DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2002/85

Biostratigraphical analysis of 12 ditch cuttings samples from the Margretheholm-1 (MAH-1) well, Copenhagen, Denmark

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Contents

Conclusion

One sample (1595 m) from the MAH-1 well in Copenhagen Denmark has been prepared and analysed for its microfossil content and 11 samples have been prepared and analysed for palynology.

The microfossil analysis of sample 1595 m suggests an early Late Cretaceous age, Early Coniacian or Late Turonian.

The content of dinoflagellate cysts in samples 1615 m – 1635 m suggests a Late Barremian –early Late Albian? age for this interval.

The content of dinoflagellate cysts and the abundance of *Spheripollenites* in samples 1655 – 1700 m suggest an Early Jurassic, latest Pliensbachian - Early Toarcian age for this interval.

The interval from 1720 m –2075 m is referred to the latest Triassic – Early Jurassic, Rhaetian to Hettangian based on dinoflagellate cysts, pollen and spores.

The sample at 2395 m could not be dated more precisely than Triassic, possibly older than Rhaetian.

Finally are the samples 2625 m – 2670m referred to ?Early Triassic, earliest Scythian (Griesbachian), based on a very sparse occurrence of spores and pollen. The age of the latter interval is uncertain, due to sparse recovery of *in situ* palynomorphs and contamination of the samples due to caving of younger material.

The results have not been compared with other geological data from the well, and attempts to evaluate the results in a regional geological context have not been performed. An expanded study with more closely spaced samples could supplement important data to the existing knowledge from the region. Core material or sidewall cores would have allowed a more detailed and precise dating of the studied succession, especially in the Triassic.

Methods

Preparation for microfossils

The ditch cutting sample at 1595 m was prepared for the study of foraminifera and nannofossils.

Foraminifera. The sample was wet-sieved, and the 0.063 – 1 mm fraction was subsequently separated in heavy liquid (δ=1.8 g/cm^3). This increases the microfossil concentration within the light fraction.

Nannofossils. The sample was prepared using the standard smear slide method. A small amount of sediment was placed on a glass slide and a drop of distilled water added to make a sediment suspension. The suspension was smeared back and forth over the slide until a uniform rippled effect was obtained. The slide was quickly dried on a hotplate. Three drops of Norland Optical Adhesive were added to a coverslip and this was placed face down on the glass slide. The slide was left to cure for 12 hours in natural daylight. This procedure was used to prepare three different slides containing material from white limestone clasts, light grey limestone clasts and dark grey limestone clasts.

Preparation for palynomorphs

The samples have been prepared with standard palynological techniques. Mineral matter was removed by hydrochloric and hydrofluoric acids, and the organic content was oxidised with fuming nitric acid and washed with potassiumhydroxide to remove humic material. The standard preparation process was followed by specific treatment of each sample such as filtering with 11 or 20 micron mesh size, ultrasonic bath, swirling or heavy liquid separation. Five slides of different steps in the preparation were prepared for the analysis

The first slides was used mainly for evaluating the composition of the organic content but all slides from each sample were scanned for stratigraphic significant taxa, which then were recorded on a record-sheet. Taxa of secondary importance were not recorded.

Results

Micro- and nannofossil analysis

Sample 1595 m
Microfossils: Only a sparse foraminiferal fauna consisting of very small specimens were found. The planktic foraminifera are dominated by *Heterohelix* spp. and tiny, glassy *Hedbergella* spp. Apart from *Lenticulina* spp. only unidentifiable benthic foraminifera were observed.

Nannofossils: The nannoflora is dominated by abundant *Watznaueria barnesae*. Other-characteristic species include e.g. *Eprolithus floralis*, *Eifellithus eximius*, *Kamptneruis magnificus* and *Gartnerago obliquum*. Nannoconid nannofossils are very rare. Reworked nannofossils from the Cenomanian and caved nannofossils from the Campanian were observed in small numbers.

Depositional environment: Marine.

Age: The foraminiferal fauna, especially the occurrence of glassy *Hedbergella*, as well as the nannofloral assemblage indicate an early Late Cretaceous age, more precisely Early Coniacian or Late Turonian (nannofossil Zone NK14 B – NK 13D of Mortimer 1987).

Palynological analysis

Samples 1615 – 1635 m
This interval comprises Lower Cretaceous strata of Late Barremian to Late Albian? age.

DCS 1615 m
Content of OM: Poor organic content of black angular grains to lath shaped black woody material. Subordinate lumps of amorphous matter.

