 5) is indicated as being particularly instructive as to the mechanics of the overthrust.

In this locality the overthrust has not been complete, in so far as only the thin moraine (e) and the overlying yellow sand (f) have finally come to rest upon the thick moraine, whereas the older deposits have not moved up sufficiently.

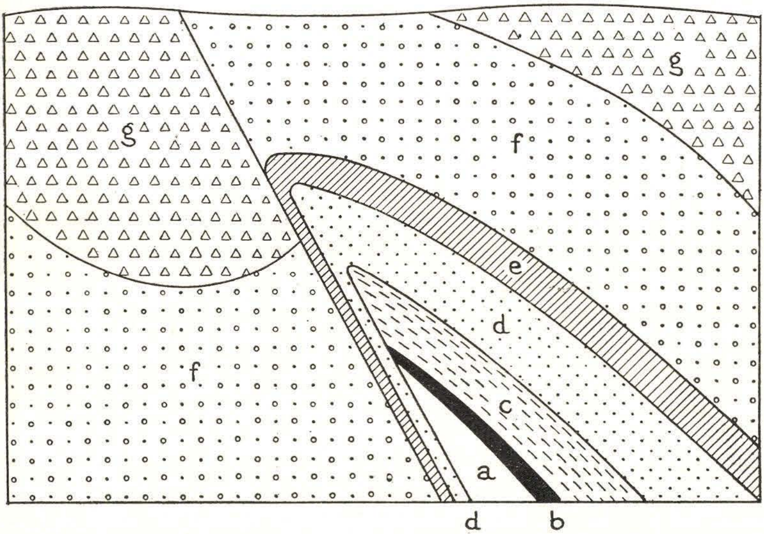


Fig. 5. Sketch of the overthrust in Locality No. 11 in Ristinge Klint. a = stoneless clay (the »shiny clay«). b = freshwater sand. c = Eem deposits. d = white, glaciofluvial sand. e = »the thin moraine«. f = glaciofluvial sand. g = »the thick moraine«.

One also sees »trails« of the strata-ends of the thin moraine (e) and the white sand (d) lying between the older deposits (c, b and a) and the yellow sand (f) in the next floe to the west. In several other places »trails« of the white sand can be seen lying within the dislocation boundary between the thick moraine and the shiny clay.

When, much later on, the sea by its erosion formed Ristinge Klint, the clay deposits were more resistant and thus came to form projecting »noses«, whereas much more sand was washed away with the result that large niches, the so-called »falls«, were formed between the noses.

The marine deposits in Ristinge Klint contain a fauna corresponding to that of the Eem deposits in West Slesvig and Holland, though scarcely so rich in species. A particular little company of molluscs must be mentioned as being especially characteristic of these deposits in contrast to all other Quartary marine deposits: *Tapes senescens*, *Lucina divaricata*, *Gastrana fragilis*, *Syndesmya ovata* and *Haminea navicula;* with these are associated such rare forms as *Mytilaster lineatus* and *Mytilaster cfr. minimus*, and some others. The Eem deposits in Holland and West Slesvig are placed to the Second (Last) Interglacial Period, and the Eem deposits in Ristinge Klint must therefore be placed to the same period. The stratigraphical details do not argue against this, and there is further support in the fact that nowhere in the Baltic region have two or more marine deposits in their original position been found with the typical Eem fauna in superposition.

Return to Rudköbing and by steamer to Svendborg, and on to **Odense,** where the night will be spent.

Monday, 2nd July.

Guides: VICTOR MADSEN and V. NORDMANN.

From Odense to the Little Belt, by ferry to Snoghöj and on to Fredericia and thence northwards over the particularly even moraine flat which rises slowly and evenly towards Vejle Fjord. It is only close by the coast that the plateau edge is cut up by the erosion of lateglacial and postglacial times. The excursion will drive down over the edge of the plateau at the village Trelde and eastwards from there to **Trelde Klint** through the rugged landscape which characterises the sides of the tunnel valley of Vejle Fjord as well as of most other tunnel valleys.

The section of Trelde Klint, 1 km long and up to 28 m high, displays Quartary deposits of various kinds. For the greater part the series comprises glacigenous layers: moraine sand, moraine clay, and glaciofluvial sand and clay. The moraine sand, which is the principal deposit, is present in the form of beds of various colours, grey, brown or black, with varying content of black, Tertiary material. The glaciofluvial clay too, which is only of subordinate importance here, is almost exclusively composed of Tertiary material, dark, micaceous clays.

In the western part of the section diatomaceous, freshwater marl and freshwater clay occur locally between the glacigenous deposits. All the strata, however, are very much disturbed and as the deposits moreover vary rather frequently, no fixed rule can be drawn up for the occurrence of the lake deposits between the moraine deposits; for the most part, however, their position is between the lowest strata in the section.

These interglacial lake deposits are most prominent in the section shown

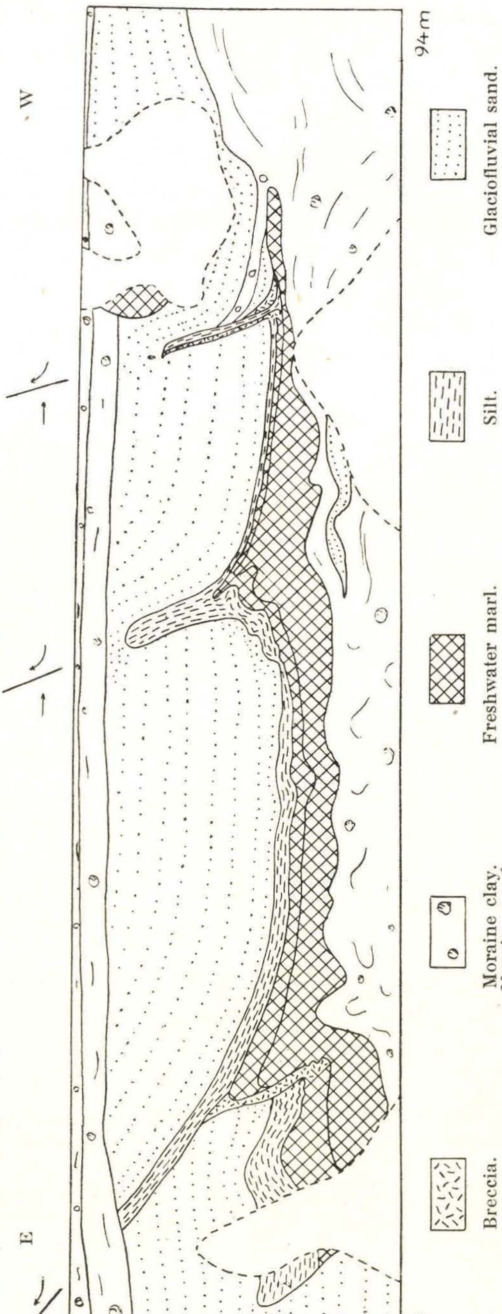


Fig. 6. Trelde Klint.

in fig. 6, close to the west end of the cliff. In the lowest part of this portion of the cliff are to be seen grey moraine clay with smears of darker clay, stoneless clay and sand; on this rests 2—5 m of freshwater lime which passes upwards into about two metres of freshwater clay and fine sand (silt) of various kinds; above these again are 13—16 m of glaciofluvial sand and, at the top, moraine.

All the deposits, with the exception of the uppermost moraine, are very much disturbed. The beds are pressed together in an east-west direction. This has brought about a folding and pressing up of the beds and also a number of overthrusts. Through each overthrust the series of freshwater strata has so to say been split, a floe of fine sand with the overlying glaciofluvial sand having been thrust up towards the east over the horizontal glaciofluvial sand. The freshwater lime and the other freshwater deposits have only to a slight degree been concerned in the overthrusting itself.

