Capture, Storage and Use of CO₂ (CCUS)

Palynology of the Gassum and lowermost Fjerritslev formations in the Stenlille area: biostratigraphic and palaeoenvironmental implications (Part of Work package 5 in the CCUS project)

Sofie Lindström



GEOLOGICAL SURVEY OF DENMARK AND GREENLAND DANISH MINISTRY OF CLIMATE, ENERGY AND UTILITIES

Capture, Storage and Use of CO₂ (CCUS)

Palynology of the Gassum and lowermost Fjerritslev formations in the Stenlille area: biostratigraphic and palaeoenvironmental implications (Part of Work package 5 in the CCUS project)

Sofie Lindström



Preface

Late 2019, GEUS was asked to lead research initiatives in 2020 related to technical barriers for Carbon Capture, Storage and Usage (CCUS) in Denmark and to contribute to establishment of a technical basis for opportunities for CCUS in Denmark. The task encompasses (1) the technical potential for the development of cost-effective CO2 capture technologies, (2) the potentials for both temporary and permanent storage of CO2 in the Danish subsurface, (3) mapping of transport options between point sources and usage locations or storage sites, and (4) the CO2 usage potentials, including business case for converting CO2 to synthetic fuel production (PtX). The overall aim of the research is to contribute to the establishment of a Danish CCUS research centre and the basis for 1-2 large-scale demonstration plants in Denmark.

The present report forms part of Work package 6 and focuses on a palynological investigation of the depositional environment of the Gassum Formation and the lowermost part of the Fjerritslev Formation of the Stenlille structure within a sequence stratigraphic framework.

Content

Preface	4
Dansk sammendrag	5
Summary	7
Introduction	10
Database	11
Results	12
Below base Gassum Fm	11
Sequence 1 (in part; Base Gassum Fm–SB2)	12
Sequence 2 (SB2–SB3)	12
Sequence 3 (SB3–SB4)	12
Sequence 4 (SB4–SB5)	14
Sequence 5 (SB5–SB6)	15
Sequence 6 (SB6–SB7)	17
Sequence 7 (SB7–SB8)	18
Sequence 9 (in part: Above SB9 to top of core)	19
Sequence 9 (in part, Above SB9 to top of core)	21
Suggestion for further work	22
References	23
Figures and table	25

Dansk sammendrag

Palynologi er studiet af organiske syre-resistente mikrofossiler, der omfatter bland andet: sporer og pollen fra landplanter, ferskvandsmikroalger fra søer og floder, og marine fytoplankton (dinoflagellater og akritarker) fra hav. Foruden disse fossile grupper indeholder en palynologisk prøve oftest også vedrester, kulpartikler, planterester og amorft materiale. En prøve der stammer fra landområder vil typisk ikke indeholde marine fytoplankton, mens en prøve af materiale dannet til havs kan indeholde både marine mikroalger, og afhængig af hvor langt fra land den er dannet, forskellige mængder af sporer og pollen og ferskvandsalger.

Der er her udført en palynologisk undersøgelse af cuttings (cu; borespåner), sidevægskerner (swc) og kerneprøver (co) fra syv brønde på tværs af Stenlille-strukturen, med det formål at tolke variationer i aflejringsmiljø over intervallet fra bund Gassum Formationen til den nedre del af Fjerritslev Formationen. Undersøgelsen er et bidrag til etablering af en reservoirmodel for Gassum formationen i den nærliggende Havnsø struktur. Kerneprøver anses for at være de mest pålidelige idet dybde of sedimentær facies kendes præcist, mens prøver af borespåner ofte vil indeholde en del spåner fra overliggende lag. Resultaterne vises på et sydvest–nordøst orienteret logpanel og indenfor det sekvens stratigrafiske rammeværk præsenteret i Vosgerau et al. (2020) og Hovikoski & Pedersen (2020).

Cuttingsprøver fra Vinding formationen under basis af Gassum Formationen i Stenlille-4 i sydvest og Stenlille-6 i nordøst indikerer, at sedimenterne herfra blev dannet i kystnære områder. Kun en enkelt cu-prøve (Stenlille-15) er analyseret fra intervallet fra basis af Gassum Formationen til sekvensgrænsen SB2 og denne indikerer ligeledes aflejring i et kystnært miljø. Ingen prøver er analyseret fra Sekvens 2.

Inden for Sekvens 3 skiftede aflejringsmiljøet i sydvest mellem kystnært, grundmarint, terrestriskt og kystnært, i følge cuttingsprøver fra Stenlille-15. Kystnær sedimentation kan også påvises i den øvre del af sekvensen i Stenlille-4. I nordøst synes kystnære til grundmarine forhold at være udviklet, baseret på analyser af cu-prøver fra Stenlille-6. Her kan prøverne dog muligvis være forurenet af, at yngre materiale er faldet ned i borehullet under boringen.

Længst mod sydvest (repræsenteret ved Stenlille-15) synes sedimenterne at være dannet på land og i kystnære miljøer under Sekvens 4. Kystnære sedimentation er også påvist i Stenlille-4. I Stenlille-18 svinger miljøet også mellem at være kystnært og land, men i Stenlille-1 og længst i nordøst i Stenlille-6 ses skift mellem kystnære og lavmarine miljøer.

Inden for Sekvens 5 udvikledes fuldt marine forhold omkring TS5 i sydvest, i følge prøver fra Stenlille-15, men i Stenlille-4 var forholdene mere grundmarine. I Stenlille-18 og Stenlille-1 synes der at have været grundmarin til kystnære aflejringsmiljøer, medens der primært var et kystnære miljø i nordøst.

l den nedre del af Sekvens 6 var der kystnære aflejringsforhold i sydvest (Stenlille-4), mens prøver fra den øvre del af sekvensen viser fuldt marine forhold. De fuldt marine forhold er

også påvist i cuttingsprøver fra den øvre del af Sekvens 6 i Stenlille-15. Et lignende skift fra grundmarine til fuldt marine forhold ses op gennem Sekvens 6 i Stenlille-1.

Prøver fra den nedre del af Sekvens 7 viser, at der rådede fuldt marine forhold i Stenlilleområdet. Det er kun i en enkelt prøve fra toppen af Gassum Formationen i Stenlille-2, at der ses indikationer på et kystnært miljø, men også her er der et skift til fuldt marine forhold ved basis af Fjerritslev Formationen. Under aflejringen af den øvre del af sekvensen sker der et havniveau fald og grundmarine forhold synes at råde i området.

Sekvens 8 kan med fordel opdeles i to dele, adskilte af MFS8. Den nedre del svarer til de såkaldte "event beds" for den slut-Triassiske masseuddøen (Lindström et al. 2012, 2015). Dette interval er tolket som dannet i et lavmarint miljø men med stor tilførsel af sedimenter fra land. Dette kan ses på den store mængede omlejrede palynomorfer i prøver fra både Stenlille-4 og Stenlille-1, der indikerer samtidig øget forvitring og erosion på land. Lige under MFS8 sker en opblomstring af ferskvandsalger, enten på grund af øget tilførsel af ferskvand eller udvikling af lagunemiljøer. I den øvre del, over MFS8, indikerer data fra Stenlille-4, -2, - 5, og -1 kystnære til grundmarine forhold og et faldende input af ferskvand opad.

I den øverste del af det undersøgte interval, dvs i den nedre del af Sekvens 9, viser analyser af prøver fra Stenlille-4 kystnære til fuldt marine forhold, medens prøver fra Stenlille-2 og -1 viser en udvikling fra grundmarine til fuldt marine forhold.

Analysen har således frembragt indikationer på den vertikale og laterale fordeling af aflejrings miljøer og bjergartstyper, som anvendes som input til den sekvenstratigrafiske tolkning af Gassum og Fjerritslev formationerne i Stenlille området, som danner udgangspunkt for en model for den nærliggende Havnsø struktur.

Summary

A palynological investigation of core, sidewall core and cuttings samples from seven wells across the Stenlille structure, has been carried out, in order to provide information on the variations in the depositional environment over the stratigraphic interval covering the Gassum to lowermost Fjerritslev formations with the scope of providing input to the reservoir model for the closely located Havnsø structure. The results are displayed on a well transect from southwest to northeast, and divided into sequences following the sequence stratigraphic framework used in Vosgerau et al. (2020) and Hovikoski & Pedersen (2020). The results of the palynological assessment of the depositional environment are summarized below and in Table 1.

Below the base of the Gassum Formation, cuttings samples from Stenlille-4 in the SW, and Stenlille-6 in the NE representing the upper part of the Vinding Formation, both indicate marginal marine conditions in the Stenlille area in accordance with the interpretation of Bertelsen (1978) of the Vinding Fm.

One sample from Stenlille-15 is so far the only sample from the Base Gassum Fm–SB2 interval, and it indicates that marginal marine conditions prevailed in the southwest.

No samples have been analyzed from Sequence 2 so far.

Within Sequence 3 conditions seem to have fluctuated between marginal marine, shallow marine, terrestrial, and marginal marine environment the southwest, as indicated by cuttings samples from Stenlille-15. One sample from the top of the Sequence 3 in Stenlille-4 also indicates marginal marine conditions. In the northeast marginal marine to shallow marine conditions may have prevailed, as indicated by cuttings samples from Stenlille-6, although the data can be disturbed by caving of younger material.

Within Sequence 4, while terrestrial to possibly marginal marine conditions prevailed in Stenlille-15 furthest to the southwest, marginal marine conditions developed in Stenlille-4. In Stenlille-18 conditions also fluctuated between marginal marine and fully terrestrial, while further to the northeast, in Stenlille-1 and -6 marginal marine to shallow marine conditions developed.

In Sequence 5 fully marine conditions had formed around TS5 in the southwest, as indicated by a core sample in Stenlille-15, but in Stenlille-4 shallow marine conditions prevailed. Shallow marine to marginal marine environments developed in Stenlille-18 and -1, while in Stenlille-6 further to the northeast, marginal marine conditions prevailed.

In the lower part of Sequence 6 marginal marine conditions had developed to the southwest (Stenlille-4), but in the upper part fully marine conditions developed. This is corroborated by a cuttings sample from the upper part of Sequence 6 in Stenlille-15, which also suggests fully marine conditions. Similarly, in Stenlille-1 to the northeast, conditions fluctuated between shallow marine and fully marine.

To the southwest, fully marine conditions continued in Sequence 7 in Stenlille-4. Fully marine conditions were also recorded in Stenlille-5 and -1 to the northeast. In Stenlille-2, from the center of the structure, a core sample from the top of the Gassum Fm suggests deposition in a marginal marine environment, but at the base of the Fjerritslev Fm fully marine conditions had developed. A shallowing towards the top of Sequence 7 is registered in Stenlille-2 and -1 towards shallow marine conditions.

In Sequence 8, the interval below MFS8 in Stenlille-4 and -1 represents the end-Triassic event beds; the Grey siltstone interval of Lindström et al. (2012, 2015). This interval is interpreted as having been deposited in a shallow marine environment with high input of siliciclastic material and increased abundances of reworked palynomorphs, signaling ongoing weathering and erosion on land. Just below MFS8 blooms of freshwater algae are recorded signaling either large scale input of freshwater to the basin or a development of lagoonal conditions. Above MFS8 data from Stenlille-4, -2, -5 and -1, indicate marginal marine to shallow marine conditions with high input of freshwater continuing in the northeast, but decreasing up section.

In the lower part of Sequence 9 marginal to fully marine conditions developed in Stenlille-4 in the southwest, while further to the northeast shallow marine to fully marine conditions pre-vailed in Stenlille-2 and Stenlille-1.

Introduction

In order to better understand variations in depositional environment across the Stenlille structure, through the Gassum to the lower part of the Fjerritslev formations, a palynological investigation has been carried out on core (co), sidewall core (swc) and cuttings (cu) samples from Stenlille wells along a transect from the southwest to the northeast (Fig. 1). The purpose is to provide input to the reservoir model for the closely located Havnsø structure. Palynology is herein not only used for biostratigraphic purposes, i.e. dating of the sedimentary succession, but also for providing environmental data for the sedimentological report (Hovikoski & Pedersen, 2020) and seismic 3D interpretation (Vosgerau et al. 2020).

Quantitative assessments of the palynological assemblages in the studied samples allows assignment to general categories of depositional environment. This is because spores and pollen, and also freshwater algae, represent vegetation on land and in lakes, mires and rivers, while marine dinoflagellate cysts, prasinophytes and acritarchs represent the marine environment. The following distinctions are made:

- **Fully marine conditions.** Marine phytoplankton; i.e. dinoflagellate cysts, acritarchs and prasinophytes, are dominant to highly abundant. In general, wind pollinated pollen are more abundant in these samples as they can be transported further from the coast.
- **Shallow marine conditions.** Marine phytoplankton are abundant. The spore-pollen flora is often quite varied, depending on proximity to freshwater sources that can transport spores and non-wind dispersed pollen to the basin.
- *Marginal marine conditions.* Minor amounts of marine phytoplankton are present. Freshwater algae may be common. Depending on which type of marginal marine environment the assemblage represents, the spore-pollen flora can vary in composition.
- **Terrestrial conditions.** Spores and pollen dominate. Freshwater algae can be present depending on the type of terrestrial environment.