Palynomorphs: Extremely poor assemblage of spores and pollen, dinoflagellate cysts and acritarchs.

Dinoflagellate cysts: Common *Oligosphaeridium asterigerum*/*O. complex*. Presence of *Circulodinium distinctum*, *Cribroperidinium* spp., *Odontochitina operculata*, *Palaeoperidinium cretaceum*, *Stiphrospharidium anthophorum*, *Spiniferites* spp. Caved *Chatangiella granulifera* (Turonian–Campanian).

Depositional environment: Marine.

Age: Early Cretaceous, Late Barremian? to early Late Albian?.

Comments: Most of the species recorded here are represented only by one specimen, and their presence in this sample could be due to either reworking or caving. Many species, which normally are common in marine successions of Lower Cretaceous in NW-Europe, are not represented here. However, the significant species have a common stratigraphical overlap in the Lower Cretaceous. *Stiphrospharidium anthophorum* have stratigraphical top in the lower part of the Upper Albian (Costa & Davey 1992, Nøhr-Hansen 1993). *Palaeoperidinium cretaceum* and *Odontochitina operculata* occurs from the Upper Barremian into the Upper Cretaceous (Costa & Davey 1992).

DCS 1635 m
Content of OM: Poor organic content of black angular grains to lath shaped black woody material. Subordinate lumps of amorphous matter.

Palynomorphs: Dinoflagellate cysts relatively common, bisaccate pollen and trilete spores present.

Dinoflagellate cysts: *Cassiculosphaeridia magna*, *Cauca parva*, *Chlamydophorella nyei*, *Cribroperidinium* spp., *Dapsilidinium multispinosum*, *Dingodinium albertii*, *Gonyaulacysta fastigiata*, *Gonyaulacysta* spp., *Heslertonia heslertonensis*, *Hystrichodinium voigtii*, *Leptodinium hyalodermopse*, *Muderongia australis*, *Odontochitina operculata*, *Oligosphaeridium asterigerum*/*O. complex*, *Phoberocysta neocomica*, *Pseudoceratium pelliferum*, *Spiniferites* spp., *Subtilisphaera perlucida*. Caved *Apteodinium grande* and *Ovoidinium verrucosum* (Albian-Cenomanian), however the species could also represent contamination from drilling mud, which could be a bentonite of Cenomanian age.

Others: Foraminifera innerlinings.

Depositional environment: Marine.

Age: Early Cretaceous, Late Barremian.

Biozone: Upper part of the Odontochitina operculata Zone (Davey 1979).

Comments: Most of the species recorded here are represented only by a few specimens, and their presence in this sample could be due to either reworking or caving. However, the significant species have a common stratigraphical overlap in the Upper Barremian. *Cassiculosphaeridia magna* has its top in the (Upper) Barremian (Costa & Davey 1992), *Phoberocysta neocomica*, and *Pseudoceratium pelliferum* have stratigraphical top in the (Upper) Barremian/(Lower) Aptian (Lister & Batten 1988; Costa & Davey 1992). *Cauca parva* occurs from the Upper Barremian into Albian (Costa & Davey 1992) *Odontochitina operculata*, occurs from the Lower Barremian into Upper Cretaceous (Costa & Davey 1992).

Samples 1655 – 1700 m
This interval comprises Lower Jurassic strata of latest Pliensbachian or Early Toarcian age.

DCS 1655 m
Content of OM: Dominance of amorphous organic matter (AOM) and brown woody material associated with abundant spores and pollen.

Palynomorphs: Dominance of non-saccate pollen and spores, common bisaccate pollen and sporadic dinoflagellate cysts, *Tasmanites* and acritarchs.

Dinoflagellate cysts: *Nannoceratopsis gracilis*, *N. senex* and *Luehndea spinosa*.

Spores and pollen: Abundant *Spheripollenites psilatus* and *Corollina torosus*. Common: *Deltoidospora toralis* and *Marattisporites scabratus*. Sporadic: *Cerebropollenites macroverrucosus*, *Chasmatosporites apertus*, *C. hians*, *Ischysporites variegatus*, *Pinuspollenites minimus*, *Striatella* spp. and *Uvaesporites* spp.

Age: Early Toarcian, Early Jurassic.

Biozone: Terrestrial - *Spheripollenites-Leptolepidites* Zone. Marine - *Luehndea spinosa*/*Nannoceratopsis gracilis* Zone.

Depositional environment: Marine.