From Trelde Klint we return to the village of Trelde and proceed onwards to the west where, between Egeskov and Hölsgaarde inn we pass Rands Fjord, which is the northern end of the remarkable valley Elbo Dal. It is a tunnel valley running south-west down to the innermost part of Kolding Fjord. The mouth of Rands Fjord is silted up with marine alluvium which, out by the coast, is covered by small areas with blown sand. Continuing northwards over the marine alluvium to **Hvidbjerg,** a flat hill, about 30 m high, of (Oligocene?) white Mica Sand which, towards the south as well as towards the north, is covered by a comparatively thin cap of moraine clay. In the middle of the bank the sand appears at the surface; only here and there can faint remains of the moraine clay cover be seen. The sand on the upper part of the bank has undoubtedly been redeposited by meltwater streams and thus must more nearly be regarded as glaciofluvial sand of Tertiary material.

The northern part of the foot of Hvidbjerg is formed of (Oligocene?) Mica Clay. The water percolating down through the sand is stopped by the clay and runs along its surface to the cliff, where it forms springs which give rise to a luxuriant vegetation on the beach.

From Hvidbjerg we continue northwest and north to Brejning Hoved, where we embark on a steamer which will take the excursion to Vejle. On the way through the fjord there is an opportunity of seeing on both sides of the tunnel valley the plateau edge which is so much cut up by erosion. Several of the »false hills« and more prominent points have separate names; the best known is Munkebjerg, on the south side of the fjord (93 m).

Leave Vejle in the evening for **Horsens,** where the night will be passed.

Tuesday, 3rd July.

Guide: V. MILTHERS.

The high road follows from Horsens the south side of the valley of the river Hansted Aa, which forms an extension to the northwest of the central depression of which Horsens Fjord is the middle (see fig. 7).

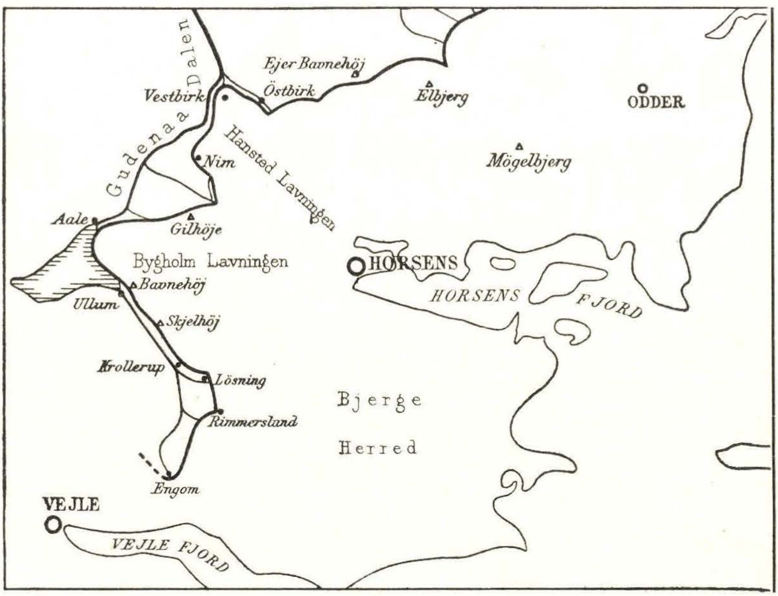


Fig. 7. Sketch map showing the ice-edge and the glacial rivers in the Horsens district. 1:500.000 (HARDER).

Between Tamdrup Church and **Nim**[1]) we pass the hilly ridges which form the corresponding marginal moraine landscape; among the highest points are Bavnehöj (Beacon Hill) at Tamdrup Mölle (105 m), Bavnehöj east of Nim (105 m) and Mögelbjerg (Big Hill), NE of Underup (109 m). From these and other hills there is a view to the east over the central depression and to the west over the extra-marginal melwater-sand plains and the lateglacial river-channels which were formed during the stagnation of the ice-edge here.

This extra-marginal landscape comes well into view south of Nim. At the river **Gudenaa,** west of Nim and Underup, we pass the lateglacial meltwater-plain corresponding to the stagnation; this plain, especially west of Gudenaa valley, is finely developed and sharply bounded from the glacial plateau on the west by a clearly defined erosion slope. This glacial plateau is passed on the way further to the northwest to **Salten Aa** valley.

Salten Aa valley is a combined subglacial and lateglacial valley with a corresponding postglacial watercourse. In certain parts of the valley its subglacial, long-lake character, in others its lateglacial terrace-character, are more prominent. About 2 km west of the high road, on the north side of the valley, is a fine natural profile in Miocene beds: Mica Clay, Mica Sand and a thin seam of Brown Coal.

Going further north towards Silkeborg we pass several subglacial valleys cut down into Miocene deposits. These deposits are visible at Virklund.

From Silkeborg and westwards to **Funder** we follow another combined subglacial and lateglacial valley. At Funder we enter the hilly country which forms the extreme ice-edge area of the Last Glacial Period and, after passing a lateglacial valley which forms the continuation of the subglacial Silkeborg-Funder valley, arrive at Paarup in the older glacial landscape, the surface forms of which

[1]) See D. G. U. II. Række. Nr. 19. Poul Harder: En østjydsk Israndslinje og dens Indflydelse paa Vandløbene. With an English summary of the Contents: An ice-edge line in East Jutland and its influence on the water-courses. 1908.

have in particular been characterised by the periglacial denudation of the Last Glacial Period.

From Paarup inn the road runs northwards over Engesvang and back over Bording to Ikast, to obtain a view of the border area of the last glaciation and the resultant heath plain with younger lateglacial terraces.

From Ikast we branch off to the south to Isenvad in order to see the typically shaped hill-island **Isenbjerg** which, of slight extent but considerable height, juts out of the surrounding flat heath plain.

From Ikast to **Herning** the road passes exclusively over old glacial landscape (Skovbjerg Hill-island).

The night will be spent in Herning.

Wednesday, 4th July.

Guides: V. Milthers, Knud Jessen and H. Ødum.

To **Herning** Brickworks to see the interglacial freshwater deposits there[1]).

The profile to be demonstrated (see fig. 8) is in the southern part of the deposits of the interglacial lake, stretching about 900 m towards the north. The greatest breadth of the lake was about 300 m. The figure illustrates the series of strata which can be shown in this southern part of the lake-area, whereas the complete series is given in this profile description.

A. Mould.
B. Sand, partly wind-blown sand, up to about 1 m.
C. Late and postglacial lake deposits.
D. Stony sand, arctic flow-earth, up to 3,2 m.
E. Stoneless sand, up to 1.5 m.
F. Stoneless clay (up to 0.7 m) with *Betula nana*.

---

[1]) See Summary of The Geology of Denmark p. 104 and D. G. U. II. Række. No. 48. Knud Jessen and V. Milthers: Stratigraphical and Paleontological Studies of Interglacial Fresh-water Deposits in Jutland and Northwest Germany. Pl. VIII of this treatise will be distributed to the members of the excursion.

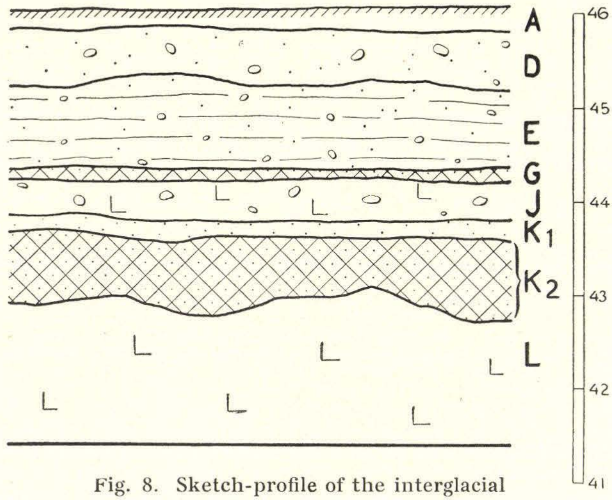


Fig. 8. Sketch-profile of the interglacial freshwater deposits in the Brickworks pit at Herning 1914. The scale shows the heights above sea-level in metres. For explanation of the letters, see the text.

G. Brown mud, more or less arenaceous (up to 2.1 m) with a thermophile flora (*Trapa natans, Brasenia purpurea, Dulichium spathaceum, Acer campestre, Carpinus betulus, Ilex aquifolium, Tilia platyphylla, Quercus robur, Picea excelsa* etc.).

