DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2005/41

A new, Ladinian palyno-flora in the Triassic of Sweden

Palynological analysis of the FFC-1 and -2 wells at Malmø and the cored well Höllviken-2

Stefan Piasecki

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Abstract

Palynological analysis of cuttings samples from the Triassic succession in the two wells FFC-1 and -2 near Malmø, Sweden, mainly show barren samples contaminated with caved material from higher, Rhaetian/Lower Jurassic and Cretaceous strata. However, some analyses reveal a limited, brown to black coloured spore-pollen flora of uppermost Ladinian, Middle Triassic age. A similar flora occurs in the Höllviken-2 well, from which core-samples are analysed to provide uncontaminated material for correlation.

The flora is named the *Protohaploxypinus* Assemblage after small, characteristic bisaccate pollen with minute sacci. These, and species of *Aratrisporites*, are characteristic for Ladinian, upper Middle Triassic, floras in Poland and Germany. Several of the recorded species are described from this interval only e.g. *Nevesisporites lubricus*, *Ovalipollis brutus* and *Parvisaccites triassicus*. Other species are reported to appear or disappear in this interval so the precise age of the flora is limited by the first occurrence of *Retisulcites perforatus*, *Ovalipollis brutus* and *Umbrosaccus keuperianus* in Lower Keuper, Upper Ladinian, and by the last occurrence of *Aratrisporites fimbriatus* at the top of Lower Keuper. *Podosporites amicus* has first occurrence at the Lower/Middle Keuper boundary but no other taxa indicate occurrence of Middle Keuper/Upper Triassic strata.

The inferred late Ladinian, late Middle Triassic age does not directly contradict earlier age assignments based on ostracods and calcareous algae (Characeae) from the Höllviken-2 well but supports a correlation to Lower Keuper rather than to Muschelkalk for the upper part of the fossiliferous succession.

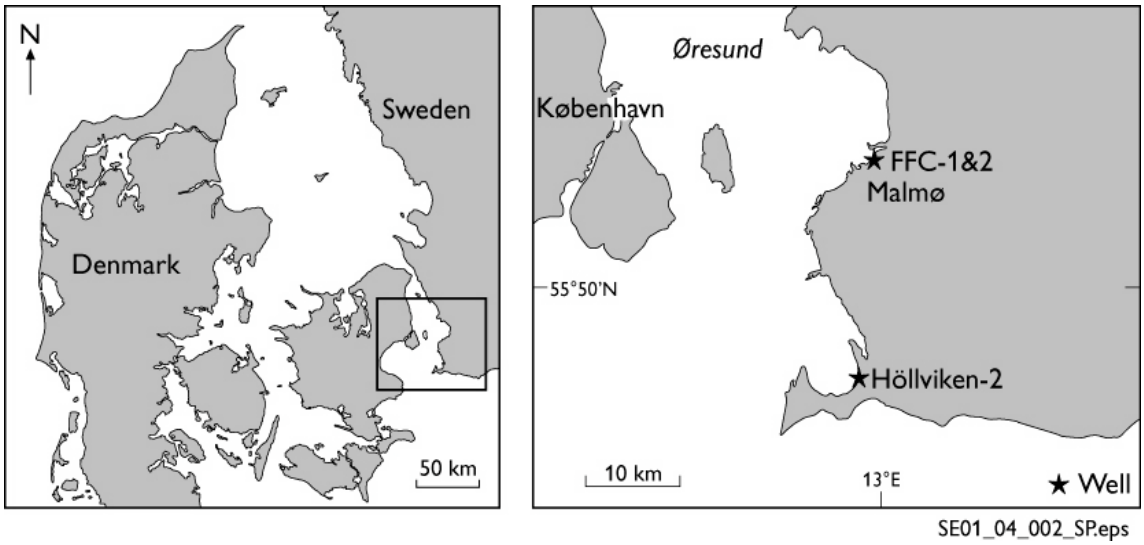

Figure 1: Map showing the position of the wells FFC-1, FFC-2 and Höllviken-2 in southwest Scania, Sweden.