For cuttings samples, 200 palynological specimens have been counted per sample. Since cuttings samples are often contaminated by caved material during the drilling operations, estimate of the confirmed caved percentage in each sample is given. For sidewall cores and core samples up to 300 specimens were counted per sample. In some cases, where very few or no palynomorphs were identified in the samples, an assessment of the palynodebris, i.e. black phytoclasts, wood remains, plant tissues, cuticles or amorphous organic matter, have been noted. The overall palynological composition of the samples can be seen in a sequence stratigraphic framework along the transect on Figure 2 and is summarized in Table 1.

Database

The palynological data reported herein are from seven of the Stenlille wells, namely: Stenlille-15, Stenlille-4, Stenlille-18, Stenlille-2, Stenlille-5, Stenlille-1 and Stenlille-6. The detailed results are shown on Figures 3–9. Due to COVID-19 restrictions at GEUS during the spring, summer and autumn of 2020, additional analyses of samples from Stenlille-2, -5, -14, -17, - 18, and -19, have been delayed.

Parts of the data reported herein have previously been reported in various publications dealing with the end-Triassic mass extinction event and the Triassic–Jurassic boundary (e.g. Dybkjær 1991; Lindström 2016; Lindström et al. 2012, 2015, 2017, 2019). The detailed palynology of Stenlille-1 and Stenlille-4 across that interval will be published in an upcoming paper (Lindström et al. in prep.).

Results

The results are presented under sequence stratigraphic intervals following Vosgerau et al. (2020). The results for each interval are discussed below in ascending order, and within each interval the data from the wells are presented in the order the wells are located from southwest to northeast along the transect shown on Figs. 1 and 2. The results are furthermore compared and summarized under "Interval comments". In addition, the results for each well are summarized in Table 1. Range charts for each well are displayed on Figs. 3–9.

Below base Gassum Fm

Stenlille-4 (Fig. 4)

A cuttings sample (1662 m) from the uppermost Vinding Formation, below the base of the Gassum Fm, is dominated by terrestrial spores and pollen, with only minor percentages of marine acritarchs and dinoflagellate cysts, 3.5%, that may be *in situ* or caved from Rhaetian beds above. If they are *in situ*, they indicate a marginal marine environment., which is in line with the interpretation that the Vinding Formation comprises shallow and restricted marine deposits (Bertelsen 1978; Nielsen 2003) The presence of *Vallasporites ignacii* and *Enzonalasporites vigens* may indicate an age not younger than the early Rhaetian (Schulz and Heunisch 2005) (Fig. 4). The presence of the acritarch *Celyphus stenlillensis* is noteworthy, as Batten et al. (1994) suggest that it is of marine affinity. The confirmed caved palynomorphs comprise 3% of the total assemblage, but because many of the spore and pollen taxa are long-ranging, the true percentage may be higher.

Stenlille-6 (Fig. 9)

A cuttings sample (1713–1716 m) from the uppermost Vinding Formation, below the base of the Gassum Fm, is dominated by spores and pollen, with minor amounts of marine acritarchs and dinoflagellate cysts, 6.6%, that may be *in situ* or caved from Rhaetian beds above (Fig. 9). Late Early Jurassic and younger (Cretaceous) dinoflagellate cysts are present in the sample, indicating caving from these intervals. The confirmed caved palynomorphs comprise 2.5% of the total assemblage, but because many of the spore and pollen taxa are long-ranging, the true percentage may be much higher. If the marine phytoplankton are *in situ*, this indicates a marginal marine environment, further corroborating the palaeoenvironmental interpretation by Bertelsen (1978).

Interval comments

Cuttings samples from Stenlille-4 in the SW and Stenlille-6 in the NE both indicate marginal marine conditions.

Sequence 1 (in part; Base Gassum Fm-SB2):

Stenlille-15 (Fig. 3)

A cuttings sample from 1675m contains a relatively sparse palynoflora that is dominated by spores and pollen, with minor percentages, 3.5%, of marine acritarchs, predominantly *Celyphus stenlillensis*, a palynomorph suggested to be of marine affinity by Batten et al. (1994). There are no confirmed caved occurrences in this sample (Fig. 3).

Interval comments

The sample from Stenlille-15 is so far the only sample from the Base Gassum Fm–SB2 interval and indicates that marginal marine conditions prevailed in the SW (Fig. 2; Table 1).

Sequence 2 (SB2–SB3):

No samples were analyzed from this interval.

Sequence 3 (SB3–SB4):

Stenlille-15 (Fig. 3)

Seven cuttings samples from 1666m to 1633m were analysed within the SB3–SB4 interval. They are all dominated by spores and pollen. From 1666m to 1642m there is an increase in the abundance of marine dinoflagellate cysts, primarily *Dapcodinium priscum*, but also occurrences of *Rhaetogonyaulax rhaetica* and *Lunnomidinium scaniense* α and β , suggesting deposition in a marginal marine environment with increased marine influence up section (Fig. 3). The assemblage from 1642m contains large amounts of blade shaped wood fragments, plant tissue and tube-like tissue. This sample also contains higher abundances of bisaccate pollen compared to the assemblages below and above, and this together with the large amounts of blade-shaped wood may indicate deposition in a lagoonal to shoreface environment (compare e.g. with Dybkjær et al. 2019), i.e. marginal marine to shallow marine conditions.

The marine influence appears to have ceased in the samples from 1636m and 1633m. In the assemblage from 1636m, *Classopollis* spp. have decreased markedly in abundance. The spore-pollen flora is dominated by *Perinopollenites elatoides*, with common *Aratrisporites* spp. (Fig. 3). The pollen *Perinopollenites elatoides*, was produced by cupressacean conifers that are believed to have grown in forested mires close to the coast (see e.g. Petersen and Lindström 2012; Petersen et al. 2013). Spores assigned to *Aratrisporites* were produced by isoetalean lycopsids (Balme 1995), of which some species were halophytes colonizing broad

tidal flats (Retallack 1975). This may suggest deposition on a coastal plain. Rare occurrences of dinoflagellate cysts may corroborate this interpretation. In the succeeding assemblage from 1633m, no marine palynomorphs were recorded and *Perinopollenites elatoides* dominate, while only minor *Aratrisporites* are recorded. This may suggest deposition in a coastal mire.

The two uppermost cuttings samples from the SB3–SB4 interval again show evidence of marginal marine influence with rare occurrences of marine acritarchs and dinoflagellate cysts. The spore-pollen flora is dominated by *Perinopollenites elatoides*.

Stenlille-4 (Fig. 4)

One cuttings sample from 1629m close to the top of the SB3–SB4 interval is dominated by spores and pollen, with very minor amounts of marine acritarchs and dinoflagellate cysts. Confirmed caved palynomorphs account for 2% of the palynoflora and includes Sinemurian and Cretaceous dinoflagellate cysts (Fig. 4). Hence, there is a possibility that the marine acritarchs are also caved. The sample contains lots of cuticles and wood fragments. The high abundances of *Perinopollenites elatoides*, which may suggest deposition in a flood plain environment (e.g. Dybkjær et al. 2019).

Stenlille-6 (Fig. 9)

Two cuttings samples from 1683–1677m and 1671–1677m are dominated by spores and pollen. Both samples contain marine acritarchs and dinoflagellate cysts. The amount of confirmed caving in the samples are 5.5% and 4.9%, respectively, and includes Sinemurian and Cretaceous palynomorphs (Fig. 9). Except for a specimen tentatively assigned to *Sverdrupiella* sp., the only Rhaetian dinoflagellate cyst present in the samples is *Dapcod-inium priscum*, with 2% and 5.9%, respectively. There is a possibility that these are caved. If not, the abundances of marine palynomorphs indicate deposition in marginal marine to shallow marine environments.

Interval comments

In Sequence 3 conditions seem to have fluctuated between marginal marine, shallow marine, terrestrial, and marginal marine environment in Stenlille-15 to the SW. One sample from the top of the interval in Stenlille-4 also indicates marginal marine conditions. In Stenlille-6 to the northeast, marginal marine to shallow marine conditions may have prevailed, although the data can be disturbed by caving of younger material (Fig. 2; Table 1).

Sequence 4 (SB4–SB5):

Stenlille-15 (Fig. 3)

Two core samples were prepared from the SB4–SB5 interval. The lower sample from 1613.64–1613.65m is completely dominated by spores and pollen, and no marine palynomorphs were registered. The spore-pollen flora continues to be dominated by *Perinopollenites elatoides*, and in this sample *Chasmatosporites* spp. are also common (Fig. 3). The depositional environment is interpreted as terrestrial. The succeeding core samples, 1604.27–1604.29m, has not yet been counted, but does contain rare dinoflagellate cysts. This probably indicates a marginal marine environment.

Stenlille-4 (Fig. 4)

A cuttings sample from 1593m is dominated by terrestrial palynomorphs, but contains rare marine dinoflagellate cysts, *Dapcodinium priscum* and *Rhaetogonyaulax rhaetica*, and acritarchs that may be *in situ*. The freshwater alga *Botryococcus braunii* was also registered (Fig. 4). The sample also contains rare caved palynomorphs from the Hettangian and Pliensbachian. The spore-pollen flora is dominated by *Perinopollenites elatoides*, and bisaccate pollen are common. Together, this may indicate a marginal marine environment.

Stenlille-18 (Fig. 5)

Five core samples from the SB4–SB5 interval indicate an environment fluctuating between terrestrial to marginal marine. The lowermost sample (1674.30–1674.60m) is totally dominated by spores and pollen indicating deposition in a terrestrial environment. It also contains a lot of black phytoclasts and black wood remains. The two succeeding samples (1663.5–1663.6m and 1662.4m) were not counted, as these are dominated by wood remains and plant tissue with very few palynomorphs. No marine palynomorphs were observed in these two core samples. In the remaining samples, marine palynomorphs are present but rare, indicating marginal marine environments, except for the assemblage from 1656.65m which only contains spores and pollen, and indicates fully terrestrial deposition. *Ricciisporites tuberculatus* dominates the lowest sample (Fig. 5). In the others, cheirolepid pollen and *Perinopollenites elatoides* are abundant. The upper two samples are dominated by *P. elatoides*.

Stenlille-1 (Fig. 8)

Two sidewall cores were analyzed from the upper part of Sequence 4, and these were both dominated by spores and pollen, with low abundances of marine dinoflagellate cysts and acritarchs. The freshwater alga *Botryococcus braunii* also occurs in low abundances (Fig. 8). The spore pollen flora is dominated by *P. elatoides, R. tuberculatus* and cheirolepidacean pollen. Deposition most likely took place in a marginal marine to shallow marine environment.

Stenlille-6 (Fig. 9)

One cuttings sample from the upper part of the massive sandstone unit in Sequence 4 contains common marine dinoflagellate cysts, primarily *D. priscum*, but also *R. rhaetica*. The spore-pollen flora is dominated by *Perinopollenites elatoides*, with abundant tree fern spores, cheirolepidiacean pollen and *R. tuberculatus*. *Ovalipollis ovalis* is also common (Fig. 9). Confirmed caving is 2%. If *in situ* the marine phytoplankton indicate marginal to shallow marine conditions.

Interval comments

In Sequence 4 terrestrial conditions prevailed in Stenlille-15 in the SW, and marginal marine conditions developed in Stenlille-4. In Stenlille-18 the conditions fluctuated between marginal marine and fully terrestrial, and in Stenlille-1 marginal marine to shallow marine conditions developed, the latter also in Stenlille-6 to the NE (Fig. 2; Table 1). In general, the massive sandstone in the lower part of Sequence 4 appear to have been deposited in a terrestrial environment.

Sequence 5 (SB5–SB6):

Stenlille-15 (Fig. 3)

One core sample, 1572.21–1572.22m, is dominated by marine dinoflagellate cysts and acritarchs. *Dapcodinium priscum* is the most dominating dinocyst, but the assemblage also contains *Beaumontella? caminuspina*, *Lunnumidinium scaniense* ß, and *Suessia swabiana* (Fig. 3). The spore-pollen flora is dominated by cheirolepidiacean pollen (35%); *Classopollis classoides, C. meyerianus, Corollina (Geopollis) zwolinskai,* and *Granuloperculatipollis rudis* (Fig. 3). Members of the extinct conifer family, Cheirolepidiaceae, are generally considered to have preferred a subtropical to tropical, drier climate (Vakhrameev, 1981, 1991). The cheirolepids were wind-pollinated (Ziaja 2006). At least some members were adapted to coastal habitats (Batten 1974; Abbink 1998). *Perinopollenites elatoides* are common, but not dominant. This suggests deposition in a fully marine environment, off a coast with cheirolepid conifers.