H. Sand (up to 3 m) with a subarctic flora as in J.

J. Stoneless, grey clay (up to 7.4 m), at the top containing thin sand strata with plant detritus. In the marginal facies of the bed are small scattered stones. Subarctic flora with *Betula nana, Empetrum nigrum, Salix cfr. phylicifolia, Selaginella selaginoides, Myriophyllum alterniflorum* etc. and a number of other species.

K_1 Light sand (up to 0.75 m), decomposition zone of K_2.

K_2 Brown mud with marginal facies of arenaceous mud or sand mixed with mud (up to 3.2 m). Thermophile flora exactly as in G. (*Trapa, Brasenia, Dulichium* etc.).

L. Grey, stratified clay (up to 2.5 m) with an arctic flora: *Betula nana, Salix herbacea, S. reticulata* and arctic mosses.

M. Sand with mosses, up to 0.5 m.

N. Glacial varved clay, unfossiliferous.

O. Moraine clay.

The interglacial lake-basin is hollowed in moraine clay which lies exposed in the surroundings of the basin. This moraine was deposited during the last glaciation of West Jylland, i. e. it belongs to the Last but one Glacial Period, the last North-European glaciation not extending to Herning. There are no moraine deposits above the interglacial lake deposits here, but during the climax of the last glaciation they were covered by flow-earth which, under the influence of the arctic climate, slid out over the basin from the higher, surrounding terrain. The lake strata were deposited during the Last Interglacial Period.

The numerous interglacial bogs contemporaneous with the Herning lake, found in Jylland west of the extreme boundary of the last glaciation, at first at Brörup and later on at many other places (the Brörup bogs), are also covered by flow-earth. It is typical of these bogs and lakes that their basins still appear in the terrain in the form of shallow hollows with no outlet. These must be regarded as orographic relic-forms of the more rugged interglacial terrain-forms which were evened out by the periglacial denudation. Over the interglacial lake at Herning, too, there are two such areas with no outlet.

The Herning profile is remarkable because of the two horizons of mud with thermophile plant species and the subarctic beds of clay and sand (H and J), the Middle Bed between these two horizons. Corresponding profiles (of the Herning type) have been found in some other interglacial freshwater deposits in Jylland and they show that in the Last Interglacial Period there has been a very marked climatic oscillation. While the two gytje beds were being deposited, the summer heat was undoubtedly a good deal higher than in Denmark at present, and the Polar forest line lay in Jylland while the Middle Bed was being deposited. The advance of the inland ice contemporaneously with the sedimentation of the Middle Bed did not reach so far as it did during the last glaciation, for no traces have been found anywhere of arctic earth-flow from the period of the Middle Bed.

From Herning to **Skjelhöje** we pass the extensive, flat

Karup heath plain, interrupted only at Karup by the younger lateglacial terraces and the postglacial valley along Skive Aa.

At Skjelhöje[1]) is the boundary between the heath plain and the young-glacial, rugged landscape to the east of it. South of Skjelhöje the plain and the moraine landscape lie at about equal heights; northeast of Skjelhöje a deeply eroded subglacial valley, enclosing Hald Lake, extends right up to the eastern edge of the heath plain. North of the heath plain, between Skjelhöje and Finderup, the rugged, young-glacial moraine landscape lies several metres lower than the heath plain and shows that the latter, while being deposited by the meltwater stream from the east, lay up against a covering of dead ice to the north. Here the heath plain is cut up by lateglacial, terrace-shaped valleys which mark the closing stage of the activities of the meltwater at this place.

From Skjelhöje we go westwards over the northern part of Karup heath plain and, south of Davbjerg, come into the younger glacial landscape north of the heath plain.

At **Mönsted** a visit will be paid to the quarry of De jydske Kalkværker (The Jutland Lime Works), 1400 m NW of the church. The quarry is very large, with sections, 12—14 m high, in Danian limestone (Blegekridt), overlain by some metres of glaciofluvial sand. Besides the large, open quarry the limestone is also accessible in long levels (Kover) which open at the floor of the quarry. The limestone is Coccolith Chalk, soiling the fingers, sandy to the touch, light or dark grey-white, sometimes with a reddish shade. The flint is grey and occurs partly as nodules in the limestone, partly in thinner and thicker beds. The position of the strata is very complicated as sometimes they dip in various directions whilst folds and faults are numerous. There are also unconformities between the flint beds. The chalk is very poor in fossils; it belongs

---

[1]) See Map: Viborg Egnens Mergellag og deres geologiske Omgivelser. (The marl deposits of the Viborg district and their geological surroundings). D. G. U. III. Række. Nr. 9. 1913.

to Younger Danian, Zone D (see this Guide p. 31 and Summary of The Geology of Denmark p. 61).

From Mönsted via Skive, through Salling to Glyngöre, thence by ferry to **Nyköbing on Mors,** where the night will be spent.

Thursday, 5th July.

Guide: O. B. Böggild.

From Nyköbing to the northern part of Mors for the localities of the Moler (Eocene diatom-earth with beds of volcanic tuffs, occurring as dislocated floes in the Quartary deposits, see fig. 9 and Summary of The Geology of Denmark p. 71).

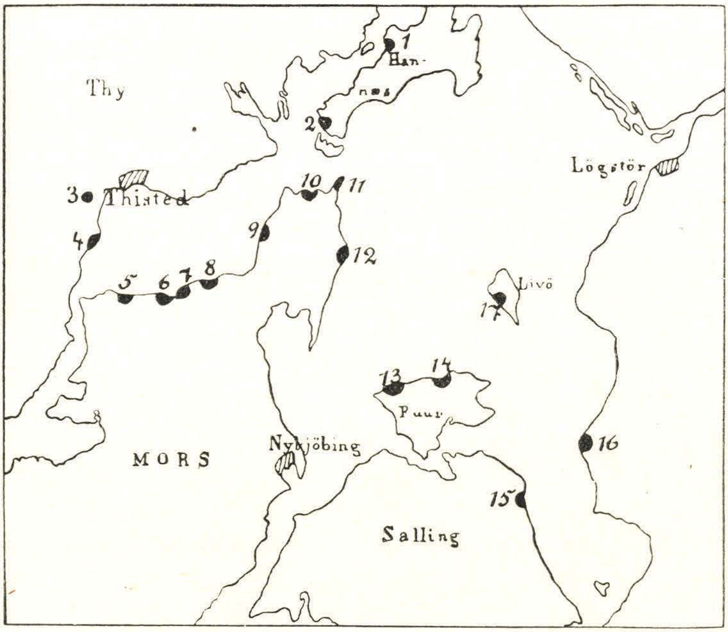


Fig. 9. Map of the Moler area in Northwest Jylland. 1:500,000. 1: Veslös. 2: S. Arup. 3: Tilsted. 4: Silstrup. 5: Svalklit. 6: Gullerup. 7: Hanklit. 8: Salgjer Höj. 9: Skjærbæk Klint. 10: Skarrehage. 11: Feggeklit. 12: Ejerslev. 13: Fur Knudeklint. 14: Fur Stolleklint and Östklint. 15: Junget. 16: Ertebölle. 17: Livö.

First a visit will be paid to the two big Moler quarries **Ejerslev** and **Skarrehage.** At Ejerslev (see fig. 10) there is, towards the shore, a slope containing the Upper Moler with many beds of black tuff[1]) (the »positive series«); in the quarry is seen Lower Moler with its few beds of tuff (the »negative series«) overlain by Upper Moler with many tuff-beds. At Skarrehage occur Lower Moler and also vari-coloured Moler beds without volcanic tuffs, whose position in the Moler series is not known.

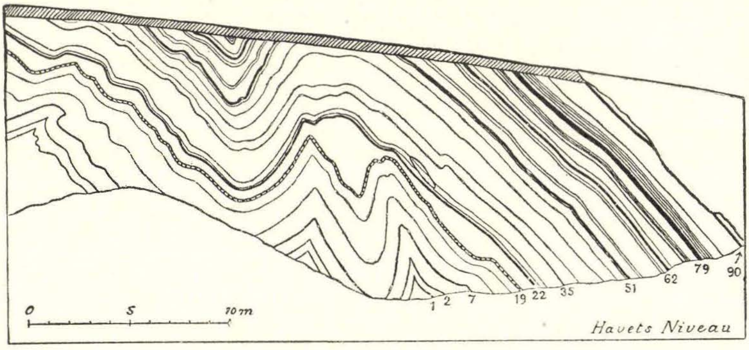


Fig. 10. View of Ejerslev Klint with tuffs of the »positive series«.