Introduction

The pre-Rhaetian, Triassic succession in Southwest Scania comprises terrestrial to marginal marine sediments. In association with abundance of coarse-grained deposits, red and green colours of the sediments indicate deposition under severe primary oxidation and consequently with little or no organic matter preserved. However, more palynologically promising, fine-grained lithologies of grey to black colours are locally associated with coals at certain levels in the succession.
Samples were collected from such a succession in the cores of the Höllviken-2 well, 1755–1862 m (Figure 1). Previously, nine different cuticles and three unidentified sporomorphs were reported together with seed-like organic bodies from this succession (Lundblad 1949). Based on sparse microfossil faunas this succession was referred first to the Lower Keuper, possibly including uppermost Muschelkalk, Middle Triassic (Brotzen 1950) and later to Upper Muschelkalk possibly including Lower Keuper in the uppermost part (Kozur 1974).

The purpose of the present study is to provide biostratigraphic data for the Triassic succession in the new FFC-1 and -2 wells at Malmø, Sweden, to support the predominantly lithostratigraphic correlation of the succession (Figure 1). Mikael Erlström and Ulf Sivhed from SGU (Sveriges Geologiska Undersökelse in Lund) selected cuttings samples for palynological analysis from the pre-Rhaetian, succession of the two wells. Supplementary material of 4 core-samples was collected from the Höllviken-2 well to obtain material not contaminated by caving.

Triassic stratigraphy comprises a very complex system of regional stratigraphic schemes. However, the international Triassic stratigraphy has recently been revised and presented by the International Commission on Stratigraphy on their homepage (www.stratigraphy.org) (Figure 2). In Sweden, the German Triassic stratigraphic scheme has been traditionally applied to the Triassic succession due to the dominantly lithostratigraphic correlation. The lithological units of the Swedish Triassic are correlated with the international stratigraphy (via the German stratigraphy) in figure 2.