Stenlille-4 (Fig. 4)

Two cuttings samples, from 1572m and 1557m, and one core sample from 1543.5m were analyzed from the SB5–SB6 interval. The samples are dominated by terrestrial palynomorphs, but marine dinoflagellate cysts and acritarchs are common. The most common marine palynomorph in all three samples is *Dapcodinium priscum*, but *Rhaetogonyaulax rhaetica* and *Beaumontella? caminuspina* was also registered. The core sample also contains *Celyphus stenlillensis* (Fig. 4). No freshwater algae were recorded. The spore-pollen flora in

the cuttings samples is dominated by cheirolepidacean conifer pollen, and *Perinopollenites elatoides* are also abundant. In the core sample *P. elatoides* dominates over the cheirolepidacean pollen. There are no confirmed caved palynomorphs in the two cuttings samples. The depositional environment is interpreted as shallow marine.

Stenlille-18 (Fig. 5)

Four core samples were analyzed from the SB5–SB6 interval. The three lowest samples are dominated by spores and pollen, with very low abundances of marine acritarchs and dino-flagellate cysts, indicating deposition in marginal marine environments. Cheirolepidacean co-nifer pollen dominates together with *P. elatoides,* and tree fern spores (*Deltoidospora*) (Fig. 5).

The upper sample contains an assemblage dominated by spores and pollen but with abundant marine phytoplankton, indicating shallow marine conditions. *Dapcodinium priscum* and *Lunnomidinium scaniense* α are abundant. The spore-pollen flora is dominated by *Perinopollenites elatoides* (Fig. 5).

Stenlille-1 (Fig. 8)

Three core samples were analyzed from Sequence 5. The lowest one is similar in composition to the previous two samples from Sequence 4, with low amounts of marine dinoflagellate cysts, and a terrestrial flora dominated by *P. elatoides, R. tuberculatus* and cheirolepidiacean pollen, indicating deposition in a marginal marine environment. However, no freshwater algae were recorded in this sample. The middle sample is dominated in equal parts of spores and pollen, and marine dinoflagellate cysts. *Dapcodinium priscum* dominates the marine phytoplankton, but *Lunnomidinium scaniense* α , *Beaumontella? caminuspina* and *Suessia swabiana* were also recorded (Fig. 8). The spore-pollen flora is dominated by cheirolepidiacean conifer pollen. The depositional environment is interpreted as fully marine. In the upper sample the influence of marine dinoflagellate cysts and acritarchs have decreased. *Dapcodinium priscum* is common, together with low amounts of the freshwater alga *B. braunii. Perinopollenites elatoides* and *R. tuberculatus* dominate the spore-pollen flora (Fig. 8). The depositional environment is interpreted as marginal marine.

Stenlille-6 (Fig. 9)

One cuttings sample from the lowermost part of Sequence 5 contains common marine acritarchs and a few specimens of *D. priscum*. Confirmed caving is 2.5%. The spore-pollen flora is dominated by tree fern spores and bisaccate pollen, with common cheirolepidiacean pollen and *P. elatoides* (Fig. 9). If the marine phytoplankton are *in situ* this indicates marginal marine conditions.

Interval comments

In Sequence 5 fully marine conditions appear to have developed around TS5 in Stenlille-15 in the SW, while shallow marine conditions prevailed in Stenlille-4, with shallow marine to marginal marine in Stenlille-18 and -1, and marginal marine conditions in Stenlille-6 to the NE (Fig. 2; Table 1).

Sequence 6 (SB6–SB7):

Stenlille-15 (Fig. 3)

One core sample, 1535.67–1535.69m, has only been partially counted, as it contains large amounts of thinwalled, fragmented and folded laevigate palynomorphs of unknown affinity, and is therefore a very difficult sample to analyze. Further preparation may resolve this issue.

Stenlille-4 (Fig. 4)

Fifteen core samples are included in this interval (Fig. 4). The lowermost sample from 1525.8m differ markedly from the rest of the samples above. It is totally dominated by terrestrial palynomorphs, with only rare occurrences of marine palynomorphs, including the dinocysts *Lunnomidinium scaniense ß* and *B*?. *caminuspina,* the acritarch *C. stenlillensis* and the prasinophyte *Cymatiosphaera polypartita* (Fig. 4). *Perinopollenites elatoides* dominates the spore-pollen flora. The depositional environment is interpreted as marginal marine.

The remaining fourteen samples, from 1523.79m to 1517.24m, show somewhat fluctuating variations in composition, but always with a high abundance or dominance of marine palynomorphs, with *D. priscum* being dominant. The spore-pollen flora is generally dominated by cheirolepid conifer pollen, with abundant *P. elatoides* and common *Ricciisporites tuberculatus* (Lindström 2016; Lindström et al. 2015, 2017). The depositional environment is interpreted as fully marine.

Stenlille-1 (Fig. 8)

In Sequence 6, samples were analyzed from the middle to the upper part. In general, conditions fluctuate between shallow marine to fully marine in the more finegrained parts of the core. A shallowing upwards into a sandstone at 1522–1518m is accompanied by a decrease in abundance of marine phytoplankton, but at the top of the sandstone this pattern appears to reverse into shallow marine conditions. This is succeeded by fully marine conditions were marine dinoflagellate cysts dominates the assemblages. *Dapcodinium priscum* is the dominant marine phytoplankton, but many other dinocysts are also registered within Sequence 6 (Fig. 8). Freshwater algae were also recorded in low amounts. In the sandstone at 1522– 1518m the spore-pollen flora is dominated by *P. elatoides* and *R. tuberculatus*, but otherwise cheirolepidiacean conifer pollen and *P. elatoides* dominates. The depositional environment is interpreted as fluctuating between shallow marine and fully marine conditions.

Interval comments

In the southwest, marginal marine conditions had developed in the lower part of Sequence 6 in Stenlille-4, but in the upper part fully marine conditions developed. This is corroborated by a cuttings sample from the upper part of Sequence 6 in Stenlille-15, which also suggests that fully marine conditions prevailed. Similarly, in Stenlille-1 to the NE, conditions fluctuated between shallow marine and fully marine (Fig. 2; Table 1).

Sequence 7 (SB7–SB8):

Stenlille-4 (Fig. 4)

Thirteen core samples from this interval show that deposition took place in a predominantly fully marine environment, with high abundances to dominance of marine palynomorphs, primarily *D. priscum. Rhaetogonyaulax rhaetica* was also recorded in high abundances around 1513m (Fig. 4). In the spore-pollen flora there is a decreasing trend in the abundance of cheirolepid pollen, and *P. elatoides* and *R. tuberculatus* are still abundant (Lindström 2016; Lindström et al. 2015, 2017). The depositional environment is interpreted as fully marine.

Stenlille-2 (Fig. 6)

Data from Dybkjær (1991) show a marked change from marginal marine deposition with only minor marine acritarchs and dinoflagellate cysts at the top of the Gassum Fm, to fully marine to shallow marine in the lowermost part of the Fjerritslev Fm (Fig. 6).

Stenlille-5 (Fig. 7)

One core sample from the SB7–SB8 interval is dominated by marine dinoflagellate cysts, primarily *Rhaetogonyaulax rhaetica*, signaling fully marine conditions. The spore-pollen flora is dominated by *Ricciisporites tuberculatus* with abundant *Deltoidospora* (Fig. 7).

Stenlille-1 (Fig. 8)

In Sequence 7 conditions are fully marine in Stenlille-1, but with an upwards declining trend in marine phytoplankton abundance from MFS7 to the top of the interval where shallow marine conditions prevail. *Dapcodinium priscum* is generally the most dominant phytoplankton, but around MFS7 *Rhaetogonyaulax rhaetica* and acritarchs also become abundant. The spore-pollen flora is dominated by *P. elatoides* and cheirolepidiacean pollen, with sporadic peaks in *Ricciisporites tuberculatus* (Fig. 8). First cheirolepidiacean pollen and then *P. elatoides* decrease in abundance up section in the upper part of the interval (Lindström et al. 2012; Lindström, 2016). The depositional environment is interpreted as fully marine to shallow marine.

Interval comments

In Sequence 7 fully marine conditions had developed in Stenlille-4 in the SW, as well as in Stenlille-5 and -1 in the NE, while in Stenlille-2 a core sample from the top of the Gassum Fm suggests marginal marine conditions, while the base of the Fjerritslev Fm is fully marine. There appears to be a shallowing towards the top of Sequence 7, where shallow marine conditions had developed in Stenlille-2 and -1.

Sequence 8 (SB8–SB9):

Stenlille-4 (Fig. 4)

This interval can be divided into two different parts; below and above MFS8. The interval below MFS8 represents the end-Triassic mass extinction interval. The assemblages are characterized by low amounts of marine palynomorphs, mainly acritarchs and sparse occurrences of *D. priscum* and *R. rhaetica.* The spore-pollen flora is dominated by ground fern and tree fern spores, while, apart from *R. tuberculatus*, pollen grains are much less abundant (Fig. 4). The interpretation is that this interval was deposited in shallow marine environment, while the vegetation on land point to deforestation and dominance of pioneering vegetation of ferns and fern allies (van de Schootbrugge et al. 2009). The amount of reworking of material from Ordovician–Silurian, Carboniferous and Middle Triassic is significant, signaling increased weathering and erosion (e.g. Lindström et al. 2012; van de Schootbrugge et al. 2020). The interval is easily recognized palynologically all over the Danish Basin.

The interval above MFS8 again contains abundant dinoflagellate cysts and acritarchs, indicating at least a shallow marine environment. Here, it needs to be noted that several typical Triassic dinoflagellate cysts went extinct during the end-Triassic mass extinction, hence, the marine signal may partially reflect lack of marine phytoplankton after the crisis. In the sporepollen flora fern spores and *Perinopollenites elatoides* dominate, probably reflecting mires developing along the coast. This is preceded by a brief bloom of freshwater algae, primarily *Botryococcus braunii*, probably reflecting increased runoff of freshwater (Fig. 4).

Stenlille-2 (Fig. 6)

Two core samples (data from Dybkjær 1991) from the uppermost part of this interval contain low amounts of marine acritarchs and dinoflagellate cysts. The samples are dominated by spores and pollen, primarily *Deltoidospora*, but *P. elatoides* and in the upper sample also *P. minimus* are abundant (Fig. 6). The low amounts of marine phytoplankton may indicate marginal marine environments, or possibly a shallow marine environment lacking phytoplankton in the aftermath of the end-Triassic crisis.

Stenlille-5 (Fig. 7)

A core sample from the middle part of the interval is dominated by *Deltoidospora* spp. and *Polypodiisporites polymicroforatus* spores, and *R. tuberculatus* pollen, and represents the pioneering flora of the mass extinction interval (Fig. 7). Low amounts of marine dinoflagellate cysts and acritarchs are present indicating a marginal marine or possibly shallow marine environment following the same argument as above.

Stenlille-1 (Fig. 8)

As in Stenlille-4, Sequence 8 in Stenlille-1 can be divided into two different parts; below and above MFS8. The interval below MFS8 represents the end-Triassic mass extinction interval. There, marine phytoplankton only occur in low abundances. Ground fern and tree fern spores dominate the spore-pollen flora together with *R. tuberculatus*, reflecting pioneering vegetation on land (van de Schootbrugge et al. 2009) (Fig. 8). The amount of reworking of material from Ordovician–Silurian, Carboniferous and Middle Triassic is significant, signaling increased weathering and erosion (Lindström et al. 2012; van de Schootbrugge et al. 2020). This interval represents the end-Triassic mass extinction (Lindström et al. 2017). The interpretation is that this interval was deposited in shallow marine environment (Lindström et al. 2012, 2015). A brief bloom of *Botryococcus braunii* is registered just below MFS8, followed by a brief bloom of another freshwater alga *Lecaniella* (Fig. 8).

In the interval above MFS8 marine dinoflagellate cysts, predominantly *D. priscum*, again become common to abundant, but freshwater algae continue to be common is some samples but decrease in abundance up section (Fig. 8). Spores and pollen dominate the assemblages, primarily *P. elatoides* and tree fern spores (*Deltoidospora*). Towards the top of the interval *P. minimus* becomes abundant (Fig. 4). The depositional environment is interpreted as marginal marine to shallow marine with high input of freshwater.