On to the imposing coast-cliff **Hanklit** which, prior to 1910, presented the following series:

Blown sand
Glaciofluvial gravel
Moler
Moraine clay
Glaciofluvial sand
Glaciofluvial gravel
Palaeocene clay

Afterwards there was a big landslide, the strata below the Moler being hidden by the fallen masses, whereas the

---

[1]) See D. G. U. II. Række. Nr. 33. O. B. Bøggild: Den vulkanske Aske i Moleret . . . . Avec résumé en français: Le cendres volcaniques du Moler (terre éocène á diatomèes) avec un aperçu des roches tertiaires les plus anciennes du Danemark. 1918.

Moler itself appeared as a high, vertical wall with very folded strata (fig. 11).

A portion of the positive, Upper Series can be seen here with the most marked, thickest strata outlined. From the top downwards will be seen No. 129 (4.5 cm), the uppermost thick stratum; 118 (13 cm) and 114 (14 cm) are both characteristic owing to a peculiar, unconformable stratification. Strata 102 (8 cm) and 101 (12 cm) form a coherent cementstone bed,

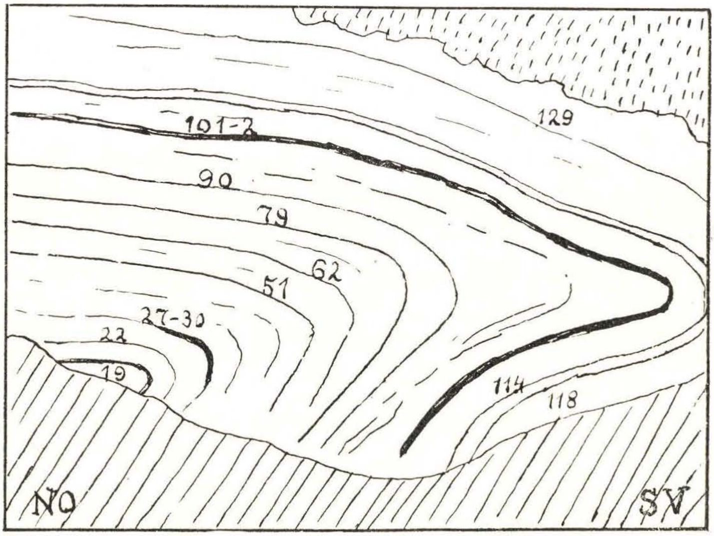


Fig. 11. Profile in Hanklit with Moler bed and tuffs (numbered) of the »positive series« forming a big fold.

the most striking in the whole cliff. 90 is a double bed (1.5 + 6.5 cm); strata 79 (12 cm), 62 (7 cm) and 51 (8.5 cm) are prominent. In several places the thin strata 27—30 are cemented into cementstone concretions, of which one is to be seen in the figure. Stratum 22 is 6 cm. At the bottom is stratum 19 (18 cm), the thickest of them all, grey in colour and of andesitic consistence. To the left — off the picture — the series continues downwards in the negative series which can be followed to the light, andesitic stratum ÷ 17 (4 cm). Among the thinner, not especially conspicuous strata a few will be referred to as being more peculiar: 30 is a double-bed (0.5 + 1.2 cm), as are 18 (1 + 2 cm), 16 (2 + 1 cm) and 14 (0.5 + 2 cm). 13 (1 cm) is andesitic like 19, whilst all strata in the Upper Series are, besides, basaltic.

The Lower Series contains only few and scattered tuff-beds, the composition of which is much more varying than those of the Upper Series; the strata here are numbered from the top with negative numbers. The upper ten strata are very thin and difficult to find; but then follow 3 basaltic, rather conspicuous strata, No. ÷ 11 (3 cm), ÷ 12 (5 cm) and ÷ 13 (6 cm) after which follow some quite unimportant strata above the already mentioned ÷ 17.

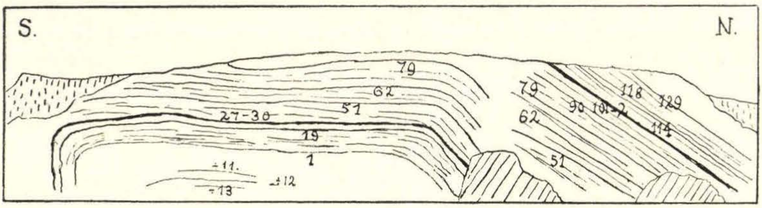


Fig. 12. Profile in Silstrup Klint south of Thisted.
Moler and volcanic tuffs forming a flat fold.

By boat to Thisted, passing en route close to **Silstrup Klint,** in which the beds of Moler and tuffs form a flat fold (see fig. 12). The tuffs are essentially the same as in Hanklit with the same thicknesses; the position of the more conspicuous strata appears from the figure. The principal difference between the two localities is that the thin tuffs 27—30 are here embedded in a coherent cement-stone bed, which is the most prominent element in the cliff; only the uppermost of the negative strata occur here.

The night will be spent in **Thisted.**

Friday, 6th July.

Guides: H. ØDUM, V. NORDMANN and AXEL JESSEN.

In the morning a visit to a quarry in Danian limestone in the southeastern border of **Thisted,** close to the slaughter-house. The limestone varies in nature. In the upper, northern part of the pit it is Coccolith Chalk which here and there contains a small quantity of Bryozoa, whereas in other — and most — places the Bryozoa content is so high that the rock must be called Bryozoan Limestone. It has hardened irregularly and in parts passes smoothly into white flint, whereas other parts are more soft, whilst in cavities in the adjoining flint beds there is incoherent lime powder. In the lower, southern part of the pit there is white Coccolith Chalk, usually very poor in Bryozoa; only in one stratum close to the bottom are there streaks of bryozoa in the limestone. This contains many grey »Ophiomorphs«. The tectonic conditions are rather complicated. The limestone beds have been exposed to disturbances and in the west wall are to be seen both a sharp saddle and a fault zone 2.75 m wide.

The lime deposits which the excursion will have an opportunity of seeing in Jylland are distributed as follows:

<table>
<tr><td rowspan="4">Danian........</td><td>Zone D.</td><td>Mönsted (4th July)</td></tr>
<tr><td>Zone C.</td><td>Thisted</td></tr>
<tr><td>Zone B.</td><td>Bulbjerg</td></tr>
<tr><td>Zone A.</td><td rowspan="2">Kjölby Gaard</td></tr>
<tr><td rowspan="2">Senonian......</td><td>........</td></tr>
<tr><td>.........</td><td>Aalborg</td></tr>
</table>

Thus the Thisted locality belongs to Upper Danian (Zone C).

On to **Kjölby Gaard** near Hunstrup Station, where, in a pit, lying in the old cliff of the Litorina (Tapes) Period, Danian can be seen overlying Senonian (see fig. 13).

At the bottom White Chalk, about 9 m, typical, containing a Senonian fauna. Only little flint. Overlying this is clay, 9 cm. The limit against the underlying White Chalk is definite, partly wavy and pitted and partly a little cracked and split, so that the clay which fills up all the cavities sends small ramifications into the chalk. The clay is very rich in lime and does not seem to contain quartz sand. On the other hand it is full of pebbles of White Chalk. These vary very much in size, from the most minute to those as large as a hen's egg.

The surface of the pebbles is more or less rough, they are often angular and do not appear to have been rolled to any great extent. Besides pebbles of White Chalk this layer contains a number of Senonian fossils, washed out from the White Chalk. Overlying the clay follows 1.25 m of Coccolith Chalk. The quantity of clay in the conglomerate layer decreases upwards and the White Chalk pebbles disappear. The rock becomes a homogeneous Coccolith Chalk and becomes firmer and harder. It is exceedingly poor in fossils. As regards cavities, a few ochre-coloured, narrow holes are seen, evidently due to sponges; fine holes, due to sponge spicules, are common; furthermore, there are three layers of flint.

