Danmarks Geologiske Undersøgelse

Geological Survey of Denmark . Yearbook 1972

Årbog 1972

I kommission hos C. A. Reitzels Forlag
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Indhold

Preface

With this yearbook the Geological Survey of Denmark wishes to introduce a new series of publications, which is intended to be an annually-published collection of short papers and articles by the members of the institute. The contents of the yearbook will range over all types of written contributions from scientific papers to popular articles, but main emphasis will be placed on the former. The yearbook aims to create a forum for short papers and also to illuminate the many aspects of the work of the institute through the wide variety of the contributions.

With the introduction of the yearbook our IV. series publications, which consisted exclusively of shorter papers, will be discontinued. Such papers will in future appear in the yearbook, where there will also be room for even the briefest of written contributions.

Forord

Med den her foreliggende årbog ønsker Danmarks Geologiske Undersøgelse at introducere en ny serie publikationer, der er tænkt som en årligt udkommende samling af små afhandlinger og artikler fra instituttets medarbejdere. Årbogens indhold vil kunne spænde over alle former for skriftlige bidrag ligefra videnskabelige afhandlinger til populære artikler, dog med hovedvægten på den første gruppe. Hensigten med årbogen er at skabe et forum for små afhandlinger og tillige gennem forskelligartede bidrag at belyse alle sider af instituttets virksomhed.

Samtidig med introduktionen af årbogen nedlægges vore publikationsseriers IV. række, der kun omfattede mindre afhandlinger. Sådanne vil for fremtiden være at finde i årbogen, hvor der også vil være plads for de helt små skriftlige bidrag.

On the occurrence of pollen similar to Bruckenthalia spiculifolia (Salisb.) Reichenb. in Danish Quaternary deposits

Svend Th. Andersen

Andersen, Svend Th.: On the occurrence of pollen similar to *Bruckenthalia spiculifolia* (Salisb.) Reichenb. in Danish Quaternary deposits. *Danm. geol. Unders., Årbog 1972*, pp. 5–6. København, 3. december 1973.

Menke (1970) has called attention to the fact that pollen grains very similar to pollen of the ericaceous genera *Blaeria* and *Bruckenthalia* occur in Quaternary deposits of various ages in Schleswig-Holstein. Pollen from these genera resemble *Frangula alnus* Miller pollen, and the fossil grains were earlier referred to "Rhamnaceae-type" (Menke 1969). They occur as late as Brørup-Interstadial deposits in Schleswig-Holstein, and Menke (1970) suggests that other finds from deposits of such age referred to *Frangula alnus* also belong to the *Blaeria*-type.

Pollen tetrads occur in *Blaeria patula* Engl., whereas the pollen grains of *Blaeria ericoides* L., *Bruckenthalia spiculifolia* and *Frangula alnus* Mill. are tricolporate and ± psilate. These tricolporate grains have pronounced costae colpi (sensu Iversen and Troels-Smith 1950) and the pore appears in surface view as a colpus transversalis; however, as pointed out by Menke (1970) they differ slightly, as the pore is seen as a simple slit in *Blaeria* and *Bruckenthalia* in optical cross-section, whereas a vestibulum-like structure appears in *Frangula* pollen (illustrations in Menke l.ic.). This is due to the presence of costae transversales in *Frangula*, but these are not always pronounced and may be missing. The *Blaeria ericoides* and *Bruckenthalia* pollen in our material have convex intercolpia. The *Frangula* pollen grains often have concave intercolpia, but grains with convex intercolpia also occur.

Tricolporate and psilate pollen grains from various Danish Quaternary deposits including the Brørup Interstadial have been referred to *Frangula alnus* by the present author (Andersen 1961, 1965). The reference collection examined comprised North and Central European species, and *Blaeria* and *Bruckenthalia* were not represented. The author felt slightly bothered by the absence of costae transversales in the fossil grains, but there seemed no other possibility of identification than *Frangula alnus*. After a re-examination of the material from the Brørup Interstadial (Brørup Hotel Bog, Nørbølling, Andersen 1961), the author feels convinced that these grains should rather be referred to an ericaceous genus, probably *Bruckenthalia* or *Blaeria.* Similar grains also occur at sites of middle Quaternary age, whereas scattered *Frangula* pollen occurs at the sites from the Eemian Interglacial (Andersen 1965). Further revision of this material will be necessary, however.

Bruckenthalia spiculifolia is monotypic. It is calcifuge and occurs today in woods and subalpine pastures in mountains of Jugoslavia, Romania, Bulgaria, Greece and Asia minor (Hegi 1908–31, Flora Europaea), whereas *Blaeria* occurs with numerous species in tropical and southern Africa. No ericaceous macrofossils were recorded in the deposits from Brørup and Nørbølling. As *Picea omorika* from Jugoslavia is represented it is not unlikely that the ericaceous pollen belongs to *Bruckenthalia spiculifolia.* Its occurrence would not contradict the acidophilous vegetation otherwise indicated at that time (Andersen 1961). The identity of the tricolporate ericaceous pollen grains from the older sites mentioned above is more uncertain; however a widespread occurrence of an ericaceous shrub is in accordance with the increasingly open and heathlike vegetation otherwise indicated in the oligocratic and telocratic phases of the interglacial successions (cp. Andersen 1969).

The present revisions suggest that surprising plants may have been widespread even in a rather young stage of the Quaternary, and such unexpected discoveries must be welcomed.

Literature

Andersen, S. T., 1961. Vegetation and its environment in Denmark in the early Weichselian Glacial (Last Glacial). Geol. Surv. Denmark, II. 75.

– 1965. Interglacialer og interstadialer i Danmarks kvartær. Geol. Soc. Denm., Bull. 15, 486–506.

– 1969. Interglacial vegetation and soil development. Geol. Soc. Denm., Bull. 19, 90–102.

Flora Europaea. 3. 1972. Ed. Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M., Webb, D. A. Cambridge.

Hegi, G., 1908–31. Illustrerte Flora von Mitteleuropa. München.

Iversen, J., and Troels-Smith, J., 1950. Pollenmorfologiske definitioner og typer. Geol. Surv. Denm. IV, 3, 8.

Menke, B., 1969. Vegetationskundliche Untersuchungen an altpleistozänen Ablagerungen aus Lieth bei Elmshorn. Eiszeitalter u. Gegenwart, 20, 76–83.

– 1970. Ergebnisse der Pollenanalyse zur Pleistozän-Stratigraphie und zur Pliozän-Grenze in Schleswig-Holstein. Eiszeitalter u. Gegenwart, 21, 5–21.

Spor af muldflugt i keltisk jernalder påvist i højmoseprofiler

Henner Bahnson

Bahnson, Henner: Spor af muldflugt i keltisk jernalder påvist i højmoseprofiler. *Danm. geol. Unders., Årbog 1972,* pp. 7–12. København, 3. december 1973.

About seven hundred peat samples were taken from six profiles in the raised bog of Fuglsø Mose (located in the peninsula of Djursland, eastern Jutland). By determining the ignition residue in each of the samples, a historic and a prehistoric (early Iron Age) dust storm soil layer could be shown to exist all over the bog. In a marginally placed profile two additional layers were found. It is supposed that these layers represent dust storms in the Subboreal and in the late Iron Age.

Ved en undersøgelse af humificeringsgradens vekslen op gennem tørvelagene i højmosen Fuglsø Mose på Djursland (Bahnson. 1968) fandtes en række overgange fra stærkere humificeret til svagere humificeret tørv, som ved C^{14}-datering viste sig nogenlunde at svare til de svenske og tyske klimabetingede grænsehorisonter. Undersøgelsen byggede på analyseresultater fra to prøveserier, »420« og »Balk I«, som supplerede hinanden stratigrafisk. For at undersøge resultatets reproducerbarhed er yderligere fire prøveserier fra Fuglsø Mose blevet underkastet samme analyseproces. Ved sammenligning af humificeringsdiagrammerne viste det sig imidlertid på grund af lokale variationer at være meget vanskeligt at korrelere de mange grænsehorisonter. Det besluttedes derfor at foretage gløderest bestemmelser, for om muligt ad denne vej at nå et resultat.

Materialebeskrivelse. (Fig. 1)

Fem af prøveserierne ligger med 100 til 170 meters indbyrdes afstand og er udvalgt således, at de foruden at supplere hinanden vertikalt også giver et indtryk af de stratigrafiske forhold over et større område i mosens midte, medens det sjette profil, »5«, ligger i et randområde, 300 til 400 meter fra de øvrige. De to korte profiler, »Balk I« og »Balk II«, som udelukkende omfatter lag med sphagnumtørv, når ikke til mosens bund, til gengæld kan man i dem finde de yngste, sidst afsatte tørvelag. I de to profiler, »420«

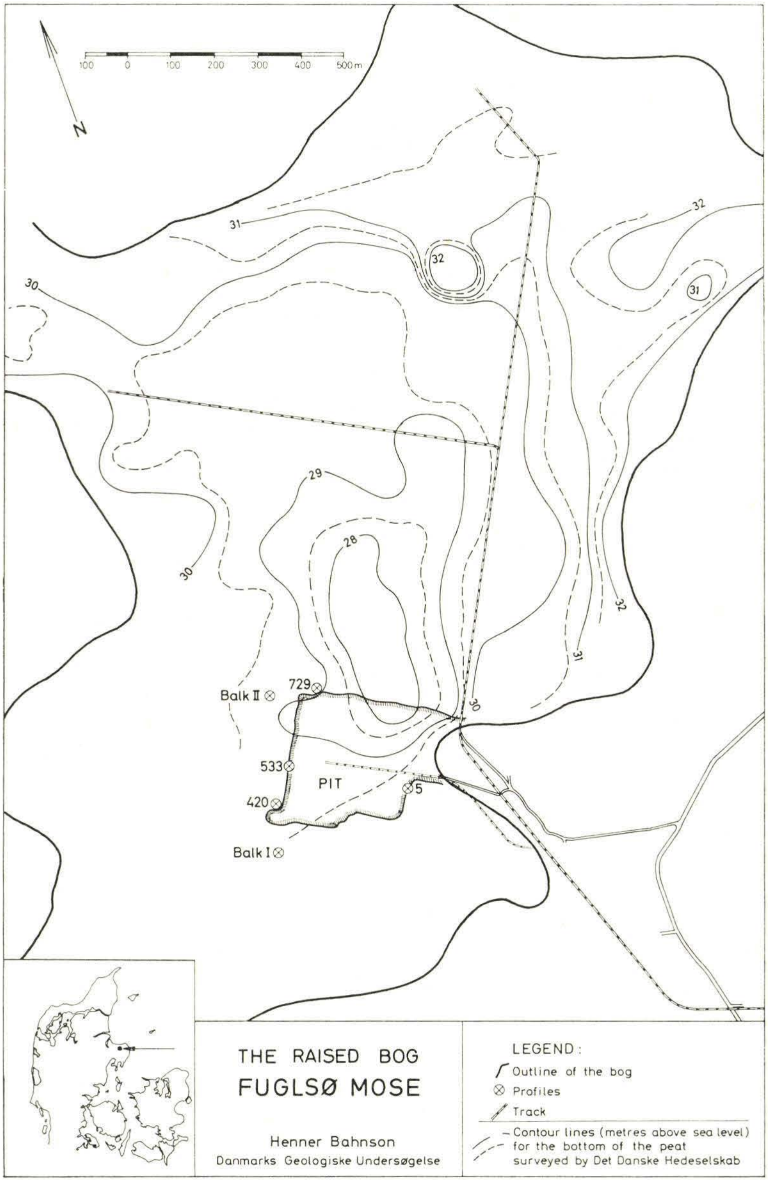


Fig. 1: Kort over Fuglsø Mose. Placeringen af de seks profiler samt nogle højdekurver for tørvelagets bund.

og »533«, som går til mosens bund, er de yngste lag, »hundekødet«, stort set afgravet. I dem begge finder man foroven et ca. tyve centimeter tykt, omrodet lag, hidrørende fra vegetationen og den alleryngste tørv, som blev skrællet af mosens oprindelige overflade inden tørveskæringen, og derpå spredt ud over allerede afskårne flader. I begge profiler finder man et ca. fyrre centimeter tykt lag af birkekærtørv over mosens bund, medens den øvrige del består af sphagnumtørv, som stedvis er rig på Eriophorum vaginatum-skeder. Profilerne »729« og »5« omfatter hver især hele den afsatte tørveserie, men medens »729« ligger i mosens midte ved bredden af en tørvedækket, senglacial sø, og derfor har en lavere bundkote, så har man i profil »5« et eksempel på, hvorledes sedimentationen er foregået ganske nær ved mosens rand. Også i disse profiler hviler den egentlige højmosetørv på en birkekærtørv, hvis mægtighed er størst i randprofilet. Efter mosens dræning har udtørringen bevirket en sammensynkning af tørvelagene. Dette gælder især den store tørvegravs gamle, åbne profiler, »533«, og »5«, hvor sammensynkningen har medført omfattende revnedannelser. En noget mindre sammensynkning kunne iagttages i de frigravede profiler, »420« og »729«, medens de ændringer, der er sket ved balkprofilerne inde på mosefladen må antages at være af meget begrænset størrelse.

Analysemetode

I de undersøgte profiler blev udtaget uafbrudte serier af én til to centimeter tykke tørveprøver, som efter tørring blev glødet ved 1000° C for at bestemme mængdeforholdet mellem organisk og uorganisk materiale.

Resultater. (Fig 2)

Som det fremgår af diagrammerne, ligger vægten af gløderesten i samtlige profiler for hovedparten af prøvernes vedkommende på ca. 1 % af tørvægten. I de to velafgrænsede horisonter er gløderesten dog betydeligt større. Ved petrografisk undersøgelse af det mineralske indhold i tørvemassen i disse horisonter fandtes næsten udelukkende velafrundede kvartskorn i silt- og finsandsfraktionerne. Det synes derfor ikke at kunne drages i tvivl, at disse maximer er opstået ved støvstorme. Det ældste af maximerne findes i alle seks diagrammer og er for to profilers vedkommende blevet tidsfæstet af H. Tauber på C^{14}-laboratoriet i København. I profil »729« viste det sig, at maximet lå mellem 600 ± 100 og 10 ± 100 år f. Kr. (K. 1355 og K. 1356), og i profil »5« mellem 480 ± 100 år f. Kr. og 160 ± 100 år e. Kr. (K. 2100 og K. 2099).

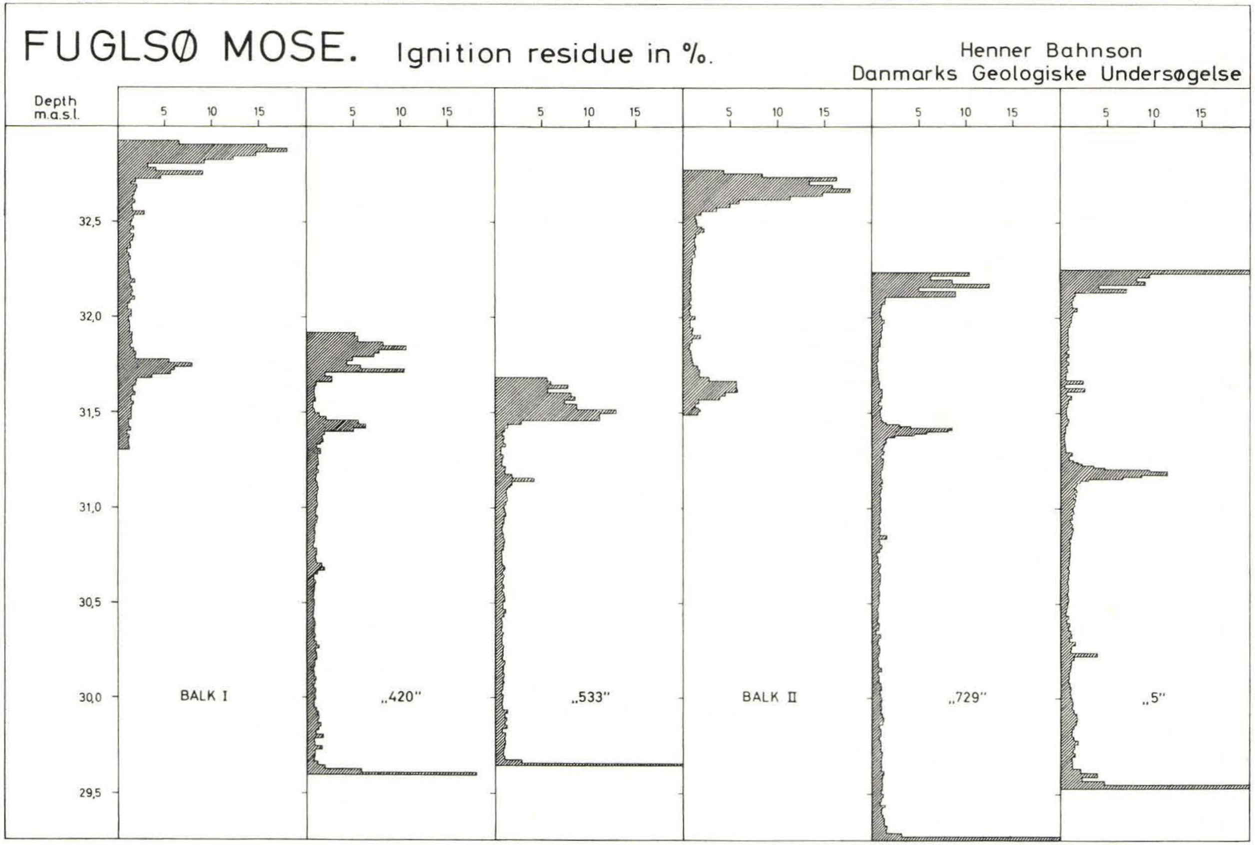


Fig. 2: Gløderest diagrammer.

Dette tidsrum dækker netop den arkæologiske periode, der benævnes Keltisk Jernalder, og i hvilken en kraftig udvidelse og ændring af den kulturelle aktivitet fandt sted. Det afvigende mineralindhold i det pågældende tørvelag må derfor antagelig ses som et resultat af muldflugt fra dyrkede marker i mosens omgivelser.

Når vægtprocenten af gløderesten igen falder til ganske små værdier ved overgangen til Romersk Jernalder, så må det være forårsaget af en regeneration af skovene omkring mosen. Dette kunne tyde på en affolkning efter rovdriften på de lette jorder. Imidlertid følges dette fald i mineralsk indhold af et fald i humificeringsgrad (Bahnson 1968). Det er derfor rimeligt at antage, at den subatlantiske klimaforværring også kan have spillet en rolle for muldflugtens ophør. Skovenes tilbagegang og regeneration i forbindelse med gløderestmaximet synes at blive bekræftet ved nogle upublicerede, foreløbige pollenanalyser, foretaget af Svend Th. Andersen. Pollenanalyserne tyder iøvrigt på, at den regenererede skov har fået en anden sammensætning. Bøgepollen forekommer over maximet i stort antal, medens Eg og Lind var dominerende i den ryddede skov.

Den yngste horisont med højere gløderest findes intakt i profilerne »729« og »5« og i de to balkprofiler, medens det tilsvarende lag i de to øvrige profiler befinder sig i det tidligere nævnte omgravede materiale. Selvom gløderestværdierne i det yngste maximum er betydeligt større end i det ældre (12–30 % mod 3–8 %), så fastslår sedimentundersøgelser, at det uorganiske indhold i tørven også i dette tilfælde er tilført med vinden. Denne horisonts tidsmæssige begrænsning er ikke fastlagt opad, men den synes at begynde allerede i Vikingetid, 980 ± 100 år e. Kr. (K. 2097), og man må formode, at de højeste gløderestværdier i dette øverste lag af mosen repræsenterer den historisk velkendte sandflugtsperiode, som bl. a. på grund af rovdrift på agerjord og skov startede i 1600-tallet og varede, efterhånden i noget afsvækket form, til helt op i vort århundrede.

I et par af profilerne viser nedgangen i gløderestværdi i de allerøverste lag, hvorledes plantager og læbælter i forbindelse med ændringer i landbrugets driftsform i de sidste 100 år har begrænset vindens mulighed for omlejrende virksomhed.

I randprofilet, »5«, ses tydeligt, hvorledes flere støvstorme har kunnet gøre sig gældende her end i profilerne på mosens midte. Dette gælder såvel for tiden før jernaldermaximet som for tidsrummet mellem de to store maximer. Også disse små maximer er blevet tidsfæstet på C^{14}-laboratoriet til henholdsvis 2160 ± 100 år f. Kr. (K. 2101) og 460–500 ± 100 år e. Kr. (K. 2098 og K. 2102), og de kan således være følger af landnam i henholdsvis Yngre Lindetid (neolitisk) og Romersk Jernalder.

Slutning

Som de fleste andre danske højmoser er Fuglsø Mose temmelig ødelagt ved afvanding og tørvegravning. Alligevel kan man stadig i dens profiler hente værdifulde oplysninger. Mosens vækstforhold afspejler den klimatiske udvikling i de sidste 12.000 år, og i de næsten tre meter tykke tørvelag gemmer sig talrige arkæologiske og vegetationshistoriske vidnesbyrd, såvel af regional som af lokal art. Det er derfor mit håb, at denne undersøgelse, som vil blive fulgt op af pollenanalyser, kan medvirke til, at de værdifuldeste danske højmoserester bliver bevarede til fremtidig forskning.

Litteratur

Bahnson, H., 1968: Kolorimetriske bestemmelser af humificeringstal i højmosetørv fra Fuglsø Mose på Djursland. Meddr dansk geol. Foren. 18, 55–63.

Aktuelle geologiske dokumentationsproblemer

Ole Bruun Christensen

Christensen, Ole Bruun: Aktuelle geologiske dokumentationsproblemer. *Danm. geol. Unders., Årbog 1972*, pp. 13–18 København, 3. december 1973.

Arbejder med dokumentationsproblemer ved Danmarks Geologiske Undersøgelser er led i instituttets brug af automatisk databehandling. Udarbejdelse af et dansk bidrag til en mangesproget thesaurus for geologi er dels bidrag til internationalt samarbejde og dels et udviklingsarbejde med betydning for geologer, for biblioteker og for danske erhvervsvirksomheder med tilknytning til geologiske arbejdsområder.

Some documentation works refering to EDP by Geological Survey of Denmark are sketched. A participate to a development of a multilinguan thesaurus for geology is as well usefull for geologists as for parts of the Danish trade.

Vigtige funktioner i det geologiske arbejde er indsamling, ordning og genfindelse af informationer om geologiske iagttagelser. Når iagttagelserne dokumenteres, bringes de på en eller anden bestandig form – i bredeste betydning – et dokument.

Dokumentationsarbejder udføres af den enkelte geolog, ved institutionen, på national og international plan.

Med datamaskinernes hurtige udvikling er automatisk databehandling blevet en værdifuld arbejdsmetode indenfor geologi. En del geologiske problemer kan løses gennem komplicerede beregninger, mens andre løses ved omfattende routinearbejder. Som et værktøj ved disse to arbejdsfunktioner er de elektroniske datamaskiner velegnede. En effektiv brug af datamaskiner i geologi medfører specielle dokumentationsbehov, der må tilfredsstilles tidligt ved indsamlingen af geologiske informationer.

Edb og geologiske problemløsninger

Gennem en årrække er der i Danmark blevet løst geologiske problemer ved hjælp af elektronisk databehandling (edb). Det er dog overvejende beregningsproblemer, der har været overladt til edb, og endnu er der ikke installeret større edb-anlæg i danske virksomheder eller institutioner beskæftiget med geologiske routinearbejder.

En del geologiske routinearbejder kan ved brug af edb kombineres med komplicerede beregninger. Automatisk udtegning af posteringer eller af konturkort beregnes som residualflader eller tilpasse de regressionsflader af forskellig type er blevet almindelig ved dokumentation af geologiske analyser. Simple sammenstillinger af data kan automatisk udtegnes som isometriske (fig. 1) eller perspektiviske, simple eller stereoskopiske diagrammer til brug ved visuel analyse.

Geologiske informationer til beregning og automatisk udtegning af lagflader i form af konturkort eller som blokdiagrammer er relativt simple at omforme til numeriske data og benytte ved edb. Afstandene fra et givet punkt til de kendte punkter på fladerne bestemmes. Punkterne koordinatsættes i rummet med tre koordinater. Fig. 1 er et eksempel derpå og kan med samme data og udstyr ligesåvel udføres som konturkort med højdekurver etc.

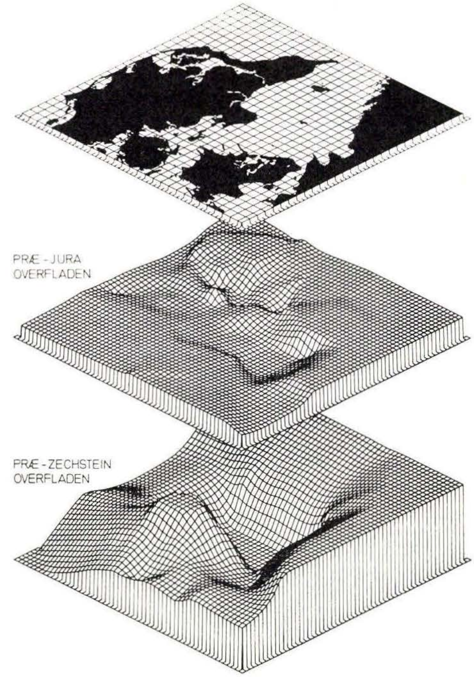
Andre geologiske informationer – forskellig fra mange af de numeriske – er betydelig vanskeligere at dokumentere ved edb. Således er lagring, sortering og vedligeholdelse, samt genfindelse af geologiske beskrivelser og af litteraturreferencer (information retrieval) i datamaskinernes lagre (files) relativt komplicerede og kræver et stort og grundlæggende forarbejde med løsning af dokumentationsproblemer.

Muligheder for at benytte edb til komplicerede eller routinemæssige arbejdsprocesser kræver tilstedeværelse af datamaskinemateriel (hardware) og et oftest lige så kostbart programmel (software), samt at informationsmængden foreligger i en form (data), som kan benyttes til edb. Datamaskiner til beregninger i forskningens tjeneste har geologerne haft adgang til at benytte i de regionale edb-centre i Danmark, hvor der ligeledes findes nogle faciliteter til udtegning og programmering.

Dokumentationsbehov og geologiske arbejdsopgaver

Den enkelte geologs dokumentationsproblemer er nøje sammenknyttet med arbejdsopgaverne i de forskellige geologiske institutioner eller virksomheder, og med de dokumentationsfaciliteter, der er til rådighed. En række institutioner, de offentlige biblioteker og edb-centrene yder i vid udstrækning en nyttig servicevirksomhed på dette område. Samlinger af primærmaterialer (prøver, fotos, dagbøger, notater og boreprofiler) og sekundærmaterialer (prøvebeskrivelser, analyseresultater i listeform, kort og tegninger) er imidlertid af en sådan karakter, at disse registreres i de enkelte institutioner (Jensen & Kristiansen 1971).

Fig. 1. Isometriske netdiagrammer afbilder flader ved basis af zechstein og basis af jura mellem kote 0 meter og en valgt nedre grænse i Det Danske Sænkningsområde. De to nederste blokdiagrammer er udtegnet automatisk på grundlag af data (i og noget udenfor området) fra de dybdeboringer, hvor de geologiske aflejringer er påtruffet. Til beregning og automatisk udtegning er benyttet edb-systemet SURFACE II, som er udarbejdet ved State Geological Survey of Kansas.



Et betydningsfuldt værktøj til edb-søgning i litteraturfortegnelser og geologiske profilbeskrivelser udgøres af en geologisk nøgleordsliste (thesaurus). Udarbejdelse af sådanne foretages meget tidligt i dokumentationsarbejdet. Flere af disse ordfortegnelser med danske og udenlandske nøgleord (keywords, descriptors) og accessoriske ord (synonyms, non-descriptors) foreligger udarbejdede i nogle danske virksomheder.

Borearkivet ved Danmarks Geologiske Undersøgelse (DGU) kan bringes på en form, hvorved edb kan benyttes ved søgning af data og ved automatisk udtegning af kort. Dokumentationsstudier af det store borearkivmateriale finder i vid udstrækning sted med automatisk databehandling som mål. Nogle af de største problemer ved brug af borearkivet har været at jævnføre stratigrafiske, lithologiske og tekniske udtryk i de geologiske beskrivelser, som anføres af geologer, boreteknikere og andre. Disse problemer er blevet endnu mere aktuelle ved automatisk databehandling. Nogle af de samme problemer kendes ved arbejdet med et mindre søgeprogrammel (information retrieval system) i brug ved DGU og ved Geologisk Institut, Århus Universitet. Systemet, der både kan bruges gennem terminal (on line) og til retrospektiv søgning og udskrivning på datacentret (batch-run), vil efterhånden blive benyttet af geologer med vidt forskellige specialer og brugerønsker til søgning af prøver, litteratur, fotos etc.

Mange af disse problemer kan imidlertid løses gennem ensartet brug af geologiske nøgleord med en til formålet tilfredsstillende begrebsværdi, hvortil de forskellige typer af accessoriske termer henviser. En thesaurus skal kunne benyttes af alle typer brugere, såvel geologiske specialister som brugere, der er mindre fortrolige med geologiske begreber. Blandt DGUs publikum forekommer alle typer af brugere, og flere listetyper med ord fra den geologiske sprogbrug foreligger ved DGU.

Nogle danske virksomheder som Betonforkningslaboratoriet Karlstrup (Andersen 1970) og Statens Vejlaboratorium (I.R.R.D. 1969) har udarbejdet nøgleordslister med geologiske begreber, flere vil følge og danske biblioteker vil til edb-søgning i geologisk litteratur meget snart have behov for nøgleordslister indenfor geologi.

Nøgleordslister bruges f. eks. både ved udarbejdelse af referater og til søgning. En thesaurus' nøgleord vil derfor ofte blive benyttet i beskrivelser. Et ensartet valg af nøgleord med notering af accessoriske geologiske ord vil være af stor betydning for den enkelte referent, der måske skifter arbejdsplads og kan risikere at skulle skifte nøgleordsliste. En udarbejdet thesaurus er desuden en besparende foranstaltning for den virksomhed, der kun anvender en del af nøgleordene herfra til udarbejdelse af thesaurus til brug i et tværfaglig arbejdsområde.

Samordning af geologisk edb-dokumentation

Det danske undervisningsministerium nedsatte i 1970 et udvalg for videnskabelig og teknisk information og dokumentation (DANDOK) ved Forskningens Fællesudvalg. Dette udvalg er rådgivende og har søgt oplysninger om dokumentationsaktiviteter blandt danske virksomheder, ligesom det har taget initiativ til udsendelse af informative publikationer (Unesco 1968). Nogle af vore større videnskabelige biblioteker har dokumentationstjenester, der er udbygget med søgeprogrammer til edb. Imidlertid indgår geologiske informationer heri kun som dele af tekniske, kemiske og biologiske informationstjenester.

Blandt geologer har der været arbejdet med en registrering af dansk geologisk bibliografi på edb-basis og mulighederne for at få adgang til en geologisk databank (Jensen & Kristiansen 1971). Sådanne muligheder synes nu meget aktuelle ved på international plan at yde en dansk arbejdsindsats. Ved DGU udarbejder et team på fem geologer ordlister til brug ved indkøring af danske nøgleord på andre sprog gennem Arbejdsgruppen for Automatik under Den internationale Union for Geologiske Videnskabers Kommite for Studiet af Geologisk Dokumentation. Ved andre institutter har det været på tale, at nedsætte arbejdsgruppe for kanalisering af geologisk litteratur i tilknytning til dansk og til Danmark med det formål for danske geologer at betjene og blive betjent af en international databank.