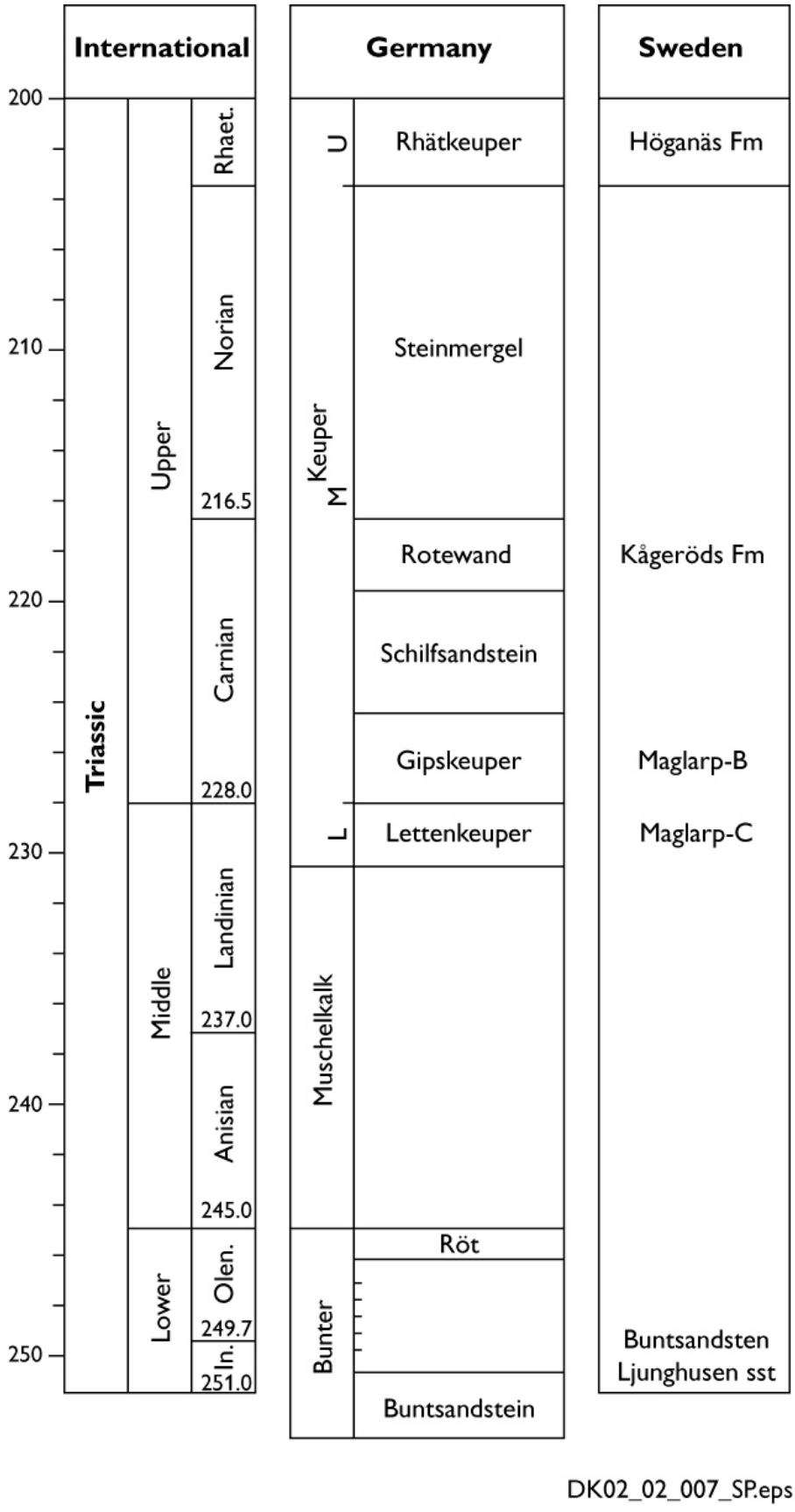

Figure 2: Correlation of regional German and Swedish Triassic stratigraphy with International Triassic standard stratigraphy.

Previous biostratigraphy

The Triassic biostratigraphy of the new wells FFC-1 and -2 has not been studied before in contrast to the much older Höllviken-2 well drilled in 1944–1945. The succession from 1755–1862 m in the Höllviken-2 well was first classified as Lower Keuper with the lowest strata probably equivalent to Muschelkalk, i.e. Ladinian, Middle Triassic in age (Brotzen 1950) (Figure 3). The succession was divided into "zones" a – f based on the lithology and content of fossils (Brotzen 1950). The "zones" b, d and f contained microscopic fossil fauna (e.g. scales and bones of fish and ostracods) and flora (bisaccate pollen, cuticles and Characeae) whereas "zones" a, c and e were considered barren (Figure 3).

In a comprehensive work on the German Middle Triassic Kozur (1974) specify the ages of the fossiliferous units of the same Höllviken-2 succession. Kozur refers to the units defined by Brotzen (1950). The boundary of Middle and Upper Muschelkalk (mm/mo boundary) is referred to the "zone" b based on the presence of a characean assemblage spanning the transition from Middle to Upper Muschelkalk. The next higher fossiliferous unit, "zone" d, was correlated to a characean biozone, the *Sellingii* Zone from the German Middle Triassic ("Tabelle" 4 in Kozur 1974) due to the occurrence of the zonal species (*Stellatochara sellingii*) in the basal strata of "zone" d (Horn af Rantzien 1953, 1954). Kozur (1974) correlates the *Sellingii* Zone to the Upper Muschelkalk (embracing the mo_2/mo_3 boundary) (Figure 3). Furthermore, Kozur (1974) mentions the characean assemblage Zone VI, *Stellatochara hoellvicensis* Zone from the Triassic of the Russian platform (Sajdakovskij 1966), which is correlated to the Anisian/Ladinian transition, the zone includes the boundary. According to Kozur (1974), this biozone is confined to the "zone" d and f in the Höllviken-2 succession. Here it comprises only upper Ladinian strata, Middle Triassic (upper Muschelkalk – Lower Keuper (Lettenkeuper)) ("Tabelle" 4 in Kozur 1974) based on the presence of *Stellatochara sellingii* Horn af Rantzien (1953, 1954) as mentioned above.

The two productive samples from Höllviken-2 in the present study are positioned in the basis of the barren? "zone" e and in the fossiliferous "zone" f referred to Ladinian (Lower Keuper) by Kozur (1974) (Figure 3).

Conclusively, the age of the studied succession was Middle Triassic, uppermost Anisian – Ladinian, deposited over a time span of approximately 10 million years. The three fossiliferous units of Brotzen (1950) probably represent short, humid periods with flourishing brackish water fauna and flora.