Interval comments

The interval below MFS8 in Stenlille-4 and -1 represents the end-Triassic mass extinction event beds, the Grey siltstone interval of Lindström et al. (2012, 2015). This interval is interpreted as having been deposited in a shallow marine environment with high input of siliciclastic material and increased abundances of reworked palynomorphs, signaling ongoing weathering and erosion on land. Below MFS8 blooms of freshwater algae occurred. Above MFS8 data from Stenlille-4, -2, -5 and -1, indicate marginal marine to shallow marine conditions with high input of freshwater in the northeast.

Sequence 9 (in part; Above SB9 to top of core):

Stenlille-4 (Fig. 4)

The interval above SB9 (to 1490.42m) is interpreted to have been deposited in shallow marine to marine conditions, similar to the interval between MFS8 and SB9. The spore-pollen flora remains dominated by fern spores and *P. elatoides*, but the pinacean conifer pollen *Pinuspollenites minimus* also becomes abundant (Fig. 4).

Stenlille-2 (Fig. 6)

Data from eight core samples, originally reported by Dybkjær (1991), indicate deposition in a shallow marine environment, however, while dinoflagellate cysts are usually rare, acritarchs may be abundant. The spore-pollen flora continues to be dominated by *Deltoidopora* and *Pinuspollenites minimus* (Fig. 6).

Stenlille-1 (Fig. 8)

In the interval from SB9 to top of the core, abundant marine dinoflagellate cysts and acritarchs indicate fully marine to shallow marine conditions. *Dapcodinium priscum* is the most dominant phytoplankton, and the typical Triassic dinocysts have disappeared. The influence of freshwater appears to have ceased. The spore-pollen flora is dominated by tree fern spores, *P. elatoides*, and *Pinuspollenites minimus* (Fig. 8).

Interval comments

In the lower part of Sequence 9 marginal to fully marine conditions developed in Stenlille-4 in the southwest, while further to the northeast shallow marine to fully marine conditions prevailed in Stenlille-2 and Stenlille-1.

Suggestion for further work on the palynology of the Gassum and lowermost Fjerritslev formations in the Stenlille area

Unfortunately COVID restrictions have delayed the preparation of palynological material, and therefore also the palynological analyses. Additional material that remains to be studied include core material from the Gassum Formation in Stenlille-2, -14, -15, -17, and -19, which will increase our understanding of how the depositional environment changed through time. In addition, a more high-resolution subdivision of the existing palynostratigraphic zonation is expected, with particular focus on the middle and lower parts of the Gassum Formation. A refined palynological zonation encompassing the upper parts of Gassum Formation and the lower parts of the Fjerritslev Formation was introduced by Lindström (2016). The upper part of the Gassum Formation in Stenlille-1 and -4 was assigned to the Granuloperculatipollis-Classopollis-Perinopollenites (GCP) Zone. The preliminary data of this study (as indicated by the CONISS analysis on the range charts, see Figs. 3–9), suggest that palynological assemblages from the middle and lower part of the Gassum Formation can be separated biostratigraphically from the GCP Zone, and most likely subdivided into two different subzones. Further work is needed to confirm this. Traditionally, palynological sampling tends to be carried out on more fine-grained sediments, e.g. shales and siltstones, as these generally contain high abundances of palynomorphs per gram of rock. Here, we have targeted more coarse-grained units with reservoir potential, to explore the potential for discriminating between various sand-generating depositional environments, and the preliminary results are promising. Future, more high resolution, sampling of cores encompassing the reservoir units across the Stenlille structure will allow for a more detailed depositional model to be constructed, which in combination with a refined palynostratigraphical framework for the entire Gassum Formation will be important for correlation of the different sequence stratigraphic surfaces and units, and will be essential for steering future drilling operations in the area including the potential CO₂ storage site of Havnsø.

References

- Abbink, O. 1998. Palynological investigations in the Jurassic of the North Sea Region. LPP Contribution Series 8. Universiteit Utrecht (PhD thesis).
- Balme, B.E., 1995. Fossil in situ spores and pollen grains: an annotated catalogue. Review of Palaeobotany and Palynology 87, 81–323.
- Batten, B.E. 1974. Wealden palaeoecology from the distribution of plant fossils. Proc. Geol. Assoc. 85, 433–458.
- Batten, D.J., Koppelhus, E.B. & Nielsen, L.H. 1994. Uppermost Triassic to Middle Jurassic palynofacies and *palynomoscellanea* in the Danish Basin and Fennoscandian Border Zone. Cahiers de Microplaéontologie, 9(2), 21–54.
- Bertelsen, F. 1978. The Upper Triassic–Lower Jurassic Vinding and Gassum Formations of the Norwegian–Danish Basin. Danmarks Geologiske Undersøgelse Serie B 3, 26pp.
- Dybkjær, K. 1991. Palynological zonation and palynofacies investigation of the Fjerritslev Formation (Lower Jurassic–basal Middle Jurassic) in the Danish Subbasin. Danmarks Geologiske Undersøgelse, serie A 30, 1–22.
- Dybkjær, K., Rasmussen, E.S., Śliwińska, K.K., Esbensen, K.H. & Mathiesen, A. 2019. A palynofacies study of past fluvio-deltaic and shelf environments, the Oligocene–Miocene succession, North Sea Basin: A reference data set for similar Cenozoic systems. Marine and Petroleum Geology 100, 111–147.
- Hovikoski, J. & Pedersen, G. K. 2020. Capture, Storage and Use of CO2 (CCUS): Sedimentological description of Gassum and Fjerritslev Formations from cores in the Stenlille area, with interpretations of depositional environments (Part of work package 6 in the CCUS project). Danmarks og Grønlands Geologiske Undersøgelse Rapport 2020/42, 61 pp.
- Lindström, S., 2016. Palynofloral patterns of terrestrial ecosystem change during the end-Triassic event – a review. Geological Magazine 153. Special issue 02, 223–251.
- Lindström, S., van de Schootbrugge, B., Dybkjær, K., Pedersen, G.K., Fiebig, J., Nielsen, L.H., Richoz, S., 2012. No causal link between terrestrial ecosystem change and methane release during the end-Triassic mass extinction. Geology 40: 531-534.
- Lindström, S., Pedersen, G.K., van de Schootbrugge, B., Hansen, K.H., Kuhlmann, N., Thein, J., Johansson, L., Petersen, H.I., Alwmark, C., Dybkjær, K., Weibel, R., Erlström, M., Nielsen, L.H., Oschmann, W., Tegner, C. 2015. Intense and widespread seismicity during the end-Triassic mass extinction due to emplacement of a large igneous province. Geology 43, 387-390.
- Lindström, S., van de Schootbrugge, B., Hansen, K.H., Pedersen, G.K., Alsen, P., Thibault, N., Dybkjær, K., Bjerrum, C.J., Nielsen, L.H. 2017. A new correlation of Triassic–Jurassic boundary successions in NW Europe, Nevada and Peru, and the Central Atlantic Magmatic province: A time-line for the end-Triassic mass extinction. Palaeogeography, Palaeoclimatology, Palaeoecology 478, 80–102.
- Lindström, S., Sanei, H., van de Schootbrugge, B., Pedersen, G. K., Lesher, C.E., Tegner, C., Heunisch, C., Dybkjær, K., Outridge, P.M., 2019. Volcanic mercury and mutagenesis in land plants during the end-Triassic mass extinction. Science Advances 5, eaaw4018.
- Nielsen, L.H. 2003. Late Triassic–Jurassic development of the Danish Basin and the Fennoscandian Border Zone, southern Scandinavia. Geological Survey of Denmark and Greenland Bulletin 1, 459–526.

- Petersen, H.I. & Lindström, S. 2012. Synchronous wildfire activity rise and mire deforestation at the Triassic–Jurassic boundary. PLoS One 7, e47236.
- Petersen, H.I., Lindström, S., Therkelsen, J. & Pedersen, G.K. 2013. Deposition, floral composition and sequence stratigraphy of uppermost Triassic (Rhaetian) coastal coals, southern Sweden. International Journal of Coal Geology 116–117, 117–134.
- Retallack, G.J. 1975: The life and times of a Triassic lycopod. Alcheringa, 1, 3–29.
- Schulz, E. & Heunisch, C. 2005: Palynostratigraphische Gliederungmöglichkeiten des Deutschen Keupers. Courier Forschungsinst. Senckenberg, 253, 43–49.
- Vakhrameev, V.A.1981: Pollen *Classopollis*: indicator of Jurassic and Cretaceous climates. The Palaeobotanist, 28–29, 301–307.
- Vakhrameev, V.A. 1991: Jurassic and Cretaceous floras and climates of the Earth. Cambridge University Press, Cambridge, 318pp.
- van de Schootbrugge, B., Quan, T., Lindström, S., Püttmann, W., Heunisch, C., Pross, J., Fiebig, Petschik, R., Röhling, H.-G., Richoz, S., Rosenthal, Y. & Falkowski, P.G., 2009: Floral changes across the Triassic/Jurassic boundary linked to flood basalt volcanism. Nature Geoscience, 2, 589-594.
- van de Schootbrugge, B., Weijst, C.M.H., Hollaar, T., Vecoli, M., Strother, P.K., Kuhlmann, N., Thein, J., Visscher, H., van Konijnenburg-van Cittert, H., Schobben, M., Sluijs, A. & Lindström, S., in press 2020: Catastrophic soil loss associated with end-Triassic deforestation. Earth-Science Reviews.
- Vosgerau, H., Gregersen, U. & Laghari, S, 2020: Seismic interpretation of existing 3D seismic data around the Stenlille structure within the framework of sequence stratigraphy and with focus on the Gassum Formation. GEUS Report 2020/34, 53 pp.
- Ziaja, J. 2006: Lower Jurassic spores and pollen grains from Odrowąż, Mesozoic margin of the Holy Cross Mountains, Poland. Acta Palaeobotanica, 46(1), 3–83.

Figures and table

Figure 1

The Stenlille structure outlined by closed depth (below sea level) contours. The figure is provided by DONG and reused from a report by Larsen. The stippled line shows the transect, along the wells Stenlille-15, -4, -18, -2, -5, -1, and -6, from southwest to northeast.



General palynological composition of the analyzed samples from Stenlille-15, -4, -18, -2, -5, -1, and -6, displayed in a sequence stratigraphic framework (Hovikoski & Pedersen 2020; Vosgerau et al. 2020). The different palynological categories are: AC=acritarchs, AL=freshwater algae, ALBO=*Botryococcus braunii* and *Pediastrum*, ALIN=freshwater algae of uncertain affinity, DC=dinoflagellate cysts, FT=foraminiferal test linings, FU=fungi, MM=miscellaneous microfossils, MP=miscellaneous palynomorphs, PF=palynofacies, SP=spores and pollen. These categories can also be found on Figures 3–9.



Palynostratigraphic range chart of Stenlille-15.