Geologisk edb-dokumentation på internationalt plan

Ved siden af en række mere eller mindre private organiserede internationale organisationer med arbejdsopgaver indenfor geologisk dokumentation har Den internationale Union af Geologiske Videnskaber (International Union of Geological Sciences – IUGS) to kommiteer for international samordning af disse problemer. Kommitteen for Lagring, Automatisk Bearbejdelse og Søgning af Geologiske Data (IUGS Commitee on Storage, Automatic Processing and Retrieval of Geological Data – COGEODATA) arbejder især med dokumentation af primærmaterialer og geologiske informationer, mens Kommitteen for Studier af Geologisk Dokumentation (IUGS Committee for the Study of Geological Documentation) er mere orienteret mod klassifikationsproblemer og litteraturdokumentation. Her udnytter en arbejdsgruppe mulighederne for gennem edb og internationale midler at arbejde sig gennem sprogbarrierer. Ved brug af et omfattende basisdokument (AGI 1972) bygges en mangesproget thesaurus. En thesaurus omfattende et geologisk område (tektonik) forelå som prøve i 1972 på tjekkisk, engelsk, tysk og fransk. Erfaringer og det tekniske apparat herfra benyttes ved det mere omfattende program, hvori Danmark deltager med en ved DGU rimelig indsats. Planer for dokumentationsarbejdet, dets historiske baggrund og målsætning er beskrevet hos Delbos & Dumort (1972) og andre (IGC 1972). I det danske arbejde tages der det største hensyn til tidligere udarbejdede nøgleordslister, anden geologisk litteratur på dansk og øvrige terminologistudier på det geologiske område. Ved hydrologisk afdeling ved DGU er der således i forbindelse med Den Internationale Hydrologiske Decade udarbejdet en dansk terminologi på næsten 3000 fagord (Tollan 1969).

Litteratur

AGI 1972. Glossary of Geology – American Geological Institute, pp. 805. Washington DC.

Andersen, M. E. 1970. Betonforskningslaboratoriet Karlstrups Biblioteks- og Dokumentationstjeneste – BLF-Særtryk nr. 51, Byggeindustrien, 21 (1970): 18, pp. 3–7.

Delbos, L. & Dumort, J. C. 1972. Collaboration international en documentation des Sciences de la Terre – 24th Internat. Geol. Cong., Sec. 16, pp. 191–195. Montreal.

IGC 1972. Computer-Based Storage, Retrieval and Processing of Geological Information – Internat. Geol. Cong., Sec. 16. Montreal.

I.R.R.D. 1969. International Road Research Documentation (I.R.R.D.). Engelsk-Dansk liste over nøgleord. – Statens Vejlaboratorium. København.

Jensen, S. B. & Kristiansen, E. 1971. Centralregistrering af geologisk originalmateriale samt behovet for et geologisk informationsorgan – Geologisk landsmøde 8.–10. oktober 1971 på Hotel Nyborg Strand, pp. 23–25. (Rapport). København.

Tollan, A. 1969. Nordisk hydrologisk terminologi – Vannet i Norden, IHD-nytt, nr. 2, p. 35. Oslo.

Unesco 1968. Retningslinier for udformning af videnskabelige artikler. – Oversættelse af Unesco-dokument (SC/MD/5 (1968)). DANDOK 1972. København.

Plot of s versus t/r^2 on semilogarithmic paper by using a simple stencil

Zvonimir Haman

Haman, Zvonimir: Plot of s versus t/r^2 on semilogarithmic paper by using a simple stencil. *Danm. geol. Unders., Årbog 1972,* pp. 19–24, København, 3. december 1973.

In this paper it is shown how to plot s (drawdown) versus t/r^2 (time divided by the square of distance to the observation well) by using a stencil, which can easily be constructed to fit any dimension of the logarithmic decade.

When more observation wells in a pumping test of an aquifer are available, the composite semilogarithmic and logarithmic graphic plot of s versus t/r^2 is recommended instead of the usual plot of s versus t, because the composite plot gives at the same time data about spatial distribution of the hydraulic properties of the aquifer.

In earlier works (references 1 and 2) the plotting procedure and its application in the analysis of pumping test data is described and discussed in detail. However, for plotting data on semilogarithmic paper as described in the abovementioned papers, a series of auxiliary curves must be constructed and transparent semilogarithmic data sheet or a light-table is required in the plotting procedure.

In this article a more simple way of plotting s versus t/r^2 on semilogaritmic paper by using a stencil is presented.

Construction of the Stencil

1. Take a semilogarithmic paper with desired decade length and mark the ordinate t in minutes as shown on the far left side in fig. 1.
2. Find on the abscissa axis in fig. 2 values for points of intersection between the straight line and the t axis.
3. Plot the found values on the semilogarithmic paper and draw the curve through the plotted points, as shown in fig. 1. In this case values for points of intersection in the range from 1 to 160 min. (fig. 2) are sufficient to make the stencil.

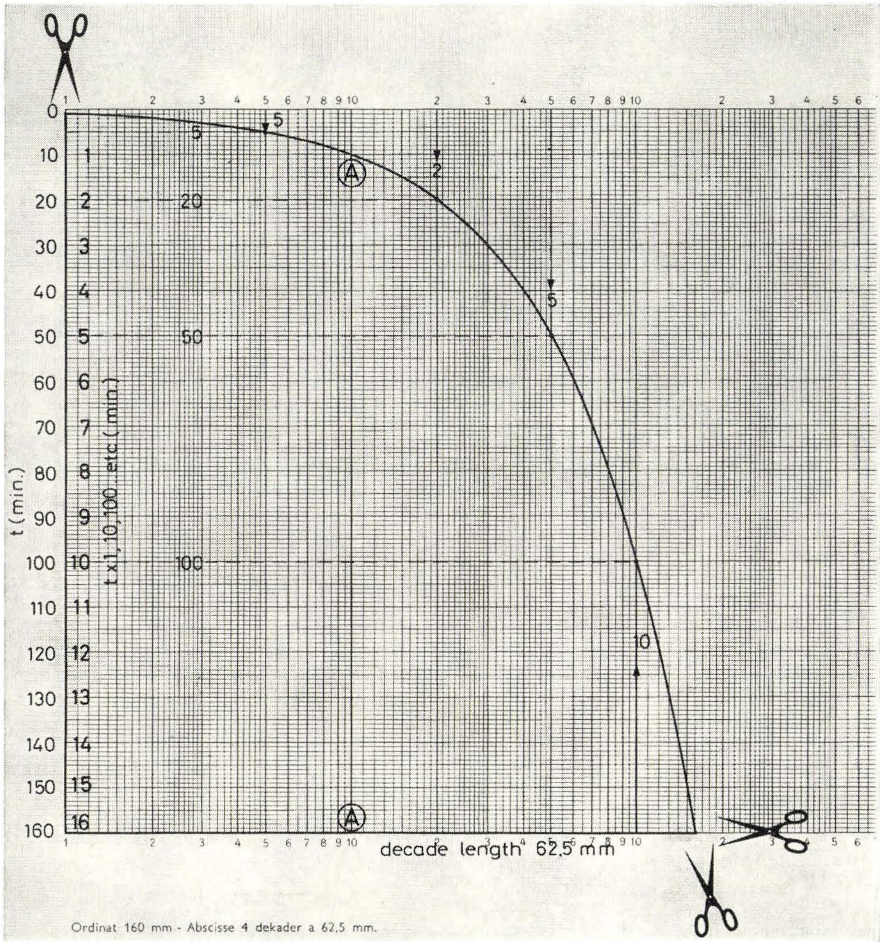


Fig. 1: Example illustrating construction of the stencil.

4. Mark intervals from 0–16 on the ordinate inside the stencil, as shown in fig. 1.
5. Cut the paper as indicated on fig. 1. It is important that the stencil is cut correctly and smoothly, and that abscissa and ordinate axis form an angle of 90 degrees. When this is done, the stencil is ready for use.

Plot of s Versus t/r^2 by using a stencil

Time-drawdown data for one observation well (table 1) are used to explain the procedure of plotting s versus t/r^2 by using the stencil.

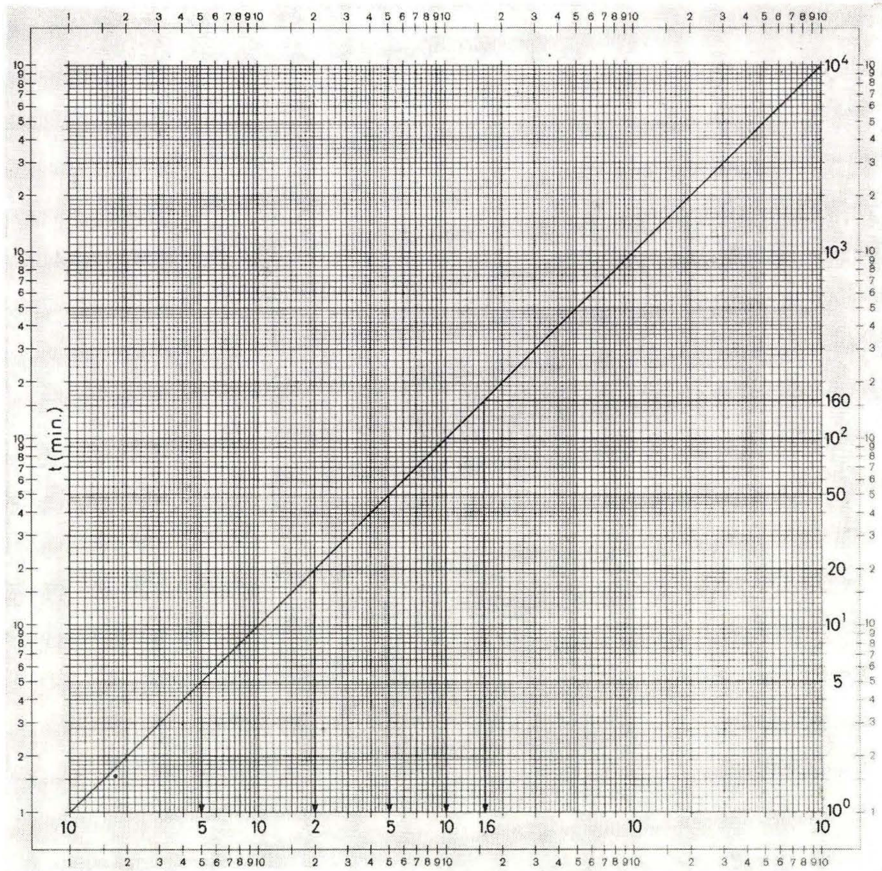


Fig. 2: Example ilustrating construction of the stencil.

1. Find t/r^2 for t = 1 min., 5,700 min., r = 121.8 (from table 1).

   1:14,835 = 6.74×10^{-5} min./m²
   5,700:14,835 = 3.84×10^{-1} min./m²

2. Indicate the interval $10^{-6} \leqslant t/r^2 \leqslant 10^0$ min./m² on the abscissa axis of the semilogarithmic data sheet (scale 62.5 mm per logarithmic decade) as shown in fig. 3.

3. Choose a convenient scale for s (m) on the ordinate axis of the semilogarithmic data sheet.

4. Place the line on the stencil marked A–A over $t/r^2 = 6.74 \times 10^{-5}$

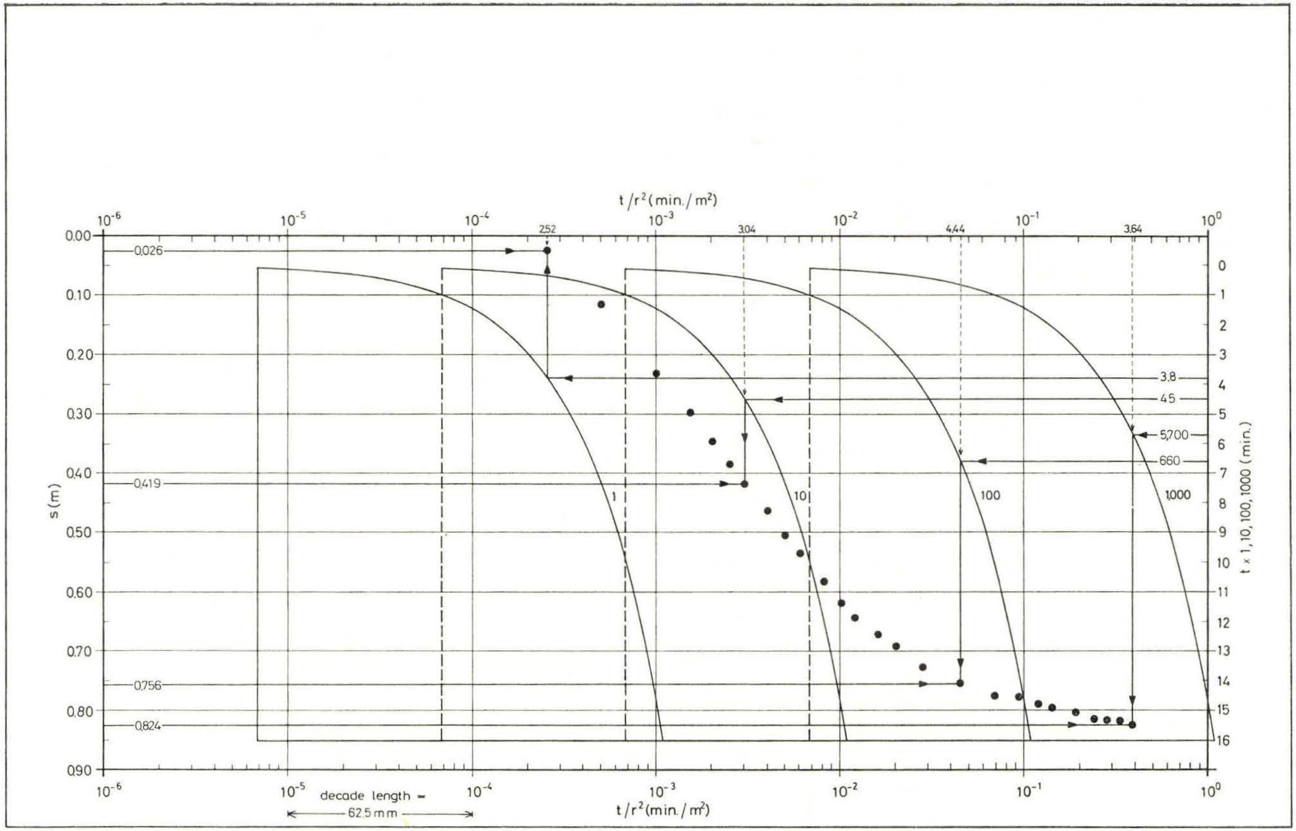


Fig. 3: Plot of s versus t/r² by using a simple stencil.

Time t in min.	Drawdown s in m	t/r^2 min./m^2
0	0.000	
3.8	0.026	2.52 x 10^{-4}
7.5	0.116	
15.0	0.232	
22.5	0.198	
30.0	0.348	
37.5	0.386	
45.0	0.419	3.04 x 10^{-3}
60.0	0.466	
75.0	0.507	
90.0	0.538	
120.0	0.583	
150.0	0.618	
180.0	0.643	
240.0	0.673	
300.0	0.693	
420.0	0.728	
660.0	0.756	4.44 x 10^{-2}
1,020.0	0.777	
1,380.0	0.780	
1,740.0	0.790	
2,100.0	0.797	
2,820.0	0.807	
3,540,0	0.814	
4,260.0	0.816	
4,980.0	0.817	
5,700.0	0.824	3.64 x 10^{-1}

Distance from the observation well to the pumping well $r = 121.8$ m
$r^2 = 14{,}835$ m^2

Table 1. Time-drawdown data used for illustration of the plotting procedure, s versus t/r^2 by using a stencil.

min./m^2 on the semilogarithmic data sheet, keeping corresponding axes parallel.

5. Trace the curve with the stencil using a thin sharp pencil point, then move the line marked A-A one decade to the right, trace the next curve, and so on. The number of curves depends on the duration of the test, and in this case 4 curves (marked 1, 10, 100, 1000 multipliers of t (min.) axis) are sufficient to plot all drawdown data.

6. Mark intervals 0–16 from the stencil on the right ordinate of the semilogarithmic data sheet, taking care that zero value for each particular curve corresponds to the position of the zero on the stencil when the curve was drawn. The most practical way is to keep zero point at the same level for all curves (see fig. 3).
7. Find t (min.) for the respective drawdown s (m) on the t axis (to the right), follow the horizontal line to the intersection with the respective curve, then follow the vertical line to the intersection with the corresponding s (m) value. Intersection point represents plot of s versus t/r^2.

In fig. 3 the plotting procedure for four different sets of s–t values from table 1 is demonstrated. As shown in fig. 3, t/r^2 values found graphically correspond to calculated t/r^2 values from table 1.

If data from more observation wells are available, the curves on the semilogarithmic data sheet should be drawn in different colours. This will easily distinguish curves for different observation wells during plotting.

It is preferable to leave all the curves drawn by stencil on the semilogarithmic data sheet, so that the time for the respective point of drawdown may easily be determined directly from the plot.

For permanent use the stencil can be constructed from hard plastic folio.

Conclusion

As shown by this example, drawdown data can easily be plotted graphically versus t/r^2 on semilogarithmic paper by using a simple stencil. Besides the fact that calculations of t/r^2 values are avoided, the advantage of using the stencil is that no light-table or transparent data sheet used with a series of auxiliary curves is required, and that the time for the respective point of drawdown may easily be determined directly from the plot.

References

La Rocque, A. J. Jr., 1963. Graphic Method for Plotting Aquifer Test Data. Short Cuts and Special Problems in Aquifer Tests. Geological Survey Water Supply Paper 1545–C, pp. 4–9.

Haman, Z., 1972. Kombineret afbildning af s versus t/r^2 som hjælpemiddel ved undersøgelse af grundvandsreservoirer, metode og anvendelse. Vannet i Norden, 5. årgang nr. 4.

Studies on some Elphidiidae (foraminifera) from the Miocene of Denmark

Finn Nyhuus Kristoffersen

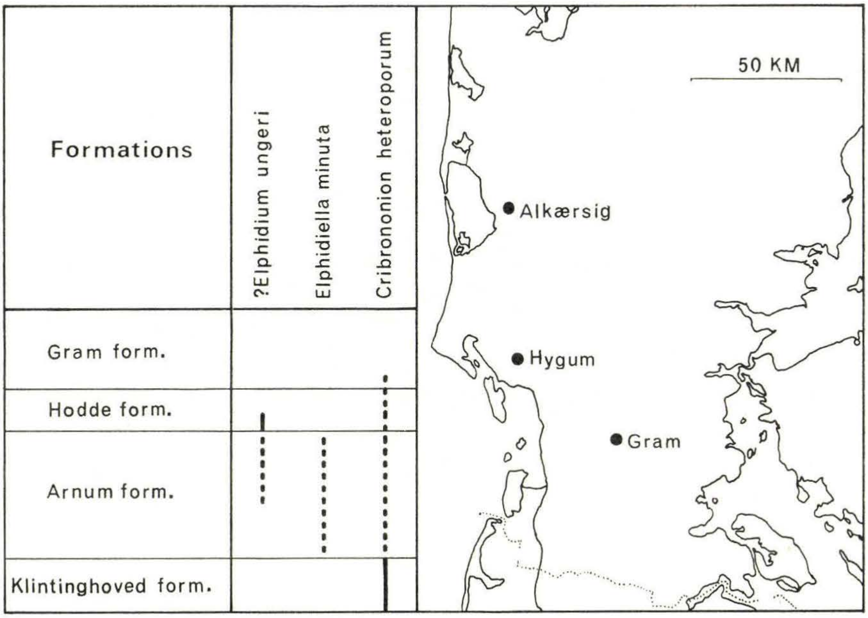
Kristoffersen, Finn Nyhuus: Studies on some Elphidiidae (foraminifera) from the Miocene of Denmark. *Danm. geol. Unders., Årbog 1972*, pp. 25–36. København, 3. december 1973.

The three Elphidids examined, *?Elphidium ungeri* (Reuss), *Elphidiella minuta* (Reuss) and *Cribrononion heteroporum* (Egger) are derived from the Lower and Middle Miocene formations of Denmark.. They are shown to differ considerably from each other in distinct features diagnostic at the generic level.

The spiral canals are rather complicated in *?E. ungeri* and *C. heteroporum,* which show a system af anastomosing canals connecting different parts of spiral canals, while the spiral canal in *E. minuta* is rather simple. The specimens referred to *C. heteroporum* show a distinct apertural chamberlet, which is decided to be of generic importance in the emended diagnosis of the genus *Cribrononion*.

The results of preliminary investigations of the species *Cribrononion heteroporum* (Egger 1857) and the problems concerning the genus *Cribononion* Thalmann 1947 were discussed by the author at a meeting held in May 1971 at the University of Aarhus with the title 'Symposium on the taxonomy of neritic, benthonic foraminifera from Quaternary and Recent deposits, with special reference to the taxonomic problems of *Elphidium* and *Nonion*'. Since then these investigations have been completed with studies in the scanning electron microscope. Subsequently the two species *? Elphidium ungeri* (Reuss 1850) and *Elphidiella minuta* (Reuss 1865) have been examined. A number of plastic casts have been prepared in order to study the canal systems.

With the exception of some species of the genus *Protelphidium* Haynes 1956, all Elphidids recorvered from the Lower tnd Middle Miccene formations of Denmark are dealt with in the present paper. The three species, however, constitute only a minor part of the faunas found in the formations in question. Nevertheless they are of a certain stratigraphic importance at least within the Danish part of the North Sea basin. Thus *Elphidiella minuta* seems to be restricted to the Arnum Formation in which it is a rare constituent. *?Elphidium ungeri* shows a scattered occurrence in the Arnum



Text-fig. 1. Situation of the borings and the vertical distribution of the species within the Miocene formations in Denmark.

Formation, while its occurrence in the Hodde Formation is restricted to the basal sandy beds, in which it composes about 4 per cent of the fauna. *Cribrononion heteroporum* is common in the Klintinghoved Formation, less common in the Arnum Formation and has a scattered occurrence in the Hodde Formation. A few badly preserved specimens of *C. heteroporum* have been recorded from the lower part of the Upper Miocene Gram Formation.

Materials and methods

The specimens examined came from the Alkærsig boring (D.G.U. file No. 93.101), the Hygum boring (D.G.U. file No. 121.211), both located in Western Jutland, and the Gram boring (D.G.U. file No. 141.277) located in South Jutland. Although the three species investigated have been recorded from several other borings in Jutland, only specimens from the Alkærsig, Hygum and Gram borings have been prepared for the present study.

In order to study the canal systems the author prepared a number of plastic casts showing canal systems, impressions of test surfaces and sometimes the retral processes if present. The embedding method used differs slightly from the one described by Nørvang (1966). The specimens were embedded in a mixture of Araldite (a two-component epoxy glue) and xylene. The polymerisation was activated by heating the specimen to 150° C for about 15 minutes. With a needle or a sharp knife a small area of the test surface was exposed, after which the specimen was dissolved in EDTA. The object was then cut horizontally and deep enough to allow the casts of the chamber cavities to be removed with a needle or a moist brush with a water soluble glue on the tip, leaving the impression of the test surface and the casts of the canal system and the perforations exposed. Because evacuation was not used during the embedding process, one large air bubble frequently persisted in each chamber, separated from the inner chamber surface by a thin plastic film. Thus only the more peripheral parts of the chamber, such as retral processes, were filled with solid plastic. When the plastic film was removed the solid casts of the retral processes often persisted in the correct position (Pl. 1, fig. 5). After coating with gold the specimens were studied in the scanning electron microscope.

The figured specimens are stored in the collections of the Geological Survey of Denmark.

Systematical part

Family Elphidiidae Galloway 1933
Genus *Elphidium* Montfort 1808
?Elphidium ungeri (Reuss 1850)
Pl. 1, figs. 1–6; Pl. 2, fig. 1; Pl. 4, figs. 1–2.

1942. *Elphidium ungeri* (Reuss) – ten Dam and Reinhold, p. 79, pl. 5, fig. 7.
1962. *Elphidium ungeri* (Reuss) – Indans, p. 56, pl. 8, fig. 4.

Diagnosis: Species of the genus *Elphidium* with distinct peripheral keel, 9–11 chambers in the adult coil and covered with numerous small rounded bosses. Length of septal bridges about one third of the chamber length. Spiral canal with complicated anastomoses. Bilamellar and radiate.

Dimensions: Diameter 0.19 – 0.72 mm, breadth 0.10 – 0.39 mm.

Description: Test planispirally coiled, consisting of two convolutions with 9–11 chambers to the adult coil, involute and bilaterally symmetrical. Test discoidal and almost circular in outline. Periphery rather sharply rounded with distinct peripheral keel. The margin is slightly lobulated. The sutures are curved and rather indistinct. Distinct apertural pores are present at the base of the apertural face, each pore bordered by a thickened rim. Septal pores of the same shape and arrangement. The elongate sutural pores and rather strong septal bridges orientated at right angles to the sutures constitute about one third of the chamber length. The entire test including septal bridges and the area around apertural pores is densely covered with small rounded bosses. The test is densely and finely perforate, the pores being restricted to the area between the small bosses. Distinct retral processes which do not connect with the preceding chamber are present below septal bridges alternating with sutural pores. The canal system is well developed. The sutural canals, compressed in a plane parallel with the septal surfaces, communicate with the surface through compressed sutural pores, which are slightly branched near the surface. Successive sutural canals connect in the umbilical region through an irregular spiral canal. Different parts of the spiral canal are connected by a complicated system of anastomosing canals. The test is bilamellar and radiate in microstructure.

Remarks: The species found in the Miocene of Denmark is generally slightly more compressed than the species recorded by ten Dam and Reinhold (1942) and Indans (1962). The author has previously (Kristoffersen 1972) referred this species to *Elphidium inflatum* (Reuss 1861), though distinct specimens have not been recorded. A sample from Dingden, however, collected and placed at the author's disposal by Dr. Leif Banke Rasmussen, yielded a number of distinct *Elphidium inflatum* and *?Elphidium ungeri* as well as a number of specimens which might possibly be interpreted as intermediate forms. Thus the degree of compression, the length of septal bridges and the extent and distinctness of the peripheral keel seem to be strongly variable. The individuals obtained from the Dingden sample are covered by numerous small bosses, also shown on the specimens from the Miocene of Denmark. The numerous coarse perforations indicated on the original figure of *E. inflatum* (Reuss) are presumably due to the presence of these small bosses. Only rather compressed and distinctly keeled individuals of the type which ten Dam and Reinhold (1942) and Indans (1962) refer to *E. ungeri* are met with in the Miocene of Denmark. It seems debatable, however, whether this form is referable to *E. ungeri* (Reuss) described from the Vienna Basin or not. Apparently it has been difficult to decide which form Reuss really described. Thus specimens recorded from the type area by Cushman (1939) and Papp (1963) seem to differ considerably from the form figured by Reuss. As already mentioned by Marks (1951) the original figure of Reuss indicates a somewhat more angular periphery and shorter septal bridges than shown on Cushman's figure. A distinct umbilical plug, as shown on the figure of Papp, was stated by Reuss not to be present.

The present specimens differ from the one figured by Reuss mainly in the rather long septal bridges.

Distribution:
Holland: Middle Miocene (ten Dam and Reinhold 1942)
Belgium: Houthalenian and Anversian (Meuter 1970)
Niederrhein area: Hemmoor-Stufe and Reinbek-Stufe (Indans 1962)
Denmark: Arnum and Hodde Formations.

Genus *Elphidiella* Cushman 1936

Elphidiella minuta (Reuss 1965)
Pl. 2, figs. 2–5; Pl. 4, fig. 3.

1865. *Polystomella minuta* Reuss, p. 478, pl. 4, fig. 6.
1951. *Elphidium minutum* (Reuss) – Marks, p. 53, pl. 6, fig. 6.
1958. *Elphidium minutum* (Reuss) – Batjes, p. 164, pl. 12, fig. 1.
1962. *Elphidium minutum* (Reuss) – Indans, p. 56, pl. 8, fig. 6.

Diagnosis: A smooth discoidal species with 9–12 chambers in the adult coil. Rather densely pustulous area in front of basal apertural pores. Canal system with simple spiral canal. One row of tiny stutural pores. Retral processes are lacking. Bilamellar and radiate.

Dimensions: Diameter 0.15 – 0.49 mm, breadth 0.08 – 0.20 mm.

Description: Test planispirally coiled, consisting of two convolutions, 9–12 chambers to the adult coil, involute and bilaterally symmetrical. Test discoidal with almost circular outline and rather broadly rounded periphery without peripheral keel. The margin is slightly lobulated. Sutures slightly curved and somewhat depressed in the younger part of the last coil. In the older part the sutures are flush with the surface. Last few chambers weakly inflated. Test surface smooth and finely perforate. Apertural pores bordered by thickened rim are present at base of apertural face. The part of the previous coil situated immediately in front of apertural pores is rather densely pustulous. One row of sutural pores communicate with subsutural canal. Spiral canal forming a simple and rather regular spiral without complicated anastomoses. Retral processes not present. Bilamellar and radiate in microstructure.

Remarks: This species, so far referred to the genus *Elphidium*, is excluded from this genus because of the absence of retral processes. It is realized, however, that the reference of the species to *Elphidiella* is debatable. Thus the double row of sutural pores which should characterize this genus are not present. When the species nevertheless is placed in the genus *Elphidiella* it is due to a superficial resemblance with the type species *Elphidiella artica* (Parker and Jones 1864) and especially to the striking resemblance with *E. hannai* (Cushman and Grant 1927) and to the fact that it does not fit into any of the remaining genera available.

Distribution:
Vienna Basin: Tortonian (Marks 1951)
Belgium: ?Sand of Antwerp (Batjes 1958)
Niederrhein area: Hemmoor-Stufe (Indans 1962)
Denmark: Arnum Formation.

Genus *Cribrononion* Thalmann 1947

Type species: Cribrononion heteroporum (Egger 1857)

Emended diagnosis: Test planispirally coiled and bilaterally symmetrical. Distinct apertural chamberlet is present. Apertural face, apertural chamberlet and adjoining part of previous coil densely pustulous. Test finely perforate, only apertural chamberlet with scattered coarse perforations. Different parts of spiral canal connected through anastomosing canals. Wall structure granular. Retral processes are not present.

Remarks: The type species *Cribrononion heteroporum* (Egger 1857) recorded from Miocene deposits of Niederbayern is rather thoroughly described and figured for that period. The depository is unknown, however, and the type species has apparently not been recorded by later authors. Nevertheless Thalmann (1947) designated this form as type species, although it had not been recovered for almost a hundred years. For that reason many authors have referred species to the genus *Cribrononion* more from an idea of what the type might possibly look like than from real knowledge of the type. That a species has not been recorded for more than a hundred years and is known from the original description alone, is remarkable, and therefore it seems natural to presume that the type descriptions and figures are misleading and that the actual form has been referred to another species.

The form described below and referred to *C. heteroporum* has so far been referred to *Cribrononion hiltermanni* (Hagn 1952), which species was described from Upper Rupelian of Oberbayern, that is to say from the same part of Germany as *C. heteroporum*. The only difference between the two species, as it appears from the type descriptions, seems to be in the size of the specimens, *C. heteroporum* being somewhat bigger than *C. hiltermanni*. The dimensions given by Egger are debatable, however, mainly because of the restricted possibilities in his time of accurate measurements of smaller specimens. Hagn (1952) mentions that 'Gewisse Elphidien aus dem Burdigal von Maierhof stehen unserer Art ebenfalls sehr nahe, doch sind die miozänen Formen dickbauchiger und etwas grösser (Durchmesser 0,4 mm). Sie stellen vielleicht eine Varietät der forliegenden Art dar'. It is interesting to note that the locality Maierhof is one of the Miocene localities near Ortenburg, from where Egger (1857) described *C. heteroporum* and thus it is obvious that the specimens mentioned by Hagn, being only 0,1 mm smaller than Egger's type, are identical with *C. heteroporum*.