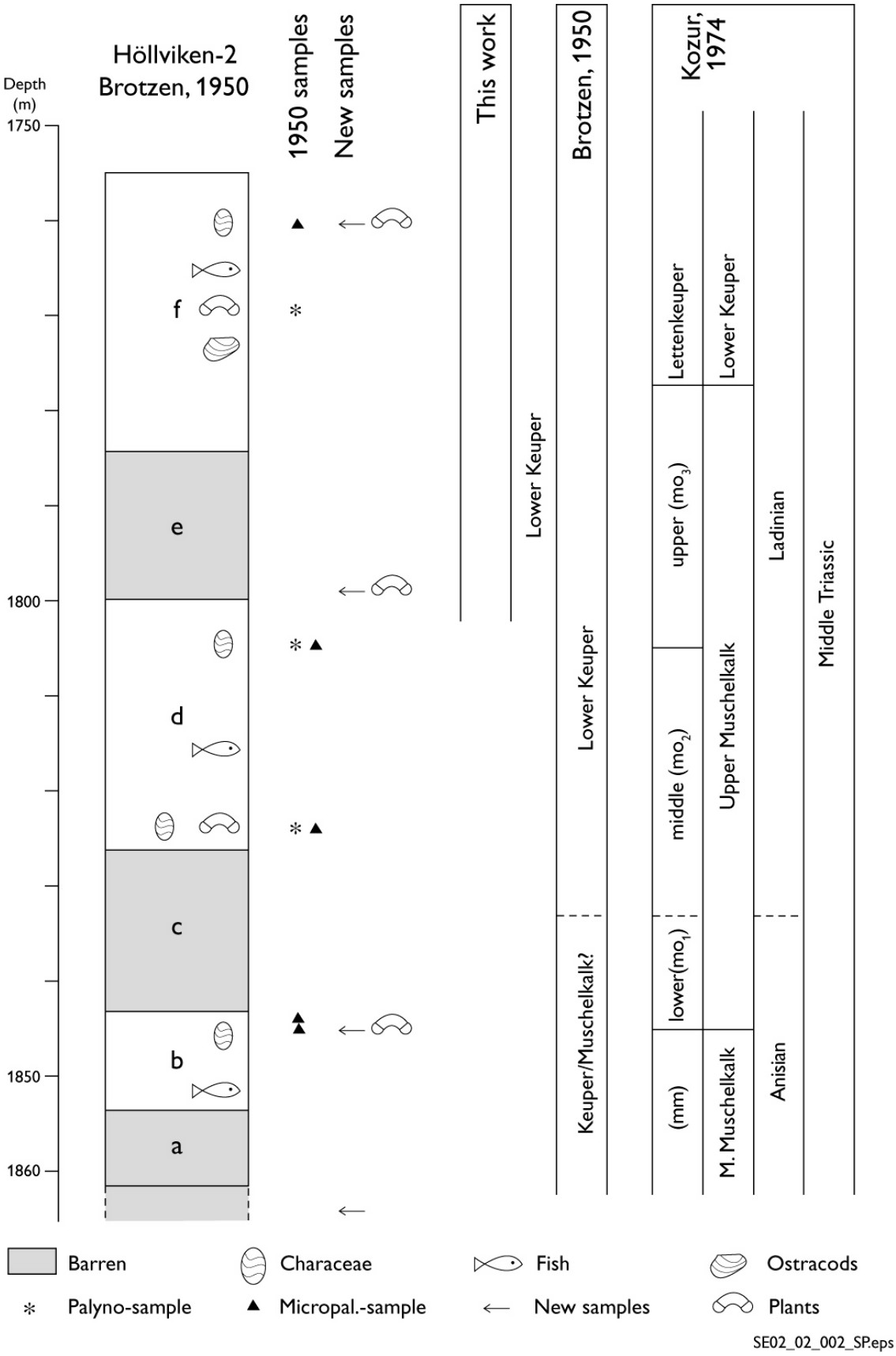

Figure 3: Illustration of the Höllviken-2 core (1755–1862 m) and the results of the biostratigraphic analyses.

Material and methods

The sample material from FFC-1 and -2 comprise washed cuttings of several different lithologies in each sample (DCS = Ditch Cuttings Sample). Sediment grains from 1 to 4 millimetres were used for analysis in order to minimise the content of caved material and mud contamination. The uppermost sample in FFC-2 at 2510 metres is located just below the casing at the basis of the Kågerød Formation at 2500 metres. In FFC-1 the casing was installed at 700 metres, well above the first sample at 1954 metres. The Höllviken-2 samples are core samples (CS).

