INTERNATIONAL GEOLOGICAL CONGRESS
XXI SESSION NORDEN 1960

GEOLOGY OF BORNHOLM

GUIDE TO EXCURSIONS NOS A 45 AND C 40

BY
HELGE GRY

Editor of Danish guide-books:

THEODOR SORGENFREI

COPENHAGEN 1960

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Key map: see back side of cover.
Map of Bornholm: see folder.

Excursion no. A 45: Aug. 7th—11th 1960.
C 40: Aug. 25th—29th 1960.

Leader:

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Charlottenlund.

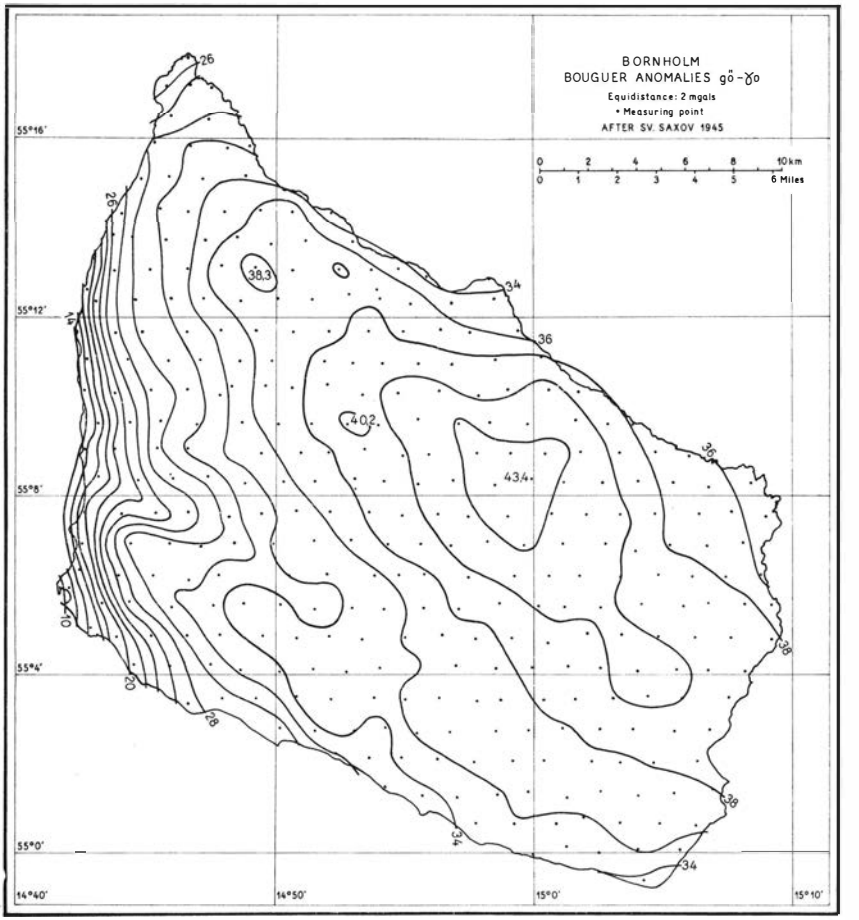


Fig. 1.

Outline of the Geology of Bornholm

The island of Bornholm (587 km²) is one of the horsts of the Fenno-scandian border zone, i.e. the faulted zone between the Fennoscandian shield and the Danish – Polish sedimentary basin.

The shape of the island is to a certain degree determined by the directions of the important faults of the area viz. faults trending WNW, N, NNE and NNW.

Two faults are especially important, the one running along the west coast and the other running along the western part of the southwestern coast. These two faults are border faults of the horst proper. The displacement of the western fault

is, according to gravity measurements, abt. 1500 m (5000 ft), and the displacement of the southwestern fault is also considerable compared with the rest of the faults of the island. West and south of the two faults Triassic, Jurassic and Cretaceous rocks occur, whereas the rest of the island is built up of Pre-Cambrian and Lower Palaezoic rocks. In smaller down-faulted areas within this horst area Cretaceous strata resting on the Pre-Cambrian – Palaeozoic basement have also been preserved.

The northern two thirds of the island consist of Pre-Cambrian granite-gneisses and granites, possibly belonging to the Karelides of Scandinavia. The Pre-Cambrian is penetrated by numerous diabase dykes, most of which trend NNE. The landscape is furrowed by rectilinear valleys, formed by erosion of the inland ice in lamellated joint zones. Movements along strike-slip faults in the zones have been proved.

To the south the Pre-Cambrian is overlain by abt. 100 m of Eo-Cambrian continental sandstone (Nexø sandstone) which in turn is succeeded by abt. 60 m of Lower Cambrian marine quartzitic sandstone (Balka Quartzite) and abt. 100 m of glauconitic siltstone. This is again overlain by Cambrian, Ordovician and Silurian rocks, mostly shales, rich in fossils (see below).

Stratigraphic table of the Paleozoic of Bornholm.