Recently Meuter (1970) appears to have been of the same opinion as the present author. Thus in table 1 he refers one of his species to *C. heteroporum* and mentions that this form has been dealt with by Indans (1962). The only form in the paper of Indans, however, which resembles the type species is the species referred to *Elphidium hiltermanni*.

Thalmann (1947) stated that 'Das neue Subgenus zeichnet sich aus durch das Vorhandensein einer siebplatten-artigen Mündungsfläche sowie lochartiger Perforationen in den Kammernaht-Furchen'. Studies in the scanning electron microscope have shown, however, that the entire test surface including the pustulous area is finely perforate. Only the apertural chamber shows a few coarse perforations.

Cribrononion heteroporum (Egger 1857)
Pl. 2, fig. 6; Pl. 3, figs. 1–6; Pl. 4, figs. 4–6

1857. *Nonionina heteropora* Egger, p. 300, pl. 14, figs. 19–21.
1952. *Elphidium hiltermanni* Hagn, p. 163, pl. 1, fig. 6, pl. 2, fig. 14.
1958. *Elphidium hiltermanni* Hagn – Batjes, p. 165, pl. 12, fig. 4.
1959. *Elphidium sp.* Dinesen, p. 90, pl. 8, fig. 6.
1962. *Elphidium hiltermanni* Hagn – Indans, p. 56, pl. 8, fig. 8.
non 1969. *Cribrononion hiltermanni* (Hagn) – van Voorthuysen and Toering p. 106, pl. 7, fig. 16.
?non 1970. *Elphidium hiltermanni* Hagn – Y. Calvez, p. 167, pl. 26, fig. 1.

Diagnosis: A species of the genus *Cribrononion* in which apertural face, apertural chamberlet, adjoining part of previous coil, and umbilical area are densely pustulous. 5–6 chambers in the adult coil and 7–8 chambers in all.

Dimensions: Diameter 0.11 -- 0.26 mm, breadth 0.07 – 0.16 mm.

Description: The test is planispirally coiled with 5–6 chambers in the adult coil, involute, and bilaterally symmetrical. Test slightly compressed, greatest diameter about twice as large as greatest thickness. Periphery broadly rounded and with weakly lobulated outline. Sutures slightly curved and depressed. Chambers inflated. The test is almost circular in outline because the aperture is covered by a small bulla-like apertural chamberlet, which eliminates the angle between the apertural face and the adjoining part of previous coil. The area comprising the apertural face, the apertural chamberlet, the adjacent part of previous coil and the umbilical region is densely covered with pustules. The entire test is finely perforate and only the apertural chamberlet shows scattered coarse perforations, mainly restricted to the sutures. The aperture is a low, rather short slit at the base of the apertural face, bordered by a thickened rim. The aperture is not visible in undamaged specimens, but in specimens with a damaged or dissected last chambers the aperture is easily observed (Pl. 3, fig. 3). The septal foramina are mostly a row of a few large pores resulting from a subdivision of the originally slitlike aperture. The surface of the previous coil inside the chambers shows an irregular system of keels and furrows running parallel with the margin and continuing through the aperture into the apertural chamberlet. The septa, originally densely pustulous, are covered with reduced and rather indistinct pustules and indistinct furrows radiating from the septal foramina. Sutural pores are rather small, and septal bridges are weakly developed. Sutural pores connect with subsutural canal situated between septal flap and the edge of previous chamber. A spiral canal is present, but seems to be of a rather primitive nature. The proximal parts of the sutural canals connect with a system of anastomosing canals of which the ones which directly connect the successive sutural canals are interpreted as the spiral canal. Retral processes are not present. The test is bilamellar and granular in microstructure.

Remarks: Egger's descriptions and figures show a specimen with apertural face and adjoining part of previous coil densely covered with coarse perforations and pustules. Even in modern light microscopes, however, it has been impossible with certainty to decide whether coarse perforations are present between the pustules or not. Because of reflections from the pustules, the observer gets an impression rather of a coarsely perforate surface with scattered pustules than of a finely perforate and densely pustulous surface. Studies in the scanning electron microscope have finally shown that scattered coarse perforations are restricted to the apertural chamberlet while the remaining part of the pustulous area is finely perforate, as is the non-pustulous part of the test. Egger did not observe any apertural openings, and consequently it seems reasonable to assume that it has been covered by an apertural chamberlet, as shown on the present specimens. The apertural chamberlet is only visible in dissected specimens or in thinsections, however, and therefore its presence was easily overlooked by Egger. The distinct suture drawn between final chamber and previous coil on the type figure 21 (Pl. 4, fig. 5) seems to be drawn according to Egger's idea of how a foraminifera is normally built. At least the side view in the type figure 19 shows a rather smooth transition from apertural face to previous coil, the angle between them being more or less eliminated by a small lobe, which might suggest the presence of the apertural chamberlet.

The form recorded by Y. Calvez (1970) from the Eocene of the Paris Basin and referred to *Elphidium hiltermanni* differs slightly from the present species, the umbilical area being rather strongly excavated. The figures of Y. Calvez, however, suggest the presence of features of the genus *Cribrononion*. Thus the figured fragment shows septal foramina which are subdivided original basal slitlike apertures, and furthermore an apertural chamberlet seems to be visible. Retral processes are missing and information on the wall structure is not given. In the author's opinion this form may prove to be a new species of the genus *Cribrononion*, and so far the only species known by the author, besides *C. heteroporum* which is referable to this genus. It may possibly represent an ancestral form of *C. heteroporum*.

Distribution:

Bayern: Upper Rupelian, Kattian, Aquitanian and Burdigalian (Hagn 1952)
Niederrhein area: Hemmoor-Stufe and Reinbek-Stufe (Indans 1962)
Belgium: Houthalenian and Anversian (Meuter 1970)
Denmark: The Vejle Fjord Formation (Dinesen 1959), the Klintinghoved, Arnum and Hodde Formations.

Acknowledgements.. The present work has been supported by *Leif Banke Rasmussen*, head of the Department of Subsurface Geology.

Mr. *O. Neegaard Rasmussen* has done the photographic work.

The scanning electron micrographs have been taken by a Jeol JSM-S1, provided by the Danish Research Council of Natural Sciences and installed at the Geological Survey of Denmark.

Dansk sammendrag

De tre undersøgte elphidider, *?Elphidium ungeri* (Reuss), *Elphidiella minuta* (Reuss) og *Cribrononion heteroporum* (Egger), stammer fra de nedre og mellem miocæne formationer i Jylland. Selvom de kun udgør en ringe del af faunaerne i de respektive formationer repræsenterer de en vis stratigrafisk værdi (text-fig. 1). Således er *Elphidiella minuta* tilsyneladende begrænset til lag tilhørende Arnum formationen. *?Elphidium ungeri* optræder sparsomt i Arnum formationen, medens den i Hodde formationen er begrænset til den nedre sandede del, i hvilken den udgør omkring 4 procent af faunaen. *Cribrononion heteroporum* er almindelig i Klintinghoved formationen, medens den i det store og hele optræder ret sparsomt i Arnum og Hodde formationerne. I den nedre del af Gram formationen er fundet enkelte dårligt bevarede eksemplarer af *C. heteroporum*.

De undersøgte arter har hidtil næsten uden undtagelse været henført til slægten *Elphidium*. Imidlertid er kun *?E. ungeri* fundet i besiddelse af de for denne slægt karakteristiske retral processer (pl. 1, figs. 2 og 5; pl. 2, fig. 1). *Cribrononion heteroporum* har granulær skalstruktur og det basale apertur er dækket af et lille aperturalt kammer (pl. 3, fig. 2; pl. 4, fig. 4). I den reviderede slægtsdiagnose er dette aperturale kammer tillagt særlig betydning.

Plastik afstøbninger af kanal systemerne er undersøgt i scanning elektron mikroskop. Spiralkanalen hos *?Elphidium ungeri* (pl. 1, figs. 4 og 6) og *Cribrononion heteroporum* (pl. 3, figs. 5–6) har vist sig at være ret komplicerede, idet forskellige dele af den egentlige spiral er forbundet ved et system af anastomoserende kanaler. Derimod er sådanne anastomoser ikke påvist hos *Elphidiella minuta* (pl. 2., fig. 4).

References

Batjes, D. A. J. 1958: Foraminifera of the Oligocene of Belgium. Mém. Inst. r. Sci. Nat. Belg. 143, 1–188.

Brady, H. B. 1864: Contribution to the Knowledge of the Foraminifera. On the Rhizopodae Fauna of the Shetlands. Trans. Linn. Soc. Lond. 24, 463–476.

Calvez, Y. le 1970: Contribution a l'étude des Foraminifères paléogenes du Bassin de Paris. Centre National Recherche Scientifique, Paris. 326 pp.

Cushman, J. A. 1936: Some new species of *Elphidium* and related genera. Contr. Cushman Lab. Foram. Res. 12 (4), 78–91.

Cushman, J. A. 1939: A Monograph of the foraminiferal family *Nonionidae*. U. S. geol. Surv., prof. paper 191, 100 pp.

Cushman, J. A. and Grant, U. S. 1927: Late Tertiary and Quaternary Elphidiums of the West Coast of North America. San Diego Soc. Nat. Hist., Trans., Calif. 5 (6), 69–82.

Dam, A. ten and Reinhold, T. 1942: Die Stratigraphische Gliederung des niederländischen Oligo-Miozäns nach Foraminiferen. Meded. geol. Sticht. C-V, 2, 106 pp.

Dinesen, A., see Larsen, G. and Dinesen, A.

Egger, J. G. 1857: Die foraminiferen der Miocän-Schichten bei Ortenburg in Nieder-Bayern. Neues Jb. Miner. Geogn. Geol. Petrefakt. 266–311.

Ellis, B. F. and Messina, A. R. 1940 ff.: Catalogue of Foraminifera. Am. Mus. Nat. Hist., spec. Publ.

Glover, Everett D. 1961: Method of solution of calcareous materials using the complexing agent, EDTA. J. Sedim. Petrol. 31 (4), 622–626.

Hagn, H. and Hölzl, O. 1952: Geologisch-paläontologische Untersuchungen in der subalpinen Molasse des östlichen Oberbayerns zwischen Prien und Sur mit Berücksichtigung des im Süden anschliessenden Helvetikums. Geologica Bav. 10, 208 pp.

Indans, J. 1962: Foraminiferen-Faunen aus dem Miozän des Niederrheingebietes. Fortschr. Geol. Rheinld.-Westf. 6, 19–81.

Kristoffersen, F. N. 1972: Foraminiferzonering i det jyske miocæn. Dansk geol. Foren., Årsskrift 1971, 79–85.

Larsen, G. and Dinesen, A. 1959: Vejle Fjord Formationen ved Brejning. Sedimenterne og foraminiferfaunaen. (oligocæn-miocæn). Danmarks geol. Unders. række 2, 82, 114 pp. (Summary in English).

Marks, P. 1951: A revision of the smaller Foraminifera from the Miocene of the Vienna Basin. Contr. Cushman Found Foram. Res. 2, 33–73.

Meuter, F. J. C. de 1970: The Foraminifera in the Houthalen Sands (Middle Miocene) of the deepboring Helchteren (NE Belgium). Bull. Soc. belge Géol. Paléont. Hydrol. 79 (2), 129–132.

Nørvang, A. 1966: The internal tooth of *Bulimina striata* d'Orbigny (Foraminifera) a preliminary notice. Vidensk. Mddr. dansk naturh. Foren. 129, 285–286.

Papp, A. 1963: Die biostratigraphische Gliederung des Neogens im Wiener Becken. Mitt. Geol. Ges. Wien 56 (1), 225–317.

Parker, W. K. and Jones, T. R. 1864: See Brady, H. B.

Rasmussen, L. B. 1956: The Marine Upper Miocene of South Jutland and its Molluscan Fauna. Danmarks geol. Unders. række 2, 81, 166 pp.

Rasmussen, L. B. 1961: De miocæne formationer i Danmark. Danmarks geol. Unders. række 4,4(5), 45 pp.

Reuss, A. E. 1850: Neue Foraminiferen aus den Schichten des österreichischen Tertiärbeckens. K. Akad. Wiss. Wien, math.-naturwiss. Cl. Denkschr. 1, 365–390.

Reuss, A. E. 1861: Beiträge zur Kenntnis der tertiären foraminiferen-Fauna. K. Akad. Wiss. Wien, math.-naturwiss. Cl. Sitzber. 42 (24), 355–370.

Reuss, A. E. 1865: Zur Fauna des deutschen Oberoligozäns. K. Akad. Wiss. Wien, math.-naturwiss. Cl. Sitzber. 50 (1), 435–482.

Sorgenfrei, T. 1940: Marint Nedre-Miocæn i Klintinghoved på Als. Danmarks geol. Unders. række 2, 65, 143 pp.

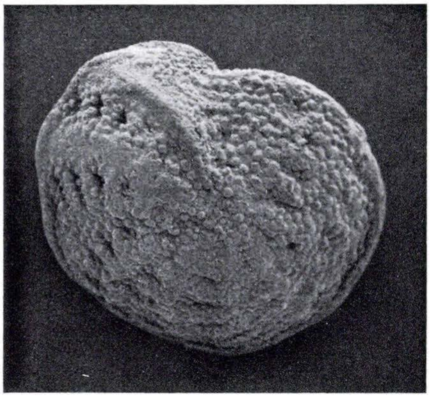
Sorgenfrei, T. 1958: Molluscan Assemblages from the Marine Middle Miocene of South Jutland and their Environments. Danmarks geol. Unders. række 2, 79, 503 pp.

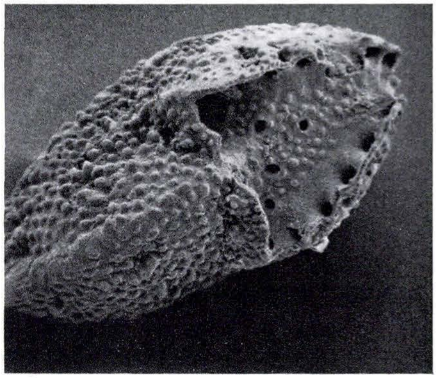
Thalmann, H. E. 1947: Mitteilungen über Foraminiferen V. Eclog. Geol. Helv. 39 (2), 309–314.

Voorthuysen, J. H. van and Toering, K. 1969: Distribution quantitative des foraminifères néogènes et quaternaires aux environs d'Anvers. Meded. Rijks Geol. Dienst, nieuwe Ser. 20, 93–123.

Plate 1

	D.G.U. Catalogue No.
Figs. 1–6. *?Elphidium ungeri* (Reuss)	
Locality: Alkærsig, D.G.U. file No. 93.101, depth 51 m.	
Fig. 1. Side view. SH–8,14–FNK, × 130.	1972–FNK–1
Fig. 2. Specimen with broken final chamber showing retral processes and distinct septal pores with thickened rim. SH–8,12–FNK, × 210.	1972–FNK–2
Fig. 3. Edge view. SH–8,14–FNK, × 110.	1972–FNK–1
Fig. 4. Detail of fig. 6 showing plastic cast of anastomosing spiral canal and proximal parts of sutural canals. SH–8,9–FNK, × 200...	1972–FNK–3
Fig. 5. Plastic cast showing retral processes, sutural pores and canals. SH–8,2–FNK, × 330.	1972–FNK–4
Fig. 6. Plastic cast showing canal system and impresion of the test surface. SH–8,9–FNK, × 200.	1972–FNK–3





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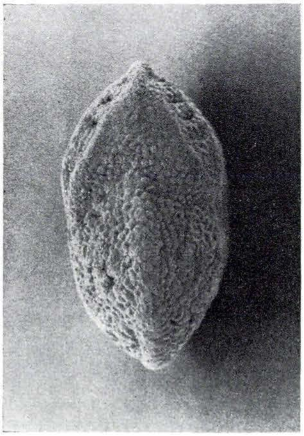

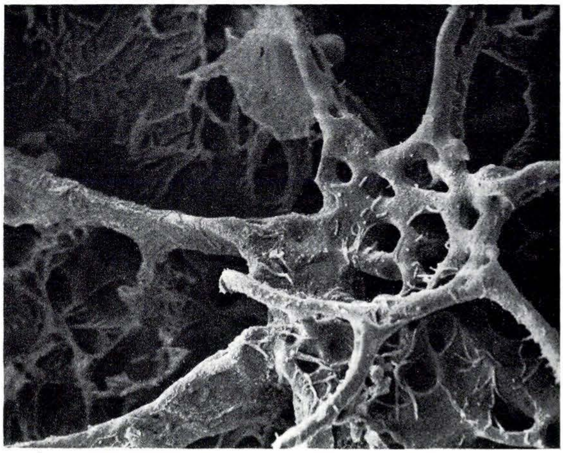

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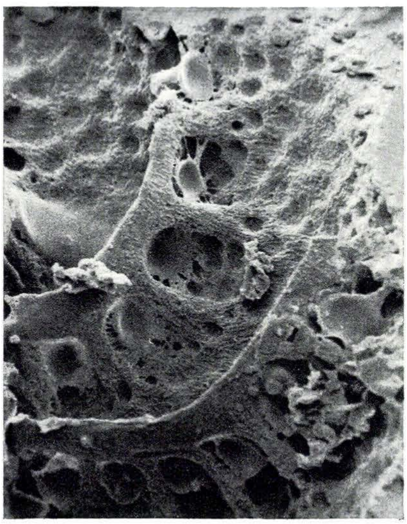

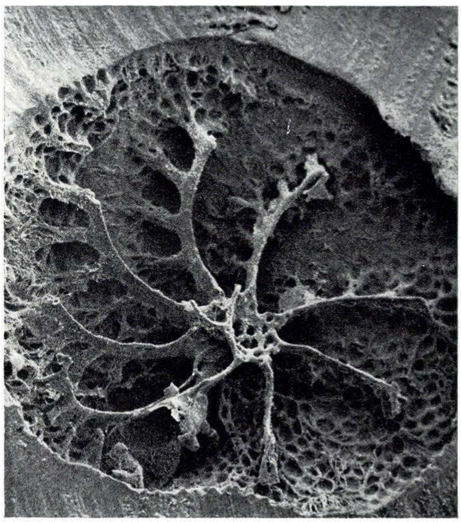

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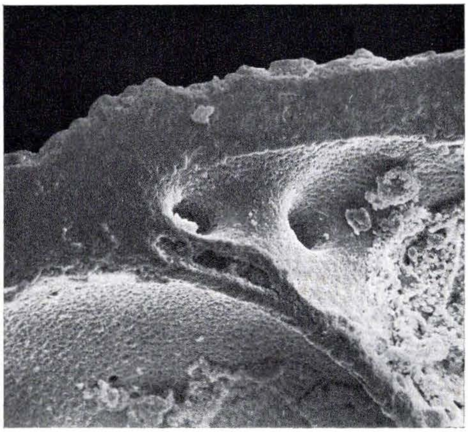
6

	D.G.U. Catalogue No.
Fig. 1. *?Elphidium ungeri* (Reuss)	
Horizontal section through peripheral area showing retral processes, septal flap and sutural canal. Locality: Alkærsig, D.G.U. file No. 93,101, depth 51 m. SH–11,3–FNK, × 670.	1972–FNK–5
Fig. 2–5. *Elphidiella minuta* (Reuss)	
Fig. 2. Side view. Locality: Alkærsig, D.G.U. file No. 93.101, depth 60 m. SH–8,15–FNK, × 100.	1972–FNK–6
Fig. 3. Edge view. Locality: Hygum, D.G.U. file No. 121.211, depth 122–123 m. SH–13,4–FNK, × 300.	1972–FNK–7
Fig. 4. Plastic cast showing umbilical part of canal system with spiral canal and sutural canals. Locality: Alkærsig, D.G.U. file No. 93.101, depth 80 m. SH–10,1–FNK, × 670.	1972–FNK–8
Fig. 5. Oblique apertural view of specimen with broken final chamber. Locality: Alkærsig, D.G.U. file No. 93.101, depth 80 m. SH–10,2–FNK, × 200 m.	1972–FNK–9
Fig. 6. *Cribrononion heteroporum* (Egger)	
Side view. Locality: Alkærsig, D.G.U. file No. 93.101, depth 53 m. SH–3,30–FNK, × 200.	1972–FNK–10



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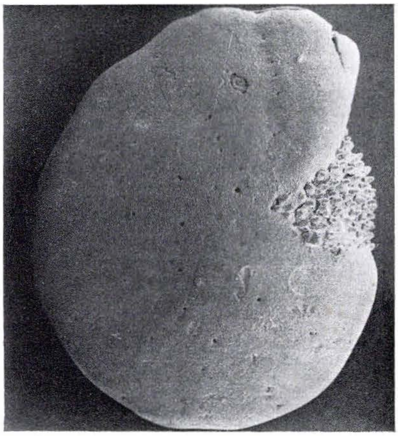

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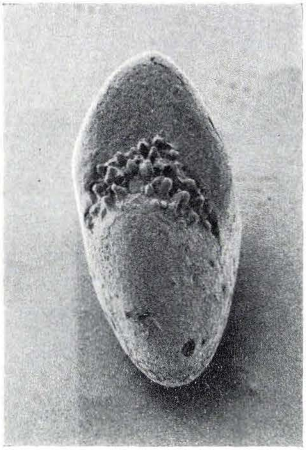

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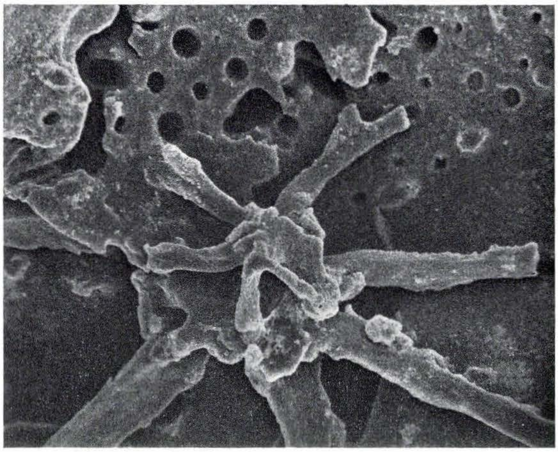

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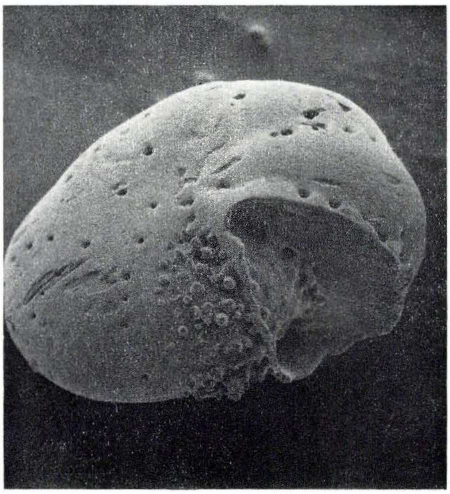

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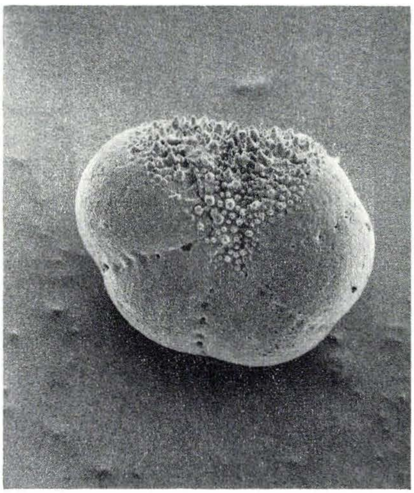

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Catalogue Nc

Fig. 1–6. *Cribrononion heteroporum* (Egger)

Fig. 1. Edge view. Locality: Alkærsig, D.G.U. file No. 93.101, depth 53 m. SH–13,8–FNK, × 270. .... 1972–FNK–11

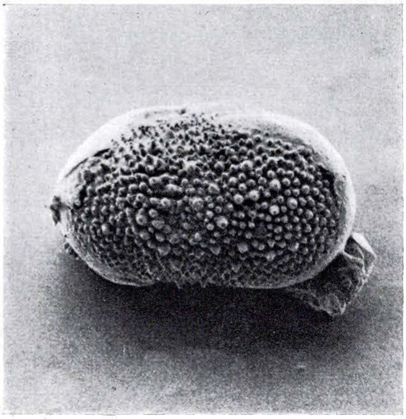
Fig. 2. Horizontal section showing apertural chamberlet. Locality: Alkærsig, D.G.U. file No. 93.101, depth 54 m. SH–11,4–FNK, × 670. .... 1972–FNK–12

Fig. 3. Specimen with broken final chamber showing the slitlike aperture from the reverse. Locality: Alkærsig, D.G.U. file No. 93.101, depth 51 m. × 200. (specimen lost).

Fig. 4. Damaged specimen showing coarse striations on previous coil inside the chambers. Locality: Alkærsig, D.G.U. file No. 93.101, depth 51 m. × 200. (specimen lost).

Fig. 5. Plastic cast showing canal system and impression of the test surface. Locality: Alkærsig, D.G.U. file No. 93.101, depth 51 m. SH–11,2–FNK, × 670. .... 1972–FNK–13

Fig. 6. Plastic cast showing primitive spiral canal. Remnants of the chambers casts persist in the specimen. Locality: Alkærsig, D.G.U. file No. 93.101, depth 51 m. SH–7,5–FNK, × 670. .... 1972–FNK–14



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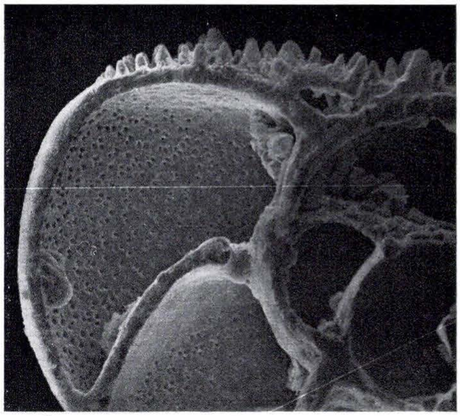

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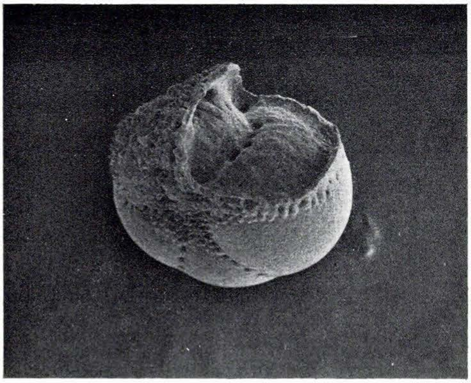

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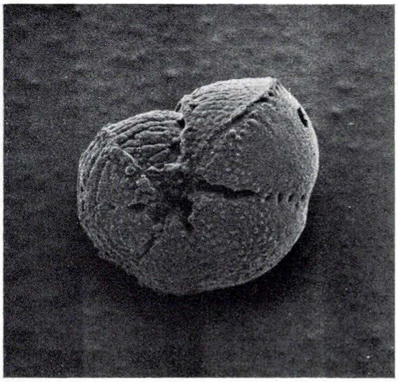

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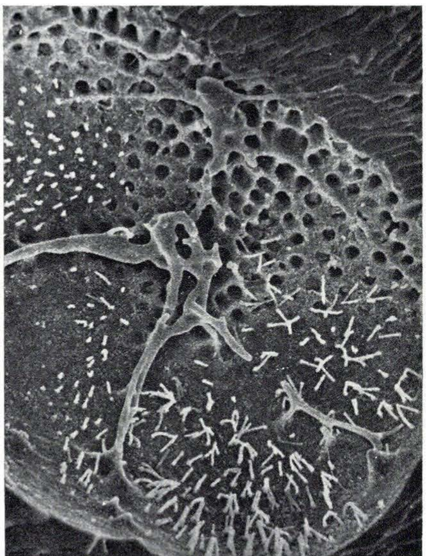

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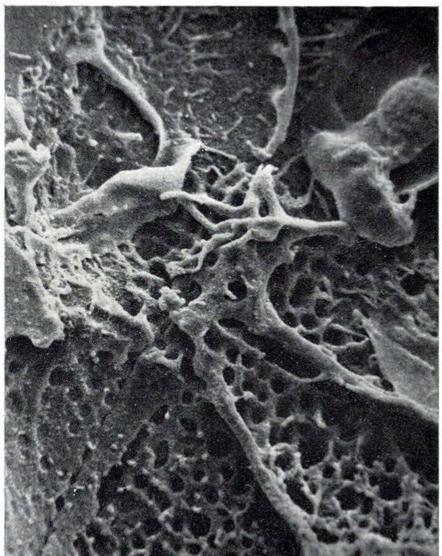

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Figs. 1–2. *?Elphidium ungeri* (Reuss)

Fig. 1. Locality: Gram: D.G.U. file No. 141.277, depth 34.70–35.00 m. × 90. .... 1972–FNK–15

Fig. 2. Vertical section. Locality: Gram, D.G.U. file No. 141.277, depth 34.70–35.00 m. × 110. .... 1972–FNK–16

Fig. 3. *Elphidiella minuta* (Reuss)
Locality: Alkærsig, D.G.U. file No. 93.101, depth 54 m. × 90. .. 1972–FNK–17

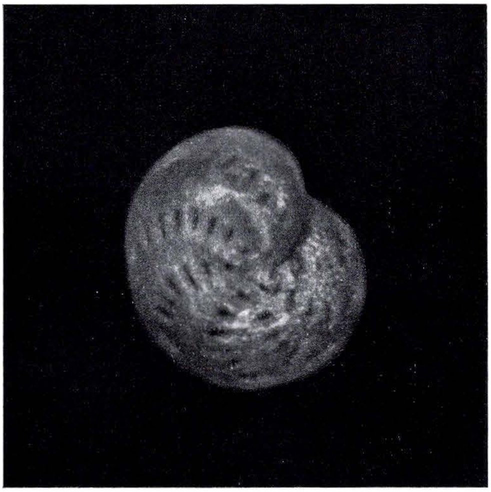
Figs. 4–6. *Cribrononion heteroporum* (Egger)

Fig. 4. Horizontal section showing apertural chamberlet. Locality: Alkærsig, D.G.U. file No. 93.101, depth 61 m. × 240. .... 1972–FNK–18

Fig. 5. Holotype after Egger 1857, Pl. 14, fig. 19–21. × 60.