Sofie Lindström Scale: 1:500

Scale					Interval Comments		Palynology			Events	
			1 :41	Biozones: Boreal	(Rw, Cv excluded)	Dinoflagellate cysts (in situ) Acrit MP Fr CONISS dinocy	ysts Spores and pollen (in situ)	CONISS spores (Rw exclu	ded) (Rw excluded) (Rw excluded) Re	Biozones:	Biozones:
	Chronostratig TJ Danish Ba	jraphy isin	LITNO- stratigraphy TJ Danish Basin	Ammonite Zonation TJ Danish Basin	*1	(Rw excluded) quant/semi-quant abundance, % all Paly. *3 *4 *3 *5 Q ULL ULL CLL CLL CLL CLL CLL CLL CLL CLL	(Rw, Cv excluded) quant/semi-quant abundance, % panel		×6 *4	Triassic-Jurassic Danish Basin TJ Danish Basin	Triassic-Jurassic Danish Basin dc TJ Danish Basin
Measured depth (m)	Deriod/Epoch	Age	Formation		AC AL ALBO DC FU MM MM SP	Bamples (m) Samples (m) DC Dapcodinium priscum DC Dapcodinium scaniense (beta) DC Dapcodinium scaniense (beta) DC Dapcodinium scaniense (beta) DC Dapcodinium scaniense (beta) DC Dapcodinium spina DC Dinofagellate cysts unidentified DC Mendicodinium scaniense (affa) DC Mendicodinium spina DC Lunnomidinium scaniense (affa) DC Lunnomidinium scaniense (affa) DC Lunnomidinium scaniense (affa) DC Lunnomidinium spina DC Lophosphaeridium spina AC Lophosphaeridium spina AC Lophosphaeridium spina AC Lophosphaeridium spina AC Lophosphaeridium spina AL Macufatas pointes spina AL Macufatas spina AL Macufatas spina AL Macufatas spina AL Lophosphaeridium spina <t< td=""><td>SP Camerosporites secatus SP Calamospora tener SP Calamospora tener SP Classopollis classoides SP Classopollis classoides SP Classopollis classoides SP Classopollis meyerianus SP Classopollis devigata SP Protopinus scanicus SP Protopinus scanicus SP Protopinus scanicus SP Patrisporites spinosus SP Patrachysporites spinosus <t< td=""><td> P. Construction oppressus S.P. Cordogranisporities oppressus S.P. Cordogranisporities spp. S.P. Cyclogranisporities spp. S.P. Cyclogranisporities comaumensis S.P. Cyclogranisporities australis S.P. Cyclogranisporities australis S.P. Chasmatosporities magnus S.P. Araucariacties australis S.P. Araucariacties polynoitisporties magnus S.P. Polypodilisporities major S.P. Polypodilisporities minuus S.P. Chasmatosporites spp. S.P. Chasmatosporites spp. S.P. Chastratisporites andora S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Aulisporites spp. S.P. Aulisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Chastratisporites spp. S.P. Chastratisporites spp. S.P. Chastratispori</td><td>P Spores and pollen (species richness) B Spores and pollen (cosine theta similarity Spores and pollen (cosine theta similarity SP Spores and pollen (cosine theta similarity</td><td></td><td></td></t<></td></t<>	SP Camerosporites secatus SP Calamospora tener SP Calamospora tener SP Classopollis classoides SP Classopollis classoides SP Classopollis classoides SP Classopollis meyerianus SP Classopollis devigata SP Protopinus scanicus SP Protopinus scanicus SP Protopinus scanicus SP Patrisporites spinosus SP Patrachysporites spinosus <t< td=""><td> P. Construction oppressus S.P. Cordogranisporities oppressus S.P. Cordogranisporities spp. S.P. Cyclogranisporities spp. S.P. Cyclogranisporities comaumensis S.P. Cyclogranisporities australis S.P. Cyclogranisporities australis S.P. Chasmatosporities magnus S.P. Araucariacties australis S.P. Araucariacties polynoitisporties magnus S.P. Polypodilisporities major S.P. Polypodilisporities minuus S.P. Chasmatosporites spp. S.P. Chasmatosporites spp. S.P. Chastratisporites andora S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Aulisporites spp. S.P. Aulisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Chastratisporites spp. S.P. Chastratisporites spp. S.P. Chastratispori</td><td>P Spores and pollen (species richness) B Spores and pollen (cosine theta similarity Spores and pollen (cosine theta similarity SP Spores and pollen (cosine theta similarity</td><td></td><td></td></t<>	 P. Construction oppressus S.P. Cordogranisporities oppressus S.P. Cordogranisporities spp. S.P. Cyclogranisporities spp. S.P. Cyclogranisporities comaumensis S.P. Cyclogranisporities australis S.P. Cyclogranisporities australis S.P. Chasmatosporities magnus S.P. Araucariacties australis S.P. Araucariacties polynoitisporties magnus S.P. Polypodilisporities major S.P. Polypodilisporities minuus S.P. Chasmatosporites spp. S.P. Chasmatosporites spp. S.P. Chastratisporites andora S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Aulisporites spp. S.P. Aulisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Duplicisporites spp. S.P. Chastratisporites spp. S.P. Chastratisporites spp. S.P. Chastratisporites spp. S.P. Chastratispori	P Spores and pollen (species richness) B Spores and pollen (cosine theta similarity Spores and pollen (cosine theta similarity SP Spores and pollen (cosine theta similarity		
- - - - - - - - - - - - - - - - - - -				1555.5	Sequence 6: Fully marine 1555.50	• 1535.67 - 1535.69				1535.69 Top Camerosporites secatus Top Dapcodinium priscum Top Rhaetipoliis germanicus	
-1580 -1580 -1590 -1590 - - -1600	Late Triassic	Rhaetian	Gassum	1600.5	Sequence 5: Fully marine	-• 1572.21 - 1572.22 -• 1604.27 - 1604.29 + +			+ + + + + + + + + + + + + + + + + + +	1604.29 Top Quadraeculina anellaeformis	
-1610 - - -1620 - - - - - - - - - - - - - - - - - - -				1620.0 	Sequence 4: terrestrial to possibly marginal marine environment 1620.00 00 Sequence 3:	- 1613.64 - 1613.65 - 1621 - 1627 - 1633 - 1633 - 1633 - 1636 - 1642 -			+ + +	1613.65 Top Chasmatosporites hians Top Striatella seebergensis	
-1650 				1668.0	1668.00 1668.00 Sequence 2: no data				+ + + - 1666	Base Cerebropollenites thiergartii 1651	
-	1680.0	1676.0		1674.5	*2 1674.50 50 1677.00				+ + 1675	Base Classopollis classoides 1675	
Text Ke *1 quan *2 Belov *3 (Rw *3 (Rw *4 quan *5 quan *6 (Rw	/s /semi-quant abundance, / SB2: Marginal marine xcluded) /semi-quant abundance, itative abundance, % all nly; Cv excluded)	Bon % panel Sar % all Paly Paly	 Confident Confident mpling Cutting Core Sidewall Core 	 AL - Aigae ALBO - Botryococcus and performance DC - Dinoflagellate cysts FU - Fungi MM - Miscellaneous microfo MP - Miscellaneous palynon PF - Palynofacies SP - Spores and pollen 	ediastrum ssils norphs						

 Taxon Categories

 AC - Acritarchs

Stenlille-15



Palynostratigraphic range chart of Stenlille-4, data from Lindström et al. (2012, 2015, 2017, 2019, and in prep.).

Scale	Chrono- stratigraphy TJ Danish Basin	Litho- stratigraphy TJ Danish Basin	Biozones: Boreal Ammonite Zonation	Interval Comments	(Rw, Cv excluded) *1		Di (Rw excluded) quant/semi-quant a	noflagellate c bundance, % all P	cysts (in situ) Paly.	1	(Rw exclud quant/sem	Acritar ded) i-quant abur	chs (in situ) ndance, % all Paly.	MP Freshwater al *2 (Rw excluded) quantitative abunda
lepth (m)					AC		cum	atus p. roenlandicum ggii rhaetica	nulatus " caniense (alfa) caniense (beta) a	/ermiculatum " enensis " aminuspina ts unidentified pp. (e	graciiis D. p.	spp. 1 spp. P.	sp. X s sp. s "hyphae" s "hyphae" polypartita archs archs debilispinum s cf. sp. insis	lynomorphs tt. rugulate tt. laevigate tt. spinose braunii braunii
Measured c		Formation			AL ALBO ALIN DC MM MP SP	Samples (n	DC Dapcodinium pris	DC Rotundus granul. DC Mendicodinium s DC Mendicodinium g DC Beaumontella lar DC Rhaetogonyaulax	DC Rotundus nongra DC Lunnomidinium s DC Lunnomidinium s DC Lunnomidinium s DC Lunnomidinium s DC Suessia swabian	DC Mendicodinium " DC Suessia "hoellvik DC Beaumontella ? c DC Dinoflagellate cys DC Lunnomidinium s DC Liasidium variabi	AC Pleurozeratopsis AC Pleurozonaria sp AC Micrhystridium sp AC Leiosphaeridia sp	AC Cymauospnaera AC Veryhachium spp AC Tasmanites spp. AC Lophosphaeridiur AC Circulisporites sp	AC Cymatiosphaera AC Leiofusa spp. AC Reduviasporonite AC Acritarch indet. AC Cymatiosphaera AC Cymatiosphaera AC Unidentified acrit AC Baltisphaeridium AC Reduviasporonite AC Celyphus stenlilk AC Sphaeromorph st	MP Unidentifiable pa MP Sporomorph inde MP Sporomorph inde MP Sporomorph inde ALBO Botryococcus
-1492 1494 				Sequence 9 (in part): Marginal to fully marine		$\begin{array}{c} 1492 16 538690 (547707) \\ 1492.32 538691 (547707) \\ 1492.32 538691 (547708) \\ 1492.32 538671 \\ 1493.02 - 1492.82 538670 \\ 1493.02 - 1493.11 538672 \\ 1493.02 - 1493.97 538673 \\ 1494.14 - 1494.15 538674 \\ 1494.14 - 1494.15 538674 \\ 1494.48 - 1494.52 538675 \\ 1495.51 - 1494.88 538676 \\ 1495.51 - 1495.83 538677 \\ 1495.85 - 1495.85 538678 \\ 1496.48 - 1496.51 538678 \\ 1497.09 - 1497.75 538681 \\ 1497.09 - 1497.75 538681 \\ 1498.01 - 1498.04 538682 \\ \end{array}$								
- -1498 - - - - - - - - - - - - - - - - - - -				1499.50 Sequence 8 above MFS8: Shallow marine 1502.4		1498.16 1498.18 538683 1499.30 538630 1499.30 538630 1499.30 538629 1499.30 538628 1500.10 538627 1500.10 538625 1500.10 538625 1500.10 538625 1500.10 538625 1501.39 538634 1501.79 538635 1501.79 538635 1501.81 538637 1501.81 538637								
- 		Fjerritslev (in part)		1502.40 Sequence 8 below MFS8: Shallow marine with		1501.86 538639 1501.90 538640 1502.15 538623 1502.35 538622 1502.35 538640 1502.35 538622 1502.35 538624 1503.42 538621 1503.42 538621 1504.60 538619 1504.90 538619 1505.40 538616 1505.89 538616 1506.10 538642 1506.49 538615			+					• • • • • • • • • • • • • • • • • • •
-1508 -1510 - - -1512				1512.00		1507.14 538644 1507.14 538644 1507.54 538643 1507.54 538643 1507.54 538613 1508.39 538612 1508.30 538612 1510.80 538610 1510.18 538609 1510.18 538608 1510.27 538607 1511.26 538645 1511.55 538606 1511.55 538606 1511.59 538647		· · · · · · · · · · · · · · · · · · ·						
- 1514 - - 1516 -				Sequence 7: Fully marine 1517.0									+]] 	
-1518 - - - - - - - - - - - - - - - - - - -						 1516.93 538656 1517.24 538657 1517.86 538658 1518.36 538659 1518.80 538660 1519.68 538661 1520.20 YH 6125 1520.86 538662 1520.86 538663 1521.23 538664 1521.83 538665 1522.33 538666 							- · · · · · · · · · · · · · · · · · · ·	
-1524				Sequence 6: Lower part: marginal marine. Upper part: fully marine		● 1522.80 538667 ● 1523.28 538668 ● 1523.79 538669 ● 1525.80 YH 6126								
-1530 1532														
- -1534 - - 1536 - - - 1538				1537.00	0 	-								
-1540 -1542 -1542						• 1543.50 YH 6123								
-1544 - -1546 - - -1548 -														
-1550 -1552 -1552 -1554														
- 1558 - - - - - - - - - - - - - - - - - -						1557								
- -1560 - - 1562 - - 1564				Sequence 5: Shallow marine environment		-								
- 1566 - - 1568 -						-								
-1570 - - - - - - - 1574 -						1572								
-1576 -1578 -1580						-								
-1582 - - - - - - - - - - - - - - - - - - -		Gasavar		1584.00	10 10									
- -1586 - - -1588 - - - 1590		Gassum												
- 1592 - - 1594 -						1593					v 1			·
-1596 - - -1598 - - - - 1600						-							- · · · · · · · · · · · · · · · · · · ·	
-1602 -1604 - -														
-1608 				Sequence 4: Marginal marine environment		-		· ·· ·· ·· ·· ·· ·· ·· ·· ··						
-1612 -1614 -1614 -						-								
-1618 -1620						-								·
-1622 -1624 -1626														
-1628										Cv Cv				
-1634 -1636				1637.0	<u>o</u>	-								
-1638 -1640 -1642				Sequence 3: Marginal marine environment										
-1644 -1646				1644.00	10 									
-1648 -1650 -1652				Sequence 2: No data		-								
-1654				1656.50	<u>io</u>									
-1658 -1660 -1662				Below base Gassum: Possibly marginal marine		1662								
-1664 Text I *1 qua *2 qua	Xeys ant/semi-quant abunda ant/semi-quant abunda	ance, % panel ance, % all Paly.	 Core Sidewall Core Sidewall Core 	MM - Miscellaneous m MP - Miscellaneous pa PF - Palynofacies SP - Spores and poller	icrofossils Ilynomorphs									
ত (Rı Boun — Samp	dary Types Confident		AL - Algae ALBO - Botryococcus ar ALIN - Incertae sedis DC - Dinoflagellate cysts	nd pediastrum										