Formation	*Thickness*	*Age*
Cyrtograptus shale Rastrites shale	80 m	Lower to Middle Silurian
Tretaspis shale	3	
Middle Dicellograptus shale	10	Upper Ordovician
Lower Dicellograptus shale	0.6	
Shale	1.6	
Phosphorite conglomerate	0.3	Middle Ordovician
Orthoceras limestone	5	
Basal conglomerate	0.1	
Dictyonema shale	2.5	Lower Ordovician
Alum shale	21	Upper Cambrian
Alum shale	2	
Andrarum limestone	0.6–0.9	
Anthraconite	0.2	Middle Cambrian
Alum shale	0.8–1.4	
Exsulans limestone	0.3	
Rispebjerg sandstone	3	
Glauconitic siltstone	100	Lower Cambrian
Balka quartzite	60	
Nexø sandstone	100	Eo-Cambrian
Granite-gneisses		Pre-Cambrian

The Paleozoic series is broken by a series of normal faults, the most significant of which trend WNW, another important direction is NNW-SSE or N-S. The general dip of the Palaeozoic strata is SE or SSE, other directions are rarely found. The dip is very flat, seldom more than 3–4° except close to the faults where steeper dips may occur.

No deposits of Devonian, Carboniferous, or Permian age appear in Bornholm, which, undoubtedly, remained above sea-level during the major part of the corresponding period. The area was subjected to denudation and at the beginning of Mesozoic time a deeply weathered kaolinized surface existed. Remnants of the kaolinized surface is still to be seen.

The Mesozoic series of Bornholm includes sediments of Keuper, Jurassic and Cretaceous age.

The Keuper consists of red and green sticky clays and greenish sandstones. The series is exposed at the border fault along the south-west coast only, where it is strongly disturbed and dips southward. The thickness of the Keuper is not known, nor the character and age of the underlying rocks. The gravity anomalies indicate, however, a considerable downthrow of the sediments south of the fault.

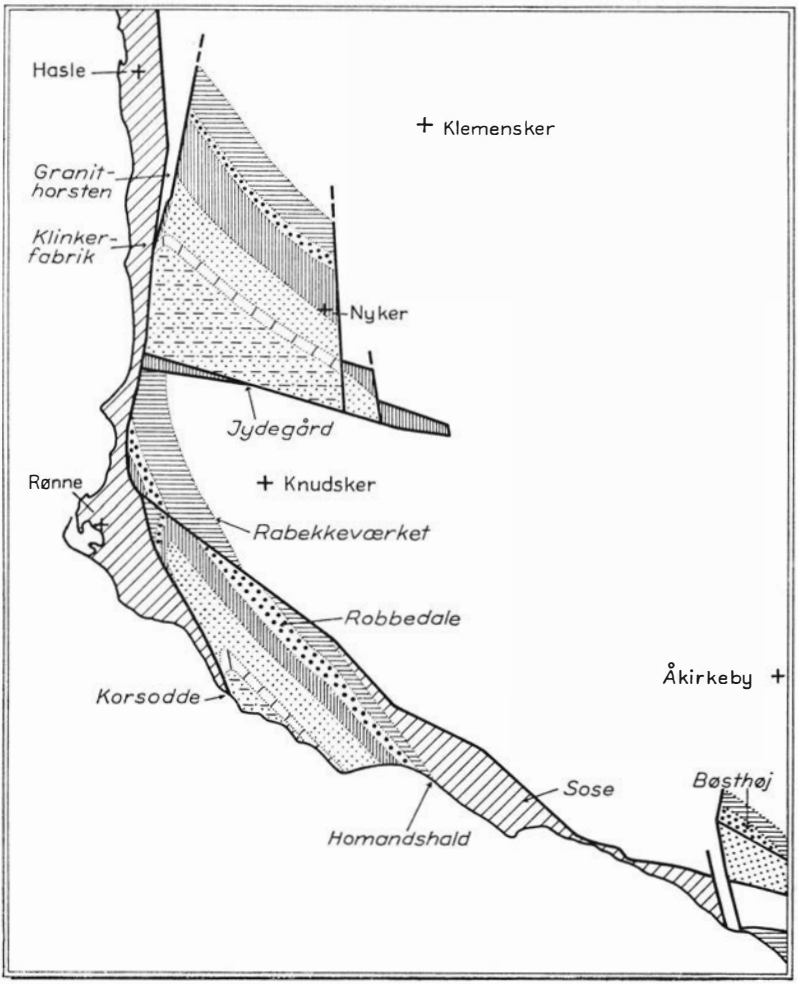
The Keuper is superposed by a series of Jurassic rocks consisting of alternating sands, clays, a large part of which is refractory clays, and thin coal seams. A common type of sediment is a deposit with graded bedding consisting of alternating fine sand, silt, and clay with ripple structure. Sideritic ironstone beds and lenses are often met with in this type of sediment.