Fig. 6. Side view. Locality: Alkærsig, D.G.U. file No. 93.101, depth 53 m. × 90. .... 1972–FNK–19

Phot. O. Neergaard Rasmussen (figs. 1,3,5–6)



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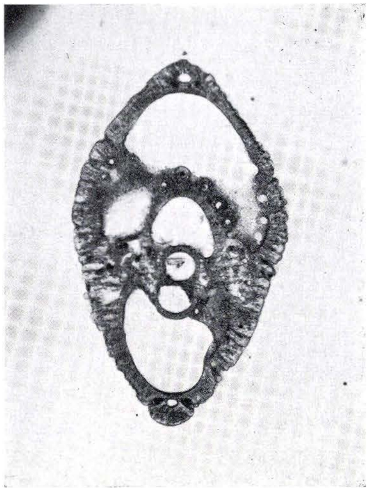

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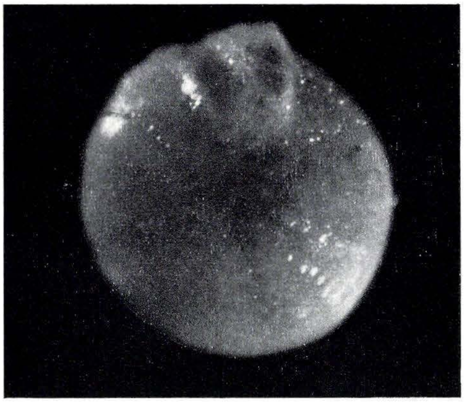

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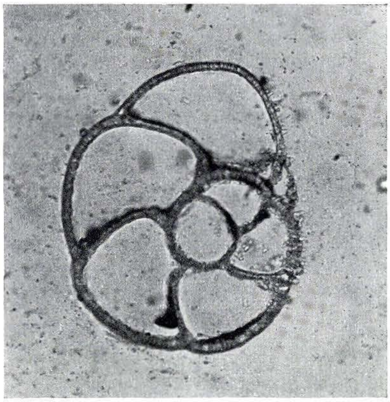

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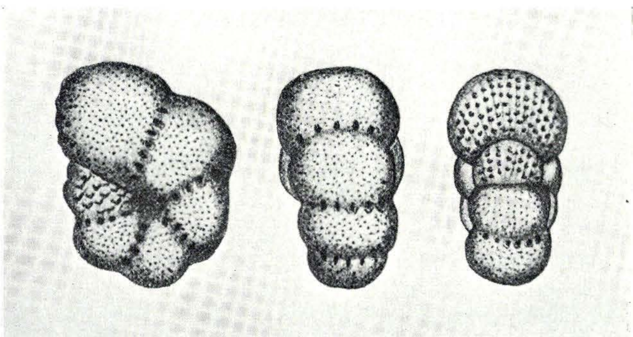

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6

The early Post-glacial development of the Store Belt as reflected in a former fresh water basin

Harald Krog

Krog, Harald: The early Post-glacial development of the Store Belt as reflected in a former fresh water basin. *Danm. geol. Unders., Årbog 1972*, pp. 37–47. København, 4. december 1973.

A pollen diagram from a former fresh water basin situated at a water depth of 27 m in the central Store Belt (Denmark) is presented. A rise in ground water level during the early Boreal, dated at 7110 ± 120 B.C., is interpreted as a reflection of the eustatic rise in ocean level. The sea level was hardly above – 30 m during the Boreal (zone V). It is supposed that the sea entered the Baltic through the Store Belt during zone VI. The transgression of the basin at the beginning of zone VII is considered a local event.

The early Post-glacial development of the Store Belt (Denmark) has been discussed by the author previously, chiefly based on pollen analytical examinations of cores from borings in the area (Krog 1960, 1965, 1971. The present article is almost identical with Krog 1971). The main conclusions were the following.

During the Pre-boreal the Store Belt was part of a landbridge which separated the Baltic from the ocean. Pre-boreal peats (in two borings) down to abt. –30 m indicate a sea level stand below this level. A general rise in ground water level started during the Boreal and continued during the early Atlantic. The rise was registered by a change from peat to gyttja in 6 former lake basins in the area, at levels ranging from – 31.5 to – 25 m. The positions of the basins are marked on fig. 1 and fig. 2. They are situated outside the deep and narrow channel running mainly N-S, and the water rise in the basins was interpreted as reflecting a submergence of the channel and its surroundings. As the submergence was represented by fresh water sediments only it could be explained as being caused either by the eustatic rise in ocean levle, or by water draining from the western Baltic. Comparisons with neighbouring areas suggested that the first explanation was the true one. It was assumed that ocean water entered the Baltic through a narrow channel in the Store Belt already during the Boreal, far earlier than the Store Belt lakes were transgressed. The lakes were supposed to have been

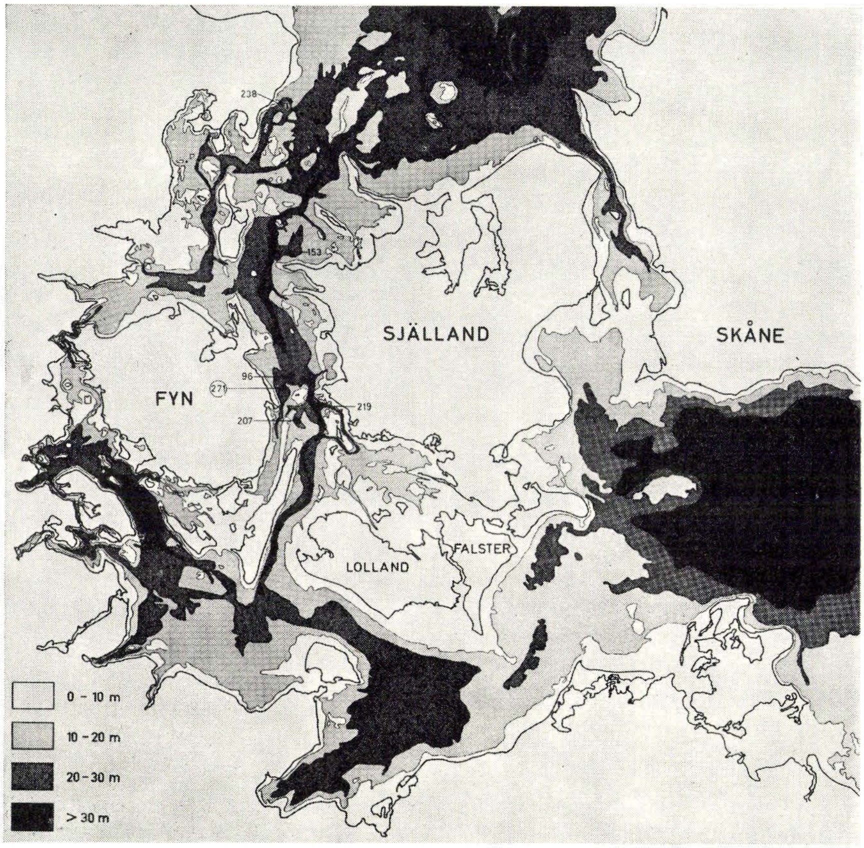

Fig. 1. Positions of the borings in the Store Belt. Cp. fig. 2.

separated from the neighbouring Store Belt water until their local thresholds were transgressed at various points of time later. The development after the early Atlantic could not be traced because of breaks in the sediment series.

The material formerly presented comprised pollen diagrams from two cores and brief information on preliminary results from a few other cores. The most complete core was one from bor. no. 271, the only one fully covering the development just outlined, including the transgression of the lake basin represented. No pollen diagram, only preliminary results were presented from no. 271. Results from additional pollen and diatom countings from this core support the ideas just advanced, but lead to an altered opinion as to the position of the sea level in the area during the Boreal.

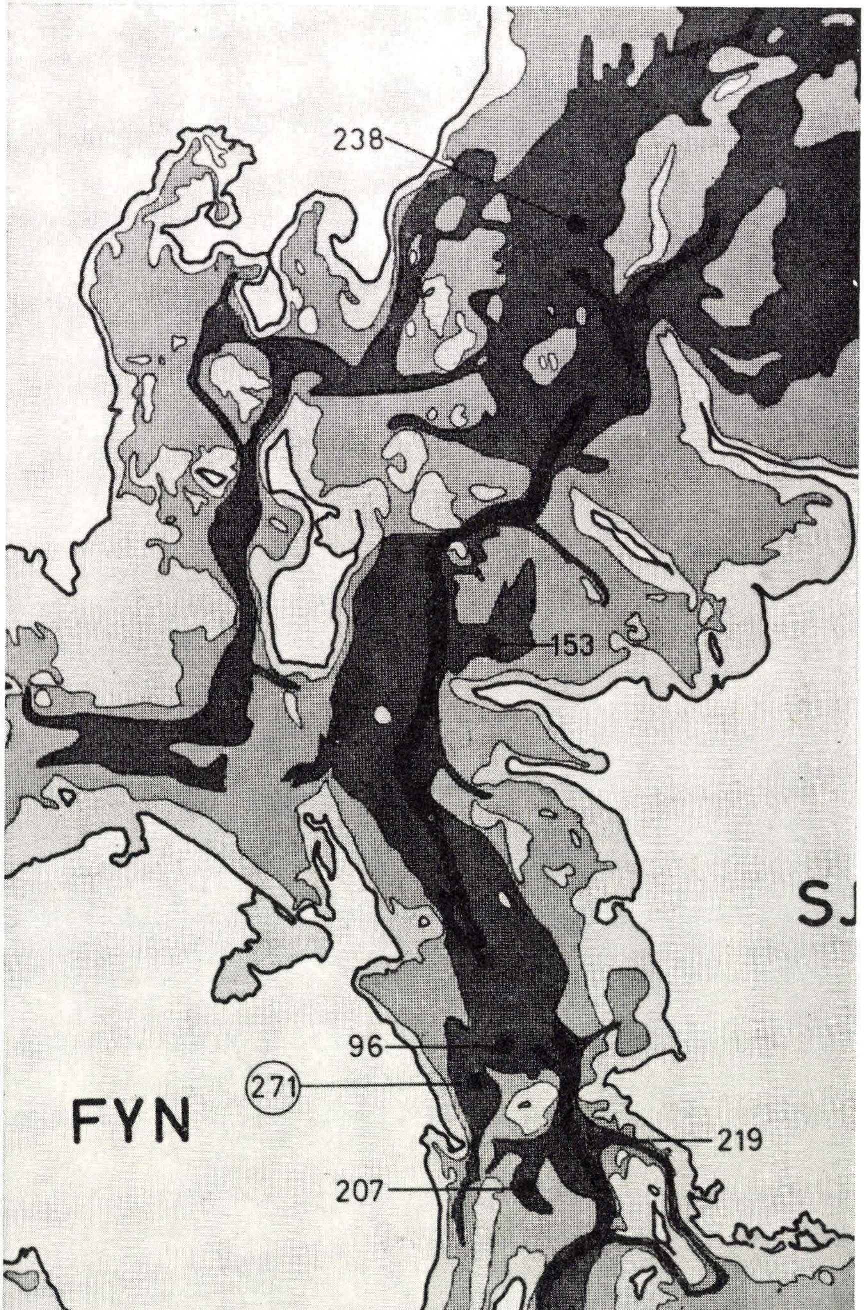

Fig. 2. Enlarged part of fig. 1 showing positions of the borings in the Store Belt. No. 271 is specially marked.

The pollen diagram, also comprising the main results of the diatom countings, is presented in this paper to show the basis for the interpretation outlined.

The position of bor. no. 271 in the western part of the central Store Belt is marked in fig. 1 and fig. 2. In fig. 3 is seen an echogram showing part of the basin in which the boring was made with a Kullenberg piston sampler (Kullenberg 1947). The N-S extent of the basin may be estimated to have been abt. 1–2 km, but its exact size is not known. A basin depth of abt. 4 m is indicated on the echogram, and observations during the boring operations also indicate that the sampler penetrated 4-4.5 m into the sea bottom. There were no signs of core loss from the sampler during boring operations. The actual core length, however, was only 2.82 m but from the observations mentioned there is reason to assume that the core recovered was originally at least 4 m long. Increasing sand content in the lowermost 2 cm of the core further indicates that part of the bottom layers of the basin is represented in the core. Compression of the core during the coring is the most likely explanation of the reduced core length. In the following the actual measurements from the fresh core are used.

The description of the core from bor. no. 271 may be summarized as follows.

0 - 27.00 m.	Water.
27.00 - 27.01 m.	Sand vith clay and gyttja.
27.01 - 29.01 m.	Clay gyttja, great clay content, esp. towards the top; slightly calcareous. Gradual transition to the following layer.
29.01 - 29.21 m.	Clay gyttja, less clayey and more calcareous than the former layer.
29.21 - 29.34 m.	Peaty gyttja. Gradual transition to the following layer.
29.34 - 29.45 m.	Alternating layers of coarse gyttja and lake marl.
29.45 - 29.52 m.	Lake marl.
29.52 - 29.56 m.	Calcareous gyttja. Less calcareous in the lower part.
29.56 - 29.81 m.	Peat, telmatic in the upper and middle part, limnic in the lowermost part. A little sandy in the lowermost few mm.
29.81 - 29.82 m.	Gyttja, increasingly sandy downwards.

The whole series was clearly horizontally stratified without signs of disturbance. Neither do the pollen curves show any signs of irregularity.

Based on the forest development, the pollen diagram from the core, fig. 4, is divided the following way. The bottom part of the core was deposited during zone IV, the Pre-boreal, dominated by *Betula* and *Pinus*. The beginning of zone V, the Boreal, is marked by the immigration of *Corylus* which rapidly spread, and the zone is characterized by very high

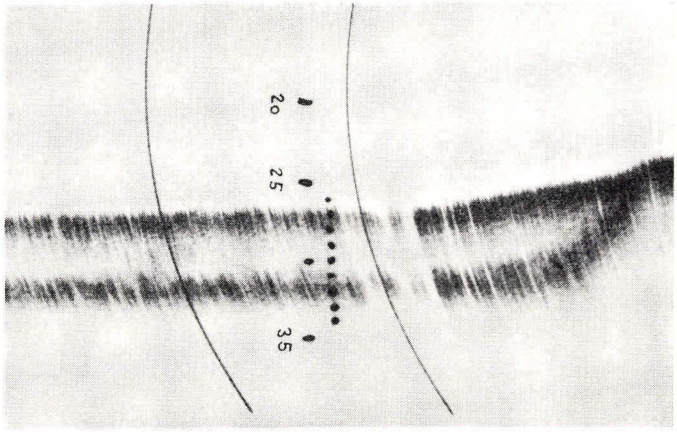

Fig. 3. Echogram from the part of the basin in which bor. no. 271 was made. Black dots mark depths for every one m between 25 and 35 m.

Corylus values – as is normal in diagrams from the Store Belt. Immigration of *Alnus* marks the beginning of zone VI, which is a vegetationally unstable period during which *Alnus* and the trees of the mixed oak forest spread. The borderline between zones VI and VII is placed at the level where stability in these curves is obtained, marked here by a constant *Tilia* curve. Zone VI is incorporated by several authors in the Boreal although it is climatologically consistent with the Atlantic. In this paper zones VI and VII cover the Atlantic. Deposits younger than zone VII are not represented in the core.

In terms of water level changes the following development of the basin is seen.

During the Pre-boreal the basin changed from lake to bog, witnessed by the shift in sediment from gyttja to peat. The limnic nature of the lowermost part of the peat tells that it was a gradual change which is naturally explained by normal overgrowth of the lake. In the diagram the relatively dry conditions during the bog period is marked by partial or total absence of the water living algae *Botryococcus* and *Pediastrum*. Presence of *Botryococcus* in the uppermost analysed peat sample may be the first indication of the rise in ground water level which transformed the basin from bog to lake during early zone V. The water level rise is clearly marked by the shift in sedimentation from peat to gyttja, and lithologically this shift seems rather abrupt as there is a sharp limit between the calcareous gyttja and the peat. The increased water supply is registered with certainty 1 cm below the top of the peat, partly by better preservation of peat sub-

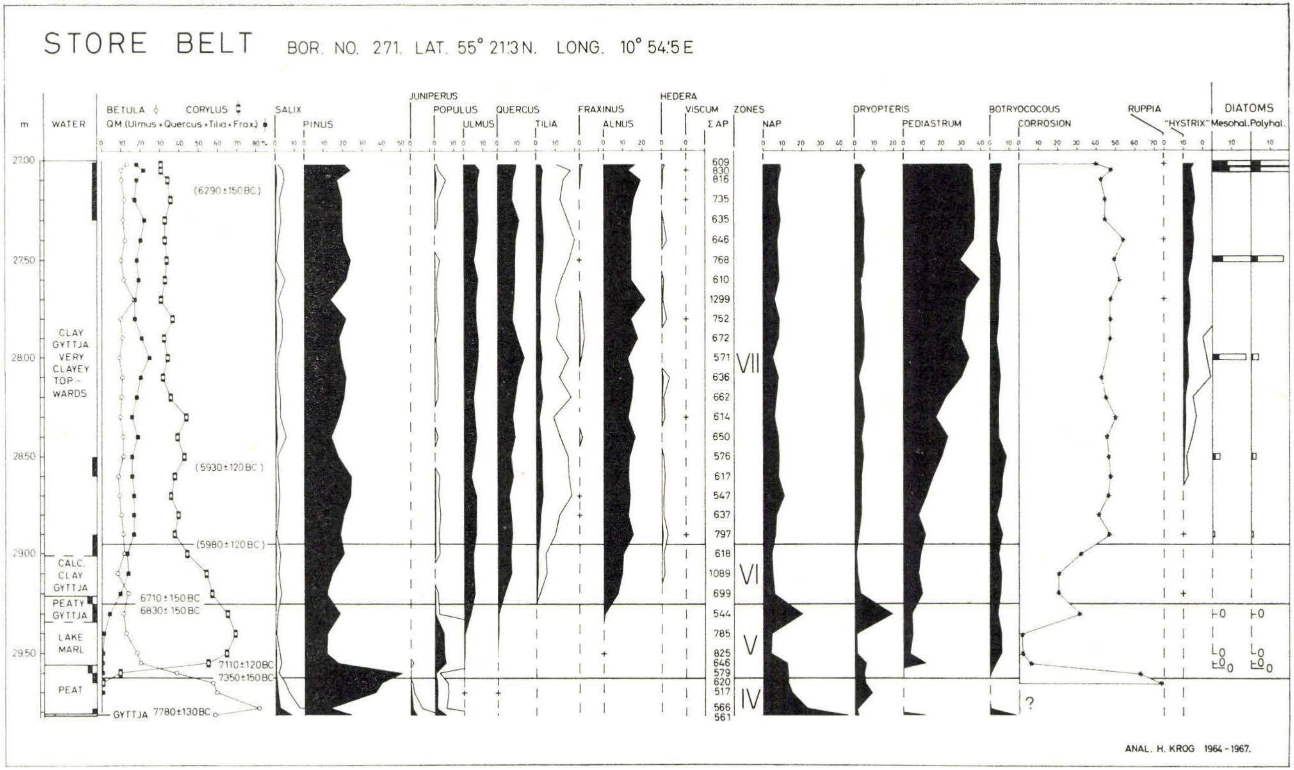
STORE BELT BOR. NO. 271. LAT. 55° 21'3 N. LONG. 10° 54'5 E
m
WATER
BETULA
CORYLUS
QM (Ulmus + Quercus + Tilia + Frax.)
SALIX
PINUS
JUNIPERUS
POPULUS
ULMUS
QUERCUS
TILIA
FRAXINUS
ALNUS
HEDERA
VISCUM
Σ AP
ZONES
NAP
DRYOPTERIS
PEDIASTRUM
BOTRYOCOCCUS
CORROSION
RUPPIA
"HYSTRIX"
DIATOMS
Mesohal. Polyhal.
27.00
27.50
28.00
28.50
29.00
29.50
CLAY GYTTJA VERY CLAYEY TOP-WARDS
CALC. CLAY GYTTJA
PEATY GYTTJA
LAKE MARL
PEAT
GYTTJA
(6290 ± 150 BC)
(5930 ± 120 BC)
(5980 ± 120 BC)
6710 ± 150 BC
6830 ± 150 BC
7110 ± 120 BC
7350 ± 150 BC
7780 ± 130 BC
VII
VI
V
IV
ANAL. H. KROG 1964-1967.

Fig. 4.

stance and by presence of *Nymphaea* pollen, compared to a level 4 cm below the top of the peat (not shown in the diagram), and partly by presence and absence, respectively, of pond diatoms at the same levels. This means that the rise in water level is contemporaneous with the very conspicuous rise of the *Corylus* pollen curve from abt. 10 % to 55 %. During the remaining part of zone V the basin was a rather shallow lake, according to the sedimentation of gyttja and lake marl. The peaty gyttja deposited at the end of the zone may mark a constant water level or a temporary lowering. An increasing content of mineral matter in the sediment series indicates a rising water table from early zone VI onwards.

The sediments in the lower part of the core clearly reflect fresh water conditions in the basin during zones IV–VI. A change in salinity is indicated during the deposition of the upper two metres of clay gyttja. In the right part of the pollen diagram the salinity change is illustrated by the curves representing *Ruppia* "Hystrix", and diatoms.

Presence of brackish water is indicated within the upper 70 cm by a few pollen grains of *Ruppia,* as *Ruppia* is a plant restricted to brackish water.

Under the heading "Hystrix" is given the collective curve for Hystricosphaerids, microorganisms connected with brackish and salt water. Within the group are also forms often found in redeposited clays, and the lowermost record in the diagram, from early zone VI, is clearly identified as one of these "old" – and redeposited – forms. The first "Hystrix" indicative of marine environment is found 190 cm below the top of the core, and from a level 30 cm higher the curve is unbroken, very low in the lower part, but with slightly increasing values upwards.

Diatom countings were made from 10 different levels in the series, and a number of 500 to 1000 valves were counted in each sample. For reasons of space the diagram only shows the percentages of valves belonging to mesohalobous and polyhalobous species, indicating brackish and marine environments respectively. The whole series is dominated by fresh water diatoms. From the beginning of zone VII, however, is seen a very slight

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Fig. 4. Pollen and diatom diagram from bor. no. 271. The calculation basis for all AP components is the tree pollen and *Corylus* (AP). Percentages for NAP, *Dryopteris, Pediastrum, Botryococcus, Ruppia,* and "Hystrix" are calculated from a total including AP + the component in question. The curve headed Corrosion shows percentages of corroded pollen grains of *Betula, Alnus, Ulmus, Tilia,* and *Corylus,* calculated from the total of these genera. Diatom percentages are based on the total of valves. All curves are drawn to the same scale; in addition some silhouettes representing very low values, e. g. for diatoms, are drawn to a scale 5 × 1. + marks occurrence of one specimen only. Radiocarbon datings are given in the left part of the diagram; the levels of the samples dated are marked by thick black lines in the stratigraphic column.

but upwards gradually increasing content of mesohalobous and polyhalobous diatoms, amounting in the uppermost two samples to abt. 13–14 ‰ together. The composition of the diatom flora from the uppermost samples does not agree with true brackish or marine conditions, but has a character of mixing which may be created when lake water is mixed with sea water.

The courses of the curves for "Hystrix" and diatoms are almost identical and it must be concluded that they reflect a gradually increasing amount of sea water carried to the basin. In other words the basin was transgressed at the beginning of zone VII.

The very uniform pollen curves in the upper two metres indicate that only a short period of the early zone VII is represented, and that the upper clay gyttja series was deposited very quickly during early zone VII. This means a sedimentation rate far greater than in the underlying part of the core. The local basin is too small to be the only source area for the relatively thick and quickly deposited series of very clayey material, and supply from a greater area of the Store Belt is required. This requirement was fulfilled by the transgression of the basin.

It is supposed that wave action and currents in the Store Belt area outside the basin implied stronger oxidation and, consequently, greater corrosion of pollen grains than inside the basin. In this way a wider source area for sediment supply of the basin explains the bad pollen preservation in the upper clay gyttja series (cp. corrosion curve in the diagram). The diatoms are badly preserved in this part of the core too.

At the beginning of the water rise in early zone V the sea level must have been somewhat lower than the bog surface, which means a level lower than abt. – 30 m. Because of the presence of the peaty gyttja at the zone transition V/VI the – 30 m level was hardly passed before early zone VI. The threshold of the basin was surpassed at the beginning of zone VII at a sea level higher than – 29 m, because the water level of the basin and, consequently, the threshold level were situated higher than the basin bottom at that time which is recorded at – 29 m in the core.

The sea level position at or below – 30 indicated in bor. no. 271 during zone V is lower than the levels of the present thresholds in the Store Belt north of the site which are at abt. – 25 m. Differential isostatic elevation presumably caused a greater uplift of the thresholds after zone V than the uplift of the boring site. Even then it is unlikely that the thresholds were as low as – 30 m. In addition the thresholds may have been erosionally lowered since the Boreal. According to these considerations the Kattegat water presumably did not enter the Store Belt channel during zone V – contrary to what was formerly supposed (Krog 1965). Inside the Store Belt area we have no definite proof for presence of sea water earlier than recorded from bor no. 271. The transgression of this basin is considered to be a local event, and the transgression of the Store Belt channel may have occurred during early zone VI, as indicated by a marked salinity increase in the western Baltic (Kolp 1964, 1965) supposed by Kolp to start at that time.

Radiocarbon measurements of 8 samples from the core of bor. no. 271 were made in the Copenhagen dating laboratory by H. Tauber. The age calculations are based on a contemporary value equal to 95 ‰ of the activity of the NBS oxalic-acid standard, and on a half life for C^{14} of 5570 yr. Results are given in years B.C. A few dates from the lowermost part of the series have been published formerly (Krog 1965; Tauber 1966 a, 1966 b). In the following list the samples dated are arranged according to their position in the core.

K - 927	27.01 - 27.30 m.	6290 ± 150 B.C.
K - 921	28.50 - 28.60 –	5930 ± 120 B.C.
K - 920	28.90 - 29.01 –	5980 ± 120 B.C.
K - 924	29.21 - 29.25 –	6710 ± 150 B.C.
K - 925	29.25 - 29.34 –	6830 ± 150 B.C.
K - 922	29.56 - 29.60 –	7110 ± 120 B.C.
K - 926	29.60 - 29.65 –	7350 ± 150 B.C.
K - 942	29.78 - 29.81 –	7780 ± 130 B.C.

The upper 3 dates, from the clay gyttja series, are nearly identical, and thus do not show the expected difference in age between top and bottom. The clay gyttja is slightly calcareous in parts; it is very poor in organic material, particularly in its upper part, and a few secondary pollen grains prove that redeposition has taken place to a small extent. For these reasons the dates are considered unreliable. They have been included in the list only to show the danger of using such material for radiocarbon dating. In particular it is regrettable that the dating of the zone boundary VI/VII cannot be trusted because this boundary is likely to be closer to zone V than in many other pollen diagrams from areas outside the Store Belt area.

The datings marking the zone boundary V/VI (6830, 6710) appear somewhat old compared to datings of late zone V in the same area (Krog 1960, 1965). The dates from the immigration of *Corylus* and its quick spreading (7350, 7110) agree with other dates from the area, but are older than dates from western Denmark (Tauber 1966 a, 1966 b, and unpublished).

Most important for the problems discussed here is the date 7110 ± 120 B.C. which marks the onset of the water rise, and the eustatic transgression, during early zone V. The variation of this rise within the Store Belt area will not be discussed here; it must suffice to say that the date from this boring fits within the range expected.

The results from this and other borings in the area have been commented on by Mörner (1969). He correlates the boreal water rise of bor. 271 with the first Post-glacial marine transgression in the Kattegat area. The onset of this transgression is dated at 7330 B.C. by Mörner, a date not far from that obtained from bor. no. 271. By extrapolation he further suggests a maximum sea level stand at – 19.9 m during zone V at the place of no. 271. As mentioned above, the present investigation indicates that the – 30 m level was hardly surpassed during this period. The change from gyttja to peat in no. 271, dated at 7780 ± 130, may according to Mörner reflect a regression. In this paper it is explained by natural overgrowth.

References

Kolp, O., 1964. Der eustatische Meeresanstieg im älteren und mittleren Holozän, dargestellt auf Grund der Spiegelschwankungen im Bereich der Beltsee. – Peterm. Geogr. Mitt., v. 108, p. 54–62.

Kolp, O., 1965. Paläogeographische Ergebnisse der Kartierung des Meeresgrundes der westlichen Ostsee zwischen Fehmarn und Arkona. – Beitr. z. Meereskunde, H. 12–14. p. 19–59.

Krog, H., 1960. Post-glacial submergence of the Great Belt dated by pollen-analysis and radiocarbon. – Report Intern. Geol. Congress, XXI Sess., Norden 1960, Part IV, Chronology and Climatology of the Quaternary, p. 127–133.

Krog, H., 1965. On the Post-glacial development of the Great Belt. – Baltica, v. 2, p. 47–60.

Krog, H., 1971. The early Post-glacial development of the Store Belt as reflected in a former fresh water basin. – Quaternaria XIV, p. 85–92.

Kullenberg, B., 1947. The piston core sampler. – Sv. Hydr.-Biol. Komm., ser 3, v. 1, h. 2, 46 pp.

Mörner, N.-A., 1969. The Late Quaternary history of the Kattegatt Sea and the Swedish West Coast. – Sveriges Geol. Undersökn., ser. C, nr. 640, 487 pp.

Tauber, H., 1966a. Danske Kulstof-14 dateringsresultater II. – Dansk. Geol. Foren. Medd., v. 16, p.153–176.

Tauber, H., 1966b. Copenhagen radiocarbon dates VII. – Radiocarbon, v. 8, p. 213–234.

Dansk sammendrag

I Storebælts bund er der mange steder påvist ferskvandsaflejringer stammende fra en tid, da Storebæltsområdet var tørt land. De fleste ferskvandsaflejringer findes i tidligere søbassiner, der nu ligger skjult i havbunden, men hvis tilstedeværelse er påvist ved ekkolodning gennem havbundens øvre lag. Der er fra skib optaget adskillige borekerner fra sådanne bassiner, og foreløbige resultater fra undersøgelser af nogle af disse kerner er tidligere publiceret (Krog 1960, 1965, 1971). I denne artikel (næsten identisk med Krog 1971) præsenteres en af de hidtil bedste borekerner og de slutninger, der på grundlag af især pollenanalytiske og diatomologiske undersøgelser af kernen kan drages vedrørende Storebælts udvikling.

Kernen stammer fra et tidligere ferskvandsbassin i den vestlige del af det centrale

Storebælt, mærket 271 på fig. 1 og 2. Vanddybden er 27 m. Fig. 3 viser ekkogrammet fra den del af bassinet, hvorfra kernen stammer. Den friske kerne var kun 2.82 m lang, medens der iflg. ekkogrammet måtte forventes en længde på ca. 4 m, og det må antages, at kernen blev komprimeret under boringen.

Kortfattet kan kernen beskrives som følger, målt fra havoverfladen:

27.00–29.01 m: Lergytje m. stort lerindhold, svagt kalkholdig
29.01–29.21 m: Lergytje, mindre lerholdig og mere kalkholdig end ovenfor
29.21–29.34 m: Tørvet gytje
29.34–29.56 m: Gytje og søkalk
29.56–29.81 m: Tørv
29.81–29.82 m: Gytje

Kernens helt igennem tydelige, vandrette lagdeling og pollenkurvernes regelmæssige forløb tyder på uforstyrret kontinuerlig afsætning af lagserien. Pollendiagrammet fig. 4 viser, at afsætningen begyndte i pollenzone IV (præborealtid), fortsatte gennem zonerne V (borealtid) og VI (begyndelsen af atlantisk tid) og afsluttedes i zone VII (atlantisk tid).

Kernens stratigrafiske udvikling registrerer følgende vandstandsændringer. Sedimentskiftet fra gytje til tørv i præborealtid viser, at bassinet da ændredes fra sø til mose. En grundvandsstigning i begyndelsen af zone V ændrede atter bassinet til en lavvandet sø med afsætning af gytje og søkalk. Den tørvede gytje fra slutningen af zonen kan tyde på begyndende tilgroning eller en lille vandstandssænkning. Sedimentskiftet til lergytje i tidlig zone VI markerer en ny vandstandsstigning, og det tiltagende indhold af mineralsk materiale opefter i lagserien indicerer, at stigningen fortsatte gennem den del af zone VII, som er repræsenteret.

Bassinet var et ferskvandsbassin uden forbindelse med havet indtil zone VII. I diagrammet sig. 4 viser kurverne for *Ruppia,* »Hystrix« og diatomeer, at havvand begyndte at trænge ind i bassinet i begyndelsen af zone VII.

Antagelig blev kernens øvre 2 m lergytje afsat meget hurtigt, så de kun omfatter den allertidligste del af zone VII.

Storebælts udvikling tolkes ud fra denne kerne på følgende måde. Tørven markerer, at Storebælt i præboreal tid var land, del af en landbro, der skilte Østersøen fra verdenshavet. I begyndelsen af borealtid begyndte en grundvandsstigning, der forøgedes fra begyndelsen af zone VI og fortsatte ind i zone VII. Grundvandsstigningen tolkes som et resultat af en samtidig eustatisk stigning af havspejlet og markerer således den postglaciale marine transgressions begyndelse. Først i begyndelsen af zone VII trængte havvandet ind i bassinet.