Comments: Abundance of *Spheripollenites psilatus* (sometimes referred to as sphaeromorph acritarchs) is a well known characteristica of the german Posidonia-shale and time-equivalent successions referred to the Lower Toarcian Falciferum Ammonite Zone (see further Dybkjær 1991). In the Danish area the *Spheripollenites – Leptolepidites* Zone was erected by Dybkjær (1991) to cover the succession with abundant *S. psilatus*. Co-occurrence of *Nannoceratopsis gracilis* and *Luehndea spinosa* strongly indicate a Late Pliensbachian or Early Toarcian age (Koppelhus and Nielsen 1994; Palliani and Riding 2000; Charnock *et al*. 2001).

DCS 1700 m
Content of OM: Dominated by brown and black woody material, while spores and pollen occur commonly. Sporadic AOM and marine palynomorphs.

Palynomorphs: Dominated by nonsaccate pollen. Bisaccate pollen and spores occur commonly. Dinoflagellate cysts and acritarchs occur sporadically.

Dinoflagellate cysts: *Nannoceratopsis gracilis*, *N. senex* and *N. triceras*.

Spores and pollen: Abundant *Corollina torosus* and *Perinopollenites elatoides*. *Alisporites robustus*, *Cerebropollenites macroverrucosus* and *Deltoispora toralis* are common. Presence of *Chasmatosporites apertus*, *C. elegans*, *Marattisporites scabratus*, *Pinuspollenites minimus*, *Quadraeculina anellaeformis* and *Spheripollenites psilatus*.

Age: Late Pliensbachian or Early Toarcian, Early Jurassic.

Biozone: Terrestrial – *Spheripollenites-Leptolepidites* Zone. Marine - *Luehndea spinosa*/*Nannoceratopsis gracilis* Zone.

Depositional environment: Marginal marine.

Comments: The sporadic occurrence of *Spheripollenites psilatus* indicates a Late Pliensbachian or Early Toarcian age. The occurrence of *Nannoceratopsis gracilis* indicates an age not older than the Late Pliensbachian (Woollam and Riding 1983; Palliani and Riding 2000).

Samples 1720 – 2075m
This interval comprises uppermost Triassic to Lower Jurassic strata of Rhaetian to Hettangian age. The occurrences of the dinoflagellate cyst species *Dapcodinium priscum* and *Rhaetogonyaulax rhaetica* strongly indicate a Rhaetian or Hettangian age. The absence of *Cerebropollenites macroverrucosus* further supports an age older than the Sinemurian.

DCS 1720 m
Content of OM: Dominated by minor pieces of brown and black woody material. Spores and pollen are common. Marine palynomorphs occur very sporadically.

Palynomorphs: Trilete spores, non-saccate and bisaccate pollen are common. Sporadic dinoflagellate cysts and acritarchs.

Dinoflagellate cysts: A single specimen of *Dapcodinium priscum* was found.

Pollen and spores: Common occurrences of *Perinopollenites elatoides*, *Deltoidospora toralis* and *Pinuspollenites minimus*. Sporadic occurrences of *Alisporites robustus*, *Cerebropollenites thiergartii*, *Chasmatosporites hians*, *Corollina torosus*, *Eucommiidites troedssonii*, *Lycopodiumsporites clavatoides*, *Marattisporites scabratus* and *Quadraeculina anellaeformis*.

Age: Hettangian, Early Jurassic.

Biozone: Terrestrial – *Pinuspollenites-Trachysporites* Zone. Marine - *Dapcodinium priscum* Zone.

Depositional environment: Marginal marine.

Comments: The absence of Rhaetian marker species (e.g. *Ricciisporites tuberculatus* and *Rhaetogonyaulax rhaetica*) is here interpreted as indicating a Hettangian or Early Sinemurian age. The absence of *Cerebropollenites macroverrucosus* indicates an age older than the Sinemurian. *Dapcodinium priscum* ranges from the Rhaetian to the Early Sinemurian.

DSC 1930 m
Content of OM: Dominated by brown and black woody material. Palynomorphs are common.

Palynomorphs: Dominated by non-saccate pollen. Bisacate pollen, spores and dinoflagellate cysts occur commonly.

Dinoflagellate cysts: Common *Rhaetogonyaulax rhaetica* and sporadic *Dapcodinium priscum*.

Spores and pollen: Dominated by *Perinopollenites elatoides*. *Corollina torosus*, *Deltoidospora toralis* and *Ricciisporites tuberculatus* are common while *Alisporites robustus*, *Pinuspollenites minimus*, *Quadraeculina anellaeformis*, *Triancoraesporites ancorae* and *Vitreisporites pallidus* occur sporadically.