The Jurassic series is deposited under deltaic conditions. The paralic character of the series is proved by the fact that foraminifera have been found in some (at least 5 or 6) horizons. One of the marine horizons is of greater significance than the others as it contains a marine fauna of Lias gamma age. Accordingly, the Jurassic on Bornholm may be divided, provisionally, in

Upper Coal-bearing Series	more than 270 m
Marine horizon Lias	abt. 100 m
Lower Coal-bearing Series	more than 350 m
	more than 720 m (2360 ft).

The Mesozoic flora of Bornholm has been described by Bartholin (1892, 1894), Hjorth (1899) and Møller (1902, 1903). In accordance with these old descriptions species ranging from the Rhaetic to the Dogger and Wealden are found in the deposits. However, according to Harris (1937) Rhaetic plants do not occur in the formations.

The Lower Coal-bearing Series include among others the Vellengsby clay, the Munkerup clay and brackish deposits SE of Rønne. According to Harris the Vellengsby clay should be referred to the *Thaumatopteris* zone (basal Lias) or, possibly, to some other younger zone of the Lias. In the Munkerup clay Helge Gry has found megaspores of *Lycostrobus Scotti* (unpublished), on the basis of which the Munkerup clay is referred to the basal Lias. The brackish deposits SE of Rønne include *Cardinia Follini* and are consequently referred to Lias alpha.



The Mesozoic of South West Bornholm

Lower Senonian: Bavnodde greensand

Turonian: Arnager limestone

Cenomanian: Arnager greensand

Wealden: Jydegaard formation

Wealden: Robbedale formation

Wealden: Rabekke formation

Jurassic and Keuper

Pre-Cambrian and Paleozoic deposits

Faults

1 0 1 2 3 4 5km

D.G.U. 1955
emended 1960

HELGE GRY

Fig. 2.

The Bagå series probably belongs to the Upper Coal-bearing series.

The Bagå flora is according to Harris an intermediate flora between the European basal Liassic flora and the upper Liassic flora of Poland and the related Lower Oolite flora of England. Harris considers the Bagå flora as definitely younger than the *Thaumatopteris* zone, while Rosenkrantz refers its lower parts to the *Thaumatopteris* zone, since they include *Thaumatopteris* and are overlain by beds including a fossiliferous zone with lamellibranchia, indicating Lias gamma age of the bed concerned. Florin's investigations of the taxads and conifers as well as the writer's studies of the megaspores suggest, however, close relationship with the Middle Jurassic flora of England.

The boundary between the subsiding areas, where the Jurassic sediments accumulated, and the rising area where rapid denudation took place, seems to coincide with the faults along the west coast and along the south-west coast. The presence of mud-flow sediments with large boulders of kaolinized granite in the Bagå series (south of Hasle) suggests the existence of a scarp at the western fault during Jurassic times.

The basal Cretaceous consists of Wealden deposits resting unconformably on the Jurassic of the Robbedale-Sose block (see fig. 2) and overlapping on the Pre-Cambrian and Lower Paleozoic rocks. The substratum of the Wealden is more or less kaolinized and the basal part of the Wealden series consists of sand and subordinate beds of sedimentary kaolin, derived directly from the substratum. Then follows a series of greasy green and dark grey limnic clays with weathering horizons of variegated clay which is called the Rabekke formation. This series is characterized by the presence of spherosiderite. Above it follows a sandy series, the Robbedale formation, consisting of rather pure quartz sand and fine gravel. A series of stratified clays and sands, partly coarse-grained with chamosite-oolite, the Jydegaard formation, follows on the top of Robbedale formation.

The Wealden sediments contain fresh water and brackish water molluscs (*Dreissensia, Cyrena, Unio, Paludina)*, ostracods (i. a. *Cypridea*) and plant remains.

The Wealden deposits vary in thickness as shown below:

Jydegaard formation	60–100 m
Robbedale formation	8– 40 m
Rabekke formation, clay	10– 80 m
– – , sand	0– 30 m

On the Wealden rest marine Cretaceous deposits; the basal beds belong to the Lower Albian and the topmost interval is referred to the Lower Senonian. The sequence includes the following formation units:

Bavnodde greensand	180 m?	Lower Senonian
Arnager limestone	12– 20	Upper Turonian
Basal conglomerate	0.2	
Arnager greensand	70–130	Middle Cenomanian
Basal conglomerate	0.5– 2	Uppermost Albian
Pebbles of glauconitic sandstone in above mentioned conglomerate		Lower Albian

Movements along faults have undoubtedly taken place in Pre-Cambrian, late Palaeozoic, and Mesozoic times. The most important movements, resulting in the formation of the present horst, are, however, supposed to have occurred during the Tertiary.

During the Ice age Bornholm was covered by the inland ice. It abraded the bedrock surface, formed "roches moutonnées" and excavated the joint valleys. The glacial deposits are generally not very thick, in most places not more than abt. 10 m. Boulder sand is found in the inner part of the island, and boulder clay is found elsewhere. Stratified glaciofluvial sands and gravels play a role, especially where the ice margin stopped for some time during the recession of the ice.