Lige før grundvandsstigningen i tidlig zone V må havspejlet have været lavere end moseoverfladen, d. v. s. lavere end ca. – 30 m, og dette niveau blev næppe overskredet førend tidligt i zone VI, hvor søens dybde øgedes. Da Storebælts nuværende tærskler N f. det undersøgte sted ligger ved ca. – 25 m, er vand fra Kattegat næppe trængt ind i Storebælts dybe rende i zone V. Ved den marine transgression af bassinet i begyndelsen af zone VII må havniveauet have været noget højere end – 29 m, der markerer bassinets bund, hvorimod dets tærskel må have ligget højere. Transgressionen af bassinet må dog anses for et lokalt fænomen, afhængig af bassinets tærskelhøjde, og er det end den tidligst kendte forekomst af saltvand i Storebælt, kan undersøgelser i Østersøen give grund til at antage, at Kattegatvand allerede i zone VI passerede – 25 m tærsklen og trængte gennem Storebælts dybe rende til Østersøen.

Vandstandsstigningen i begyndelsen af borealtid er C–14-dateret til 7.110 ± 120 f. Chr.

On Liassic holothurian and ostracod assemblages from the Danish Embayment

Olaf Michelsen

Michelsen, Olaf: On Liassic holothurian and ostracod assemblages from the Danish Embayment. *Danm. geol. Unders., Årbog for 1972,* pp. 49–68. København, 4. december 1973.

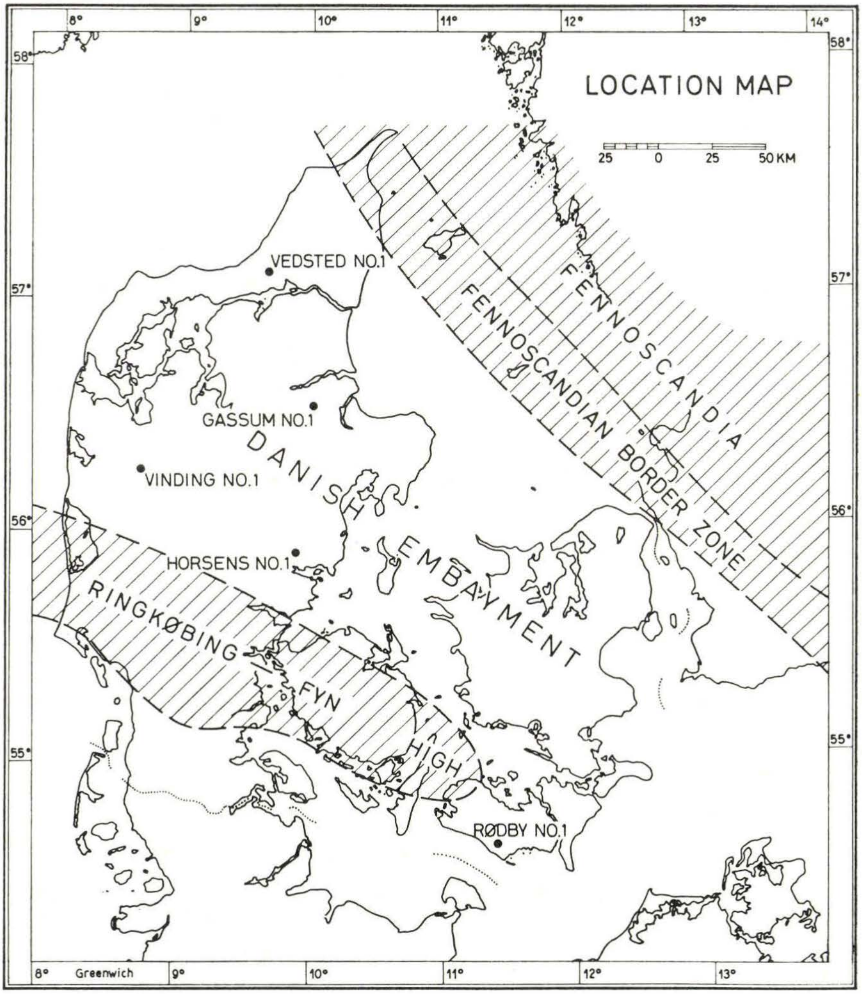
Liassic holothurian sclerites from the Danish Embayment are studied and referred to four morphospecies.

On the basis of quantitative analysis of the holothurian and the ostracod assemblages, which are compared with previous studies of the sediments (Larsen 1966), ecological aspects of the *Ogmoconchella aspinata* Assemblage Zone Michelsen 1971 (Lias Alpha) are outlined. Regional differences of the environment are demonstrated. The Rødby No. 1 boring is situated in a marginal position with an environment characterized by quiet, marine deposits interstratified by deltaic sediments. The Gassum No. 1, Horsens No. 1, and Vedsted No. 1 borings, situated more centrally in the basin, present a quiet sedimentation in a pure marine environment.

In the course of the investigation of the Lower Liassic ostracod fauna of the Rødby No. 1 boring, numerous holothurian sclerites were observed and picked out from the samples (cf. Bertelsen & Michelsen 1970, pl. XVII). Since then all occurrences of Liassic sclerites from the Danish Embayment have been recorded additionally to the study of the ostracod fauna.

Liassic sections which are mainly known in borings, have been published in Nørvang 1957 and Sorgenfrei & Buch 1964. These two publications referred to a stratigraphical subdivision of some of the sections worked out by Hans Frebold and based on the macrofossils. The stratigraphy of the Liassic sections of the Øresund borings was made by Larsen *et al.* 1968. Later on the stratigraphy of the Rødby No. 1 section was revised by Bertelsen & Michelsen (1970), who referred the whole Liassic section to Lias Alpha. The location of the borings studied here is shown on the map in text-fig. 1.

The ostracod fauna of the Rødby No. 1 section is very uniform and is named as the *Ogmoconchella aspinata* Assemblage Zone Michelsen 1970. This zone is recorded in other borings (Gassum No. 1, Horsens No. 1, Vedsted No. 1, and Vinding No. 1) and as in Rødby No. 1 it has a rather rich and well-defined holothurian assemblage. The present paper deals with



Text-fig. 1.

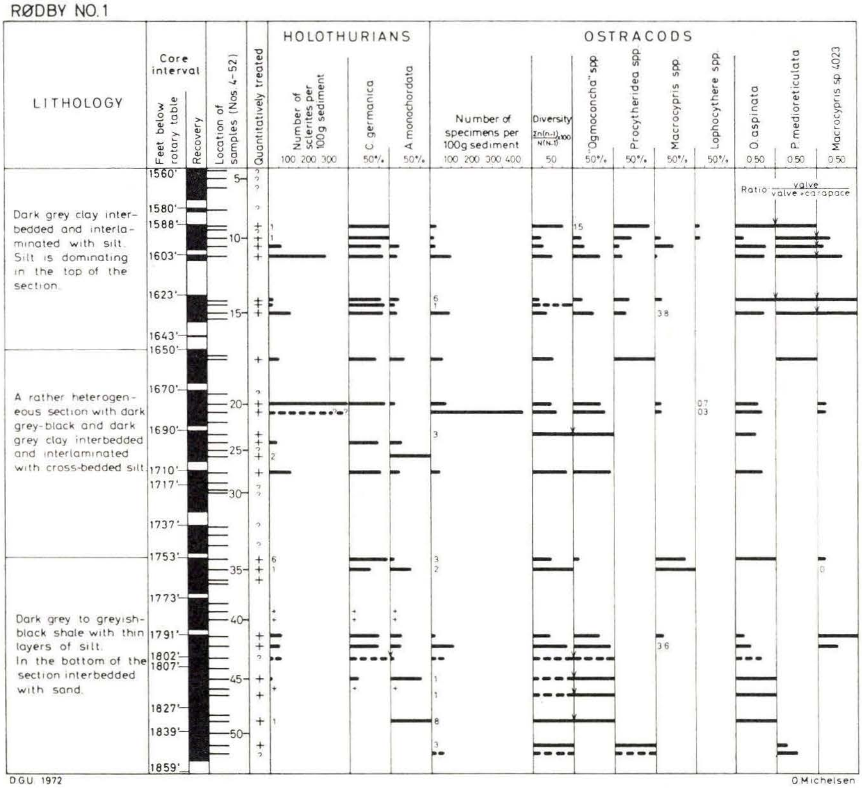
the stratigraphical and palaeoecological features of the *aspinata* Zone. The studies have been made on the core samples only.

Furthermore this paper describes the holothurian morphospecies, including species with scattered occurrence in other parts of the Liassic section.

The Ogmoconchella aspinata Assemblage Zone

Lithology

The lithology of the Lias Alpha sections are briefly described in Sorgenfrei & Buch 1964 and in Larsen 1966. In the main the Liassic sediments



Text-fig. 2.

are described as rather dark-coloured claystones or shales which have been deposited under marine conditions.

For the purpose of elucidating some of the environmental features a more detailed description of the lithology will be given here. This description is an extract of core descriptions worked out by geologists stationed at the well sites (see the list in Sorgenfrei & Buch 1964). These reports are kept at the Geological Survey of Denmark.

Gassum No. 1. The sediments in all of the cores mentioned in text-fig. 3 are very uniform. They are described as shale, dark grey, hard to medium hard, with knots and veins of pyrite, and with concretions of clay ironstone. The shale is often rich in macrofossils. The lowest part (5′) of the core 4702′-4722′ consists of sandstone, grey, hard, fine-grained, with a wavy surface of sedimentation, and without macrofossils. The shale of the cores 4850′-4870′ and 4900′-4920′ is locally interstratified by fine-grained and hard sandstone without macrofossils.

Horsens No. 1. The core 1449–1455 m (cf. text-fig. 4) is subdivided into two parts: the uppermost 5.12 m is a shale, dark grey at the top and blackish-grey below, calcareous, with mica and pyrite, and with macrofossils. The lowermost interval (5.12–6.80 m) is a dark greyish-brown and calcareous shale, with small amounts of mica and traces of fossils.

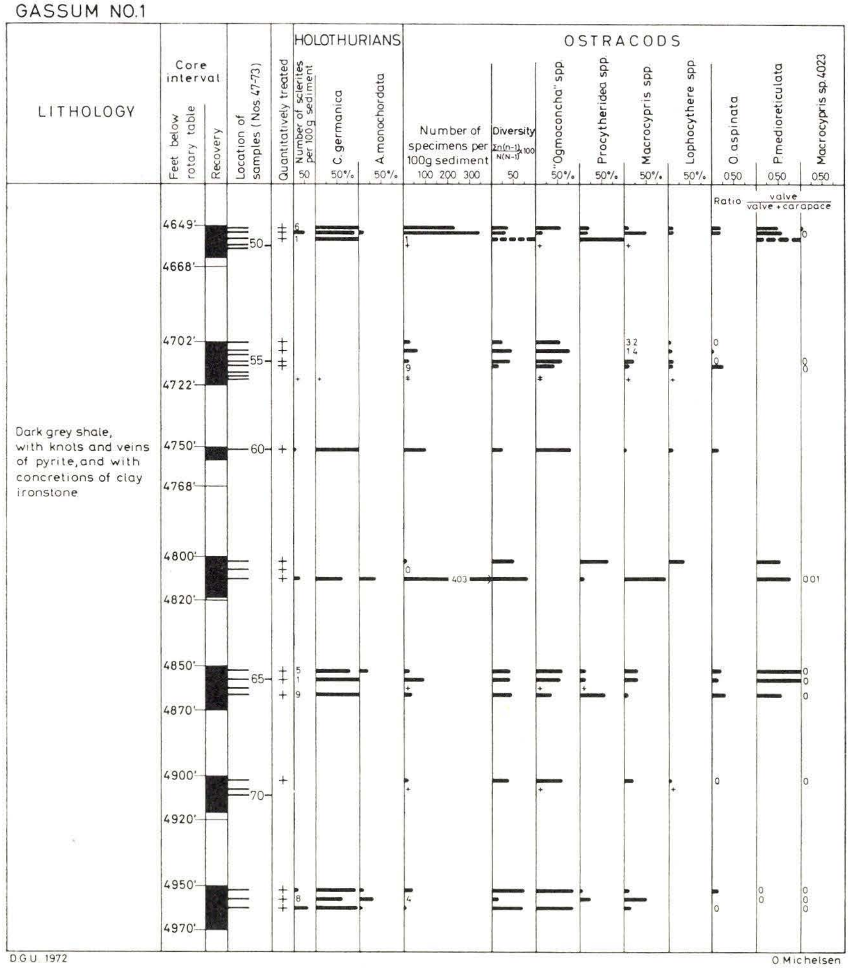
Rødby No. 1. The uppermost core, 1560′–1580′ (cf. text-fig. 2), consists of interbedded and interlaminated dark grey, non-calcareous clay and light-coloured silt, with plant remains and lignite, and with cross-bedding. The interval 1580′–1643′ consists of claystone, dark grey, slightly calcareous, interlaminated by silt, and with clay ironstone, with macrofossils in places. The lowermost layer of the core 1623′–1643′, the entire core 1643′–1650′, and the uppermost 15 cm of the core 1650′–1670′ is a greyish-brown and light greenish sandstone (sideritic ?). The cores from the interval 1650′–1753′ are described as interbedded and interlaminated clay, dark to greyish-black, slightly calcareous, and silt, light-coloured, non-calcareous, with cross-bedding. Macrofossils are found in the uppermost part, and in the lowermost one (1717′–1753′) there are plant remains and lignite. Below this rather heterogeneous section is a homogeneous interval (1753′–1839′) of shale, dark grey to greyish-black, non-calcareous, with horizontal bedding, and with a few thin layers of silt. Macrofossils are occasionally found. Near the top of this section a 22 cm thick bed with cross-bedded sandstone occurs. The lowermost core (1839′–1859′) in the Liassic section is described as interlaminated and interbedded clay, dark grey to greyish-black, non-calcareous, and silt, light-coloured to greenish-grey, non-calcareous, with brownish-black layers of organic material.

Vedsted No. 1. The core (cf. text-fig. 4) consists of shale, grey to dark grey, with pyrite and clay ironstone, and with macrofossils.

Vinding No. 1. The uppermost core, 4993′–5007′ (cf. text-fig. 4), is described as dark bluish-grey shale with pyrite. Macrofossils are locally abundant. The lowermost core, 5156′–5162′, consists of dark grey to black shale with a little pyrite, and locally with many macrofossils.

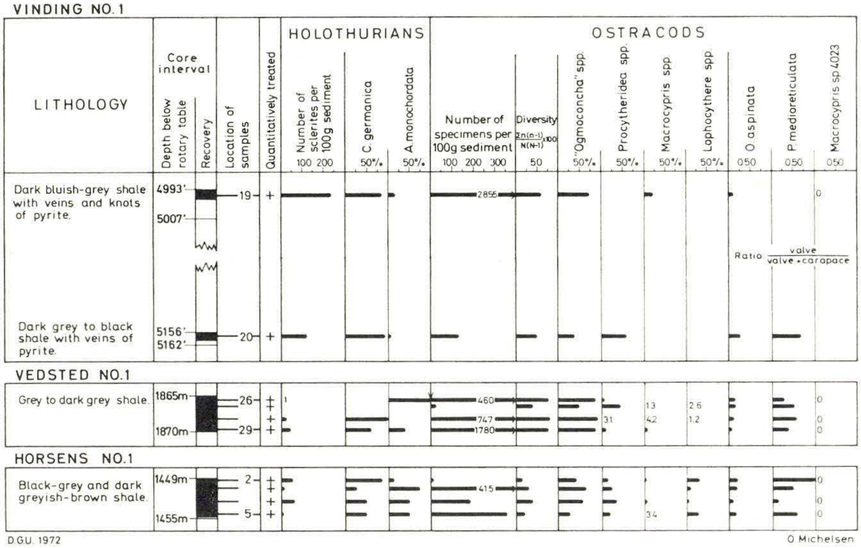
Summary. The sediments of the cores from Gassum No. 1, Horsens No. 1, Vedsted No. 1, and the lowermost core of Vinding No. 1 seem from the descriptions to be very uniform. They consist of a dark grey, fossiliferous shale, which may be of normal marine origin. The uppermost core of Vinding No. 1 differs in having a bluish-grey colour.

The section of Rødby No. 1 is heterogeneous and different from those of the other localities. It can be divided into three parts. The lowermost part (1753′–1859′) shows a uniform series of dark-coloured shales with marine fossils, including a transition from the silty Rhaetic section at the bottom. The middle part (1650′–1753′) of the Liassic section is dominated by inter-



Text-fig. 3.

bedded and interlaminated clay and silt, and shows cross-bedding as a characteristic feature. In contrast to the uniform sedimentation below, this seems to reflect an environment with deposition in quite conditions interrupted by delta-like sedimentations. At the boundary between the middle and the uppermost part layers of a rather hard (and sideritic ?) sandstone are found. Since the recovered cores are small at this level the boundary between the two parts is set at the top of the uppermost core showing the characteristic cross-bedding. The upper part (1560′–1650′) consists of claystone interlaminated by silt; it seems to form a rather uniform



Text-fig. 4.

marine series, which contains an increasing amount of silt and plant remains (but no microfossils) near the top.

Stratigraphical and palaeoecological features

Some quantitative data from the five borings mentioned above are given in the three diagrams (text-figs. 2–4). The lithology is briefly outlined according to the above description. The situation of the cores and the degree of recovery is marked. The location of the samples is also given. The samples from the four borings (Gassum, Rødby, Vedsted, and Vinding) studied in this paper are identical with those analysed by Larsen (1966). The quantitatively treated samples are marked with "+", while samples not regarded as absolutely quantitative are marked with "?".

The occurrence of holothurian sclerites is illustrated by three columns; one gives the number of sclerites per 100 g sediment, and the other two the composition of the assemblage in per cent. The size of the dried samples is usually between 100 and 200 g (the samples were washed on a sieve with 0.1 mm meshes).

The remaining parts of the diagrams include data of the ostracod fauna. The number of specimens per 100 g sediment is given. The diversity of the ostracod fauna is calculated by means of Simpson's formula

$$\frac{\Sigma n(n-1)}{N(N-1)} \times 100$$

This index of diversity describes the fauna very well (cf. Pokorný 1971), but in the case of a fauna with only one specimen this fraction cannot be used. As a fauna with two specimens (and one species) yields the index 100, it was decided to give a fauna with only one specimen the same index and to express it by a dotted line. Calculations on such small faunas may be regarded as purely supplementary to the rest of the calculations. The size of the faunas forming the basis of the calculations can be read in the diagrams.

The composition of the ostracod fauna is expressed by the relative occurrence of the four genera *Ogmoconcha (Ogmoconchella) Procytheridea, Macrocypris*, and *Lophocythere*. The genera *Polycope, ? Paradoxostoma, Cyrtheropteron,* and *? Stenestroemia* make up small parts of the fauna, but are of no importance in this connection.

From the data of the three species *O. aspinata, P. medioreticulata,* and *Macrocypris sp. 4023* the "ratio valve/carapace" is calculated by means of the fraction

$$\frac{\text{valve}}{\text{valve} + \text{carapace}}$$

as this fraction gives values which are easy to figure in a diagram (values from 0.00 to 1.00) and which are evenly dispersed. The number of valves are counted as the number of individuals and not as the entire number of valves; that is to say the fraction gives the relation between the individuals disassociated as valves and the entire number of individuals.

Oertli (1971) regards the ratio valve/carapace as an expression for the rate of sedimentation. His opinion is based on the difference in time between the death of the animal and the opening of the carapace and on the time of burying the dead animal by the sedimentation. Usually the ratio is regarded as an expression of the degree of displacement (cf. Kileney 1971). In the opinion of the present author the latter is the most likely explanation of the differences observed in the material studied here, as the ratio is rather high in Rødby (text-fig. 2) compared with Gassum (text-fig. 3); moreover the thickness of these two sections is nearly the same and the space of time represented by the two sections is supposed to be equal.

Sediments. The grain size and the mineral content of the sediments are not dealt with in this paper, but may be found in the analysis of Larsen (1966).

Holothurians. The holothurian sclerites are described separately. The sclerites from the *Ogmoconchella aspinata* Zone are regarded as belonging to the two morphospecies *C. germanica* and *A. monochordata*. When the samples contain a rather large number of sclerites (more than 20 per 100 g sediment) *C. germanica* make up about 75 % of the assemblage, and *A. monochordata* about 25 %. The relative occurrence within the *aspinata* Zone of the two morphospecies seems not to be of any value for the stratigraphical and the ecological interpretation.

Ostracods. The ostracod fauna is rather homogeneous in the sections which belong to the *aspinata* Assemblage Zone. The most important species are shown in plate 4. The genus *Ogmoconchella* occurs in the entire zone with *O. aspinata* Drexler 1958 as the most prominent species. In parts of the sections from Gassum No. 1, Horsens No. 1, and Vinding No. 1 *Ogmoconcha hagenowi* Drexler 1958 is an associated species. Furthermore a few fragmentary and undeterminable specimens occur scattered. The genus *Procytheridea* is represented by *P. medioreticulata* Michelsen 1970, but in a few samples of Rødby No. 1 the genus includes *P. sp. 4081* Michelsen 1970. The group *Macrocypris spp.* is an indeterminate one, which mainly includes the species *Macrocypris sp. 4023* Michelsen 1970. The genus *Lophocythere* comprises *L. elegans* Drexler 1958, *L. sp. 4037*, *L. sp. 4061* Michelsen 1970, and *L. sp. 4076* Michelsen 1970. As mentioned above, the ostracod fauna also includes a few rather rare species, which are not included in the diagrams.

Stratigraphy. On the basis of the ostracod fauna the *O. aspinata* Zone is correlated with Lias Alpha, Hettangian and ? Lower Sinemurian = Sinemurian *s. str.* (Michelsen 1970, p. 17). Hans Frebold analysed the macrofossils from Gassum No. 1. In the cores 4800′–4820′ and 4850′–4870′ he found *Schlotheimia angulata* and in the core 4649′–4668′ *Oxytoma inaequivalvis,* which supports the assumption that this zone should be correlated with Hettangian and Lower Sinemurian (see Nørvang 1957 and Sorgenfrei & Buch 1964). The sections of both Gassum No. 1 and Rødby No. 1 are underlain by Rhaetic deposits (cf. Sorgenfrei & Buch 1964 and Bertelsen & Michelsen 1970). In Rødby the section is overlain by Lower Cretaceous deposits. In Gassum No. 1 the ostracod fauna from the core immediately above the section studied contains very few species (and specimens), and of these *Procytheridea betzi* Klingler & Neuweiler 1959 is the most important one. From these data it seems likely that the sections comprised by the text-figs. 2–3 correlate with the German Lias Alpha. Whether they correspond to the whole Lias Alpha or only to certain parts (Alpha-1, 2, and a part of 3) is questionable.

The Rødby No. 1 boring. Based on the holothurian assemblage and the ostracod fauna the section may be divided into three parts. The uppermost (1560′–1650′) is characterized by quite a lot of holothurian sclerites and ostracods. The diversity index is low, and the "ratio valve/carapace" of the three ostracod species is remarkably high compared with the section below. In the section 1650′–1753′, the fossil content is very variable. Only five samples contain holothurians and ostracods, and two of these show very high values per 100 g sediment. The diversity index is, on average, higher than in the section above, while the "ratio valve/carapace" is lower. The lowermost section (1753′–1859′) is rather fossiliferous. The content of holothurians and ostracods is low, but nearly all the samples are fossiliferous. The diversity index is high, mostly 100, and also the "ratio valve/carapace" is high.

The interval 1560′–1588′ is divergent from the remainder in being without holothurians and ostracods. Megaspores occur frequently in this interval (cf. Bertelsen 1970). The megaspore content is also pronounced in the middle section (1650′–1753′) and the lowermost core 1839′–1859′. This core (1839′–1859′) is also divergent in its fauna, since holothurians are absent and ostracods are represented only by larvae of *P. medioreticulata*.

Lithologically the intervals 1560′–1588′ and 1839′–1859′ are characterized by the high content of arenaceous sediments. With the exception of these two small intervals, which are situated at the top and the bottom of the Liassic section, a subdivision into three parts can be made based on the lithology (see p. 52).

On his diagram of Rødby No. 1 Larsen (1966, pl. XV) shows the mineral content, among other things the composition of the light fraction. The curves in his diagram demonstrate a tripartition of the Liassic section in a way convergent with the subdivision outlined above. Of these three parts the middle one is the most interesting one because of its marked divergence from the analysis of the Gassum section. In the middle part (the one characterized by cross-bedded layers) the content of quartz and feldspar is high. The microfauna of these beds is very poor, while the content of plant remains (and megaspores) is pronounced, especially in the lowermost part. More fine-grained sediments with a high content of mica and plant remains, and very rich holothurian and ostracod faunas interbed these deltaic deposits. The fine-grained sediments are of marine origin and seem to have been deposited under quite conditions. This conclusion is supported by the relatively low "ratio valve/carapace" and by even apportionment between the eight instars of the ostracod species *O. aspinata* (cf. Michelsen 1970, text-fig. 6).

The Liassic section in the Rødby No. 1 boring is at the bottom a rather arenaceous deposit with a poor and impoverished ostracod fauna, but rich in megaspores (cf. Bertelsen 1970). Upwards the deposit develops into a more argillaceous and marine one with both holothurian sclerites and ostracods. This section (1753′–1859′) shows features of an environment with some influence of currents (cf. text-fig. 2: the high "ratio valve/carapace", and Michelsen 1970, text-fig. 9: the absence of the smallest larval stages in *O. aspinata*). Above this the deltaic deposits are found (1650'–1753') with coarse-grained, cross-bedded sediments interbedded with fine-grained marine sediments laid down under quiet conditions (see above). The abnormally large amount of fossils in these beds is probably due to a rich food supply. The deltaic deposits are followed by normal marine sediments with a representative holothurian and ostracod fauna (1588'–1650'). At the top (1560'–1588') of the section, finally, the grain size increases and neither holothurians nor ostracods are found. According to Bertelsen (1970) the frequency of megaspores increases pronouncedly upwards in this part of the Liassic section, which probably reflects an increasing terrestrial influence. Finally a 1 m thick bed above the section studied should be mentioned. This bed consists of red-yellow-green variegated, clayey, fine sand, which (according to Larsen 1966) is considered to be a weathered horizon, presumably of post-Liassic origin.

The Gassum No. 1 boring. In this boring, which is situated centrally in the basin, the lithology is rather uniform (see p. 51). Both the holothurian and the ostracod fauna are, with few exceptions, constant throughout the entire section. The faunas never become as rich in specimens as in parts of the Rødby section. The diversity index of the ostracod fauna is low, as found in the top of the Rødby section; it exceeds a value of 50 in only a few samples. The "ratio valve/carapace" of the species *O. aspinata* and *Macrocypris sp. 4023* is very low, while the ratio for *P. medioreticulata* is often high (see p. 60).

The diagram demonstrating the mineral content shows a similar uniformity (cf. Larsen 1966, pl. XII). In the light fraction the component "other aggregates" is absolutely dominating, and only in a few samples quartz, feldspar, mica, and plant remains make up a noticeable, but still small part of the fraction.

The present author supposes that nearly the entire section of Gassum (in contrast to that of Rødby) was laid down in a marine environment without remarkable influence of currents. This supposition is in accordance with the central position of the boring in the basin.

The Horsens No. 1 boring. From this boring only one core is available. The lithology of this core is similar to that of Gassum No. 1. The content of holothurians is also as found in Gassum, while the number of ostracods per 100 g sediment is high. The diversity index is low and shows similarity to that of the upper part of the Rødby section.

In all other aspects, such as "ratio valve/carapace" and mineral content, the core of Horsens No. 1 is similar to the section of Gassum No. 1.

The Vedsted No. 1 boring. This boring is situated in the northern part of the basin, but the core analysed shows nearly the same features as Horsens and Gassum.

The Vinding No. 1 boring. This boring like Horsens No. 1, is situated at the southwestern border of the basin. The number of holothurian sclerites and of ostracods per 100 g sediment is high, especially in the uppermost core. The ostracod fauna is poor in species (only two), but it must be noted that control samples show a lower diversity index in the uppermost core.

Larsen (1966, pl. XI) shows a large amount of quartz, feldspar, and plant remains in proportion to the component "other aggregates" in the composition of the light fraction.

The deposits in Vinding (as these are represented in the two cores) diverge from those of Gassum and Horsens, but seem to correspond better with parts of the Rødby section.

Final remarks

The analysis of the core samples shows certain features concerning the extent and the thickness of the *O. aspinata* Assemblage Zone as known from borings in the Danish Embayment.

In Gassum No. 1 and Rødby No. 1, which are the only two sections very well represented by cores, the thickness is nearly the same. The Rødby section is thinner, but this is perhaps due to the fact that the zone with *Lophocythere* (especially *L. elegans*) at the top of the section is thinner in Rødby. A thin zone with *Stenestroemia ? roedbyensis* Michelsen 1970 is situated at the same distance above the base of the sections of the two borings.

Two different types of environments may be demonstrated by the analysis outlined above. The Gassum No. 1, Vedsted No. 1, and Horsens No. 1 borings show lithological and biological features of a marine environment without a direct influence from the land and the coastal zone. Opposite to this mid-basin area the Rødby section shows as a whole a more near-shore situation. In the middle part of this section the deposits are characterized by interbedding of deltaic and marine deposits.

The occurrence of holothurian sclerites does not seem to be dependent on purely marine conditions alone (cf. the relation between Rødby and Gassum), but also on the type of the substratum and a rich food supply. The largest quantity of holothurian sclerites is found in fine-grained sediments interbedded by coarse-grained delaic deposits. The maximum quantity of holothurian sclerites seems to coincide with the occurrence of the genus *Macrocypris,* of which recent forms are marine bottom-dwellers. It is also remarkable that the ostracod genus *Lophocythere* is absent or only rare in samples rich in holothurian sclerites.

The calculations of the "ratio valve/carapace" show that the tendency to occur either as valves or as carapaces is species dependent (see also Kilenyi 1971, p. 33). *P. medioreticulata* is usually found as valves, while *Macrocypris sp. 4023* only occurs as valves under special conditions (as in the Rødby section).

The Liassic holothurians

Three morphospecies are described or commented below: *Achistrum monochordata, Binoculites irregularis,* and *Calclamna germanica.* The last-named is restricted to beds referable to Lias Alpha only, while *A. monochordata* is recorded from the whole Liassic section in the Danish Embayment. *B. irregularis* occurs in beds referable to Lias Beta, Gamma, and Delta. In the Lias Alpha sections the sclerites are numerous, while they are sparsely scattered in the other parts of the Liassic section.

An aggregate of holothurian sclerites including *A. monochordata* and *?Binoculites terquemi* Deflandre-Rigaud 1952 is found in sample No. 1167 of the Øresund No. 10 boring. The last-named species is not described here because of the doubtful identification. The sample with *B. terquemi* may on the basis of the ostracod and foraminiferal faunas be referred to Lias Beta (cf. Larsen *et al.* 1968).

Achistrum monochordata Hodson, Harris & Lawson 1956

Plate 2, figs. 1 and 9; plate 3, fig. 7.

1956. *Achistrum monochordata* Hodson, Harris & Lawson p. 340, text-figs. 10–11.
1961. *Achistrum (Cancellrum) monochordata* Hodson, Harris & Lawson – Rioult, p. 139, pl. I.

Material. More than 500 sclerites from core samples of the Gassum No. 1, Horsens No. 1, Rødby No. 1, Vedsted No. 1, Vinding No. 1, and Øresund Nos. 3, 9, 10, and 14 borings.