All samples have been prepared with standard palynological techniques. Hydrochloric and hydrofluoric acids removed mineral matter, and the organic content was oxidised with concentrated nitric acid and washed with potassiumhydroxide to remove humic material. The standard preparation process was followed by specific treatment of each sample such as filtering with 11 or 20 µ mesh size, ultrasonic bath, and swirling or heavy liquid separation. Four to five slides of different steps in the preparation were prepared for the analysis. The first slides were used mainly for evaluating the composition of the organic content and thermal maturity but all slides from each sample were scanned for stratigraphic significant taxa, which then were recorded on a record-sheet.

FFC-1

Sample-type/depth – assemblage/age
DCS 1954 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 1987 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 1996 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 2029 m – *Protodiploxypinus* Assemblage, Ladinian, latest Middle Triassic age
DCS 2080 m – *Protodiploxypinus* Assemblage, Ladinian, latest Middle Triassic age

FFC-2

Sample-type/depth – assemblage/age
DCS 2510 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 2535 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 2565 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 2605 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 2645 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 2665 m – caved material of Cretaceous and Lower Jurassic–Rhaetian age
DCS 2680 m – abundant fungal material, possibly *in situ*
DCS 2700 m – *Protodiploxypinus* Assemblage, Ladinian, latest Middle Triassic age
DCS 2735 m – *Protodiploxypinus* Assemblage, Ladinian, latest Middle Triassic age
DCS 2760 m – *Protodiploxypinus* Assemblage, Ladinian, latest Middle Triassic age
DCS 2785 m – *Protodiploxypinus* Assemblage, Ladinian, latest Middle Triassic age

Höllviken-2

Sample-type/depth – assemblage/age
CS 1761,20 m – *Protodiploxypinus* Assemblage, Ladinian, latest Middle Triassic age
CS 1769,29 m – Sporomorph A (*Alisporites* sp.) (Lundblad 1949)
CS 1798,15 m – *Protodiploxypinus* Assemblage, Ladinian, latest Middle Triassic age
CS 1824,69 m – Sporomorph B & C, Cuticle A–I (Lundblad 1949)
CS 1845,20 m – Functional barren (unidentifiable relicts of sporomorphs e.g. Bisaccates)
CS 1865,80 m – Barren

Analyses

FFC-1

DCS 1954 m

Organic matter: Dominated by brown and black woody material, cuticles and sporomorphs.

Palynomorphs: Dominated by trilete spores. Pollen are common and dinoflagellate cysts are rare.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica*? is common together with unidentified dinoflagellate species.

Acritarchs: *Veryhaccium* sp.

Spores and pollen: A presumably caved, Rhaetian assemblage of *Alisporites* spp., *Corollina* spp., *Limbosporites lundbladii*, *Rhaetipollis germanicus*, *Ricciisporites tuberculatus*, *Ovalipollis ovalis*.
Corroded specimens of morphologic similarity to *Leganiellea martini*, *Taeniaesporites krauselii* and *Patinasporites* sp. occur very subordinately to the total dominance of Rhaetian terrestrial and marine flora, and may indicate an Upper Triassic, relict palynoflora.

Depositional environment: Not identified.

Age: Not identified.

Biozone: Not identified.

Comments: None of the identified palynomorphs are considered *in situ* due to geological indications of definitely pre-Rhaetian strata at this depth in the well (pers. comm. M. Erlström & U. Sivhed 2004)

DCS 1987 m

Organic matter: Brown and black woody material, cuticles and sporomorphs are abundant.

Palynomorphs: Trilete spores dominate but cavate pollen are common together with dinoflagellates.

Dinoflagellate cysts: Caved *Rhaetogonyaulax rhaetica* is common and *Dapcodinium priscum* is present. Caved Cretaceous dinoflagellates are represented by *Muderongia simplex, Oligosphaeridium asterigium* and *Spiniferites* spp.

Acritarchs: None.

Spores and pollen: A presumably caved, Rhaetian assemblage of *Corollina* spp., *Ricciisporites tuberculatus*, *Ovalipollis ovalis*, *Taeniaesporites* sp., *Quadraeculina anellaeformis* and others.

Depositional environment: Not identified.