East of Rønne an outwash plain was formed by a glacial river running westwards and at the north coast varved clay was deposited in a number of ice dammed lakes.

Isostatic movements after the glaciation resulted in the formation of raised beaches. Late glacial beach sands and gravels have accordingly a wide extension along the east coast. Minor Holocene terraces are found locally.

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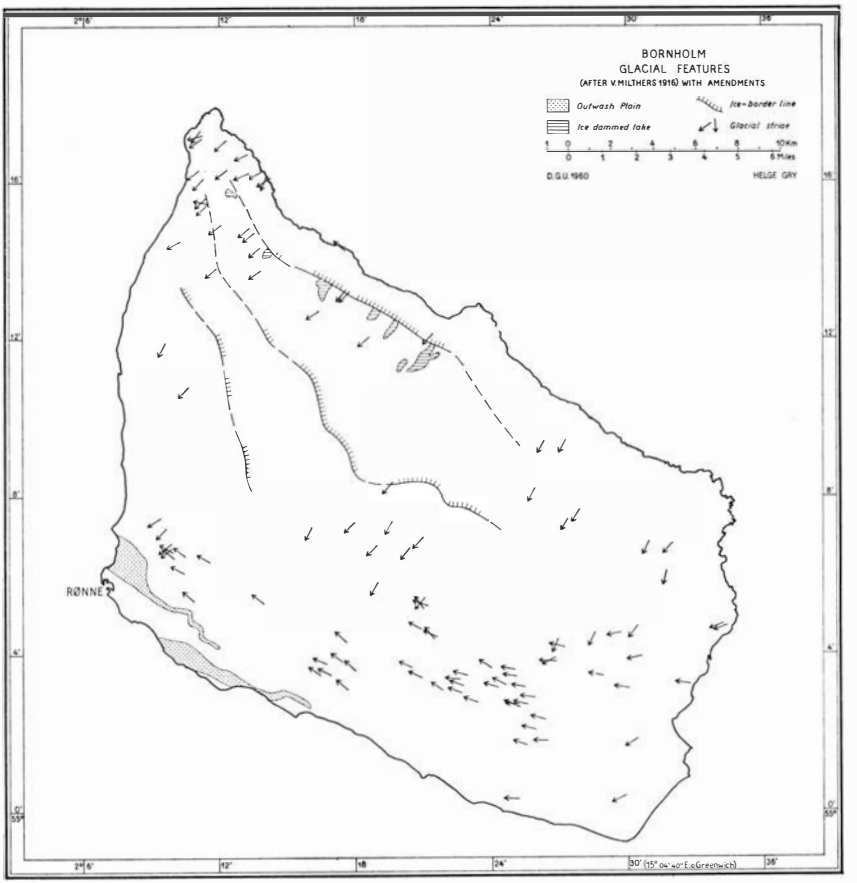

FIG. 3.

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Field Guide

August 7th (A 45) or August 25th (C 40).

Departure from Copenhagen (Havnegade) 23.15 by boat. Arrival Rønne, Bornholm, the next morning at 7.00.

August 8th (A 45) or August 26th (C 40).

Mesozoic of the south coast, Triassic to Senonian.
From Rønne by bus 9.00 to *Skelbro*. Quarry in Orthoceras limestone (Ordovician).
Risegaard. The southern border fault of the Bornholm horst. Uplifted block: Middle Dicellograptus shales and Tretaspis shale; downthrown block: tilted strata of the Keuper (red clay and greenish sandstone) overlain by Munkerup clay (basal Lias).
Sose. Coast sections in fresh water- and deltaic sediments (sands, clays, and coal) Lower Lias.
South of Aakirkeby. Quarry in Lower Cambrian quartzitic sandstone (Balka quartzite), which is separated from the gneiss by faults.
Rytterknægten. The highest point on Bornholm 162 m (532 ft).
Walk along the coast from *Homandshald to Arnager*. Sections in dark clay and sand (Wealden) overlain by Arnager greensand (Cenomanian) with basal conglomerate of phosphoritic nodules. At Arnager: Phosphorite nodules in basal conglomerate below the Arnager limestone, which is an impure limestone of Turonian age with silica sponges.
Walk from *Bavnodde* along the coast to *Korsodde* and the river *Stampeaa*. At Bavnodde: Bavnodde greensand (Lower Senonian), Korsodde: clays and sand (Upper Coal-bearing Series, Jurassic). Further westwards: ferruginous sandstone with sideritic ironstone beds (Lias gamma). At Stampeaa: Fault between the Robbedale – Sose block and the Rønne area. On the western side Jurassic beds and on the eastern side Cenomanian greensand with basal conglomerate. The strata are steeply, almost vertically, inclined. Farther upstream the Arnager limestone is dipping NE.

August 9th (A 45) or August 27th (C 40).