Occurrence. This species is common in beds referable to Lias Alpha (cf. text-figs. 2–4), but rare in Lias Beta ? (Øresund Nos. 9, 10, 14), in Lias

Gamma (Gassum No. 1), and in Lias Delta (Gassum No. 1 and Øresund No. 3). – The stratigraphical subdivision is based on macrofossils (cf. Sorgenfrei & Buch 1964) and ostracods.

Stratigraphical range. This species is known from Oxfordian, England (Hodson, Harris & Lawson 1956). In France it is found in Sinemurian *s. l.* and Pliensbachian (Rioult 1961).

Binoculites irregularis Frizzell & Exline 1955

Plate 2, figs. 2–3.

1908. *Uncinulina polymorpha* Terquem – Issler, p. 95–96. pl. VII, fig. 348.
1955. *Binoculites irregularis* Frizzell & Exline, p. 67, pl. 1, 17 (non fig. 16).
1961. *Binoculites irregularis* Frizzell & Exline – Rioult, p. 130, pl. I.

Material. 3 specimens from core samples of the Gassum No. 1 and Øresund No. 14 borings.

Occurrence. This species is found in Gassum No. 1 in beds which on the basis of the microfossils and macrofossils must be referred to Lias Delta and Lias Gamma. The bed in Øresund No. 14 may possibly be correlated with the upper part of Lias Beta.

Remarks. This morphospecies agrees in some features with certain variants of *C. germanica* (cf. pl. 3, fig. 5). It differs from the latter in having more drop-shaped apertures and especially in having an elongated, oval cross-section of the "plate" between the apertures. *C. germanica* has a nearly circular cross-section.

Stratigraphical range. In southern Germany this species is found in Lias Gamma (Issler 1908, p. 96). In France it occurs in Pliensbachian (Rioult 1961).

Calclamna germanica Frizzell & Exline 1955

Pl. 1; figs. 1–18; pl. 2, figs. 4–8; pl. 3, figs. 1–6.

1908. *Uncinulina polymorpha* Terquem – Issler, p. 95–96, pl. VII, figs. 356–360 (and 350–355?).
1936. Anker-Platten Bartenstein, p. 2, figs. 2 and 7.
1937. Holothurien-Ankerplatten Bartenstein & Brand, p. 122–123, pl. 1b, figs. 19–21; pl. 2a, fig. 24.

1937. Spicules of Holothurian Mortensen, p. 23, pl. III, figs. 16–19.
1955. *Calclamna germanica* Frizzell & Exline, p. 76, pl. 2, figs. 1–5.
1955. *Calclamnoidea irregularis* Frizzell & Exline, p. 82, pl. 2, fig. 18.
1961. *Calclamna germanica* Frizzell & Exline *f. alpha* Rioult, p. 132, pl. I.
1961. *Calclamna germanica* Frizzell & Exline *f. beta* Rioult, p. 132, pl. I.

Material. More than 1700 sclerites from core samples of the Gassum No. 1, Horsens No. 1, Rødby No. 1, Vedsted No. 1, and Vinding No. 1 borings.

Occurrence. This species is numerous in beds referable to Lias Alpha (*O. aspinata* Zone Michelsen 1970); one sclerite in Lias Beta.

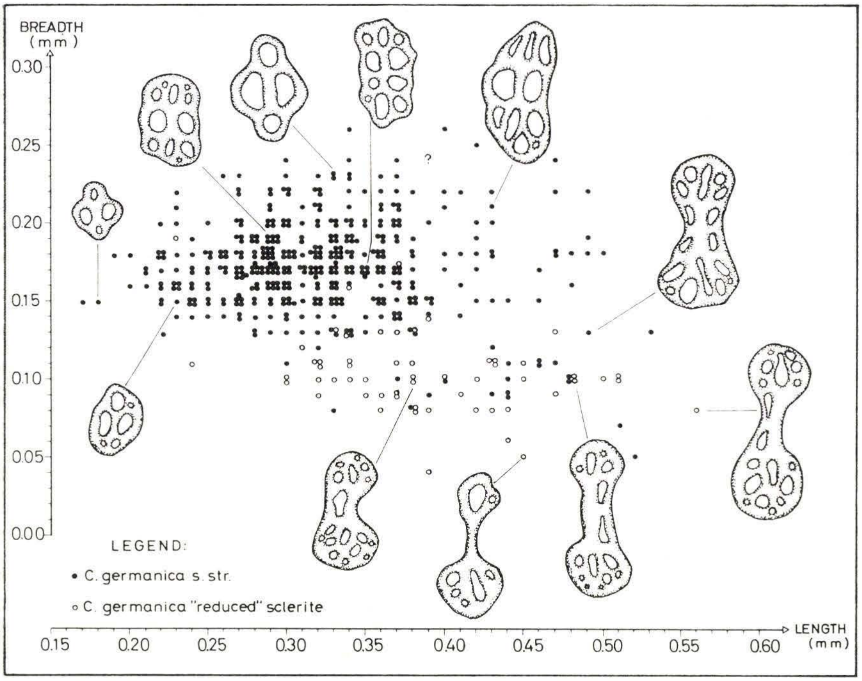
Supplementary description. By studying the sclerites in a scanning electron microscope a groove on the edge surrounding the apertures has been observed (pl. III, fig. 2). On the external edge a narrow groove also seems to occur. This latter one is most clearly visible on corroded specimens.

Measurements and statistics. The sclerites from sample No. 20 of Rødby No. 1 (cf. text-fig. 5) and sample No. 20 of Vinding No. 1 are measured. The statistical calculations are given below.

	x	s	O.R.
Rødby No. 1, sample No. 20 (N=477)			
Length	0.331	0.067	0.167–0.555 mm
Breadth	0.163	0.048	0.040–0.260 mm
Vinding No. 1, sample No. 20 (N= 67)			
Length	0.327	0.070	0.165–0.501 mm
Breadth	0.181	0.054	0.038–0.304 mm

The length is a well-defined measurement, while the breadth is questionable. Here the sclerite has been regarded as a geometrical body of which a fixed point and a fixed direction of measurement have to be chosen. For this reason the breadth is measured across the centre of the sclerite and at right angles to the length. The skewness of the scattergram (text-fig. 5) is due to this method of measuring. If the breadth of the sclerites, marked with open circles on text-fig. 5, had been measured as the largest breadth the points would have been situated higher in the scattergram. These sclerites (marked with open circles) are the ones with a "reduction" in the middle part (see below).

Remarks. The present material is not evenly distributed among the samples, e.g. one of the samples of Rødby No. 1 contains more than 600 sclerites.



Text-fig. 5. Scattergram showing relations between numbers, lengths, and breadths for *Calclamna germanica* Frizzell & Exline 1955.

This concentration of sclerites in a few samples makes possible an evaluation of the morphological variation.

Plate 1 shows the main features of the pattern of this holothurian morphospecies. The simplest model of it is figured in figs. 7, 9, and 10 with four apertures in the plate. This model may be seen in all other sclerites. Rarely sclerites with only three apertures have been observed. The sclerite of fig. 8 has four additional apertures in the corners between the primary ones; this is the classical type figured in several papers. Figs. 2, 3, and 4 show more complicated types, and fig. 1 shows some degree of "reduction" in the middle. A more irregular "reduction" is common, especially in the larger sclerites (cf. figs. 5, 11, 13, 14, and 18). "Specialized" forms such as figs. 12, 15, 16 and 17 are more rare.

The present assemblages all show variations between the types figured on plate 1. These variations are arranged around types like figs. 10, 8, and 2, of which the latter two are most common. A subdivision into more than one group cannot be done on the present material.

Discussion. The assemblage, which is very well represented in the samples No. 20 and 21 of Rødby No. 1, shows a rich variation of *C. germanica* including both of the forms mentioned by Rioult (1961): *beta* and *alpha.* In the present material *C. germanica f. beta* Rioult is relatively more common in the uppermost part of the sections, which must be referred to Lias Alpha. On the basis of the present material, *Calclamnoidea irregularis* Frizzell & Exline 1955 must be included in *C. germanica* (see also Rioult 1961, p. 133).

The assemblages of the Danish Embayment also contain forms with an appearance like *Calclamnella jurassica* Frizzell & Exline 1955 (cf. pl. 2, figs. 7 and 8) and *Binoculites issleri* Deflandre-Rigaud 1952 (cf. pl. 3, fig. 5). In this material it seems impossible to make a subdivision into more morphospecies. The statistical treatment also shows a rather homogeneous dsitribution of the sclerite types. As mentioned above, the skewness of the scattergram is due to the way of measuring. If the "breadth" had been presented as the "largest breadth" the points would have been more evenly distributed, but the intention has been to describe the species by fixed measurements.

By analysing recent holothurians Hampton (1959, p. 340) shows that one individual may contain different sclerite types, of which each single one presents a variation similar to that shown by the present material (Hampton 1959, pl. 1–4). By means of statistical analysis he collects the different types into one morphospecies; he treats fossil material in the same way (Hampton 1960). The present author supposes that the different types in the material likewise belong to one species: *C. germanica.*

Until further studies of the morphological and biometrical features have been made it must be reasonable to refer all the species mentioned above to one morphospecies.

Stratigraphical range. In southern Germany (Issler 1908) and in northern Germany (Bartenstein & Brand 1937) this species is found in Lias Alpha. In France it occurs in Hettangian, Lower Sinemurian = Sinemurian *s. str.*, and Pliensbachian (Rioult 1961).

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Dansk sammendrag

Holothurie scleriter er almindeligt forekommende i det Danske Sænkningsområde i den del af lias afsnittet, der omfattes af ostracodzonen *Ogmoconchella aspinata* (cf. Michelsen 1970). Spredt i den øvrige del af lias afsnittet er der kun fundet enkelte scleriter. I nærværende arbejde er de fire fundne morfospecies kommenteret og beskrevet: *Achistrum monochordata* Hodson, Harris & Lawson 1956, *Binoculites irregularis* Frizzell & Exline 1955, ?*B. terquemi* Deflandre-Rigaud 1952 og *Calclamna germanica* Frizzell & Exline 1955.

Holothurie og ostracod faunaerne i *O. aspinata* zonen er behandlet kvantitativt (se fig. 2–4). Sammenstillet med den makroskopiske beskrivelse af sedimenterne og analyserne af mineralindholdet (cf. Larsen 1966) danner studierne over faunaerne grundlag for en beskrivelse af de palæoøkologiske træk i denne del af den liassiske lagserie. *O. aspinata* zonen er fundet i fem boringer: Gassum nr. 1, Horsens nr. 1, Rødby nr. 1, Vedsted nr. 1 og Vinding nr. 1. Lagserien i Gassum og Rødby er repræsenteret ved tætliggende kærner, medens der i de tre andre boringer kun findes få kærner.

O. aspinata zonen kan på grundlag af ostracod faunaen korreleres med lias alpha (? nedre sinemurien = sinemurien *s. str.* og hettangien). Hans Frebold har analyseret makrofossilerne i bl. a. Gassum nr. 1 og har fundet en tilsvarende sikker korrelation med hettangien og en mulig korrelation med sinemurien *s. str.* (cf. Nørvang 1957 og Sorgenfrei & Buch 1964).

På basis af de faunistiske og de lithologiske data, der er fremstillet skematisk i fig. 2–4, og analyserne af sedimenterne hos Larsen (1966) kan der mellem de fem lokaliteter drages en skillelinie mellem det bassincentrale, marine miljø og det mere marginalt betonede. Gassum nr. 1, Horsens nr. 1 og Vedsted nr. 1 er placeret centralt i bassinet og indeholder en marin lagserie med finkornede og ensartede sedimenter (skifer). Det forholdsvis rolige aflejringsmiljø understreges af de meget lave tal for »valve/carapace« (se fig. 3–4). Lagserien i Rødby nr. 1 kan opdeles i tre hovedafsnit. Både det øvre og det nedre afsnit har lighed med lagserien i Gassum, men er i nogen grad præget af strømmende vand (kvarts- og feldspatindholdet er ret højt og »valve/carapace« forholdet er stort). Det midterste afsnit er præget af grovkornede, deltaiske sedimenter (med krydslejring) mellemlejret af finkornede, marine aflejringer (med et betydeligt indhold af glimmer og planterester, samt talrige fossiler). Ostracodernes forekomstmåde i disse finkornede sedimenter (d. v. s. med en ensartet fordeling på larvestadier, samt et lille »valve/carapace« forhold) tyder på et roligt miljø. Aflejringerne i Vinding nr. 1 indeholder træk, der i nogen grad minder om dele af lagserien i Rødby og ligeledes tyder på en marginal placering i bassinet.

References

Bartenstein, H., 1936. Kalk-Körper von Holothurien in norddeutschen Lias-Schichten. – Senckenbergiana, Bd. 18, 1/2, pp. 1–10. – Frankfurt a. M.

Bartenstein, H. & Brand, E., 1937. Mikro-paläontologische Untersuchungen zur Stratigraphie des nordwest-deutschen Lias und Doggers. – Abh. senckenberg. naturf. Ges., 439, pp. 1–224. – Frankfurt a. M.

Bertelsen, F., 1970. See Bertelsen & Michelsen 1970.

Bertelsen, F. & Michelsen, O., 1970. Megaspores and Ostracods from the Rhaeto-Liassic Section in the Boring Rødby No. 1, Southern Denmark. – Danm. geol. Unders., II. Række, nr. 94, 60 p. – København.

Deflandre-Rigaud, M., 1952. Contribution à la systématique des sclérites d'Holothurides fossiles. – Bull. Inst. océanogr. Monaco, No. 1012, 12 p. – Monaco.

Drexler, E., 1958. Foraminiferen und Ostracoden aus dem Lias α von Siebeldingen/Pfalz. – Geol. Jb., Bd. 75, pp. 475–554. – Hannover.

Frizzell, D. L. & Exline, H., 1955. Monograph of Fossil Holothurian Sclerites. – Bull Univ. Missouri Sch. min. metall., Technic. Ser., No. 89, 204 p. – Rolla.

Hampton, J. S., 1959. Statistical analysis of holothurian sclerites. – Micropaleontology, vol. 5, No. 3, pp. 335–349. – New York.

Hampton, J. S., 1960. A statistical analysis of *Rhabdotites dorsetensis* Hodson, Harris and Lawson, 1956. – Micropaleontology, vol. 6, No. 3, pp. 307–314. – New York.

Hodson, F., Harris, B. & Lawson, L., 1956. Holothurian Spicules from the Oxford Clay of Redcliff, near Weymouth (Dorset). – Geol. Mag., vol. XCIII, No. 4, pp. 336–344. – London.

Issler, A., 1908. Beiträge zur Stratigraphie und Mikrofauna des Lias in Schwaben. – Palaeotographica, Bd. LV, pp. 1–104. – Stuttgart.

Kilenyi, T. I., 1971. Some basic questions in the palaeoecology of ostracods. – Bull. Centre Rech. Pau-SNPA, vol. 5 suppl., pp. 31–44. – Pau.

Klingler, W. & Neuweiler, F., 1959. Leitende Ostracoden aus dem deutschen Lias β. – Geol. Jb., Bd. 76, pp. 373–410. – Hannover.

Larsen, G., 1966. Rhaetic-Jurassic-Lower Cretaceous Sediments in the Danish Embayment. (A Heavy-Mineral Study). – Danm. geol. Unders., II. Række, nr. 91. – København.

Larsen, G., Christensen, O. Bruun, Bang, I. & Buch, A., 1968. Øresund. Helsingør-Hälsingborg Linien. – Danm. geol. Unders., rapp. nr. 1. – København.

Michelsen, O., 1970. See Bertelsen & Michelsen 1970.

Mortensen, Th., 1937. Some Echinoderm remains from the Jurassic of Württemberg. – K. dansk. Vidensk. Selsk., biol. meddr., bd. XIII, 10, pp. 1–28. – København.

Nørvang, A., 1957. The Foraminifera of the Lias Series in Jutland, Denmark. – Meddr. dansk geol. Foren., bd. 13, 5, pp. 275–414. – København.

Oertli, H. J., 1971. The aspect of ostracode faunas – A possible new tool in petroleum sedimentology. – Bull. Centre Rech. Pau-SNPA, vol. 5 suppl., pp. 137–151. – Pau.

Pokorný, Vl., 1971. The diversity of fossil ostracode communities as an indicator of palaeogeographic conditions. – Bull. Centre Rech. Pau-SNPA, vol. 5 suppl., pp. 45–61. – Pau.

Rioult, M., 1961. Les »sclérites d'Holothuries fossiles du Lias«. – Mém. Bur. Rech. géol. minièr., No. 4, pp. 121–153. – Strasbourg.

Sorgenfrei, Th. & Buch, A., 1964. Deep Tests in Denmark 1935–1959. – Danm. geol. Unders., III. Række, nr. 36, 60 p. – København.

Plate 1

× 60

D.G.U.
Catalogue No.

Figs. 1–18. *Calclamna germanica* Frizzell & Exline 1955

Loc. Rødby No. 1, sample No. 21.

Fig. 1.	1971–OM–15
Fig. 2.	1971–OM–12
Fig. 3.	1971–OM–10
Fig. 4.	1971–OM–8
Fig. 5.	1971–OM–18
Fig. 6.	1971–OM–2
Fig. 7.	1971–OM–6
Fig. 8.	1971–OM–5
Fig. 9.	1971–OM–4
Fig. 10.	1971–OM–9
Fig. 11.	1971–OM–11
Fig. 12.	1971–OM–3
Fig. 13.	1971–OM–7
Fig. 14.	1971–OM–16
Fig. 15.	1971–OM–19
Fig. 16.	1971–OM–17
Fig. 17.	1971–OM–14
Fig. 18.	1971–OM–13

Phot. O. Neergaard Rasmussen

Note to pl. 1–4: The figured specimens are stored in the collections of the Geological Survey of Denmark.

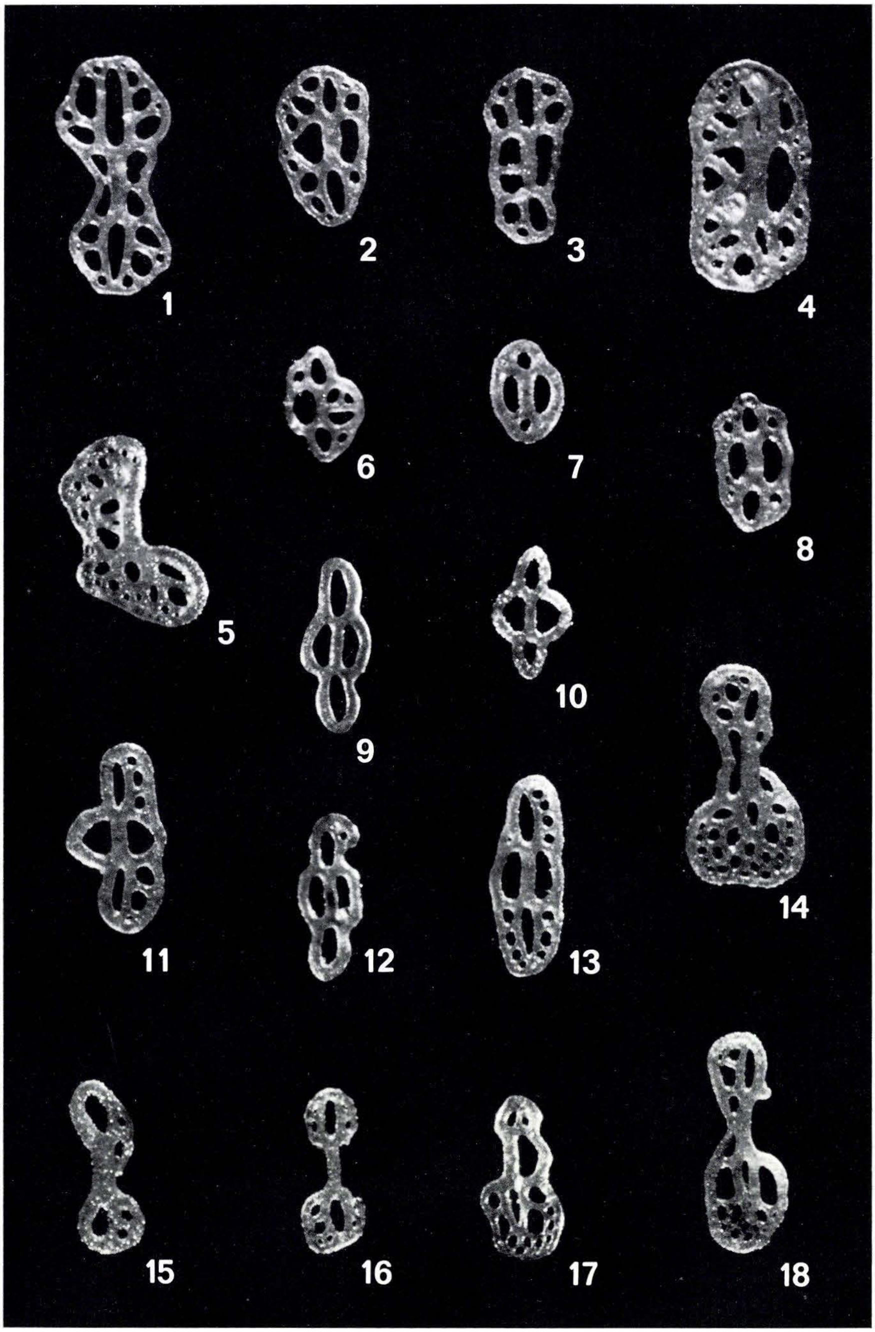
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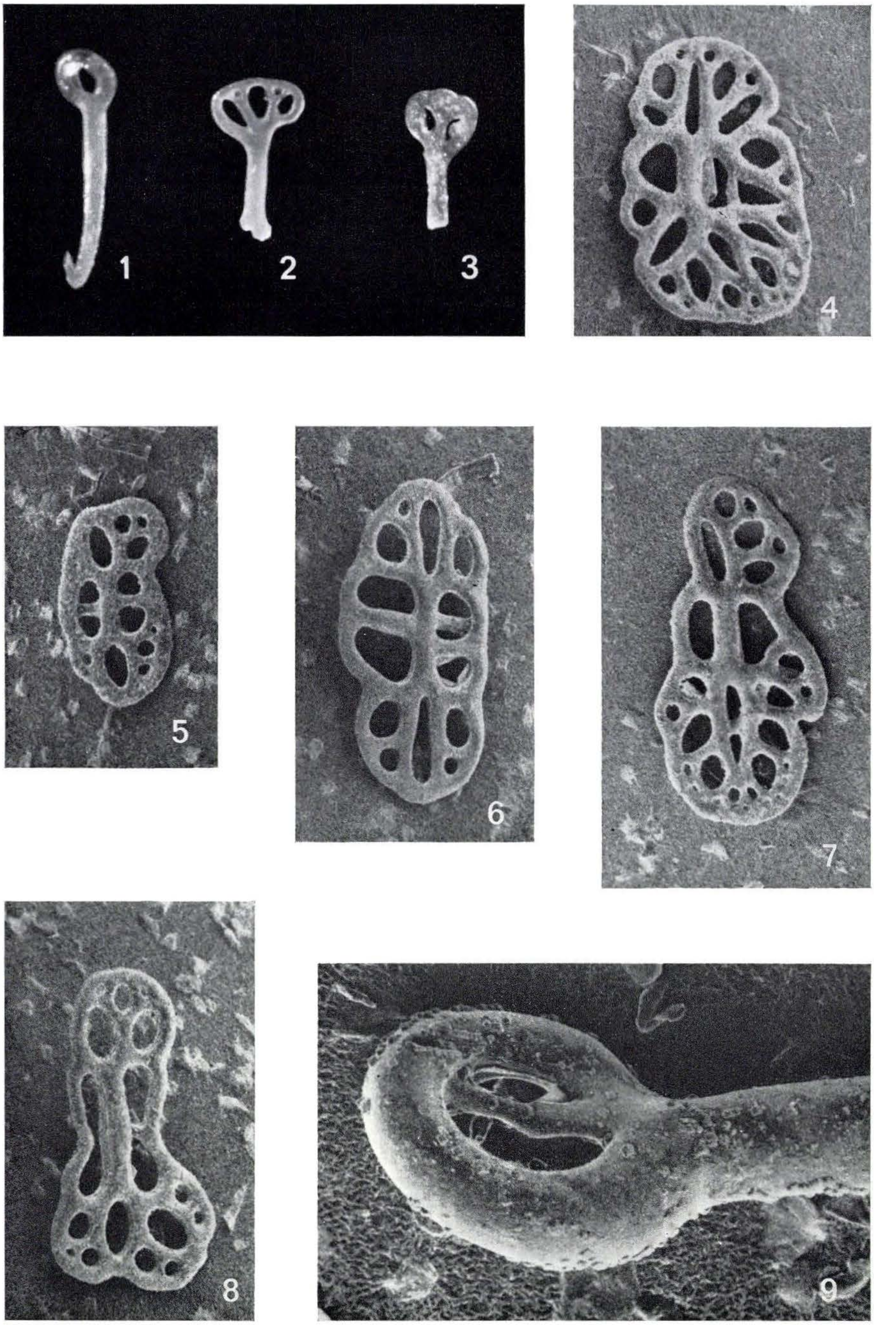
Fig. 1. *Achistrum monochordata* Hodson, Harris & Lawson 1956	
Loc. Rødby No. 1, sample No. 21. × 60.	1971–OM–20
Figs. 2–3. *Binoculites irregularis* Frizzell & Exline 1955	
Fig. 2. Loc. Gassum No. 1, sample No. 32. × 60.	1971–OM–21
Fig. 3. Loc. Gassum No. 1, sample No. 10. × 60.	1971–OM–22
Figs. 4–8. *Calclamna germanica* Frizzell & Exline 1955	
Loc. Rødby No. 1, sample No. 21. × 100.	
Fig. 4.	1971–OM–24
Fig. 5.	1971–OM–25
Fig. 6.	1971–OM–26
Fig. 7.	1971–OM–27
Fig. 8.	1971–OM–28
Fig. 9. *Achistrum monochordata* Hodson, Harris & Lawson 1956	
Loc. Rødby No. 1, sample No. 21. × 300	1971–OM–29

Phot. O. Neergaard Rasmussen (figs. 1–3).

Figs. 4–9: Scanning electron micrographs.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	D.G.U. Catalogue No.
Figs. 1–6. *Calclamna germanica* Frizzell & Exline 1955	
Fig. 1. Loc. Gassum No. 1, sample No. 48. × 100	1971–OM–30
Fig. 2. Same specimen as fig. 1. × 1000......................	1971–OM–30
Fig. 3. Loc. Rødby No. 1, sample No. 21. × 100	1971–OM–31
Fig. 4. Loc. Rødby No. 1, sample No. 21. × 100	1971–OM–32
Fig. 5. Loc. Rødby No. 1, sample No. 21. × 100	1971–OM–33
Fig. 6. Loc. Rødby No. 1, sample No. 21. × 100	1971–OM–35
Fig. 7. *Achistrum monochordata* Hodson, Harris & Lawson 1956	
Loc. Rødby No. 1, sample No. 21. × 100	1971–OM–34

Figs. 1–7: Scanning electron micrographs.

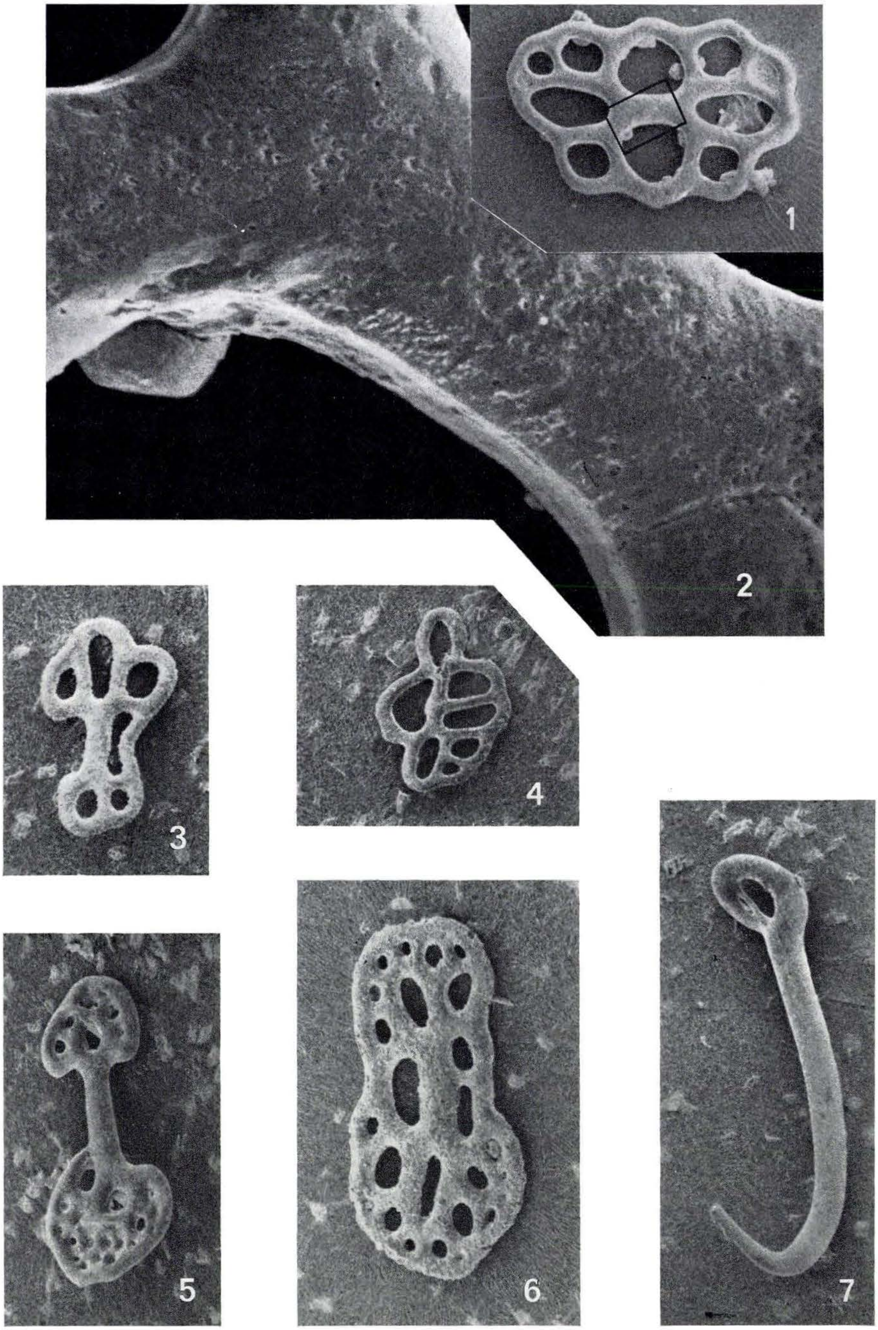
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Plate 4

× 100

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Catalogue No.