Sofie Lindström Scale: 1:150

										I	Palynology																					Events			0 5
e (in situ) % all Paly.	ocysts (Rw, Cv excluded) quant/semi-quant abundance,	6 panel							Spore	and pollen (in situ)											CONISS spores	(Rw excluded)	(Rw excluded) (Rw excluded)	(Rw only) quant/semi-quant abund	AC ance, % all Paly.	(Rw only; Cv excluded) quant/semi-quant abund	ance, % all Paly.	Reworked spore	s and pollen				Biozones: Triassic-Jurassi Danish Basin TJ Danish Basin	ic Triassic-Jura Danish Basin TJ Danish Bas	: I SSIC n dc Isin
sis ר ר TJ mar	ingularis na is icosus	tus ans e	SI,	inni se su	ormis atus artii	ata ss :us ngeri p.	atus s nosus us nulatus "	tus oides nii ris granulata "	s s ae	cus a nus idis	orae nformis sii mall	icroforatus ls sis nensis ntified " sozoicus us "	iana ergartii	iger atus sus ohorus op.	ıs ulatus ə, unidentif s	s" meroni evigatus ulatus	ensis duncus	us ae s atus	et. ensis domassulae	s s" iis iied"	J: SP	diversity)	ichness) eta similarity)	jae.	hae "	atus s atus	es natus	s SSG	o. is ilatus is us	lus tus nsis	a ulatus				
es spp. ella spp. porites spp. rrina spp. <u>phae</u> ispersior	atisporites tria sporites spp. rites crassexi a folliculosa rites scabratu sporites cicatr ora spp. radialis tes minimus	tes pallidus ites interscript sporites elega ites spp. robustus s unidentifiable ora tener	sporites apert sporites hians is classoides is meyerianus	cidites wellma enites elatoide nites minimus orites globosu	ulina anellaefo semimuris rites asper ooris spp. oorites verruca ulenites thierg nites pinoides tites punctus	a microannul tes "granulatu cidites rhaetic ra ipsviciensis porites reissir tes spp. iltenites spp. osisporites sp	seebergensis vrites fissus es microrugula rites fuscus tites stereoide tites rhaeticus tites rhaeticus tites tuberculat tes tuberculat tes bjuvensis es bjuvensis es spp. tes "micrograf	ora fossulata cidites rugulai isporites spp. anites cf. elatt sites australis fites troedsso fes minimus enites spp. sporites vulga a folliculosa ' a folliculosa '	ites laevigatus nosporites ruu tes reissingen ates rhaeticus tes punctatus bora juriensis orites spp. spp. spp. rites lundbladi fites minor orites major rites sparsus	rites thuringia sporites spp. fites granulos salebrosaces sxypinus spp. sporites magr ovalis rculatipollis ru	e spp. ssporites anco ispora alaticol thomasii enites hughes enites hughes pollen indet s pollen indet s orites spp.	porites polym, zwolinskai nidentified " ooris jurassicu rites cerebrali, urassica urassica ris aulosenen orites comaur pollen "unider tisporites me, tisporites spp. ites "verrucatu	s spp. ates sp. ooris ovalis ties australis ora cf. keuper dites spp. dites major	p. b. isportes granule portes oppress orites oppress portes telep. latisportes telep. pollenites sp.	cornuta " a laevigata dites senonicu sporites retici tenuicorpus ilete, laevigate atisporites spp. isporites spp.	tes "echinatus tes fimbriatus osisporites ca ads "aberrant" nosporites lat scanica scanica orites cf. bac es spp.	porites ipsvici spores indet. ites spp. ites spp. microsaccus 's germanicus orites sp. atisporites rec	gigas gigas rites cavernati kia spp. ocolpites spp. oris maljavkir is sp. rites annulatu rites complice sporis toralis sporis toralis	rifes spp. ate pollen ind anites spp. rites spp. is triassicus a spp. dienites pseuc	is scanicus is scanicus is spp. orra australis orra australis orra toralis orrites secatus tes "foveolatu trites aquilonal porrites vigens ilete, unidentif	ispersion	llen (shannon	llen (cosine th	indet. indet. indet. inaera spp. p. spp. aeridium spp. inum spp. inaeridium sp achium carmir scon	mella spp. rites horridus orph "various orph "various	is spp. ad acritarchs um spp. <u>era spp.</u> s astigmosus orites cf. seca orites secatus ates rhaeticus ates sp. spp. rites spp. rites complica	rites spp. rites spp. orites illacoide porites micron porites spp. fionoides enites spp. porites spp.	ites pellucidu: ites spp. spora spp. pusilla salebrosaces salebrosaces ovalis ovalis spora cancello tes amicus	tes sp. atisporites spi xypinus gracil xypinus granu xypinus sp. porites spp. s cf. perforatus s germanicus tes tuberculat rites aciulional	ora rara ora rara nidentified" cites quadrifio rites aytugii nites rieberi tites spp. tittes spp.	aletes spp. a cf. verrucata a spp. seporites reticu vetustus SS (m)			ne	
L Lecanic L Lecanic C Circulis LIN Tetrapo L Fungal hy Total D	EPolycingul Polycingul EP Laevigatos P Annulispo EP Marattispo EP Deltoidosp EP Alisporites	 P Vitreispori Zebraspori Zebraspori Zebraspori Stereispori Monosulci Alisporites Bisaccates Calamospi 	P Chasmato P Chasmato P Classopoll P Classopoll	sP Osmundac sP Perinopolk sP Pinuspolle sP Punctatisp	 P Quadraect P Quadraect P Trachyspo P Trachyspo P Taurocusp P Cerebropo P Pinuspolle Stereispon 	P Annulispon P Monosulci P Thymospodia P Thymospo P Aratrispori P Cerebropo P Exesipolle	 P Stratella (P Trachyspo P Trachyspo P Trachyspo P Stereisport P Conbacula P Conbacula P Conbacula P Conbacula P Conbacula P Vertricespori P Vertucosis P Monosulci P Lophotrilet 	 F Gordonisp Cyclogran Cyclogran Perinopolit Perinopolit Perinopolit Perinopolit Perinopolit Perinopolit Perinopolit Paraucariac Paraucariac<	 F Zebraspor Camarozo Camaro	 Perinospoi Chasmato Eucommii Eucospora Protohaple Protohaple Chasmato Ovalipollis Granulope Menaspore 	Primography Prinancorae Puvaesporites Puvaesporites Palisporites Panulate Pensoispo	P Polypodiis, Corollina 2 P Corollina 2 P Spores "u P Spores "u P Striatella j P Sculptispo P Spores or P Conbacula P Conbacula P Canulatis, P Stereispor	 Peroaletes Cingulizon Apiculatis Apiculatis Stereisport Calamosp Cerebropc Osmundac Eucommii 	 Paradita s Paradita s Paradita s Polypodiis Polypodiis Paradita 	 Striatella " Paquispora Gleicheniii Triancorae Alisporites Alisporites Polycingul Papiculat Aratrispori 	 P Monosulci P Aratrispori P Converruc P Spore tetra P Camarozo P Striatella P Cadargasy P Ephedripiti Retitriletes 	Polypodiis Polypodiis P Apiculate P Lunatispor P Limbospor P Alisporites P Callialaspo P Polycingul	P Campenia P Densospo P Neoraistric P Spinomon P Platysaccu P Densospo P Intrapuncti	P Trachyspo P Monosacc P Klausipolle P Cornutispo P Densospo P Platysaccu P Cerebropo	Protopinus Protopinus Protopinus Protopinus Peltoidosp Poettoidosp Poettoidosp Pramerosp Primaespoi Pronoalas Pronoalas	Total D	pores and po	pores and po	C Acritarch C Acritarch C Baltisphae C Cymatiosp C Evittia spp C Leiofusa s C Micrhystri C Micrhystri C Neoveryha	C Pterospern C Quadrispo C Sphaerom C Sphaerom	C Lasmanue C Unidentifie C Veryhachi C Veryhachi C Visbyspha P Camerosp P Camerosp P Cingulizon P Crassispoi P Cristatispo	P Densolspo P Densolspo P Echinitosp P Emphanis P Enzonalas P Illinites ch P Infernopoll P Kraeuselis	 Lunatispor Lunatispor Lundbladis Lycospora Lycospora Lycospora Murospora Playfordia Playfordia 	 Podospori Podospori Polycingul Protodiplo Protodiplo	 Schulzosp Schulzosp Schulzosp Schulzosp Schulzosp Schulzosp Striatoabie Striatoabie Striatoabie Striatoabie Striatoabie 	P Tetrahedra P Triadisport P Triadisport P Tripartites Sample		Zone	Sub Zo	
						<u> </u>	<u>, , , , , , , , , , , , , , , , , , , </u>	- + + + - + - + - + - + - +	<u>, , , , , , , , , , , , , , , , , , , </u>	<u>~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ </u>		<u> </u>	<u> </u>														<u> </u>	- +		<u> </u>	x x	 1492.16 Top Chasmatosporites hians Top Dapcodinium priscum Top Quadraeculina anellaeformis 1492.32 Top Striatella seebergensis Top Taurocusporites verrucatus 	^{1492.54} Perinopollenites Pinuspollenites		
							·		* * *													+	+ + + + + + + + + + + + + +		+ 	+ + +		• • • • • • • • • • • • • • •	+ 		- 1494.48 - 1494.52 538675 - 1494.85 - 1494.86 538676 - 1495.51 - 1495.53 538677 - 1495.85 - 1495.88 538678 - 1495.85 - 1496.51 5386879 - 1497.09 - 1497.12 5386880 - 1497.54 - 1497.57 5386881 - 1498.01 - 1498.18 538682 - 1498.16 - 1498.18 538683	1495.88 Top Rhaetipollis germanicus Top Rhaetogonyaulax rhaetica	^{1495.53} Deltoidospora - Perinopollen Pinuspollenites	1494.88 nites -	
																										+ + ? + - +			- + + + - +		$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Base Cerebropollenites thiergartii 1498.18	1498.04 Perinopollenites-Deltoidospora-Stereis	^{1498.60} D. priscun	m
									* + + + + + + + + + + + + +					₿_ + - - - - - - - - -	r r									-			+ 	•			• 1501.60 538634 • 1501.79 538635 • 1501.79 538635 • 1501.81 538637 • 1501.84 538637 • 1501.84 538639 • 1501.90 538640 • 1502.01 538623 • 1502.01 538623	1503 42 Top Staurosaccites quadrifidus	?Calamospora-Conbaculatisporites-Mor	1501.90 nosulcites	1501.60
									•	- · · · · · · · · · · · · · · · · · · ·			· · · · · · · · · · · · · · · · · · ·		•							+ + + + + + + + + +	* * * * * * * * * * * * * * * * * * *							- + +				D. priscum - R. r low abundar	naetica nce
													•			- +						**										■ 1507.54 Top Suessia swabiana	Polypodiisporites-Ricciisporites-Deltoid	1508.39 Barren of dino	1507.8¢
														•												$\begin{bmatrix} \bullet & \bullet $			- + + + + + - +				1511.26 Ø	D. priscum - R. r - Micrhystrid	haetica ium
					+ +	• • • - • - • - • - • -			• 1 • • 1 1 1 • 1 - - + + 1 - • 1 1 - + + - - • 1 1 - + - - + • 1 1 - - + - -							+ + + + -	·	•				÷++ + + + +					• • • • • • • • • • • • • • • • •				■ 1512.14 536004 ■ 1512.34 538603 ■ 1512.75 538602 ■ 1512.85 538602 ■ 1513.03 538648 ■ 1513.35 538649 ■ 1513.35 538650 ■ 1513.58 538650 ■ 1513.58 538650 ■ 1513.58 538650		is-Perinopollenit	1513.58	1513.35
		• • [[•] [•] • [•] \bullet]			+ 	•			• • • • • • • • • • • • • • •) + + +						+],] 		+			+ 	+ + + + +										ipollis-Classopo	D. priscum acm rhaetica pres	ne - R. sent
		• •				·			· · · · · · · · · · · · · · · · ·				· · · · · · · · · · · · · · · · ·		• • • • • • • • • • • • • • •			·				· · · · · · · · · · · · · · · · · · ·	+ + + + +			+?			+? +?		• 1518.80 538660 • 1519.68 538661 • 1520.20 YH 6125 • 1520.56 538662 • 1520.86 538663 • 1521.23 538664 • 1521.83 538664 • 1521.83 538665		Granuloperculat		
					• •									•	·]+ + + ·					,				+					◆1522.33 538666 ◆1522.80 538667 ◆1523.28 538668 ◆1523.79 538669 ◆1523.79 538669			1523.79	1523.75
				·		·								· · · · · · · · · · · · · · · · · · ·			·			· · · · · · · · · · · · · · · · · · ·		+									● 1525.80 YH 6126				
				·											,,,,,,,, .					· · · · · · · · · · · · · · · · · · ·												Base Classopollis classoides Base Rhaetogonyaulax rhaetica 1543.50	_		
				·		·		- · · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	- · · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	· ··· ·· ·· ·· ·· ·· ·· ·· ·· ·· ·· ··		·	· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·															
				·		·									· · · · · · · · · · · · · · · · · · ·		·	· · · · · · · · · · · · · · · · · · ·																	
					• • • • • • • • • • • • • • •	•			•													·													
				· · · · · · · · · · · · · · · · · · ·				- 1 1 1 1 1 1 1 1 1 1																											
		• • • • • • • • • • • • • • • • • • •		·					·				· · · · · · · · · · · · · · · · · ·	• • • • • • • • • • • • • • • • • •			·															1572 Ton Comerosporites secotus			
																					-											11572 Top Camerospontes secatus			
																					-														
				·		·								· · · · · · · · · · · · · · · · · ·	·		·				-														
				· · · · · · · · · · · · · · · · · · ·					·						·		·				-														
			• • • • • • • • • • • • • • • •	·					·		•				p							+	+								1593				
																	·																		
																					-														
				·							· · · · · · · · · · · · · · · · · · ·						·			· · · · · · · · · · · · · · · · · · ·															
						·			·								·																		
				·					·					· · · · · · · · · · · · · · · · · · ·	·		·			· · · · · · · · · · · · · · · · · · ·															
																															1629				
				· · · · · · · · · · · · · · · · · · ·				- • • • • • • • • • • • • • • • • • • •																											
																															1662	Base Callialasporites turbatus 1662 1662 Top Enzonalasporites vigens	-		
											+ + + + - + - + - + - + -		- +	+ +							-														