Important Mesozoic localities, weathered basement and the western gneiss coast at Jonskapel.

NNE SSW

Fig. 4. Section at the Stream Risebæk. a. Alum shale ; o. Orthoceras limestone; gr. Dicellograptus shale; j. Jurassic and Keuper; s. fault.

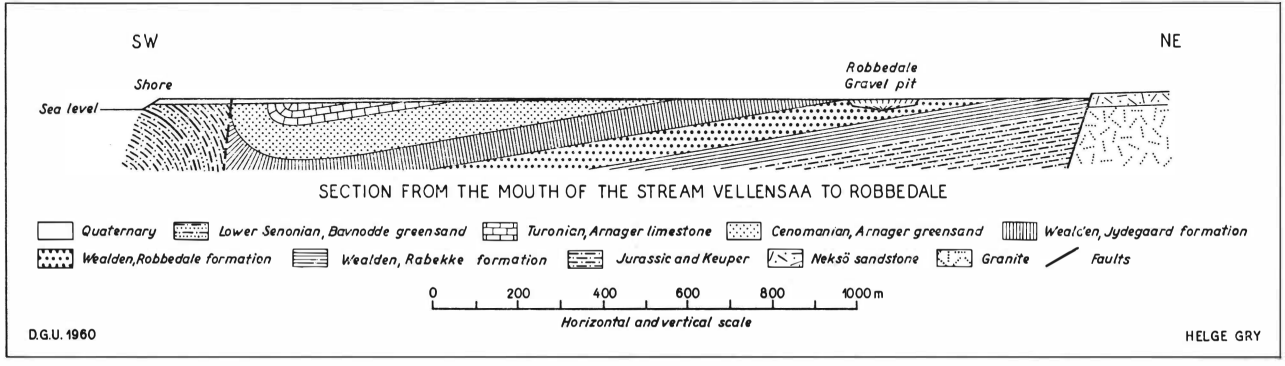
SW
NE
Shore
Sea level
Robbedale
Gravel pit
SECTION FROM THE MOUTH OF THE STREAM VELLENSAA TO ROBBEDALE
Quaternary
Lower Senonian, Bavnodde greensand
Turonian, Arnager limestone
Cenomanian, Arnager greensand
Wealden, Jydegaard formation
Wealden, Robbedale formation
Wealden, Rabekke formation
Jurassic and Keuper
Neksö sandstone
Granite
Faults
0
200
400
600
800
1000 m
Horizontal and vertical scale
D.G.U. 1960
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Fig. 5.