Fig. 1. *Ogmoconcha hagenowi* Drexler 1958
Loc. Gassum No. 1, sample No. 59 .... 1972–OM–43

Fig. 2. *Lophocythere sp. 4037*
Loc. Gassum No. 1, sample No. 52 .... 1972–OM–44

Fig. 3. *Lophocythere sp. 4076* Michelsen 1970
Loc. Gassum No. 1, sample No. 47 .... 1972–OM–45

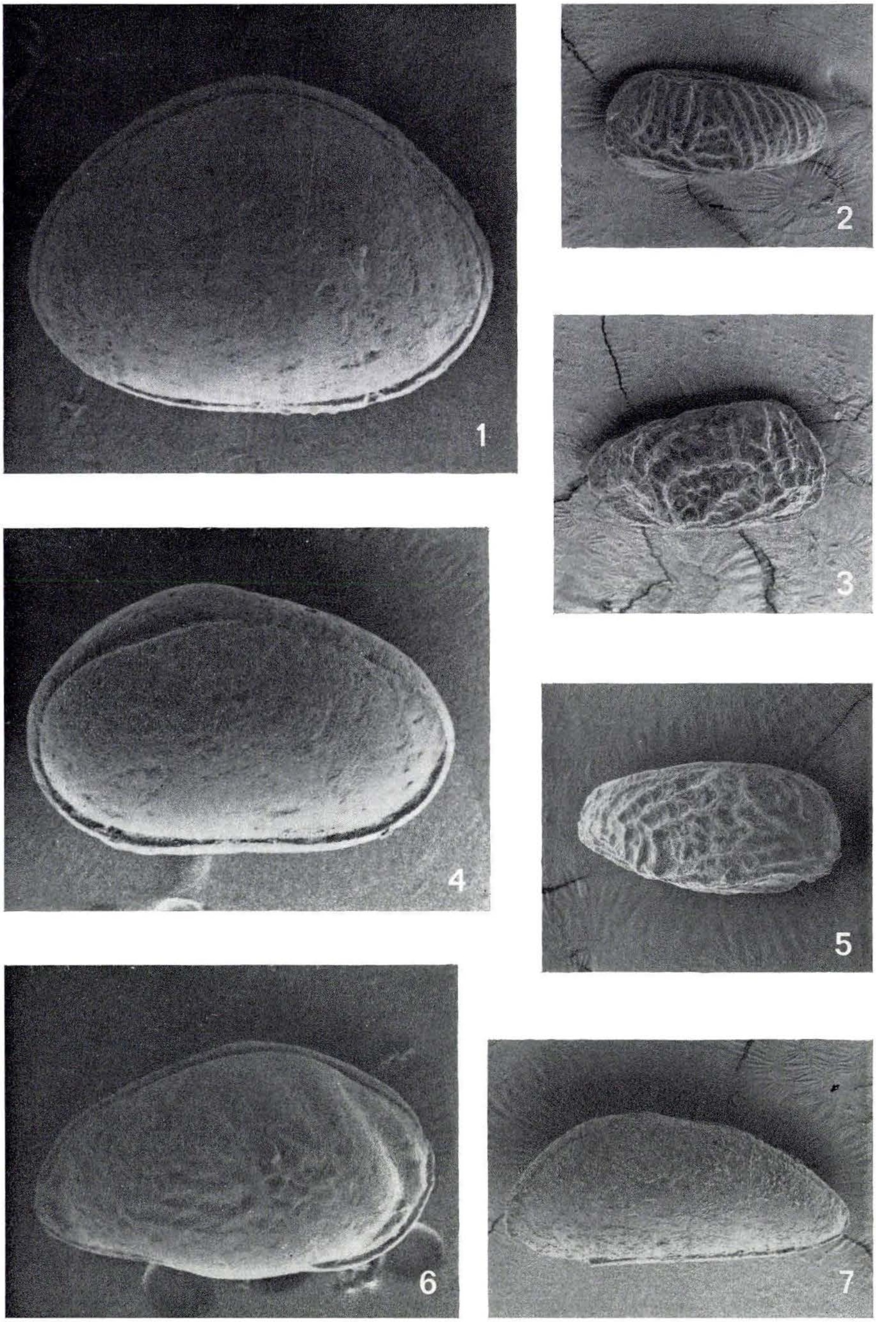
Fig. 4. *Ogmoconchella aspinata* (Drexler 1958)
Loc. Gassum No. 1, sample No. 47 .... 1972–OM–46

Fig. 5. *Lophocythere elegans* Drexler 1958
Loc. Gassum No. 1, sample No. 47 .... 1972–OM–47

Fig. 6. *Procytheridea medioreticulata* Michelsen 1970
Loc. Nøvling No. 1, sample 5960′–5990′ 1972–OM–48

Fig. 7. *Macrocypris sp. 4023* Michelsen 1970
Loc. Gassum No. 1, sample No. 47 .... 1972–OM–49

Scanning electron micrographs.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Some features in Clay with Tuff-beds from Lower Eocene on Røsnæs, Danmark

Kaj Strand Petersen

Petersen, Kaj Strand: Some features in Clay with Tuff beds from Lower Eocene on Røsnæs, Danmark. *Danm. geol. Unders., Årbog 1972*, pp. 69–78. København, 4. december 1973.

In a clay pit SW of Ulstrup on Røsnæs, Danmark, part of the formation Clay with Tuff of Lower Eocene age is demonstrated. Sedimentological and diagenetic circumstances are treated.

I en lergrav SW for Ulstrup på Røsnæs er der i en nedre eocæn lagserie blevet påvist ler med lag af vulkansk aske, som omfatter øvre del af den negative og nedre del af den positive serie. Sedimentologiske og diagenetiske forhold gennemgåes. En hiatus omfattende den øvre del af det fra andre lokaliteter kendte askeførende ler påpeges.

The investigated locality is situated 800 m WSW of the church in the village Ulstrup on Røsnæs. Here A/S Leca has been exploiting plastic clay from 1960–68 in a E-W orientated hill covering an area of 24 000 m^2. The Clay with Tuff not exploited is left as a ridge through the pit, text-fig. 1.

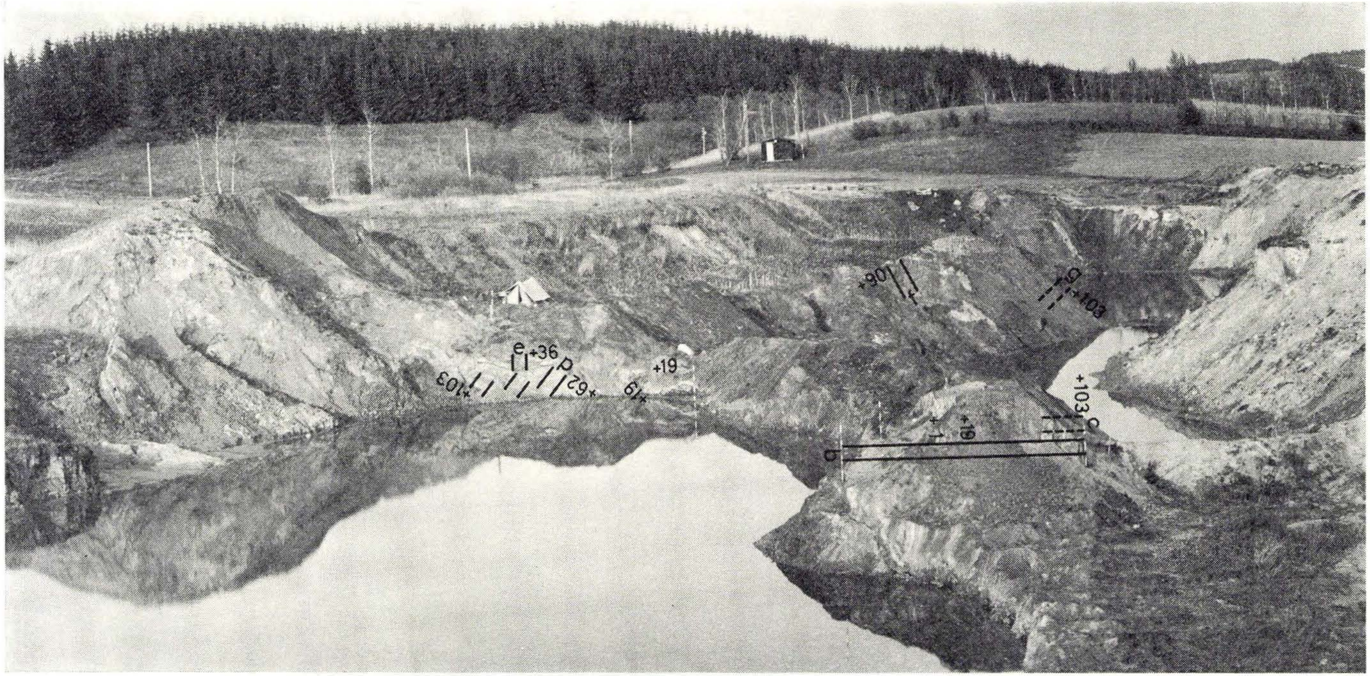
The southern coast of Røsnæs is outstanding with many Lower Eocene outcrops. The plastic clay from this locality has been known to geologists since the beginning of the last century. It occurs as floes in the drift. From borings outside the hilly part of the peninsula it is possible to judge the surface of the Tertiary deposits as being at a depth of 40 m below sealevel.

Clay with Tuff was recognized on Røsnæs in 1913 at Snogekjærgaard by the seashore. In 1937 a description of Volcanic tuff layers outside the Mo Clay area was published by Andersen (1937a). From this paper profile (a), text-fig. 2 has been taken, supplemented by recognized concretionary horizons.

Characteristic tuff beds and strata are used for correlation between the Slettenshage clay pit and the Snogekjærgaard profile 3 km to the west.

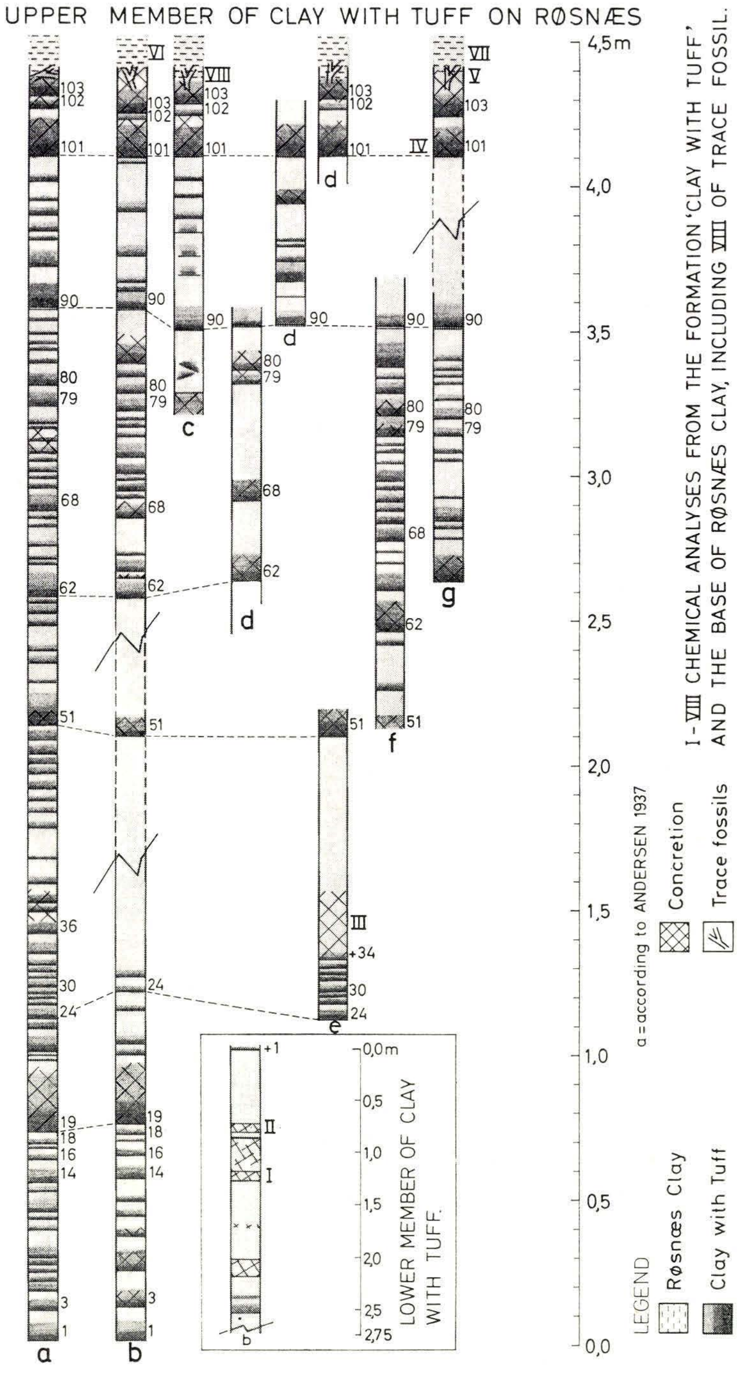
Part of the series is smeared by movement between the layers. This movement is part of the Pleistocene dislocating process which appears from the individual movement of the different parts of the ash ridge (Petersen 1973).

It has been impossible to trace all of the ashlayers from the corresponding part of the ash series in the Mo Clay area (Bøggild 1918). Thus the

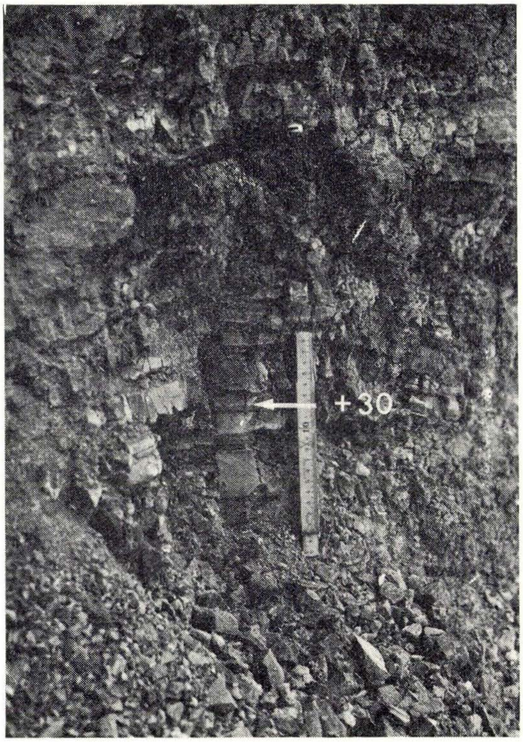


Fext-fig. 1. The folded strata of Clay with Tuff beds, seen from the west in the Slettenshage clay pit, Røsnæs.

Phot. K.S.P., 2.5.1968.



Text-fig. 2. Profiles in Clay with Tuff beds and base of Røsnæs Clay from Røsnæs. Chemical analyses I–VIII are rendered on text-fig. 6.



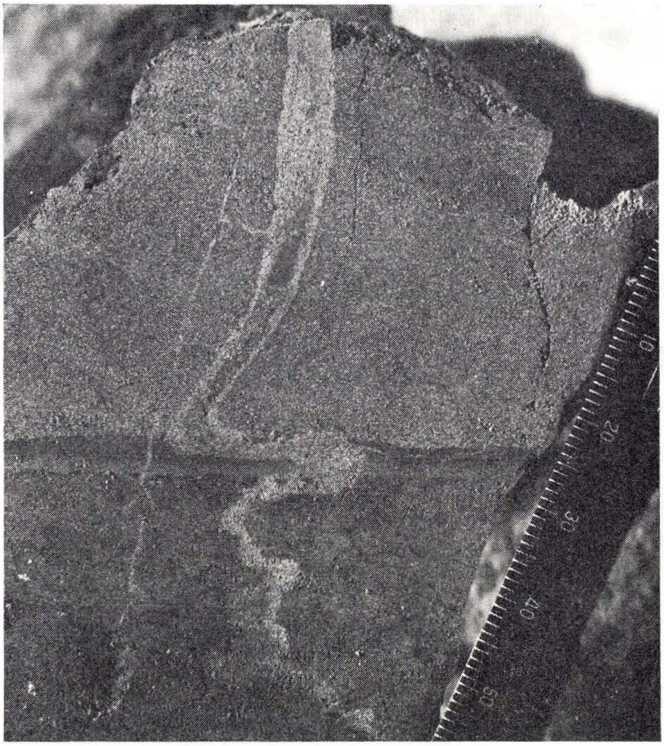
Text-fig. 3. Profile with the ash-beds +24 – +34. By the knife, a horizon of lensshaped concretions around + 36.
Phot. K.S.P. 1968.

numbering of the less characteristic and less distinct ash layers is subject to doubt.

Below the ashlayer +1 in profile b, text-fig. 2, 275 cm of dark, blue to black clay with blurred ash layers and few hardened horizons were found. This is clearly different from the more particoloured clay with closely packed ash layers in the positive series, the upper member of Clay with Tuff. Such a difference is known from other localities (Andersen, 1937a, p. 46).

The hardened horizons of the blue-black, light weathering, lime-free clay are of varying thickness and chemical composition (I & II text-fig. 6). Under the influence of the atmosphere they crumble into irregular bits.

From 232–249 cm below +1, a marked lamination of light-coloured layers $<$ 1 mm was found, partly in a hardened horizon. This lamination has a certain resemblance to the closely packed, very small ashlayers in



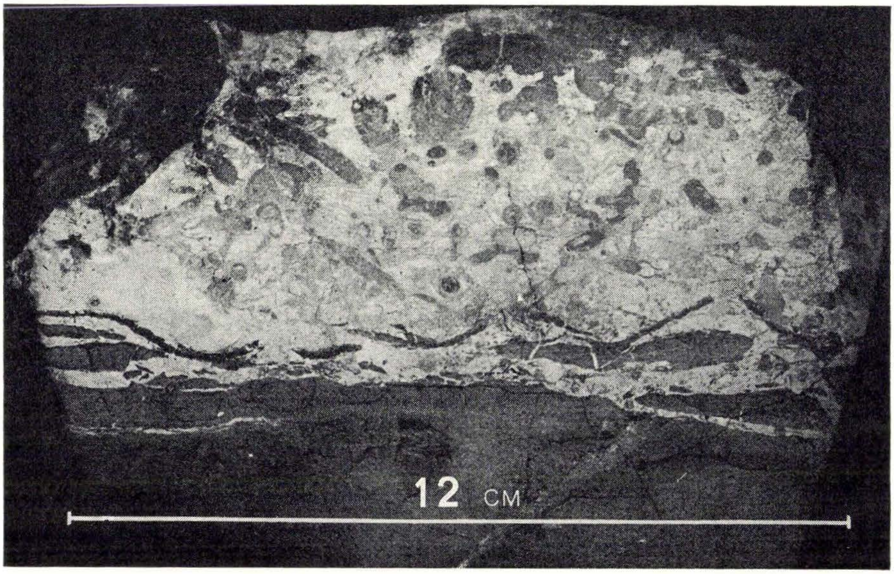
Text-fig. 4. Ptygmatic folding of an ashfilled fissure in the clay below + 90. A thin layer of clayey sediment is seen between the two components of the double-layer.

Phot. K.S.P.

the striated cementstone 2700 cm below +1 in the Mo Clay area (Pedersen 1960 p. 284). It was stated by Andersen (1937 b) that in the Mo Clay area the greatest depositional rate of diatomite was reached during the sedimentation of the upper part of the negative series of ashlayers, more than 15 times the rate of sedimentation of clay (outside the Mo Clay area). From this it is seen that the marked lamination 232–249 cm below +1 might be synchronous with the striated cementstone 2700 cm under +1 in the area of diatomite.

The ashlayer +1 is about 7,5 cm thick with graded bedding coarser in 1 cm of the bottom part. The exact thickness can not be measured, as the smaller grain-size higher in the layer makes it impossible to draw the limit ash/clay in the field. This feature, which affects most measurements outside the Mo Clay area, determines the presentation on text-fig. 2.

The layers +14, +16 and +18 were found, but not appearing as double layers as at Snogekjærgaard. +19 with its thickness (20 cm), compactness



Text-fig. 5. Intraformational sharpstone conglomerate at the top of + 103.
Phot. O. Neergaard Rasmussen.

and scraped appearance gives a firm base for the measurement. The layer is rusty where it is exposed but blue inside.

The closely packed, graded ashlayers between +24–+34 are found in a flaky, light, green clay. +30 has the appearance of a double-layer with a 0,3 cm lower layer. The cementstone known from +24–+30 is not found, but a layer of lens – shaped sideritic concretions (chemical analysis III, text-fig.6) occur around the ashlayer +36, text-fig. 3. +79 is separated from +80 by 0,5 cm of clay in the profiles b and g. In the profiles c and d the layers +79 and +80 occur in one cementstone, this having a total thickness of 10–12 cm. In the profiles f and g, ash and clay were found between +80 and +90, but in the profile d, 5,5–6,0 cm of green clay with smears of coarser ash-like particles occur between these layers. The clay series between +80 and +90 in profile c is 20 cm thick, containing broken ash-beds and fossiliferous clay at the base (Petersen, Hoch and Bonde 1973). The fossils might have gathered in a little basin; the layers were disturbed by sliding shortly after deposition.

An ash-filled fissure through +90 down into the underlying clay reflects by its ptygmatic folding the settling of the clay after the consolidation of the ash, text-fig. 4. +90 is a double layer with a thin layer of clayey sediment between the two components.

The cementstone with the ashlayers +101, +102, and +103 occurs

No.	I	II	III	IV	V	VI	VII	VIII
Percentage by weight of dry matter:								
Insoluble + SiO_2	42,7	8o,9	14,4	68,9	15,5	66,8	46,6	7,8
Fe_2O_3	2,5	3,37	33,0	7,52	15,2	7,89	9,67	6,3
Al_2O_3	2,6	5,0	2,4	9,9	2,0	10,0	9,7	1,7
P_2O_5	15,7	0,09	0,05	0,10	0,12	0,08	0,14	0,05
CaO	23,2	0,34	5,85	0,90	20,8	1,20	11,0	19,0
MgO	0,63	1,19	4,64	3,12	2,77	3,50	1,64	3,1
MnO	0,21	0,04	5,73	0,03	6,87	0,16	0,60	24,8
Na_2O	0,63	0,36	0,31	0,79	0,45	0,84	0,79	0,30
K_2O	0,61	0,95	0,43	0,32	0,43	0,49	1,19	0,29
Loss on ignition 1000°C	6,95	6,13	28,8	6,18	31,9	7,17	15,8	33,3
% CO_2 by absorption	2,1	0,1	31,0	0,3	31,8	0,1	9,5	35,7
% S-total	1,2	0,79	0,96	0/tr.	0/tr.	1,1	0/tr.	0/tr.
- S in SO_4	0,52	0,39	0,14			0,87		
Estimated carbonate composition:								
% $CaCO_3$	4,8		11,0		37,0		19,0	33,9
- $MgCO_3$	0		9,7		5,9		1,7	6,5
- $MnCO_3$	0		9,2		11,0		0	40,2
- $FeCo_3$	0		47,0		22,0		0	5,3
- FeO (excess)								2,4

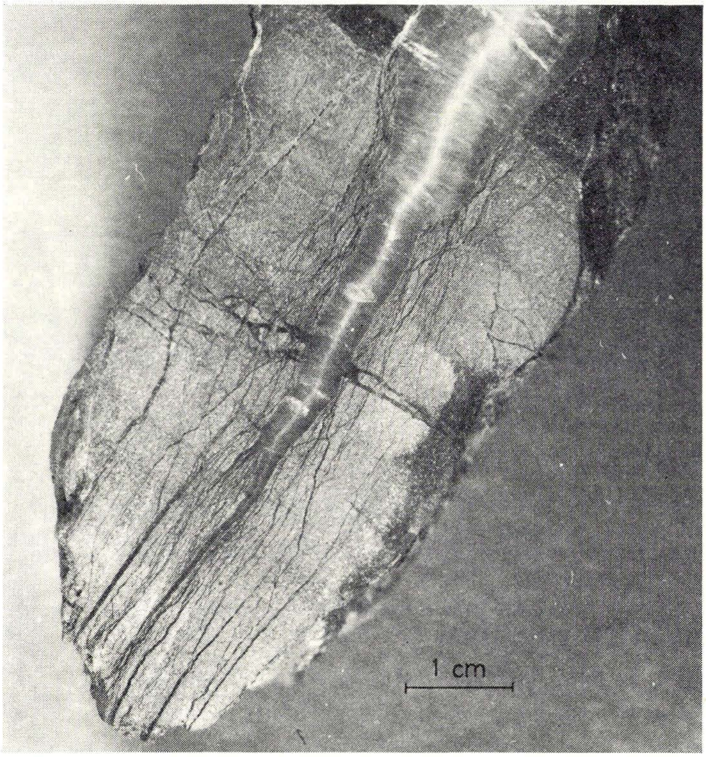
Text-fig. 6. Chemical analyses render the composition of respectively:

I–III concretions up to + 36
IV ash-bed + 101
V concretion above + 101
VI–VII Røsnæs Clay
VIII trace fossil from the base of Røsnæs Clay

The analyses have been made on components soluble after 2 hrs' boiling with aqua regia (1/3 HNO_3 + 2/3 HCL).

in all the profiles. +101 has a thickness of 10–12 cm. The thickness of +103 of 7,5 cm is outstanding for Røsnæs, as mentioned by Andersen (1973a), compared with the thickness of this layer at other localities. Plastic clay overlies this ashbed in the Snogekjærgaard profile. (On pl. VI fig. 20 Andersen 1937a, +110 is mentioned from Røgle-Røsnæs. This is a misprint; the numbers belong to Albækhoved-Røgle).

A sectional view of the concretion normal to the beding, text-fig. 5, shows the top of +103 broken up, forming an intraformational sharpstone conglomerate. Furthermore, the upper limit of an ashfilled crack at the top of



Text-fig. 7. Plates of calcite in fissures. A sectional view normal to the bedding. Notice plate-like growth of calcite parallel to the bedding. Phot. K.S.P.

+103 shows this level to be an erosional surface. However, because of the extraordinary thickness of "+103", this layer might be regarded as a "Tuffite" (Illies 1949, p. 14). The cementstone above "+103" in profile g is 12 cm thick without ash-beds. The ash-layer +104 was to be expected here as it is found within this distance at localities west of Røsnæs.

Together with the above-mentioned features, the occurrence of Røsnæs Clay above the concretion at the two localities might lead to the conclusion that there is a hiatus above "+103". This hiatus could hardly represent a tectonic break.

The presence of concretions is a conspicuous feature of the formation Clay with Tuff. Their occurrence in the profiles has been marked on text-fig. 2. Few of them are found at the same level within the peninsula, and only one (+101–+103) represents a horizon traceable to other localities outside Røsnæs.

In order to figure the concretionary composition, chemical anaylses, text-fig. 6, have been made by the DGU laboratory staff, with the following

Text-fig. 8. Gypsum. "Swallow-tail" twins are found in lower member of Clay with Tuff on Røsnæs. This one is derived from a concretionary horizon in the Snogekjærgaard profile. Phot. O. Neergaard Rasmussen.

comment by senior-geologist H. Kristiansen: "Three of the samples (III, V and VIII) show equivalent excess of CO_2 in relation to CaO and MgO. In two oft hese samples the excess of CO_2 was equivalent to the sum of FeO and MnO, while there was a small excess of FeO or MnO in the sample VIII. From these analyses an estimated carbonate composition has been calculated. Normally the reduced loss on ignition (loss on ignition $\div CO_2$) is equal to the content of organic matter + chemically bound water. If the samples contain $FeCO_3$ and $MnCO_3$, the reduced loss on ignition will be lower or negative owing to the fact that $2FeO + O \rightarrow FE_2O_3$".

Trace fossils (chem,an. VIII) are a special case owing to their high content of MnO. This does not merely reflect the higher porosity caused by bioturbation but is more probably an effect of cementation of the burrow walls made by the Callianassa-like animal (Petersen, K. Strand: Trace fossils from Lower Eocene of Denmark – in preparation). The organic component of the cement of the walls may have trapped/attached the manganese (Blatt *et al.* 1972). The existence of penecontemporaneous feeding tracks in the walls supports the presumption of the occurrence of organic matter.

Plate-like, fibrous masses of calcite ($CaCO_3$) are found anastomosing more or less parallel to the bedding, especially in the horizon +101–+103. In one case calcite is found cutting the ash-beds vertically through more than one meter having a max. thickness of 2–3 cm and at the base splitting into thin plates that fill up fissures < 1 mm, text-fig. 6.

Gypsum ($CaSO.2H_2O$) is commonly found as described by Bøggild (1943) but twinning does occur as shown in text-fig. 7.

Pyrite (FeS_2) is found in the central part of the burrows. Pyritic fillings in vertebrate bones and wood material occur but are not found in extensive masses as is the case at other localities of Lower Eocene age, viz: Katharinenhof on Insel Fehmarn and Trelde Næs near Lillebælt.

The poverty of lime-shelled fossils of this formation must be seen as a result of diagenesis. Syngenetic cementation as seen in the hardened horizon around +36 preserved the fossils (bivalves) from destruction to some extent, as reported by Illies (1949).

The hardened trace fossils met with in this formation were made by animals burrowing in a soft sediment: the trace fossils have not suffered from pressure but expose shearing at the outer side; this shearing reflects the settling in the sediment. Sedimentological investigations published by Oertel, G. and Curtis, C. (1972) and Nielsen (1973) support the abovementioned idea of syngenetic cementation.

References

Andersen, S. A. 1937 a: De vulkanske Askelag i Vejskæringen ved Ølst og deres udbredelse i Danmark. Danm. geol. Unders. række 2. 59.

Andersen, S. A. 1937 b: Et Vulkanomraades Livshistorie. Geol. Fören. Förhandl. Bd. 59 Hf. 3.

Blatt, H., Middelton, G. & Murray, R. 1972: Origin of sedimentary rocks. Prentice-Hall inc. New Jersey.

Bøggild, O.B. 1918: Den vulkanske aske i Moleret. Danm. geol. Unders. række 2. 33.

Bøggild, O. B. 1943: Danmarks Mineraler. Danm. geol. Unders. række 2. 71.

Illies, H. 1949: Die Lethogenese des Untereozäns in Nordwestdeutschland. Mitt. Geol. Staatinst. Hamburg Hf. 18.

Nielsen, O. B. 1973: Eocæne aflejringer i Ølst-området og deres indpasning i områdets Kvartærgeologi. Dansk geol. Foren. Årsskrift for 1972 p. 100–110.

Oertel, G. and Curtis, C. 1972: Clay-Ironstone Concretion preserving Fabrics Due to Progressive Compaction. Geol. Soc. Amer. Bull. v. 83, p. 2597–2606.

Pedersen, K. Raunsgaard, 1960: Written contribution to the meeting on Mo Clay. Meddr. dansk geol. Foren. 14, p. 284.

Petersen, K. Strand 1973: Tills in dislocated drift deposits on the Røsnæs peninsula, NW Sjælland, Denmark. Bull. geol. Instn. Uppsala. NOS. Vol. 4.

Petersen, K. Strand, Hoch, E. and Bonde, N. 1973: A New Species of Mytilid Bivalve, and Vertebrate Remains from Lower Eocene Marine Deposits on Røsnæs, Danmark. Danm. geol. Unders., Årbog 1972, pp. 79–86.

A new species of Mytilid bivalve, and vertebrate remains from Lower Eocene marine deposits on Røsnæs, Danmark

Kaj Strand Petersen, Ella Hoch and Niels Bonde [1]

Petersen, Kaj Strand, Hoch, Ella and Bonde, Niels: A new species of mytilid bivalve, and vertebrate remains from Lower Eocene marine deposits on Røsnæs, Denmark. *Danm. geol. Unders., Årbog 1972*, pp. 79–86. København, 5. december 1973.

A new species of bivalve, *Mytilus roesnaesiensis*, is described from the Lower Eocene marine clay with ash-layers on the peninsula of Røsnæs, NW Sjælland, and fragmentary remains of sharks, teleostean fishes, and birds are briefly discussed.