Age: Rhaetian, Late Triassic.

Biozone: Terrestrial – ? Marine – *Rhaetogonyaulax rhaetica* Zone.

Depositional environment: Marine.

Comments: The co-occurrence of *Rhaetogonyaulax rhaetica* and *Dapcodinium priscum* strongly indicates a Rhaetian age. The occurrence of *Ricciisporites tuberculatus* and *Triancoraesporites ancorae* support a Rhaetian age. The absence of the zone-fossils *Limbosporites lundbladii*, *Polypodiisporites polymicroforatus*, and *Rhaetipollis germanicus* makes it impossible to place this sample within the detailed zonation of Lund (1977).

DCS 2025 m
Content of OM: Dominated by brown and black woody material. Palynomorphs are common.

Palynomorphs: Dominated by non-saccate pollen and trilete spores. Bisaccate pollen and dinoflagellate cysts occur sporadically.

Dinoflagellate cysts: *Dapcodinium priscum* occurs sporadically.

Pollen and spores: Dominated by *Deltoidospora toralis* and *Perinopollenites elatoides*. *Corollina torosus*, *Intrapunctisporis toralis*, *Ricciisporites tuberculatus* and *Uvaesporites* spp. are common, while *Alisporites radialis*, *Chasmatosporites hians*, *C. elegans*, *Conbaculatisporites mesozoicus*, *Corollina meyeriana*, *Lycopodiumsporites clavatoides*, *Marattisporites scabratus*, *Pinuspollenites minimus* and *Platyptera trilingua* occur sporadically.

Age: Rhaetian, Late Triassic.

Biozone: Terrestrial – ? Marine – *Rhaeotogonyaulax rhaetica* Zone.

Depositional environment: Marginal marine.

Comments: The common occurrence of *Ricciisporites tuberculatus* and the presence of *Dapcodinium priscum* strongly indicate a Rhaetian age. The absence of the zone-fossils makes it impossible to place this sample within the detailed zonation of Lund (1977).

DCS 2075 m
Content of OM: Black and brown woody material dominates. Cuticle occurs sporadically. Palynomorphs are common.

Palynomorphs: Bisaccate pollen and trilete spores dominate. Non-saccate pollen are common while dinoflagellate cysts occur sporadically to commonly.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica* are sporadic to common.

Pollen and spores: Dominated by *Deltoidospora toralis* and *Pinuspollenites minimus*. *Corollina torosus* and *Ricciisporites tuberculatus* occur commonly, while *Alisporites robustus*, *Corollina meyeriana*, *Lycopodiumsporites semimuris*, *Perinopollenites elatoides* and *Zebrasporites interscriptus* occur sporadically.

Age: Rhaetian, Late Triassic.

Biozone: Terrestrial – ? Marine – *Rhaetogonyaulax rhaetica* Zone.

Depositional environment: Marginal marine.

Sample 2395 m
This sample cannot be dated more precisely than Triassic. The *in situ* material is extremely sparse and comprises only a few unidentifiable non-striate, bisaccate pollen.

DCS 2395 m
Content of OM: Generally a sparse content of organic matter. Dominated by brown and black woody material. Palynomorphs are common.

Palynomorphs: Bisaccate pollen, non-saccate pollen and trilete spores are all common. Freshwater algae (*Botryococcus* spp.) and *Tasmanites* spp. occur sporadically. The palynomorphs varies in color, indicating caving.

Dinoflagellate cysts: None *in situ*. The common occurrence of *Nannoceratopsis* spp. is interpreted as being a result of caving.

Pollen and spores: Dominated by *Corollina torosus* and *Pinuspollenites minimus*. *Alisporites robustus*, *Baculatisporites* spp./*Conbaculatisporites* spp., *Deltoidospora toralis*, *Eucommiidites minor*, *Monosulcites minimus*, *Perinopollenites elatoides*, *Pinuspollenites pinoides*, *Quadreaculina anellaeformis* and *Uvaesporites* spp. occur sporadically. A few unidentifiable dark brown bisaccate, non-striate pollen have also been found.

Age: Questionable. The occurrence of *Nannoceratopsis* spp. indicate an age not older than the Late Pliensbachian while the dominance of *C. torosus* and *P. minimus* and the general palynoassemblage compare mostly to Hettangian assemblages (*Pinuspollenites - Trachysporites* Zone). However, the datings of the samples above as Rhaetian and the recordings of the unidentifiable dark brown bisaccate, non-striate pollen indicate that most of the palynomorph assemblage is caved and that the age is older than the Rhaetian, but probably Triassic.