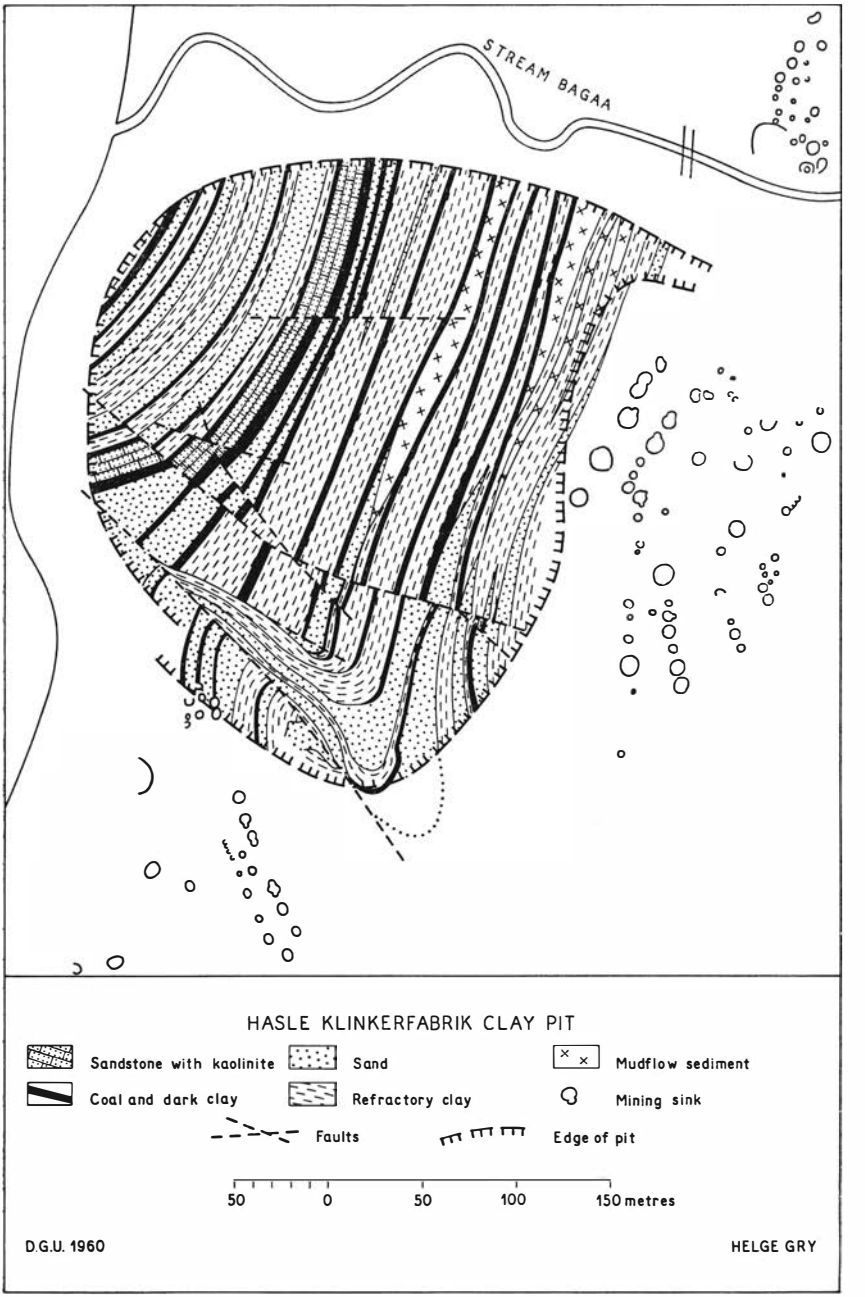

STREAM BAGAA
HASLE KLINKERFABRIK CLAY PIT
Sandstone with kaolinite
Sand
Mudflow sediment
Coal and dark clay
Refractory clay
Mining sink
Faults
Edge of pit
50
0
50
100
150 metres
D.G.U. 1960
HELGE GRY

Fig. 6.

Rabekkeværket. Pit in kaolin (in situ weathered Rønne granite) overlain by argillaceous sand and sandstone and sticky dark and green clays (Wealden).
Klippegaard. Quarry in un-weathered Rønne granite.
Robbedale. Fault. Uplifted block: Eo-Cambrian Nexø sandstone resting on red-weathered granite. To the south the Robbedale-Sose block. – Gravel pits in Robbedale gravel, underlain by sand with traces of excavating organisms. Above the Robbedale gravel sand and clay with *Paludina* and *Cyrena* (Wealden).
Skyttegaard. Clay pit in dark and greenish Wealden clay.
Jonskapel. Steep coast cliff following the principal trend of the joints of the Pre-Cambrian basement. Cleft in weathered diabase dyke.
Bagaa. Clay pit (fig. 6). Lower or Middle Jurassic coal-bearing series, alternating sands, refractory clays and coal of poor quality. Mudflow sediments with large, partly kaolinized granite boulders. The strata are dipping south-east.—In the southern part of the pit a fault zone separating the Bagaa series from the Sorthat series, same types of rocks on both sides of the fault (Jurassic, Upper Coal-bearing Series).
Jydegaard (fig. 7). Clay pit in the fault zone between the uplifted Pre-Cambrian granite-gneiss area (south) and the downwarped area with Cretaceous deposits (north). Abt. 40 m broad zone of steeply inclined beds of Wealden clay with beds of sand and gravel and chamosite-oolite. To the south an almost vertical fault separates the Wealden from kaolinized and chloritized gneiss, to the north a reversed fault separates the Wealden from the Bavnodde greensand (Senonian) dipping north.
Rønne Lervarefabrik. Clay pit in Jurassic finely bedded clay and silt with sideritic ironstone bands and lenses (marine, Lias gamma). The beds are steeply inclined, the dip being NW abt. 70°.

August 10th (A 45) or August 28th (C 40).

The Palaeozoic series at Læsaa, Eo-Cambrian and Cambrian sandstone SW of Nexø, the Pre-Cambrian of North Bornholm.
The stream Læsaa. Kalby: sections in glauconitic siltstone and Rispebjerg sandstone (Lower Cambrian), Lower alum shale (Middle Cambrian black shale) and Upper alum shale (Upper Cambrian). Vasagaard: Middle Dicellograptus shale (Upper Ordovician) with bentonite beds. Limensgade: Upper Cambrian alum shale overlain by Lower Ordovician alum shale (Dictyonema shale), superposed by Orthoceras limestone (Middle Ordovician).
Balka. Lower Cambrian Balka quartzite resting on Eo-Cambrian Nexø sandstone. Quarry in basal glauconitic part of the Balka quartzite.
Bodilsker. Quarry in continental reddish Nexø sandstone (Eo-Cambrian).
Paradisbakkerne. (Walking distance abt. 3½ km). The topography of this gneiss area (Paradisbakke gneiss) is characterized by numerous joint-valleys, crossing each other in two systems, one with a WNW trend and another trending NNE. – Quarry in the Paradisbakke gneiss.