En ny muslingeart *Mytilus roesnaesiensis* nov.sp. beskrives. De 12 hele individer er fundet i en konkretion ved askelag + 36 i det askeførende ler af nedre eocæn alder på Røsnæs, Danmark. Der drages sammenligninger med fund fra det øvrige tertiære »Nordsø«-område. Som samme art betragtes den af H. Illies 1949 anførte *Mytilus sp.*

En linse af ler tæt under akelag +90 indeholdt en del skeletrester af fisk og fugle. Af benfisk især hvirvler, kæber og finnestråler. Flg. kunne identificeres: ordenen Elopiformes, Molerets almindelige fisk (en argentinoid), torskefisk (? en merluciid), makrelfisk *(?Scombrinus)*. Af hajtænder fandtes *Lamna inflata* (tvivlsom), *Odontaspis rutoti* og *O. macrota striata.*

Fuglematerialet udgøres af fyrre, morfologisk identificerbare, små knoglefragmenter. Overfladen hos de fleste af disse er tydeligt præget af mekanisk og/eller kemisk slid, hvilket muligvis til dels kan tilskrives fordøjelsesvæskerne i tarmsystemet hos større fisk eller fugle. Tre af fossilerne har en vis lighed med de tilsvarende skeletelementer af uglelignende fugle og kan med forbehold henføres til ordenen Strigiformes. De øvriges uspecialiserethed eller fragmentariske tilstand tillader næppe systematisk klassifikation.

Mollusca

Twelve specimens of bivalves of the family Mytilidae were found in a concretionary block from the Lower Eocene of Røsnæs, Danmark. The concretion measures 31 cm × 27 cm × 16 cm and derives from a partially hardened horizon around ashbed + 36 in Lower Eocene marine Clay

[1]) The authors responsible for each part are indicated by initials.

with Tuff. The bivalves all belong to the same species, and in all of them both valves are preserved.

The shells are situated more or less in one plane of the block but are variously orientated (pl. 1, fig. 1). The presence of fossilized wood close to the shells in the block may signify that the Mytilidae were carried to the place in the gregarious way of Mytilus attached, by the byssus to a piece of driftwood. The equivalve shells all expose their exterior face; because of the film-like state of preservation, an investigation of their inner side has not proved possible. The valves have suffered from a pressure broadly perpendicular to the plane of their margins, the effects of the pressure increasing towards the outer sphere of the concretion. A right valve with an almost intact terminal beak (umbo) from the center of the concretion is demonstrated on text-fig. 1.

The shells are ornamented by a distinct, closely packed, concentric sculpture; there are no radial striae. The best preserved specimen shows the ventral margin of the valve to be straight, with the dorsal margin culminating halfway back from the beak. From the bulging front part, the valve flattens towards the posterior edge; the valve has no ridge. The mean length of the shells is 6 cm (min. 5 cm; max. 7,5 cm).

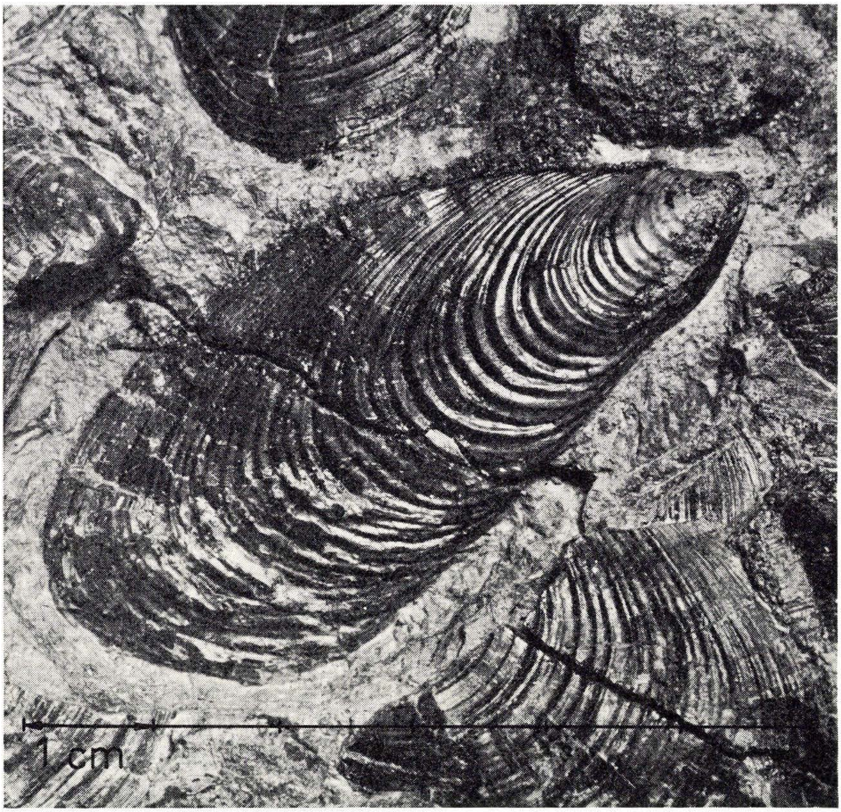
The present specimens are classed within the subfamily Mytilinae and represent the first Mytilinae to be described from the Danish Eocene. Specimens of the genus Perna, mentioned by Gagel (1916, p. 62) from clay at Røjle Klint, have never been found since (Bonde, 1968).

The family Mytilidae is well known from French and English Lower Eocene deposits. None of these specimens shows any close similarity to the present Danish fossils. However, a fragmentary shell which was described as *Modiola undulata* by Wood (1861–71, pl. XIII, fig. 13a) may be a *Mytilus* related to the Danish Mytilidae.

Mytilidae have also been described from the Eocene of northern Germany. A *Mytilus sp.* (Illies, 1949, pl. I, fig. 1) from the so-called "Pflasterhorizonten" is morphologically close to the Røsnæs specimens. The number of distinctive concentreic undulations per cm along the anterior-posterior line of the valves is 7–9 on both the German and the Danish specimens (while it is 5 on the English specimens). Furthermore, the shells from both localitites have fine growth-lines between the heavy ridges of the sculpture.

The Mytilidae specimens from ash-bed horizon + 36 in Clay with Tuff, Lower Eocene, Røsnæs, Danmark are considered a new species, *Mytilus roesnaesiensis* nov.sp.

Diagnosis: The equivalve shell shows a terminal beak. From the bulging front part the shell is ornamented by a distinct pattern of closely packed concentric ridges to the posterior edge where the valve flattens. Ventral



Text-fig. 1: Holotype no. MMH. 12824 *Mytilus roesnaesiensis* nov.sp. Phot. K.S.P.

margin straight and dorsal margin convex, culminating half way back from the beak. Fine growth lines observable between the concentric ridges of the sculpture. Length 6 cm.

Type material: the sideritic concretion containing all of the known Danish specimens was found in 1968 by the author, and now belongs to the Mineralogical Museum of København, kept here in the type collection no. MMH 12824 to no. MMH 12835; no. MMH 12824 (text-fig. 1) is chosen as Holotype. The 11 others are considered paratypes.

The specimens of Mytilidae from Lower Eocene "Pflasterhorizont" in Steinfeld Oldenburg Germany, recorded by Illies (1949), belong to the same species. They are kept in the Geologisches-Paläontologisches Institut, Hamburg.

Locus typicus: A clay pit 800 m WSW of the church in the village Ulstrup on Røsnæs, Danmark.

Stratum typicum: Clay with Tuff, Lower Eocene. KSP

Pisces

A 4 cm thick lens of clayey sediment was discovered below the ash-layer no. + 90. Between the ash-layer and the lens was a 20 cm thick clay deposit with fragments of broken ash-layers (cfr. Petersen 1973).

The fossil content of this lens included many fish remains, viz: shark teeth and fragmentary bones (e. g. vertebrae, ribs, fin rays, and jaw fragments) of teleostean fishes.

Among the groups represented in the contemporaneous Mo-clay Formation (Bonde 1966) at least spiny rayed fished (acanthopterygians) and Elopiformes (tarpons and relatives, pl. 1, fig. 4) and probably Salmoniformes can be identified from the fin spines and vertebrae.

The most common fish of the Mo-clay, a small argentinoid (called a "clupavid", Bonde 1966) is almost certainly represented by jaw bones (one maxillary) and some other fragments from the clay lens.

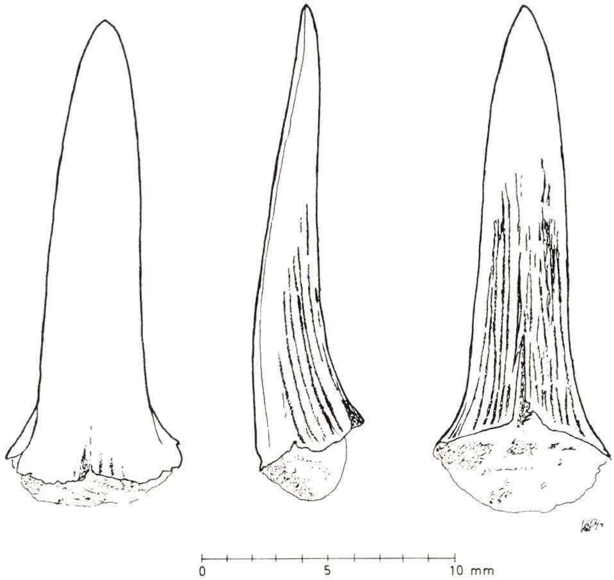
Though there were quite a few fragments of jaws with very small teeth in the lens, only two larger teleostean teeth were found. One is an incomplete, slender, conical, strongly recurved tooth crown, 2,5 mm long, which has a deep pulp-cavity, very delicate striation on the basal half, and two weak cutting-edges indicated distally, where 0,5–1 mm is missing (this was probably a "coiffe"). This tooth may well be from a gadiform fish such as the merluciid (hake) *Rhinocephalus*, which is a genus quite common in both London Clay and Mo-clay (Casier 1966, Bonde 1966 – it is definitely not the hake (?) *Trichiurides*).

The second tooth is 6 mm long, lacking about 1 mm of the apex. It is stout and conical, gently curved, with weak plications at the 3 mm wide, circular base, and is only a little compressed distally. It carries two well marked, but not sharp cutting-edges in its full length. It probably belongs to a scombrid fish and it is not a species from the Mo-clay. Many species of mackerel-like fishes have been described from London Clay, and our specimen resembles teeth of *Scombrinus* (Casier 1966, pl. 42), but proper determination is impossible without direct comparison with these fossils.

Some 50 shark teeth have been found in the clay lens, most of them isolated crowns without roots. *Lamna inflata* may be represented by one tooth, while the rest seem to be odontaspids; we have been unable to identify most of them to species.

However, on the basis of the strong vertical striation on the inner face of some crowns, these have been identified as *Odontaspis macrota striata* (Winkler) (= *Striatolamia striata* (Winkler)). Such a specimen is shown in text-fig. 2 and pl. 1, fig. 2.

One posterior lateral tooth, only 3 mm high, we identify as *O. rutoti*



Text-fig. 2: Tooth crown of *Odontaspis macrota striata.*

(?). It has the puckering of the enamel at the base of the crown, pl. 1, fig. 3, and is very similar to a Landenian tooth described by Casier (1967, pl. 6, fig. 9). Two bigger teeth (crown height 8 and 10 mm resp.) have a very weak puckering at the base and may also represent this species.

Both these species of *Odontaspis* have been identified in the contemporaneous Mo-clay Formation (Bonde 1966), but here also the specimen of *O. rutoti* (crown height 12 mm) has less puckering than typical Upper Paleocene teeth (e. g. in White 1931, Gurr 1962, Casier 1967). The puckering is still weaker in the Røsnæs teeth, which are a little younger than the Mo-clay specimen (found at ash-layer + 90 and + 28 resp.), so they may confirm the hypothesis of the progessive reduction of puckering within this species during the basal Eocene (cfr. Gurr 1962, fig. 1).

Other atypical and younger *O. rutoti* have been identified with doubt from London Clay and the Belgian "Panisélien" (M. Eocene) by Casier (1966, p. 74, pl. 8 and p. 72 resp.); these resemble the Danish specimens.

In a stratigraphic table, Ward (1971) indicated that both *O. macrota striata* (his *S. striata*) and *O. rutoi* are restricted to basal London Clay and older beds, while their presumed descendents (*S. macrota* and *O. trigonalis*) occur generally within the London Clay (undifferentiated). Cfr. discussion of *Odontaspis macrota* by Casier (1966, p. 70), who found it impossible to distinguish between two forms.

If our specific determinations of these shark teeth are correct, this may indicate that the Danish ash-series and the basal London Clay were deposited at least partly contemporaneously. This is also indicated by the ash-layer recently discovered a little above the bottom of the London Clay (Elliott 1971) and must be evident from the drillings in the North Sea.

KSP and NB

Aves

The fish-yielding deposit also contained bird-remains (pl. 2). Until now about forty morphologically identifiable pieces of avian skeletal elements have been recovered.

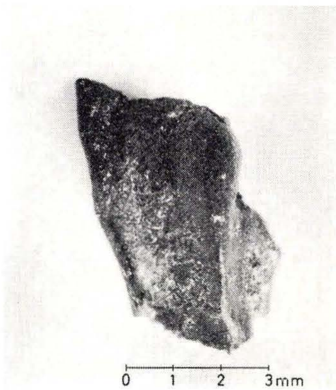
The fossils were extracted by first drying the sediment and then immersing it in water. This procedure may have caused a breakage of the majority of the bones. The sharp-edged, apparently fresh fractures of the specimens are contrasted by their surface, which in most cases is marked by wear or dissolution, some of which is probably due to catabolism inside larger animals.

A few of the specimens have pyritic fillings. In the rest of them the fossilizing processes seem to have affected only the bone-tissue, the bones being as hollow and porous as are the inorganic skeletal material of living birds.

The general visual impression of the bone-fragments is that they are of small size, and that they are derived from small birds. The largest specimen is a fragment of a carpometacarpus, text-fig. 3, which in size and morphology resembles the corresponding bone-region of a present-day golden plover *(Pluvialis apricaria)*. The largest avian member of the fossil assemblage, however, seems to be represented by the occipital condyle, pl. 2, 1; the condyle is similar in size and morphology to that of a corncrake (*Crex crex*). – In such statements it should be remembered that the relative proportions of the skeletal elements of birds are variable. The occipital condyle of a bird may be relatively small or relatively large, depending on the functional demands upon it. – The majority of the toe-joints, although some of them are complete, can not be taxonomically evaluated since in most cases it is impossible to indicate the exact position of isolated toe-joints in a bird-foot.

Bird remains, although they are generally small and fragile, are met with fairly often in Eocene deposits. At least four localities yielding several avian remains are recognized within the Lower Eocene North Sea Basin, viz.: Isle of Sheppey, the Danish Mo-clay area, Røsnæs, and Katharinenhof on Insel Fehmarn.

Text-fig. 3: Carpometacarpus, left, proximal end, carpal trochlea.



Bone no. 4, pl. 2, in its relatively strong appearance, its curvature, and its lack of lateral canals, and bone no. 12–13, pl. 2, in its relative stoutness, and in the significant ridge at the upper frontal part of the shaft, the well-marked, distal, trochlear incisure, and the two prominent cristae at the upper part of the back-side, are morphologically close to the corresponding toe-joints of the *Strigiformes* (owl-like birds), and may be derived from bird(s) of this order. Bone no. 5, pl. 2, is similar in its lack of lateral canals to the ungual phalanges of the diurnal and nocturnal birds of prey, while other characters, *e.g.* the rather flat curvature, tend to exclude it from these two groups of birds. No systematic classification of the birds represented by this bone and by the remaining specimens, the great majority of which is in a too fragmentary state for taxonomic investigation, has been ventured upon.

A number of small pebbles, most of them well-rounded fragments of quartz, have been extracted from the fossiliferous clay-sediment. They should be mentioned here as they may have been carried to the place inside birds, as grinding-stones of their gizzard.

E.H.

References

Bonde, N. 1966: The Fishes of the Mo-clay Formation (Lower Eocene) Medd. Dansk Geol. Foren. Bd. 16, p. 198–202.

Bonde, N. 1968: Nyligt fundne fossiler fra det »plastiske ler«. I. Invertebrata. Medd. Dansk Geol. Foren. Bd. 18. p. 148–151.

Casier, E. 1966: Faune ichthyologique du London Clay. British Museum (Nat. Hist.). London, 496 pp.

Casier, E. 1967: Le Landénien de Dormaal (Brabrant) et sa faune ichthyologique. Inst. R. Sci. Nat. Belg., Mém. 156, 66 pp.

Elliott, G. F. 1971: Eocene Volcanics in South-east England. Nature (Phys. Sci.), London, vol. 230, no. 1, p. 9.

Gagel, C. 1916: Ein neuer Fossilfund im dänischen Untereocän. Jahrbuch der Königl. Preuss. Geologischen Landesanstalt. Band XXXVII. Teil II Heft 1, pp. 60–63.

Gurr, Ph. R. 1962: A New Fish Fauna from the Woolwich Bottom Bed (Sparnacian) of Herne Bay, Kent. Proc. Geol. Ass. London. 73 (4), p. 419–447.

Illies, H. 1949: Die Lithogenese des Untereozäns in Nordwestdeutschland. Mitt. Geol. Staatsinst. Hamburg. Hf. 18, 43 p.

Petersen, K. Strand, 1973: Some Features in Clay with Tuff-beds from Lower Eocene on Røsnæs, Danmark. *Danm. geol. Unders., Årbog* (Yearbook) *1972*, pp. 69–78.

Ward, D. 1971: The stratigraphical distribution of Chondrichthyes in the English Lower Tertiary. Tertiary Times, vol. 1, no. 3, p. 72–76.

White, I. E. 1931: The vertebrate faunas of the English Eocene. 1. British Museum (Nat. Hist.) London 104 pp.

Wood, S. V. 1861–1871: A Monograph of the Eocene Bivalves of England Vol. 1 London, 177 p.

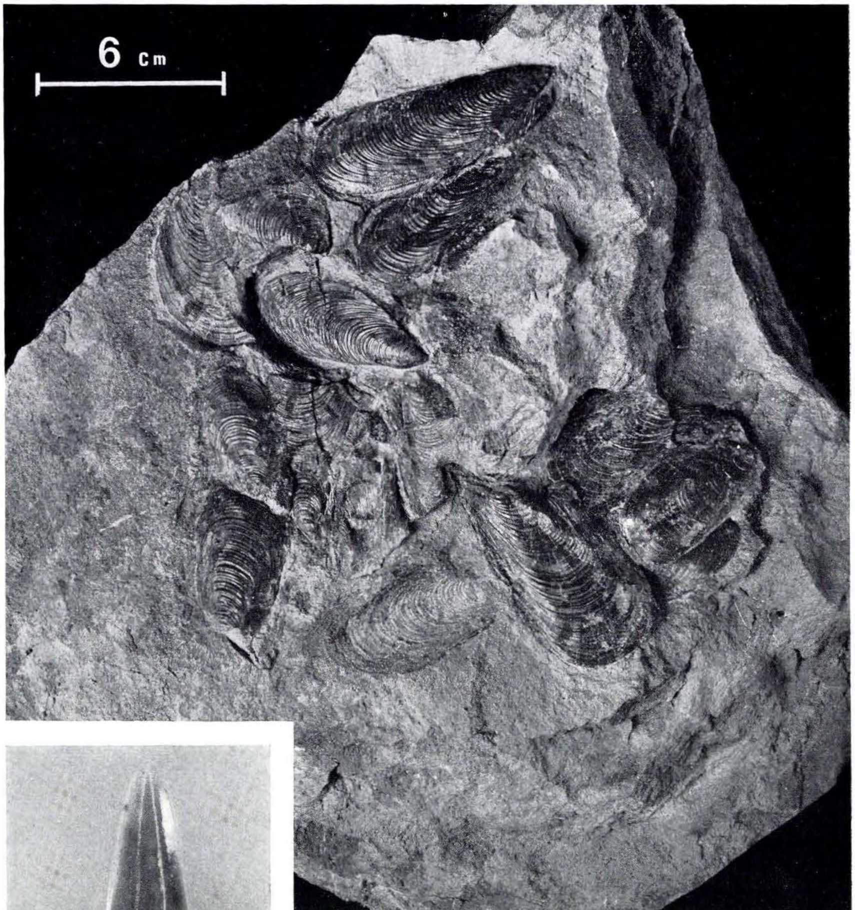
Plate 1

Fig. 1: The sideritic concretion containing all of the known Danish specimens. Holotype and paratypes of *Mytilus roesnaesiensis* nov.sp.

Fig. 2: Tooth crown of *Odontaspis macrota striata.*

Fig. 3: Tooth of *Odontaspis rutoti* (?)

Fig. 4: Half a vertebra of an Elopiform fish.
Phot. O. Neergaard Rasmussen (fig. 2, 3–4).



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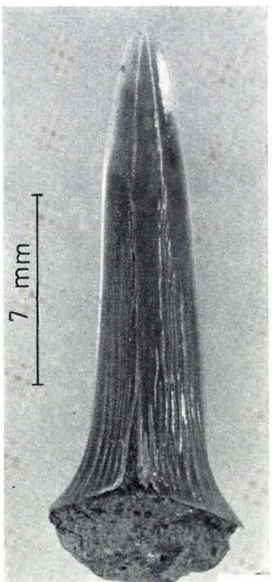

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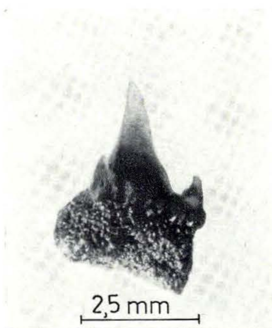

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Plate 2

Aves

Fig. 1. *Occipital condyle,* with part of skull-base, basioccipital and right exoccipital.

Fig. 2. *Humerus,* right, distal end, ectepicondyle and radial condyle.

Fig. 3. *Corpus vertebrae.*

Fig. 4. *Ungual phalanx.*

Fig. 5. *Ungual phalanx.*

Fig. 6. *Ungual phalanx,* with lateral canals for blood and nerves as known from the majority of Recent birds.

Fig. 7. *Synsacrum,* fragment of right side, with lower posterior edge of acetabulum.

Fig. 8. *Tibiotarsus,* right, distal end, outer articular condyle.

Fig. 9. *Phalanx,* distal end missing.

Fig. 10. *Phalanx.*

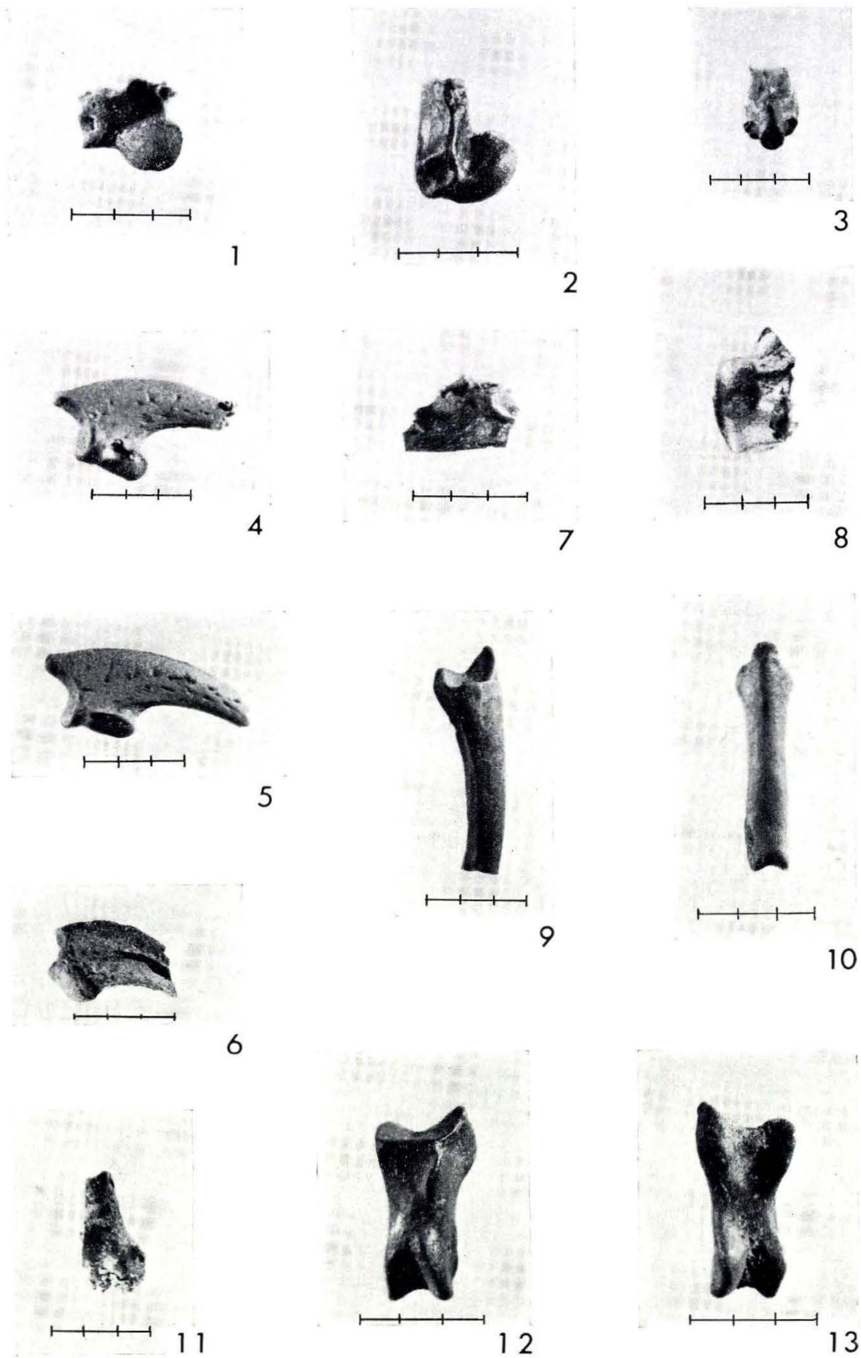
Fig. 11. *Tarsometatarsus,* left, distal end, external digital trochlea.

Fig. 12. *Phalanx,* anterior view; if from owl-like bird: left foot, toe no. II, proximal phalanx.

Fig. 13. *Phalanx,* same as no. 12, posterior view.

The scale indicates 3 mm.

Phot. O. Neergaard Rasmussen.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Determination of spore concentration with an electronic particle counter

Jens Stockmarr

Stockmarr, Jens: Determination of spore concentration with an electronic particle counter. *Danm. geol. Unders., Årbog 1972,* pp. 87–89. København, 5. december 1973.

In a new portion of tablets for absolute pollen analysis the spore content was determined with an electronic counter.

The use of tablets containing a known amount of *Lycopodium clavatum* spores for determination of the absolute pollen content of sediment samples was mentioned in Stockmarr 1971. One or more tablets are added to a fossil sample prior to preparation in the laboratory. During the analysis the modern spores are counted together with the fossil spores and pollen grains, and afterwards the total number of fossil spores and pollen grains in the sample, can be calculated from the equation:

$$\text{total fossil grains} = \frac{\text{added } Lycopodium \text{ spores}}{\text{counted } Lycopodium \text{ spores}} \cdot \text{counted fossil grains}$$

It was decided to make a large batch of tablets for distribution to other laboratories for pollen analysis.

The new tablets

The new tablets are smaller than those dealt with in the former article. The *Lycopodium* spores were given a dark colour by acetolysis prior to incorporation in the tablets. In this manner the added spores can be distinguished from fossil *Lycopodium* spores because the modern spores will become darker than the fossil ones after further acetolysis.

Spore concentrations was determined with an electronic particle counter, and afterwards a few microscope counts were made according to the method of Sv. Jörgensen (1967). A *Coulter Counter* model Zs kindly placed at my disposal by *Bie & Berntsen,* Copenhagen was used in the former case. In this counter the number and size of particles suspended in an electrically conductive liquid can be determined. The suspension and electric current flow through a small aperture having an immersed electrode on either side. Concentration is such that the particles traverse the aperture

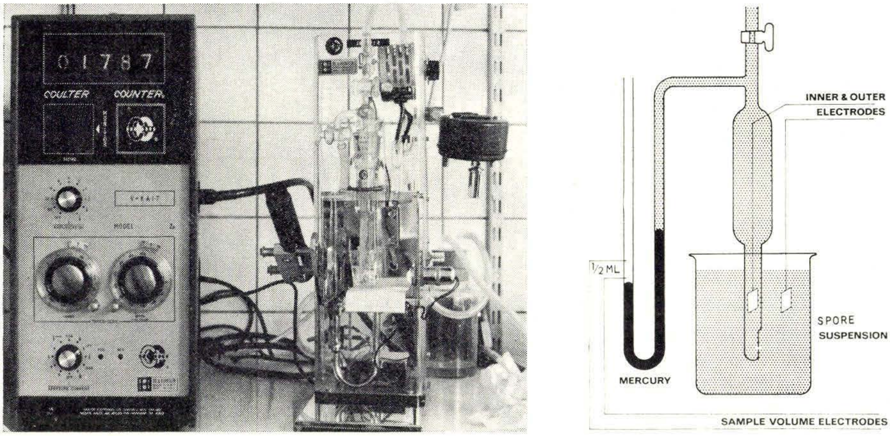


Fig. 1. The counter in the laboratory and a model demonstrating the principle.

substantially one at a time. Momentary changes in the impedance caused by displacement of electrolyte within the aperture by each succesive particle produce a series of voltage pulses of an amplitude proportional to particle volume. The resultant series of pluses is electronically amplified, scaled and counted.

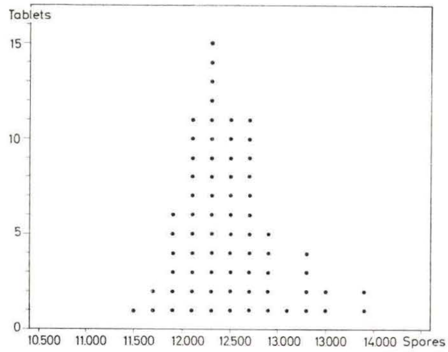
The tube on top of the model in fig. 1 leads to a vacuum pump. When the tap is open the suspension is drawn through the aperture and the mercury string is drawn away from the sample volume electrodes (the situation i fig. 1). When the tap is closed the mercury string slowly returns to the initial position drawing the suspension through the aperture. When the string reaches the first sample volume electrode the counting begins, and when it reaches the second, about 10 seconds later, it stops again. The aperture used was 140 μ, and the volume measured was half a milliliter. The spore suspension was stirred between the counts to keep a constant concentration.

71 tablets taken from different places in the batch were placed in 25 milliliter beakers, one in each, Sufficient HCl was added to dissolve the tablets. A little alcohol was added to keep the foam away and the beakers were filled up with a 0.15 molar NaCl solution. After stirring the beakers were placed in the counter. 15–20 counts each of half a milliliter were made on each tablet. In this manner more than one third of the spores in each tablet was counted.

From the counts the spore content in the tablets could be calculated. No error has been calculated on the single tablets but it is small as a large proportion of the total was counted.

Fig. 2. Number of spores in the tablets. Class intervals of 200 spores.

$\bar{X}$ = 12.488
$\hat{\sigma}$ = ± 499
V = ± 4.0 %



The arithmetic mean, $\bar{X}$, the standard deviation, $\hat{\sigma}$, and the coefficient of variation, V, of all the tablet calculations were found.

From fig. 2 it is seen that the distribution might be slightly skewed, but the skewness is so small that the material has been treated as normally distributed.

To control the method four tablets were prepared for microscope counting. From each tablet two slides were counted containing about one half of the material, with the following result:

1. tablet:	12.830
2. tablet:	12.611
3. tablet:	12.287
4. tablet:	12.418
$\bar{X}$:	12.537
$\hat{\sigma}$:	± 237
V:	± 1.9 %

Conclusion

The two methods gave almost identical results: 12.500 spores per tablet with a coefficient of variation not exceeding 4 %.

While the microscope determination lasted for three days, the electronic method was completed in one day and the certainty was much higher, since 71 samples were determined instead of only 4 in the former case.

Literature

Jørgensen, Sv. (1967): A method of absolute pollen counting. The New Phytologist 66, p. 489–493.

Stockmarr, J. (1971): Tablets with spores used in absolute pollen analysis. Pollen et Spores. Vol. 13, No. 4, p. 615–621.