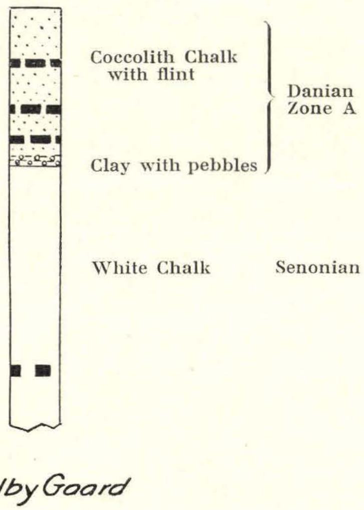


Fig. 13. Sketch of the limit between Senonian and Danian at Kjölby Gaard.

The Coccolith Chalk and its basal conglomerate are the oldest beds of the Danian, belonging to Zone A, identical with the Cyclaster Limestone and the clay bed in Stevns Klint.

At Hunstrup Church is a raised beach of the Litorina (Tapes) Period. The western part of the Limfjord was in this period cut off from the sea to the west by a bar, Agger Tangen. For short periods the sea was able to break through this bar, but the breach was soon closed again. Nowadays the channel through it (Thyborön Canal) is kept open artificially. On the other hand the Limfjord was open to the north to Skagerrak between Thisted and Fjerritslev. During the Litorina submergence this part of the country was split up into a number of islands, some of them consisting of the hard limestones of the Danian. These former islands (Hanstholm, Hjardemaal, Hannæs, Lild, Bulbjerg, Klim and others) are still to be seen with steep coast slopes.

During the emergence the sea built up gravel bars from island to island; fan-shaped systems of raised beaches were often formed gradually as the land rose and grew. The sea worked at the breaking down of the projecting points, and the abundant material transported along the coast filled up coves and bays between these solid points and endeavoured to form the most even and straight coast possible. Now the coast line is visible in the form of a series of flat curves between the points consisting of more resistant rocks and clays: from Hanstholm to Lild, from Lild to Bulbjerg, from Bulbjerg to Svinklöv, and so on.

The raised beaches in this region originate partly from the maximum of the Litorina submergence and partly from the subsequent emergence. Not only the age of the raised beaches, but also their situation out towards the open sea or in protected waters, have an influence upon their height. Whilst the back of the raised beach at Hunstrup Church is only 4.7 m above sea-level, there is, three or four km to the northwest of it, a much bigger one which measures at its highest points 7.8 m above sea-level. Furthermore, there is a perceptible increase in the height of the raised beaches as one moves from west to east or northeast. Having regard to the height to which the sea of today can throw up the pebbles on unprotected coasts, the emergence in this region may be estimated at 3 m at Nyköbing, $3^1/_2$ to 4 m at the north end of Mors at Skarrehage, $4^1/_2$ m at Hanstholm, $5^1/_2$ m at Bulbjerg, $6^1/_2$ m at Aabybro, about $8^1/_2$ m at Lökken and 13 m at Frederikshavn. A find at Vust, south of Bulbjerg, indicates that the emergence lasted until some way into the Bronze Age.

In the straits between the former islands there lived a very rich *Ostrea-Tapes* fauna, which is now found in the raised strata of sand and clay. Some of these straits were only partly filled in so that they now appear as coves from the Limfjord. During the past half century attempts have been made — though with only slight success — to reclaim some of these fjords. A few small kitchen middens, as for instance at Österild and on Hannæs, provide evidence of the fact that this archipelago was inhabited in the Stone Age (the Ertebölle Culture).

From Österild and Lild we continue to **Bulbjerg**, where Danian Bryozoan Limestone forms the 40 m cliff out towards the North Sea. The stack Skarreklit remains as a witness of the attacks of the sea upon the coast.

Geologically the Bryozoan Limestone in Bulbjerg resembles that in Stevns Klint in every way; this rather fossiliferous limestone belongs to the older subdivision of the Danian, Zone B. The flint beds, which are often very thick, in places lie very closely together, in others very far apart, so that the limestone forms thick, flintless beds. The flint beds lie in extensive curves, forming systems of unconformably touching beds so that the limestone beds vary in thickness and thin off to nothing.

Blown sand occurs both west and east of Bulbjerg as large and distinct, parabolic dunes. Up on Bulbjerg there is an irregular dune terrain, where later wind erosion in places has again exposed the old surface, which appears in the form of small, stony plains between the dunes. On these stony plains implements of both the Stone Age and the Bronze Age are sometimes found.

At **Fjerritslev** one ascends to the glacial highland, and SW of Svenstrup passes an extra-marginal meltwater valley (now devoid of watercourses) and two north-to-south ridges (ice-edge formations) between which are former straits with a rich *Tapes* fauna, oyster-beds and some small kitchen middens. At Bratskov one descends again to the low postglacial plain, over which we continue to Nörre Sundby and Aalborg.

The eastern part of the Limfjord was a strait which extended from Lögstör eastwards to the Cattegat, but was not connected with the Skagerrak. It is true that the Limfjord spread northwards over great areas in Vendsyssel: the lowland between Bratskov and Aabybro, Store Vildmose etc. and, in the form of a narrow fjord, extended northwards as far as **Lökken;** but both there and to the southwest the fjord was cut off from the Skagerrak by bars and by the glacial hills.

The fauna in the elevated strata is a pronouncedly Limfjord fauna, different to the fauna in the western Limfjord and in the Skagerrak.

In the brickwork's pit at Lindholm, just to the northwest of Nörre Sundby, there is stratified, late-glacial Yoldia Clay with no molluscs. In the hill at Nörre Sundby marks of both lateglacial and postglacial marine erosion can be seen. From the top of the hill there is a view over the landscape.

Through **Aalborg**, eastwards to the chalk-pit at the Aalborg Portland Cement Fabrik (Rørdal). White Chalk, Senonian, with almost no flint.

From Aalborg, past Hammer Bakker, over »Jydske Aas«, and through Sæby to **Frederikshavn.**

Saturday, 7th July.

Guide: AXEL JESSEN.

In Fig. 14 is a theoretical section through Vendsyssel, which exhibits the three forms of terrain; the glacial hill-country, the lateglacial plateaux (the floor of the former ice-sea) and — nearest the coast — the postglacial plain land, formed of marine deposits from the Litorina Period.

In Vendsyssel we only know deposits from the last two glacial periods and the Last Interglacial Period[1]). The series of the glacial deposits is:

Moraine clay and moraine sand.
Glaciofluvial clay, sand and gravel.
Interglacial, marine clay, uppermost arctic, underneath boreal.
Glaciofluvial sand and moraine clay.
White Chalk (Senonian).

The surface of the White Chalk lies 20—30 m above sea-level to the SW and W at Aalborg and Svinklöv, and falls from there to the NE and, near Frederikshavn, has been

[1]) See D. G. U. V. Række. Nr. 2. AXEL JESSEN: Vendsyssels Geologi. 1918 (Danish Text).

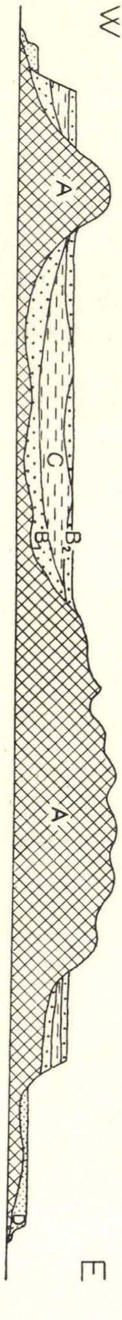


Fig. 14. Sketch-section through Vendsyssel from W to E.
A. Glacigenous deposits (hill-country). B_1 Lower, B_2 Upper Saxicava Sand. C. Lateglacial Yoldia Clay. D. Postglacial, marine deposits.

found at ÷ 177 m. In the overlying moraine (14 m thick, only known from the boring at Skærumhede[1]), Baltic boulders have been found. Of the interglacial, marine series, which at Skærumhede has a thickness of 123 m, only the upper arctic zone (Portlandia arctica Clay, Older Yoldia Clay) comes out at the surface. The boreal (and biggest) part is only known from the boring at Skærumhede, where it occurs as clay, often dark and soft, and with a very rich mollusc fauna. The glaciofluvial deposits, clay, sand and gravel, form a thick series, a direct continuation of the interglacial series, the clay predominating in the lower strata, sand and gravel in the upper ones. The glaciofluvial sand forms the main mass of the hilly country which, in eastern Vendsyssel, forms a great, continuous highland; in western Vendsyssel it occurs as isolated hills of small extent which jut out above the floor of the old ice-sea (for instance Börglum, Rubjerg, Vennebjerg, Hjörring and many others). The position of the strata in the Quartary is frequently very irregular, especially in the very rugged areas which, in part, represent smaller advances of the inland ice and partly mark the stationary lines of the ice-edge during its retreat.