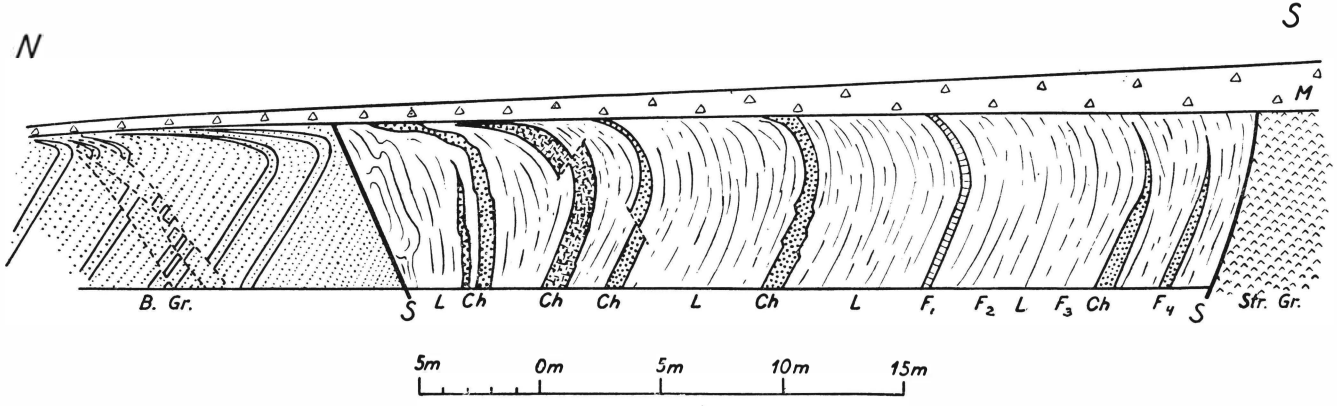
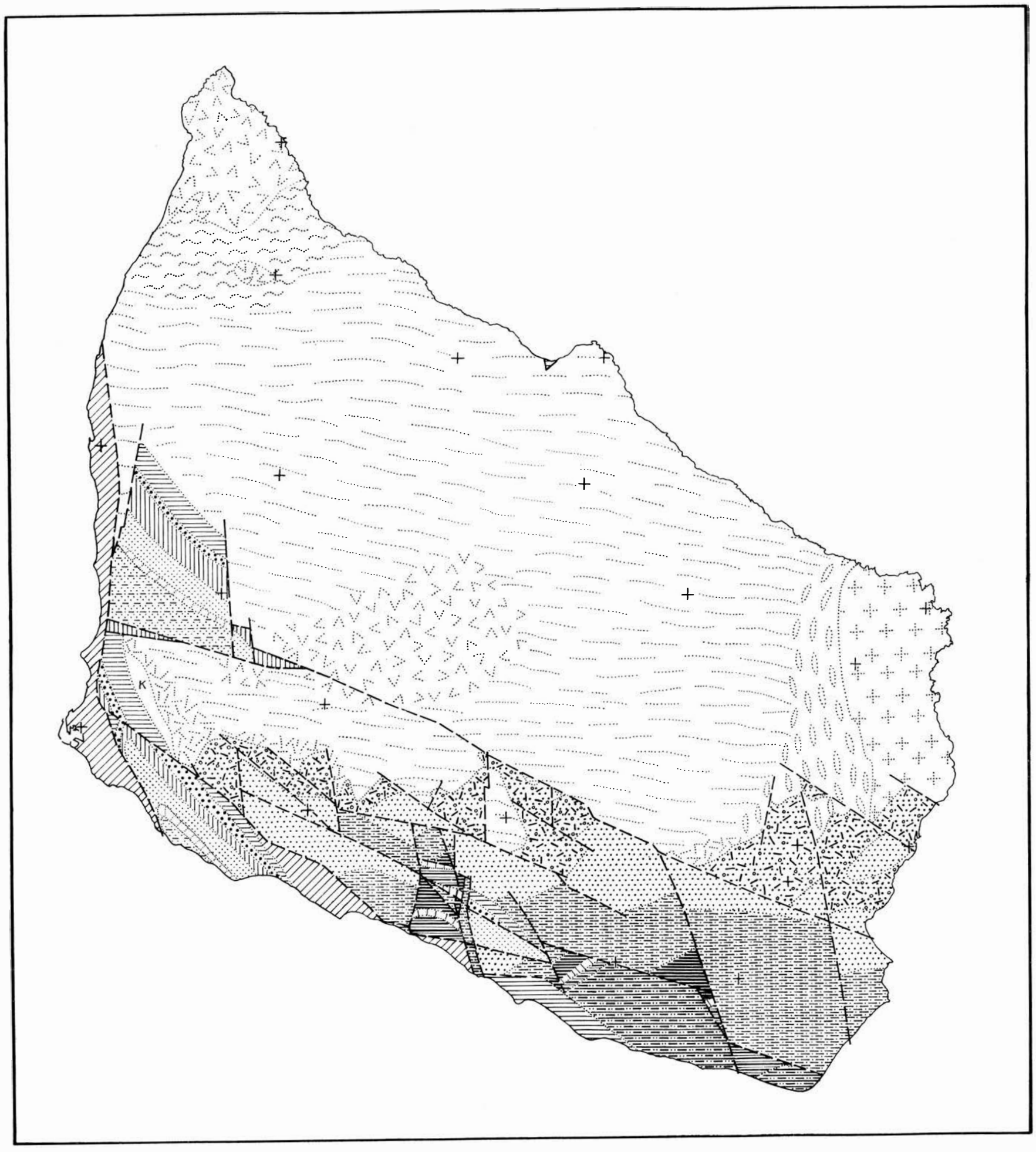