Age: Not identified

Biozone: Not identified

Comments: None of the recorded palynomorphs are considered *in situ* due to geological indications of definitely pre-Rhaetian strata at this depth in the well (pers. comm. M. Erlström & U. Sivhed 2004).

DCS 1996 m

Organic matter: Dominated by brown and black woody material, cuticles and sporomorphs.

Palynomorphs: Dominated by trilete spores. Pollen are common and dinoflagellate cysts are rare.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica*? occurs together with unidentified dinoflagellates.

Acritarchs: None recorded.

Spores and pollen: A presumably caved, Rhaetian assemblage of *Alisporites* spp., *Chasmatosporites* spp., *Corollina* spp., *Limbosporites lundbladii*, *Ovalipollis ovalis*, *Rhaetipollis germanicus*, *Ricciisporites tuberculatus*.

Depositional environment: Not identified.

Age: Not identified.

Biozone: Not identified.

Comments: None of the recorded palynomorphs are considered *in situ* due to geological indications of definitely pre-Rhaetian strata at this depth in the well (pers. comm. M. Erlström & U. Sivhed 2004).

DCS 2029 – 2080 m

The samples from 2029 to 2080 metres have a low organic content of similar composition. The uppermost sample is the richest and it comprises the most diverse and abundant spores and pollen assemblage.

DCS 2029 m

Organic matter: Dominated by black to brown woody material and abundant sporomorphs.

Palynomorphs: Spores and pollen dominates, relatively few caved dinoflagellates are present.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica* are caved from Rhaetian strata and *Cleistosphaeridium* sp., *Spiniferites* spp. and *Oligosphaeridium asterigium* are caved from Cretaceous strata.

Acritarchs: *Dactylofusa*? sp.; Crescent, thin-walled, cornu-cavate body with grey to dark brown colour possibly belonging to the Middle Triassic flora.

Spores and pollen: The strongly degraded, dark brown to black, presumably *in situ* sporomorph assemblage comprises unidentified bisaccate pollen together with *Alisporites* cf. *aequalis*, *Alisporites grauvogeli*, *Annulispora microannulata*, *Aratrisporites paraspinosus*, *Aratrisporites fimbriatus*, *Cordasporites* spp., *Illinites* sp. A, *Nevesisporites lubricus, Ovalipollis brutus*, *Protodiploxypinus potoniei*, *Protodiploxypinus gracilis* (common), *Striatoabieites* sp.α Scheuring 1978, *Taeniaesporites* sp., cf. *Triadispora verrucosum* and *Triadispora* sp.
Brown to orange, caved Rhaetian – Lower Jurassic spores and pollen occur commonly e.g. *Corollina* spp., *Deltoidospora toralis*, *Limbosporites lundbladii*, *Ovalipollis ovalis*, *Ricciisporites tuberculatus*, *Quadraeculina anellaeformis*, *Rhaetipollis germanicus*, *Trianchoraesporites ancorae*. Few, glass-clear, bisaccate pollen not affected by thermal diagenesis are recorded.

Depositional environment: Terrestrial – limnic.

Age: Ladinian, Early Keuper, Middle Triassic.

Biozone: Not identified.

Comments: The Triassic sporomorphs are darker and more degraded than the corresponding assemblage from Höllviken-2. The dark brown/black Triassic spores and pollen are rare compared to the caved material of lighter colours. The assemblage is overall similar in composition to the assemblages recorded in FFC-2 and Höllviken-2.
The composition of the present assemblage indicates a spore and pollen flora of transitional strata from Upper Muschelkalk to Lower Keuper, uppermost Middle Triassic. *Aratrisporites fimbriatus* disappears in uppermost Lower Keuper in Poland (Orlowska-Zwolinska 1979). *Umbrosaccus keuperianus* is described from Lower Keuper, Upper Mid-

dle Triassic in Germany (Mädler 1964). *Nevesisporites lubricus* is restricted to Lower Keuper in Poland (Orlowska-Zwolinska 1979). *Retisulcites perforatus* occurs in Lower Keuper and higher strata (Mädler 1964, Scheuring 1970).

DCS 2080 m

Organic matter: Black and brown woody material dominates, spores and pollen are common and rare fragments of cuticles occur.

Palynomorphs: Spores dominate, bisaccate pollen and rare dinoflagellate cysts occur. *In situ* sporomorphs are very difficult to discriminate from caved material, and basically all the organic matter could be caved.