The moraine (from the Last Glacial Period) overlying the glaciofluvial deposits consists of normal moraine clay in southern Vendsyssel, of moraine sand or stony sand without stratification in northern Vendsyssel; often there is only a scattering of large stones.

---

[1]) See Summary of The Geology of Denmark p. 101.

The lateglacial, marine deposits evidence a submergence and a subsequent emergence of the land. The series is:

Upper Saxicava Sand.
Yoldia Clay.
Lower Saxicava Sand.

These ice-sea deposits fill the hollows between the higher hilly stretches and form plateaux, whose surfaces to the NE lie 30—33 m above sea-level, the heights decreasing to the S and SW. In eastern Vendsyssel, round Voer Gaard and at Sæby, the deposits form basin-shaped infillings of older central depressions. The strata are undisturbed and horizontal. The valleys in these plateaux have another character than those in the hill-country; they are younger, their sides are sharply-cut and steep and are often not observed until one stands on their very edge. Lower Saxicava Sand, observed in excavations and in cliffs, contains a poor fauna, rich in individuals. In southern Vendsyssel the Yoldia Clay is unfossiliferous; in northern Vendsyssel it contains a high-arctic fauna, richest in the north, where the sea water had easier access and the ice lay at a greater distance during the sedimentation of the clay. Upper Saxicava Sand forms a cover over the Yoldia Clay and is, as a rule, unfossiliferous.

The postglacial deposits are:

Blown sand.
Upper freshwater deposits (peat, etc.).
Marine mud, clay, sand and gravel.
Lower freshwater deposits (peat).
Zirphaea deposits.

The Zirphaea Sand, deposited during the transition between lateglacial and postglacial times, is a coast formation deposited during a brief submergence. The deposit has only been found in northern Vendsyssel. Lower freshwater deposits originate from the Continental Period (Ancylus Period, Boreal Period) when the land had been raised to a higher level than the present one.

The marine strata were deposited during a submergence and subsequent emergence (Litorina Period or Tapes Period, Atlantic and Subboreal Period). To the NE at Frederikshavn there are beach deposits up to 15 m above sea-level, fjord deposits (mud and clay) up to $12^{1}/_{2}$ m above sea-level. As stated on p. 33, the size of the emergence decreases from here to the southwest. Upper freshwater deposits were formed in the Subboreal and Subatlantic Periods and the blown sand for the most part in historical times.

From **Frederikshavn** westwards, over a terrain that was severely abraded in lateglacial times; then down to the little lateglacial plateau south of Kvissel Station (Yoldia Clay) and onwards, up over the very rugged hill-range, **Tolne Bakker,** formed by an ice-edge with the direction N—S. From here there is a view westwards over the lateglacial plateau, the Sindal Plain. At Sindal station is a brickworks' pit in Yoldia Clay, with arctic fauna. Continuing from there to the south through Vraa and Try, through the glacial hill-country to the basin-shaped, lateglacial plateau, **Voergaard** Plain, a central depression which in lateglacial times was partly filled with Yoldia Clay and Saxicava Sand, afterwards, in the Continental Period, furrowed by watercourses which came down from all sides towards the main stream, Voers Aa. During the Litorina submergence the sea made its way into these valleys forming small fjords. It has been possible by borings to follow marine Litorina deposits far into the country.

To the SW and W is the bow-shaped ridge, **Jydske Aas,** which reaches up 100—136 m above sea-level. In southwest Vendsyssel the direction of the ice-edge lines is SE—NW. At one time during its retreat, the edge of the inland ice extended from Dronninglund northwards to Sindal, curving like a bow out to the northwest to Hirshals. After this last ice-tongue, moving from NE, had melted away, the ice-edge extended northwards out through Tolne Bakker and simultaneously it still reached as far as Dronninglund in the south. It was through this that the hill-range at this southern part of the ice-edge, Jydske Aas, became so uncommonly developed, and the Voergaard depression so pronounced. On the stretch where it is typical the moraine bow has a length of 25 km, a breadth of 2—3 km and rises 80—100 m above Voergaard Plain. On the inner side, but more especially on the outer, west side, there are smaller, sharply outlined marginal moraines, for instance at Skinderhede, where a halt will be made on the way to Hjallerup.

The road now proceeds SW to Hjallerup, eastwards to Dronninglund and again northwards over the southern part of the moraine bow, Dronninglund Forest, whence there is a view over the country. Continuing over Voergaard Plain eastwards to Albæk Bakker, a younger moraine line. Its southern end is a steep, lateglacial coast slope, below which is a terrace of lateglacial beach gravel and, at a lower level, the postglacial plain-land at Voers Aa. From there to **Sæby.** From Sæby to **Frederikshavn,** the road passing along a high coast slope of the Litorina Sea.

Sunday, 8th July.

Guide: Axel Jessen.

From **Frederikshavn** westwards past Sindal over the lateglacial plateau, Hjörring Plain — with a few hilly areas (Hjörring, Vennebjerg, Rubjerg) — to **Lönstrup.** The cleft at Lönstrup was for the most part excavated by a single shower of rain on August 11th, 1877.

Lönstrup Klint, 12 km long, 60 m high, between the two fishing villages of Lönstrup and Lökken, shows a section partly through a hill-country, Rubjerg, (of which only the eastern half is left, the other half having been washed away) and partly through the plateaux north and south of it.

A. In the northern part of the cliff (section through the plateau north of the hill-country) the series is:

Blown sand.
Yoldia Clay.
Lower Saxicava Sand.
Moraine sand.
Glaciofluvial sand.
»Diluvial clay«.

The Yoldia Clay is only slightly developed, and in places contains shells of *Saxicava arctica.* Lower Saxicava Sand has a thickness of up to 20 m. Its upper part is typically developed with numerous shells of *Saxicava arctica* in vertical position in the argillaceous sand. The lower part of the Saxicava Sand is in places irregularly stratified, contains small stones and the shells lie in all positions. Then the boundary against the moraine sand is difficult to indicate. The moraine sand is bedded, argillaceous sand with many small and a few large stones. Here and there it is almost stratified, passing upwards into the Saxicava Sand and downwards into the glaciofluvial sand, which in places contains gravel and beds of moraine sand. It was deposited in close conjunction with the advancing inland ice. The »Diluvial clay« directly overlies the youngest zone (Portlandia arctica Clay, Older Yoldia Clay) of the interglacial marine series which, however, is only seen at a few places at the foot of the cliff, most often in the form of floes. In this part of the cliff the »Diluvial clay« is very dense and homogeneous; its upper part has been affected by the inland ice and, over towards Maarup Church, a pressing out and laceration of the clay can be seen, an influence the intensity of which increases towards the south.

B. In the central part of the cliff (section through the hill-country itself) the lateglacial deposits are missing. The moraine sand disappears, too, and is substituted by a scattering of small and large stones on the old hill surface, which was later covered by blown sand. Only the glaciofluvial deposits: »Diluvial clay«, sand and gravel are to be seen in the section, in the stratigraphical position that is sketched in fig. 15. This shows the same series constantly repeated: Glaciofluvial sand, and below it alternating thin strata of glaciofluvial sand and »Diluvial clay«, and lower still a thick bed of »Diluvial clay«; the same series again: glaciofluvial sand, etc. Whilst there is conformability from the lowest, thick clay stratum up through alternating thin strata to the pure glaciofluvial sand, there is a sharp unconformability between this sand and the overlying (to the north) »Diluvial clay«. Along the thrustplane the sand beds are often bent up against the clay floe dragged with it during its movement up over the sand.