Fig. 7. Section at Jydegaard, Knudsker, Bornholm.
Str. G.=Striated granite, chloritized. L=Jydegaard formation, clay. Ch=Chamosite-oolite, gravel, sand and clay-ironstone. F_1=clay-ironstone, fossiliferous. F_2-F_4= fossiliferous horizons. B. Gr.=Bavnodde greensand. S=fault. M=boulder clay.

Listed. Coarse grained Svaneke granite intersected by a Pre-Cambrian diabase dyke (width 31 m); the granite and the diabase is penetrated by dykes of Eo-Cambrian sandstone.
Østerlars. Round-church from the 13th century.
Salne. Small down-faulted area with Wealden clay and kaolinized Balka quartzite.
Between Allinge and Sandvig. Rock engravings from the Bronze age (abt. 1000 B. C.).
Hammershus. Ruin of castle from the 13th century.

Boat departs Rønne 22.45, arrives Copenhagen 7.00.



MESOZOIC

- Bavnodde greensand, Lower Senonian
- Arnager limestone, Upper Turonian
- Arnager greensand Middle Cenomanian
- Jydegaard formation, Wealden
- Robbedale formation Wealden
- Rabekke formation, Wealden.
- Coal-bearing Jurassic & Keuper.

PALAEOZOIC

- Rastrites & Cyrtograptus shale, Lower to Middle Silurian
- Dicellograptus shale & Tretaspis shale, Upper Ordovician
- Orthoceras limestone, Middle Ordovician
- Alumshale & Dictyonema shale, Middle and Upper Cambrian, Lower Ordovician
- Glauconitic siltstone, Lower Cambrian
- Balka quartzite, Lower Cambrian
- Nexø sandstone, Eo-Cambrian

PRE-CAMBRIAN

- Svaneke granite
- Hammer granite & Almindingen granite
- Granite-gneiss
- Vang granite
- Paradisbakke gneiss
- Rønne granite
- K — Kaolin
- Faults
- Church

GEOLOGICAL MAP OF BORNHOLM – PRE-QUATERNARY DEPOSITS

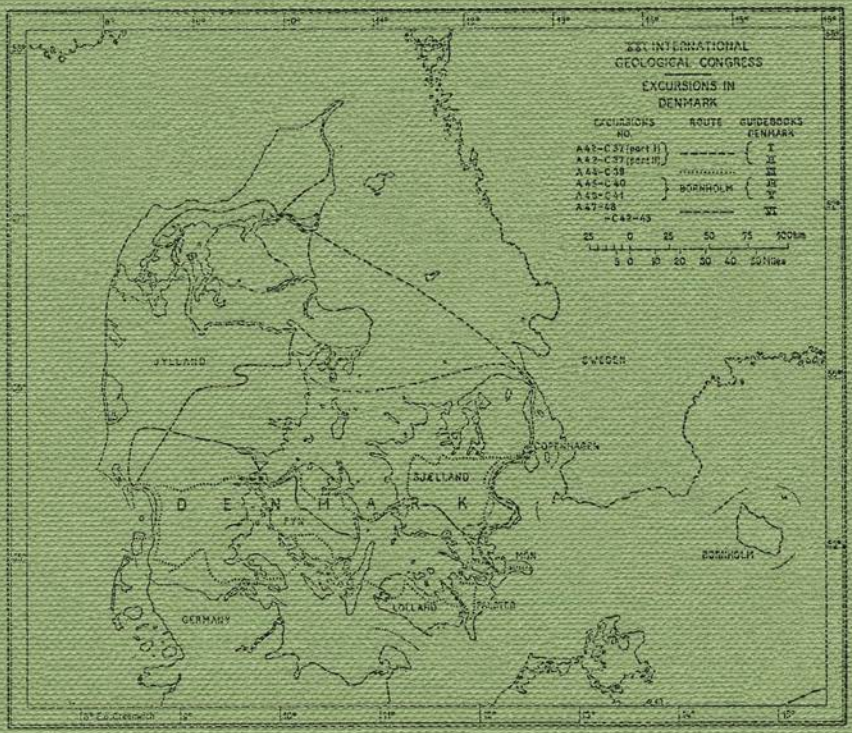
1 0 2 4 6 8 10

GEOLOGICAL SURVEY OF DENMARK 1960

HELGE GRY

DENMARK

Guide-book IV



Price 5 Danish crowns

DET BERLINGSKE BOGTRYKKERI