Palynostratigraphic range chart of Stenlille-18.

sured depth (m) ∃ sured depth (m)	Chrono- ratigraphy Danish Basin	Litho- stratigraphy TJ Danish Basin	Biozones: Boreal Ammonite Zonation TJ Danish Basin		(Rw, Cv excluded) *1		Din (Rw	ofl excl	age	lla	t	A	:ri
sured depth (m)							*2		udeo	d)		*3 *2	
Mea		Formation			AC AL ALBO DC MP SP	Samples (m)	DC Dinoflagellate cysts unidentified	DC Lunnomidinium scaniense (alta)	DC Dapcodinium priscum DC Rotundus aranulatus	DC Rhaetogonyaulax rhaetica	DC Mendicodinium sp. DC Lunnomidinium scaniense (beta)	AC Micrhystridium spp.	AC Lophosphaeridium spp.
						•1603.35							
- 				Sequence 5: Marginal marine to shallow marine									
- 1630 - -						•1632.20			 				_
- 1640 - -		Gassum		1641.50		•1641.00 •1642.60] [+]]]]	
- 1650 - -						• 1656.65							_
- 1660 - -				Sequence 4: Fluctuating between marginal marine and fully terrestrial		• 1661.75 • 1662.40 • 1663.50 - 1663.60] []	
-1670 -						•1674.30 - 1674.60 24							

Stenlille-18

																																		Ρ	al	yn	olo	gy									
crit		MP)		CONISS dinocysts																											Sp	or	es	a	nd	po	le	n (i	n :	sit	u)					
	*	2		*3 *4	arine p	(Rw, quar	, Cv nt/se	emi-	clude -qua	ed) nt ab	unda	ance	e, %	oane	el.																																
Lophosphaeridium spp. Sphaeromorph spp.	Leiosphaeridia spp.	Unidentifiable parynomorpus	Sporomorph indet. granulate	30 Botryococcus braunii Ovoidites son	Total Dispersion: TJ ma	Granulatisporites spp. Uvaesporites reissingerii	Protohaploxypinus spp.	Alisporites thomasii Detroidospora australis	Bisaccates unidentifiable	Calamospora tener	Classopollis classoides	Conbaculatisporites spinosus	Deltoidospora toralis	Granuloperculatipollis rudis	Lunatisporites rhaeticus		Baculatisporites comaumensis	Lycospora pusilla	Microreticulatisporites spp.	Nevesisporties sp. Distremente en	rtauysaucus sp. Stereisporites stereoides	Cingulizonates rhaeticus	Trachysporites asper	Eucommidites minor	Stereisporites spp.	Allsporttes robustus Aratrisporttes minimus	Chasmatosporites apertus	Classopollis meyerianus	Corollina zwolinskai	Deltoidospora minor	Klausipollenites gouldii	Monosulcites minimus	Ovalinollis ovalis	Dinuspolla ovalis Dinuspollanitas minimus	Punctatisporites globosus	Rhaetipoliis germanicus	Ricciisporites tuberculatus		Spheripollenites spp. Aratrisportites spp.	Monosulcites "aranulatus"	Retitriletes semimuris	Stereisporites punctus	Trachysporites sparsus	Densolsporites TISSUS Densosmarites perehralis	Polypodiisporites polymicroforatus	Limbosporites lundbladiae	Perinonollenites of elatoides
A A A		∑ ∑	МΡ	ALE	Į	ი ი	Ъ Г	S S S S S S S S S S S S S S S S S S S	<u>5</u> 0	SР	SР	SР	Ъ	SР	Ъ.	5	 ЪР	Ъ	с С	<u>ה</u> ה	р Q	ц Ч	S P	S D	S Г	<u>ה</u> ה	ր Մ	Ъ	Ъ	Ъ	Ъ	5	ה ה ה	<u>ה</u> ה	р С	SP SP	<u>Р</u>		S S S S S S S S S S S S S S S S S S S	2 00	с В	P B	<u>Р</u>	<u>ን ቤ</u>	<u></u> 5	с Ч	ц С
·																																															
		I]						p						1]		1]	1		I]		þ					1							-
							+											· ·				+					*																- +			+	
																				_		+ -																						_			





Events		
	Biozones: Triassic-Jurassic Danish Basin TJ Danish Basin	Biozones: Triassic-Jurassic Danish Basin dc TJ Danish Basin
 ■1603.35 Top Dapcodinium priscum		
 ■1632.20 Top Rhaetipollis germanicus		
 ──1641.00 Rhaetogonyaulax rhaetica T1642.60 Top Camerosporites secatus		
► 1661.75 Top Taurocusporites verrucatus		
 Base Classopollis classoides 1674.60		

Palynostratigraphic range chart of Stenlille-2, data from Dybkjær (1991).

ale				Interval Comments						
	Chrono- stratigraphy TJ Danish Basin	Litho- stratigraphy TJ Danish Basin	Biozones: Boreal Ammonite Zonation TJ Danish Basin		(Rw, Cv excluded) *1		Dino (Rw ex *2	flageII kcluded)	Acritarchs (i (Rw excluded) *2	W
Measured deptri (m)		Formation			AC AL ALBO DC MP	Samples (m)	DC Dinoflagellate cysts unidentified DC Dapcodinium priscum	DC Mendicodinium sp. DC Rotundus nongranulatus" DC Rotundus granulatus	AC Leiofusa jurassica AC Pterospermella spp. AC Tasmanites spp. AC Veryhachium spp. AC Micrhystridium spp.	AC Cymatiosphaera spp. MP Unidentifiable palynomorphs
+ 4				1475.00		100 • 1476.00 • 1476.08 • 1477.00 • 1477.00 • 1478.00				
4 4 4				Sequence 9 (in part): Shallow marine		 				· · · · · · · ·
4 4 4		Fjerritslev (in part)		1493.90	90	• 1491.00 • 1491.78 • 1493.00 • 1494.00 • 1494.00				
5 5 5				Sequence 8 above MFS8: Shallow marine to marginal marine						
5 5				1509.50	50	•				
5 5		Gassum		Sequence 7: Fluctuating from marginal marine, to fully marine, to shallow marine		● 1512.00 ── ● 1513.00 ── ● 1513.00 ──				
15									-	

Sofie Lindström Scale: 1:300

*7 (Rw only; Cv excluded)

Taxon Categories

Stenlille-2

			Palynology			
(i	d N	CONISS dinocysts	sts Spores and pollen (in site	tu) CONISS spores (Rw excluded) (R	≀w excluded)	(F
	 Unidentifiable palynomorphs Novoidites spp. BO Botrococcus braunii 	Total Dispersion: TJ marine p.	Corollina torosa " tetrad " Defloidospora australis Stereisportes hauter/viensis Aratrisporites spinitus Chasmatosporites spinitus Spinerioollenites spinitus Chasmatosporites apertus Chasmatosporites apertus Chasmatosporites apertus Spinerioollenites spinitus Spinerioollenites spinitus Stereisporites radisporites telephorus Stereisporites radisporites elegens Combaculatisporites elegens Stratella seebergensis Intrapunctisporites rugulatus Monosucites minimus Protopinus scansus Stratella seebergensis Intrapunctisporites sparsus Stratella seebergensis Intrapunctisporites sparsus Stratella seebergensis Stratella seebergensis Anapiculatisporites sparsus Alisporites rubustus Protopinus scansus Stratella seebergensis Intrapunctisporites rubustus Stratella seebergensis Anapiculatisporites sparsus Bisaccates unidentifiable Defloidospora minor Defloidospora minor Stereisporites elatoides Prinuspollenites punctus Prinuspollenites punctus Prinuspollenites sustroolavatidites Prinuspollenites sustroolavatidites Prinuspollenites sustroolavatus Prinuspollenites sustroolavatidites Prinuspollenites sustroolavatidites Prinuspollenites sustroolavatidites Returites sustroolavatidites sporties spinitus Prinuspollenites spinitus Prinuspollenites spinitus Prinuspollenites spinitus Prinuspollenites sustroolavatidites Returites sustroolavatidites spinitus Prinuspollenites spinitus Prinuspollenites spinitus Prinuspollenites spinitus spinitus Prinuspollenites spinitus spinitus Prinuspollenites sustroolavatidites Prinuspollenites spinitus Prinuspollenites spinitus spinitus Prinuspollenites spinitus spinitus Prinuspollenites spinitus spinitus Prinuspollenites spinitus spinitus Prinuspollenites spinitus spinitus Prinuspollenites spinitus spinitus spinitus spinitus spinitus sp	 Spreingolines priarus Spreingolines priarus Spreingolines sterenides strenides Trachysporites asper Wrreisporites saper Uraespora tener Corollina torosa (Classopolils classoides) Deltoidospora toralis Densoisporites tuberculatus Uvaesporites tuberculatus Uvaesporites tuberculatus Consertucosisporites firmbialus Densoisporites firmbialus Densoisporites firmbiatus Densoisporites firmbiatus Densoisporites firmbiatus Densoisporites firmbiatus Densoisporites firmbiatus Densoisporites fundiatus Perinosporites firmbiatus Densoisporites fundiatus Densoisporites fundiatus Densoisporites fundiatus Densoisporites fundiatus Densoisporites fundiatus Densoisporites fundiatus Densoisporites fundiatis Densosporites fundiatis D		ores and pollen (cosine theta similarity)
 			מממממממ מי מי מי ממימי מייי מי ממממממממ	אַרַיַּיּאַלאָלאָל אָאָאָאָאָאָאָאָאָאָאָאָאָאָאָאָ		80 80





Palynostratigraphic range chart of Stenlille-5.

Scale				Interval Comments					
			Biozones: Boreal		(Rw, Cv excluded)		Dinoflagella	Ac	
	Chrono- stratigraphy TJ Danish Basin	Litho- stratigraphy TJ Danish Basin	Ammonite Zonation TJ Danish Basin		*1		(Rw excluded) *2	*3 *2	*3 *4
Measured depth (m)		Formation			AC AL ALBO DC MM SP	Samples (m)	DC Dapcodinium priscum DC Rhaetogonyaulax rhaetica	AC Cymatiosphaera spp. AC Micrhvstridium spp.	AC Cymatiosphaera polypartita ALBO Botryococcus braunii AL Lecaniella spp.
- - - - -1550		Fjerritslev (in part)		Sequence 8: Marginal marine or shallow marine (depauperated) 1548.00		-●1545.00 YH 6190 -●1550.94 YH 6169			
-		Gassum		Sequence 7: Fully marine					
Tout	(L	۱ ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰ - ۲۰۰۰	L AL - Algae	I		1		

Text Keys

- *1 quant/semi-quant abundance, % panel
- *2 quant/semi-quant abundance, % all Paly.
- *3 (Rw excluded)
- *4 quantitative abundance, % all Paly.
- *5 (Rw only)
- *6 (Rw only; Cv excluded)

- Boundary Types
- —— Confident

— Cutting

---• Core

- Sampling
- DC Dinoflagellate cysts 📕 FU - Fungi
- MM Miscellaneous microfossils

ALBO - Botryococcus and pediastrum

- MP Miscellaneous palynomorphs
- PF Palynofacies
- SP Spores and pollen
- Taxon Categories AC - Acritarchs

— Sidewall Core

Stenlille-5

Palynology CONISS dinocysts CONISS spores... (Rw excluded) Spores and pollen (in situ) (Rw excluded) (Rw, Cv excluded) quant/semi-quant abundance, % panel Δ S spp. spp. \Box \frown otal C ር ር



			Events		
v excluded)	A 2 *6 2 *2			Biozones: Triassic-Jurassic Danish Basin TJ Danish Basin	Biozones: Triassic-Jurassic Danish Basin dc TJ Danish Basin
= - - - - - - - - - - - - - - - - - - -	SP Lycospora salebrosacea	Samples (m)			
2		-●1545.00 YH 6190 -●1550.94 YH 6169	1545.00 Top Rhaetogonyaulax rhaetica Base Rhaetogonyaulax rhaetica 1550.94∟_		

Palynostratigraphic range chart of Stenlille-1, data from Lindström et al. (2012, 2015, 2017, 2019, and in prep.).