Thus we have a number of identical series, broken up from the original position and thereafter thrust up one above the other, so that they now lie like fish scales with a dip towards the NNE. The dip of the strata varies greatly in the different series, from nearly horizontal to almost vertical. It is the rule that the thrust-plane (the underside of the »Diluvial clay« bed) is steeper than the strata. In many places it can be seen that the »Diluvial clay« bed is wedge-shaped, being very thick at the foot of the cliff and tapering off towards the upper part of the cliff. This has been taken to be the result of the friction against

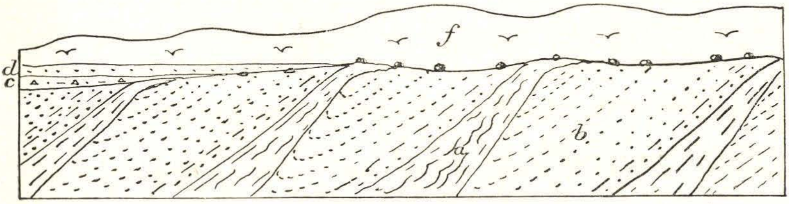


Fig. 15. Sketch-profile through the dislocated part of Lönstrup Klint (the northern part of Rubjerg hill-country). *a* Glaciofluvial clay. *b* Glaciofluvial sand. *c* Moraine-sand. *d* Lower Saxicava Sand. *f* blown sand.

the beds under the thrust-plane, but is more probably due to the fact that the thrust-plane originally has passed obliquely up through the strata or has been a curved flat.

That the inland ice moved over the hill after the strata had taken up their present position can be seen by the fact that the moraine sand can be traced some distance south over the oblique series, and by the strewing of large stones on the surface of the hill. Furthermore it can be seen how the upper ends of the clay strata may have been bent over and pressed out towards the south in the direction of the movement of the ice.

Local folds can frequently be seen in the big clay floes as a consequence of the pressure in the direction of the strata; but apart from a single abnormal stratigraphical position in the clay and sand strata just north of Stortorn, the main impression is one of unusual regularity, and there are no big folds in this cliff. So much of the sand strata may in some cases have been removed by the overthrusting that the big clay strata come together at the foot of the cliff and, at the top, are only separated by a wedge-shaped sand portion. In other places nearly all the sand may have been carried away, or is to be found in the form of smears in the big clay portions which have been thrust together.

The »Diluvial clay« is sometimes distinctly stratified and, in some cases, the same clay and sand strata can be identified in several series lying side by side. The sand has the usual glaciofluvial structure (false-bedding); ripple marks have been observed on the surface of argillaceous sand beds. The surface of the thick »Diluvial clay« bed is frequently waterworn and covered by a layer of river gravel and pebbles of clay. The glaciofluvial sand, especially in the lower strata, sometimes contains rolled fragments of wood, branches, seeds and other plant remains as well as amber.

The southern boundary of this central portion (in the most southerly part of which the strata lie almost horizontally) is formed by a steep plane, dipping towards the south, probably a fault, south of which the strata have sunk about 20 m. The hollow thus formed is infilled with moraine sand and lateglacial deposits; only at the foot of the cliff can one see the glaciofluvial deposits: »Diluvial clay« and sand as the upper ends of deep, slightly oblique clay floes with intermediate sand beds. A little further south the glaciofluvial strata again reach high up the cliff turning into horizontal, unbroken strata where the glacial effect is restricted to a folding of the upper layers.

C. The southern part of the cliff (section through the plateau south of the hill-country) is built almost like the plateau in the north. And yet Lower Saxicava Sand does not appear in the cliff until a long way further south, whereas Upper Saxicava Sand is general and attains great thickness. In the basin at Stensnæs one sees glaciofluvial deposits at the bottom, then an alternation of thin beds of glaciofluvial sand and moraine sand as a transition to typical moraine sand. Overlying this is dark, very rich clay, Yoldia Clay, which is overlain by Upper Saxicava Sand. On a long stretch to the south of this lie »Diluvial clay« and glaciofluvial sand in horizontal, undisturbed beds. The basin i Tvonnet Rende is infilled with shell-bearing Yoldia Clay, overlain by Upper Saxicava Sand and, in a basin about 200 m to the south of this, just north of **Nörre Lyngby,** may be seen Yoldia Clay at the bottom, then Upper Saxicava Sand (which here contains shells of *Saxicava arctica)* and, overlying it, postglacial freshwater deposits, clay and sand, with a rich flora and fauna *(Salix polaris, Salix reticulata, Dryas octopetala, Betula nana, Potamogeton, Spermophilus rufescens, Rangifer tarandus, Castor fiber, Lagopus mutus* etc.) and an arrow head of flint, probably contemporaneous with the reindeer. On the beach a find has been made of a worked reindeer antler. The deposit is at the transition from Lateglacial to Postglacial. South of this the cliff consists of shell-bearing Yoldia Clay which, south of Nørre Lyngby, is covered by Upper Saxicava Sand. Still more to the south the cliff mostly consists of glaciofluvial deposits and moraine sand.

From Nörre Lyngby back to Frederikshavn via the Hjörring Plateau.

Monday, 9th July.

Guide: Axel Jessen.

During the maximum of the Litorina submergence the north coast of Vendsyssel extended from Frederikshavn northwest to Tversted. The great lowland, Skagens Odde (the Point of the Scaw), was built up after this period by a co-operation between the emergence and the sand and gravel carried by the coast current. A point of support in this work was provided by a big clay bank north of Raabjerg; after this bank had been connected with the main land by means of gravel and sand shoals, one raised beach was gradually formed outside the other, and the land grew both in breadth and outwards to the northeast. Since then the current has again cut away a part of the west coast, i. a. at Kandestederne, while land was still being added to the east coast south of Skagen. In our day the land is still growing on the north coast north of The Scaw, whereas the land south of Skagen town to Skagen Light house is now being cut away. In the period from 1787 to 1888 there has been a growth of land amounting to three to five hundred metres on the north shore (west of the Hotel), and in 1787 the extreme point of the land, »Grenen«, lay 900 metres further south than it did in 1888.

From **Frederikshavn** the road leads northward over flat land, an abrasion surface in Portlandia arctica Clay (Older Yoldia Clay), covered by a layer of large stones, which in turn is overlain by Litorina deposits. To the west is a »rimme« landscape: a system of narrow sand ridges (»rimmer«) separated by hollows which are filled in with peat (»dopper«). The »rimmer« were originally narrow raised beaches of sand which were later heightened by washed up seaweed, by vegetation and blown sand. They radiate from a junction east of Gaardbosö and spread from there in the shape of a fan to the south and southeast towards Frederikshavn. This »rimme« landscape has a length of about 10 km and a breadth of 3—4 km.

At Hulsig Station the road turns westwards to **Kandestederne.** In the cliff along the beach are isolated dunes, in which there are deposits of »Martörv«, peat compressed by the weight of the blown sand, and, below this, horizontal beds of beach sand and beach gravel. The dunes are separated by stony plains which lie a little lower than the peat beds. This terrain has been formed by wind erosion. The peat layers can be traced as narrow strips into the country; they are old »dopper«. The stony plains are the »rimmer« lying between the dopper, originally jutting up above the peat layer but later blown away, and where wind erosion thereafter has had free scope to continue right down into the beach gravel, until the stones remaining formed a sufficiently close and protecting covering. Just as the whole of this lowland (disregarding the blown sand) lies at its highest in towards the original land and becomes lower and lower out towards the northeast, so the surfaces of the stony plains lies highest to the southwest, lowest out towards The Scaw.

Then the excursion proceeds to **Raabjerg Mile,** a bare dune which originally (thirty or forty years ago) had the form of a Barcan, but which has now gradually become lower and broader, with indefinite boundaries. Formerly the top of the dune lay 41 m above sea-level, 20—22 m above the surrounding plain, and on an average it moved about 8 m annually.