Biozone: Questionable.

Depositional environment: Presumably terrestrial.

Comments: Due to severe caving *in situ* palynomorphs are very sparse. Therefore it is not possible to refer this sample to biozones, or to date it more precisely than Triassic.

Samples 2625 – 2670 m
This interval is referred to ?Early Triassic, based on the recovery of a few stratigraphically important, presumed *in situ*, spores and pollen. Also in these samples caving is a severe problem.

DCS 2625 m
Content of OM: Dominated by brown and black woody material and palynomorphs.

Palynomorphs: Dominated by bisaccate pollen. Non-saccate pollen and spores are common, while only a single acritarch (*Baltisphaeridium* spp.) and no dinocysts were found.

Dinoflagellate cysts: None *in situ*. The occurrence of a single specimen of *Nannoceratopsis gracilis* is interpreted as being the result of caving.

Pollen and Spores: *Protodiploxypinus potonei* dominates while *Triadispora* spp. is common. The following presumed *in situ* species occur sporadically; ?*Cycloverrutriletes resselensis*, ?*Enzonalasporites vigens*, *Klausipollenites* spp., *Lundbladispora obsoleta*, *Striatites* spp., *Taeniaesporites* spp., *Tsugapollenites oriens* and *Verrucosisporites* spp.

The occurrence of the following spores and pollen; *Chasmatosporites thiergartii*, *Corollina torosus*, *C. meyeriana*, *Lycopodiumsporites clavatoides*, *Marattisporites scabratus*, *Pinuspollenites minimus*, *Striatella* spp., and the dinoflagellate cyst *Nannocerotopsis gracilis* are strongly presumed to be due to caving from Lower Jurassic sediments. Some of the spores and pollen mentioned above (e.g. *Triadispora*, *Protodiploxypinus potonei*), may also be due to caving, as they are not mentioned as being characteristic for the *obsoleta – pantii* Zone (see below), but are common in the Upper Muschelkalk and Keuper in Poland.

Age: ?earliest Scythian (Griensbachian), Early Triassic. The presence of one specimen of *Lundbladispora obsoleta* may indicate an Early Triassic age. The presence of this species together with *Protohaploxypinus pantii*, found in the sample below, characterise the *obsoleta – pantii* Zone of Orlowska-Zwolinska (1983; 1985), defined in the lower Buntsandstein in Poland. The *obsoleta – pantii* Zone is referred to the earliest Scythian, (Griesbachian) (Fijalkowska-Mader 1999).

The general palynomorph assemblage with common occurrences of *Protodiploxypinus potonei* and *Triadispora* spp. correlates better to Upper Muschelkalk or Keuper (Fijalkowska-Mader 1999), and the single specimen of *L. obsoleta* could be reworked.

However, due to the abundant caving in the well, most confidence is placed on the oldest events, suggesting that this sample should be referred to the Early Triassic, Scythian.

Biozone: ?The *obsoleta – pantii* Zone (Orlowska-Zwolinska 1983; 1985) (Lower Buntsandstein).

Depositional environment: ?Terrestrial. The single recordance of the acritarch *Baltisphaeridium* spp. may indicate a weak influx from a marine environment, or its occurrence may be due to caving.

DCS 2670 m
Content of OM: Dominated by brown and black woody material. Palynomorphs are sporadic to common.

Palynomorphs: Dominated by bisaccate pollen. In addition a few, presumed caved, non-saccate pollen were recorded.

Dinoflagellate cysts: None.

Pollen and Spores: *Protodiploxypinus potonei* and *Klausipollenites* spp. dominates while *Brachysaccus* spp., *Granuloperculatipollis rudis*, *Ovalipollis ovalis* and *Triadispora* spp., are common. The taxa *Protohaploxypinus pantii*, *Ricciisporites tuberculatus* and *Taniaesporites* spp. occur sporadically.

Age: ?earliest Scythian (Griensbachian), Early Triassic. See the discussion for the sample above. The recordings of *G. rudis*, *R. tuberculatus* and *O. ovalis* strongly indicate caving from the Norian or Rhaetian (Lund 1977; Fijalkowska-Mader 1999). The common occurrence of *P. potonei* and *Triadispora* spp. further indicate caving from the Upper Muschelkalk or Keuper (Fijalkowska-Mader 1999).

Biozone: ?The *obsoleta – pantii* Zone (Orlowska-Zwolinska 1983; 1985) (Lower Buntsandstein).

Depositional environment: Terrestrial.

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