CaleLitho- stratigraphy TJ Danish BasinBiozones: Boreal Ammonite Zonation TJ Danish Basin	Interval Comments Dinoflagellate cysts (in situ) Acritarchs (in situ) *1 (Rw, Cv excluded) (Rw excluded) *2 (Rw excluded) quant/semi-quant abundance, % all Paly. *3 quant/semi-quant abundance, % all Paly.	MP Freshwater alga indext index index index indext </th <th>Spores</th> <th>Palynology es and pollen (in situ)</th> <th>Image: Constant of the spores (Rw excluded) (Rw excluded) (Rw excluded) (Rw excluded) (Rw only) (</th> <th>Dines: Jurassic Biozones: Triassic-Jurassic Danish Basin do TJ Danish Basin Sh Basin</th>	Spores	Palynology es and pollen (in situ)	Image: Constant of the spores (Rw excluded) (Rw excluded) (Rw excluded) (Rw excluded) (Rw only) (Dines: Jurassic Biozones: Triassic-Jurassic Danish Basin do TJ Danish Basin Sh Basin
Measured depth (m) Formation	 G M M G L L O TY P N d M G L M G Ranulatus d M G Ranundatus d M G Ranundatus	AC Leiofusa structure spp. AC Celophaera polypartita AC Celophus stenillensis MP Unidentifiable palynomorphs MP Sporomorph indet. granulate ALBO Botryococcus braunii AL Lecaniella korsoddensis AL Lecaniella korsoddensis AL Lecaniella korsoddensis AL Lecaniella korsoddensis AL Lecaniella spp. AL Lecaniella spp. A Lotatosportes spinosus SP Monosulcites spinosus SP Perinopolenites elatoides Perinopolenites elatoides	 SP Pinuspollenites minimus SP Punctatisporites globosus SP Retitrietes austroclavatidites SP Quadraeculina anellaeformis SP Retitrietes austroclavatidites SP Stareisporites subtroclavatidites SP Stratella seebergensis Striatella seebergensis Striveisporites vallatus Serbisporites vallatus Stripsporites vallatus Stripsporites vallatus Stereisporites vallatus Stereisporites vallatus Stereisporites stereoldes <	 Spores aberrant indet Spores apportes spores Sportigalatisporites spores spores Sportigalatisporites spores Sportigalatisporites spores spores Sportigalatisporites spores ander and aberologian Sportigalatisporites spores spores Sportigalatisporites spores apportes spores Sportigalatisporites spores Sportigalatisporites spores Sportigalatisporites spores ander abores Sportalicaborites spores andrais Sportalicaborites spores and abores Sportalicaborites spores and abores Sportalicaborites spores and abores Sportalicaborites spores and abores Spore landate pollen indet. Polycolaborites spores and abores Spore landatorites spore sportes spores Spore stradisportes spores Spores sportes spores Spores sportes spores Spores sportes spores and abores Spores apores apolacies spores	Scores where, unique to the second se	Zone Sub Zone
484 1 486 486 488 490 490 Fjerritslev 494 Fjerritslev 496 1 498 1 500 1 502 1 504 1 506 1	Sequence 9 (in part); fully mame to shallow marine to					Illenites - Illenites - Illen
108 11 110 11 112 11 114 11 114 11 116 11 118 11 118 11 119 11 110 11 111 11 111 11 111 11 111 11 114 11 <td< td=""><td>Sequence 7: fully marine to shallow marine and fully marine 100 00 00 00 00 00 00 00 00</td><td></td><td></td><td></td><td></td><td>Rhaetogonyaulax rhaetica Zone D. priscum acme 1520.00 common D. priscum - F rhaetica 152 1523.40</td></td<>	Sequence 7: fully marine to shallow marine and fully marine 100 00 00 00 00 00 00 00 00					Rhaetogonyaulax rhaetica Zone D. priscum acme 1520.00 common D. priscum - F rhaetica 152 1523.40
530 1 532 1 534 1 536 1 538 1 540 1 542 1 544 Gassum 548 1	159.30 502.30 (159.29 core 9 (159.29 core 9 (159.28 core 9 (159.28 core 9 (159.28 core 9 (159.28 core 9 (159.28 core 9 (159.28 core 9) (159.28 core 9					
530	Sequence 5: Marginal mathe to shallow mathe					
568 1 570 571 572 574 574 576 576 578 578 578 570 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 578 579 578 570 578 578 578 578 578 579 578 579 578 570 578 578 578 578 578 578 578 578 578 578 578 578 578 579 578 579 578 579 578 579 578 579 579	sequence 4: marginal marine to shallow marine Sequence 4: marginal marine to shallow marine AL - Algae Sequence 4: marginal marine to shallow marine to shallow marine to shallow marine Sequence 4: marginal					

Stenlille-1



Palynostratigraphic range chart of Stenlille-6.

Scale				Interval Comments											
	Chrono- stratigraphy TJ Danish Basin	Litho- stratigraphy TJ Danish Basin	Biozones: Boreal Ammonite Zonation		(Rw, Cv excluded) *1		Dinoflagellate cys (Rw excluded) *2				; / (,	. Acritarchs (Rw excluded) *2			
Measured depth (m)		Formation			AC AL ALBO DC MP SP	samples (m)	DC Dapcodinium priscum DC Mendicodinium groenlandicum	DC Rotundus nongranulatus"	DC Rotundus granulatus DC Sverdrupiella spp.	DC Lunnomidinium scaniense (aita) DC Dinoflagellate cysts unidentified	DC Liasidium variabile	DC Mancourriurri serrinauuaturri DC Nannoceratopsis gracilis	AC Lerospriaeriua sup. AC Multiplicisphaeridium spp.	AC Micrinystriaium spp. AC Cymatiosphaera spp.	AC Sphaeromorph "various" AC Lophosphaeridium spp. AC Vervhachium spp.
-1620						_									
-				Sequence 5: Marginal marine											
_ -1630						-				/					
-				1635.70		— 1635———]Cv	Cv C	v Cv]			
-1640						-									
-1650						- 1645]]Cv]	
-		Cossum		Sequence 4: snallow marine											
		Gassum				-									
- - -1670				1667.40		_									
-											h .				
- 1680 -				Sequence 3: marginal marine to shallow marine		1671 - 1677 —				Cv			+	+	
						1677 - 1683 —			?]Cv]Cv				
-1690 - -				1690.00 Sequence 2: no data		-									
-1700				1698.40		_									
-			т	Base Gassum to SB2: no data 1705.80	-										
- -1710				Below Base Gassum:		-				/					
-				marginal marine		1713 - 1716 -			1	?] Cv]	Cv]Cv		1	+]]
Text K *1 qua *2 qua *3 (Rw *4 qua *5 (Rw Bound	Xeys ant/semi-quant abunda ant/semi-quant abunda v excluded) antitative abundance, v v only; Cv excluded) dary Types	Sance, % panel — ance, % all Paly. — % all Paly. —	ampling Cutting Core Sidewall Core axon Categories AC - Acritarchs AL - Algae	DC - Dinoflagellate cyst FU - Fungi MP - Miscellaneous pal PF - Palynofacies SP - Spores and pollen	ynomorphs		<u> </u>								

Stenlille-6

Palynology									
chs MP uded) *2 *3 *4 *4	CONISS dinocyst	S (Rw, Cv excluded) quant/semi-quant abundance, % panel	Spores and poll	en (in situ)	CONISS spores (Rw excluded)	(Rw excluded) (Rw excluded) (Rw excluded) Rew (\$\vec{k}\$) (\$\vec{k}\$) (\$\vec{k}\$) (\$\vec{k}\$) (\$\vec{k}\$) (\$\vec{k}\$) (\$\vec{k}\$) (\$\vec{k}\$)		Biozones: Triassic-Jurassic Danish Basin TJ Danish Basin	Biozones: Triassic-Jurassic Danish Basin dc TJ Danish Basin
C Sphaeromorph "various" C Lophosphaeridium spp. C Veryhachium spp. IP Unidentifiable palynomorphs IP Sporomorph indet. granulate LBO Botryococcus braunii	Total Dispersion: Tu	 P Camerosporites verrucatus P Chasmatosporites verrucatus P Contignisporites problematicus P Contignisporites fissus P Densoisporites fissus P Alausipollenites gouldii P Manumia delcourtii P Klausipollenites crassexina P Karbysporites verrucatus P Limbosporites lundbladiae P Lunatisporites rhaeticus P Retitriletes semimuris P Alisporites robustus P Alisporites robustus P Alisporites robustus P Alisporites semonicus P Alisporites robustus P Alisporites robustus P Alisporites comaumensis 	 P Calamospora tener P Calamospora tener P Chasmatosporites apertus P Chasmatosporites hians P Chasmatosporites hians P Classopollis meyerianus P Canollina zwolinskai P Deltoidospora australis P Deltoidospora minor P Deltoidospora minor P Deltoidospora minor P Deltoidospora toralis P Politoidospora toralis P Politoidospora P Pol	 P Spheripollenites spp. P Striatella seebergensis P Trachysporites asper P Chordasporites sep. P Marattisporites sep. P Marattisporites vallatus P Nevesisporites vallatus P Protohaploxypinus spp. P Aratrisporites minimus P Aratrisporites australis P Nuctatisporites australis P Nuctatisporites australis P Nuctatisporites spinosus P Manosulcites minimus P Nonosulcites minimus P Nonosulcites tenuicorpus P Reaetipollis ovalis P Reaetipollis germanicus P Anatrisporites spinosus P Polypodiisporites polymicrofore 	P Stereisporites spp. P Cerebropollenites spp. P Chasmatosporites spp. P Chasmatosporites spp. P Chasmatosporites spp. P Lophotriletes spp. P Alisporites radialis P Anapiculatisporites spp. P Cyclogranisporites spp. P Eucommidites minor P Rimaesporites interscriptus P Zebrasporites interscriptus pores and pollen (shannon diversi	pores and pollen (species richness pores and pollen (cosine theta sirr pores and pollen (cosine theta sirr polygonal pollen (cosine theta sirr pollen (cosine theta sirr polyg			
	۲	<u> </u>		<u> </u>	· · · · · · · · · · · · · · · · · · ·	Ø Ø Ø Ø Ø 4 80 2 1 1			
					▶ ▶ ▶ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	+ 			
+						+ + - 1713 - 1716-	Base Rhaetipollis germanicus 1716		
	1								



Table 1.

A summary of the depositional environments based on the palynological investigation of wells in the Stenlille area.

	Stenlille-15	Stenlille-4	Stenlille-18	Stenlille-2	Stenlille-5	Stenlille-1	Stenlille-6
Sequence 9 (in		Marginal to fully		Shallow marine		Fully marine to	
part)		marine				shallow marine	
Sequence 8		Above MFS8,		Above MFS8,	Marginal marine	Above MFS8,	
		shallow marine.		Shallow marine	or shallow marine	shallow marine to	
		Below MFS8,		to marginal	(depauperated)	marginal marine	
		shallow marine		marine		with freshwater	
		with high input of				input.	
		siliciclastic mtrl				Below MFS8,	
						shallow marine	
						with high input of	
						siliciclastic mtrl	
Sequence 7		Full marine		Fluctuating from	Fully marine	Fully marine to	
				marginal marine		shallow marine	
				to fully marine to			
				shallow marine			
Sequence 6	Fully marine	Upper part, fully				fluctuating	
		marine.				between shallow	
		Lower part				marine and fully	
		marginal marine				marine	
Sequence 5	Fully marine	Shallow marine	Marginal marine			Marginal marine	Marginal marine
			to shallow marine			to shallow marine	
Sequence 4	terrestrial to	Marginal marine	Fluctuating			Marginal marine	Shallow marine
	possibly marginal		between			to shallow marine	
	marine		marginal marine				
	environment		and terrestrial				
Sequence 3	Fluctuating	Marginal marine					Marginal marine
	between marginal						to shallow marine
	marine, shallow						
	marine, terrestrial,						
	and marginal						
	marine						
	environment						
Sequence 2							
Base Gassum to	Marginal marine						
SB2							
Below Base		Marginal marine					Marginal marine
Gassum							