On the way from Kandestederne to **The Scaw** several big rows of dunes are passed. These are the parallel branches of parabolic dunes which run from WSW to ENE.

The night will be spent in **Skagen,** where the excursion terminates.

Danmarks geologiske Undersøgelse.

*The International Meeting
of Geologists
in Copenhagen 1928.*

Excursion D.

GUIDE

FOR THE EXCURSIONS IN DENMARK

NORTHEAST SJÆLLAND

KÖBENHAVN
NIELSEN & LYDICHE (AXEL SIMMELKIÆR)
1928

The excursion during the Meeting.

Excursion D.

Northeast Sjælland.

Thursday, 28 June 1928.

The Kitchen Midden at »Bilidt«.

Guide: V. Nordmann.

On the east side of Roskilde Fjord, a little to the north of Frederikssund by the old ferry inn »Bilidt«, lie the remains of what was once an extensive kitchen midden. In the years about 1840 Japetus Steenstrup made some preliminary investigations there and described the following section[1]):

1. Uppermost, 0.15—0.50 m sandy earth with fragments of shells;
2. A layer, about 2 m thick, the upper half of which mostly consisted of shells of *Ostrea, Cardium, Mytilus, Litorina* and others, mixed together in disorder and having among them crudely made flint implements, whilst the lower half, besides molluscs, contains a large number of small, rounded stones, 0.05—0.08 m in diameter.
3. About 2 m of beach-sand and gravel, almost without traces of animal remains.

Later the spot was repeatedly examined by the »Lejre Committee«[2]) whereby it was proved that the layer of mussel shells lying 3—3.5 m above the highest water level was a kitchen midden in which were found fire-places as well as layers of coal and ash. This place, which thus belongs

---

[1]) Oversigt kgl. Danske Vid. Selsk. Forhandl. 1848.

[2]) Ibidem. 1851.

to the classic localities from which we have our knowledge of one of the earliest passages of the habitation-history of our country — and indeed of the whole of Scandinavia — has repeatedly been examined by naturalists but nevertheless has never been properly described. Only a few times has it been mentioned in the literature, for instance in the reports of the Lejre Committee and by RØRDAM (Danm. geol. Unders. II Række. No. 2. pp. 90 and 117), where it is pointed out that the kitchen midden rests upon raised sea-floor (marine alluvium), which is likewise the case with several other kitchen middens (Havelse, Sölager etc.), from which he concludes that the kitchen midden period is contemporaneous with the last part of the marine period (Litorina Period)[1]. Finally, »Bilidt« has been briefly mentioned by SARAUW (Medd. fra Dansk geol. For., Vol. 3, p. 234). For about fifty years the material from the kitchen midden and from the underlying beach deposits was used for road-fill and marl, and gravelpits of varying sizes have from time to time been opened in the heaps. The result was that, in 1912, there was only an unimportant remnant of the original raised beach and kitchen midden.

In 1912 the gravelpits covered an area of about 3000 sq. m, but have since been reduced considerably by parcelling out for villa sites. At that time several more or less good sections were to be seen in the pits, that in the most westerly part of the north wall being the most interesting. The upper edge was highest about 5 m over the mean water level, and from there it fell rapidly to both sides, mostly so towards the fjord side. At the place where it was highest was the following series: 1) 0.55 m kitchen midden, 2) 0.15 m fine sand and gravel with a few shells, 3) 0.20 m shell-layer (redeposited kitchen midden), 4) 0.5 m fine sand with a few stones, very few shells or small heaps of shells as well as small, scattered pieces of charcoal, 5) 0.20 m of thin layers of shells alternating with fine sand, 6) 0.30 m fine sand with scattered

[1]) Later investigations have shown that the Litorina Period may not be considered to have ended before in the Bronze Age, or rather the beginning of the Iron Age.

shells, 7) 0.40 m gravel with shells. By excavating at the foot of the section I found further: 8) 1 m fine sand with scattered stones and one or two fairly thick layers of shells, 9) 0.20 m rust-coloured gravel with a few shells, 10) moraine clay, through which I dug down 0.30 m and bored 0.5 m without getting through the layer. (In excavations in other places, however, much deeper levels have been reached without coming to moraine clay, but merely fine sand (glaciofluvial)). In layers 8 and 9 there is a fairly rich fauna consisting of *Ostrea edulis* (which occurs in real deposits of oyster-shells and attains a size of 110 mm), *Mytilus edulis* (about 60 mm), *Cardium edule* (45 mm), *C. exiguum* (11 mm), *Montacuta bidentata, Tapes aureus* (31 mm), *T. pullastra* (43 mm), *T. decussatus* (about 55 mm), *Scrobicularia piperata* (41 mm), *Tellina baltica* (20 mm), *Litorina litorea* (about 30 mm), *L. obtusata* (very large and thick-shelled), *L. rudis* with *var. tenebrosa, Rissoa membranacea, R. inconspicua, Onoba striata, Hydrobia ulvae, Nassa reticulata* (25 mm), *Bittium reticulatum, Odostomia rissoides, Utriculus truncatulus, Chiton (marginatus?)*[1]).

The thin shell layers in the upper parts of the section contain more or less of these forms. In the kitchen midden layer itself the edible species, *Ostrea, Cardium, Mytilus* and *Litorina litorea* are, of course, all-prevailing, although practically all the other species appear in it too, even the small forms, but naturally more infrequently. In this layer has also been found a piece of the shell of *Mya truncata* (an immature specimen). Thus the kitchen midden is not outstanding by reason of the species it contains but by the proportion between the frequence with which the various species occur and by the whole character of the layer (the crushed, split, scorched and disorderly heaped-up shells) from the natural shell deposits deeper

---

[1]) For purposes of comparison it may be mentioned that the mollusca in the »recent« Roskilde Fjord comprise the following species: *Mytilus edulis, Cardium edule, Tellina baltica, Scrobicularia piperata, Mya arenaria* (immigrated after the Litorina Period), *Litorina litorea, L. tenebrosa, Rissoa membranacea, R. inconspicua, Hydrobia ulvae, Bittium reticulatum* and *Neritina fluviatilis.*

down. No mammal or bird bones have with certainty been found in the kitchen midden at »Bilidt«, whereas roughly hewn flint implements, fire-places, coal and ash layers have been met with. Small remains of coal are also found so far down in the beach-sand as Layer 4. The other sections in the gravelpit outside the area of the kitchen midden display beach-sand and gravel, finely stratified, and the latter plays a much more important part here than in the section first described. In these sections are to be seen extensive layers of *Ostrea* and *Mytilus* mixed up with the other species which have been named; here, too, it is possible to find pieces of coal and flint implements down among the beach-gravel beds. In several sections in the east wall, the upper edge of which (the surface of the ground) is 2.6 to 2.8 m above mean water level, are peculiar inclined beds, some earth-coloured, others lighter, consisting of fine gravel and numerous shell remains. The size of the grains differs, but is always the same within each bed. These beds, which form the infilling of pits or hollows in the upper layers of the beach, come from the old gravelpits and consist of the waste material after screening.

Thus it appears that the kitchen midden at »Bilidt« lies upon a Litorina-(Tapes-) beach which, stretching from a small Diluvial sand-hill about 9 m high (in this period a small island in Roskilde Fjord, which was much wider at that time) to the south almost to the present highway between Frederikssund and Jægerspris. To the east the beach was separated by a sound from the large island, on the south end of which a part of the town of Frederikssund now stands. The floor of this sound has, through a subsequent emergence, been covered by a peat bog that is now tilled and cultivated. Layer 3 differs from the kitchen midden only in that the material is partly sorted and arranged by the action of the waves on the top of the beach and, as this layer lies near the Litorina-sea boundary (Rørdam reckons the water-level at that time at 3.5 m higher at mean tide than now), it must have been deposited at the time when the Litorina submergence was at its maximum; the coal remains found in the deeper layers, in conjunction with the flint implements found in the beach gravel, however, indicate that the district was already inhabited before this maximum was reached.