Dinoflagellate cysts: Caved dinoflagellates from Rhaetian – Lower Jurassic and Cretaceous strata e.g. *Rhaetogonyaulax rhaetica*, *Cleistosphaeridium* sp., *Oligosphaeridium asterigerum* and *Cribroperidinium* spp.

Acritarchs: One questionable *Dactylofusa*? sp. is recorded.

Spores and pollen: A very limited assemblage of strongly degraded, dark brown to black, presumably *in situ* sporomorphs comprise unidentified bisaccate pollen *Aratrisporites* sp., *Aratrisporites fimbriatus*, *Aratrisporites scabratus, Alisporites aequalis*, *Alisporites* sp., *Protodiploxypinus* cf. *potoniei* and *Protodiploxypinus gracilis*.
A dominating assemblage of brown to orange, caved Rhaetian – Lower Jurassic spores and pollen comprises *Deltoidospora toralis*, *Chasmatosporites apertus*, *Corollina* spp., *Limbosporites lundbladii*, *Quadraeculina anellaeformis*, *Ricciisporites tuberculatus*, *Trianchoraesporites ancorae*. Few, glass-clear, bisaccate pollen not affected by any thermal diagenesis are recorded.

Depositional environment: Terrestrial.

Age: Uncertain, but presumably Ladinian, Early Keuper, Middle Triassic, or older.

Biozone: None recorded.

Comments: The presumed *in situ*, black Triassic spores and pollen are very rare compared to the caved material of lighter colours. All the species in the present assemblage are also recorded in the overlying samples.

The FFC-1 *Protodiploxypinus* Assemblage

An assemblage characterised by species of *Protodiploxypinus* is recorded in the two lowermost samples from FFC-1. The upper sample (2029 m) provides a diverse and abundant assemblage in contrast to the poor assemblage recovered from the lower sample (2080 m), which may be caved.

The *Protodiploxypinus* assemblage is very similar to the assemblage recovered from the Höllviken core samples. *Aratrisporites* spp. and *Protodiploxypinus* spp. (*Minutosaccus* spp. of Mädler (1964)) occur frequently. Bisaccate pollen are common and especially represented by *Alisporites, Protodiploxpinus* and *Triadispora*. Striate bisaccate pollen are rare e.g. *Striatoabieites* and *Striatites.* Trilete spores are also common but most of the recorded species are not stratigraphic significant.
Both the *Aratrisporites* and *Protodiploxypinus* species suggest an age equivalent to the latest Muschelkalk and Early Keuper. However *Ovalipollis brutus* appears in Lower Keuper, Middle Triassic (Scheuring 1970).
In conclusion, the age of the succession represented by the samples 2029 – (2080?) meters in FFC-1 is considered Early Keuper, Middle Triassic.
Dactylofusa? sp. is the only morphologically well defined algae (acritarch?) recorded in the *Protodiploxypinus* Assemblage and furthermore it is only recorded in the FFC-1 succession. It may indicate deposition in a limnic or possibly marginal marine environment.

FFC-2

2500 m – Casing at the basis of Kågerød Formation

DCS 2510 m

Organic matter: Brown and black woody material dominates together with abundant palynomorphs.

Palynomorphs: Degraded spores and pollen are abundant, dinoflagellates are common.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica* is abundant. *Hystrichodinium voigtii*, *Stiphorosphaeridum* spp. and a few other Cretaceous dinoflagellates have been recorded.

Acritarchs: None recorded.

Spores and pollen: Trilete spores are abundant. Stratigraphical important species are e.g. *Deltoidosporites toralis*, *Densoisporites* sp., *Limbosporites lundbladii*, *Semiretisporis gothae*, *Tigrisporites scurrandus*, *Triancoraesporites ancorae*, *Zebrasporites interscriptus*. The stratigraphical important pollen *Alisporites robustus*, *Chasmatosporites apertus*, cf. *Granuloperculatipollis rudis*, *Ovalipollis ovalis*, *Quadraeculina anellaeformis* and *Ricciisporites tuberculatus* are also recorded.

Depositional environment: Not identified

Age: Not identified.

Biozone: Not identified.

Comments: The sporomorph and dinoflagellate assemblages indicate an overall Rhaetian, Late Triassic age. However, the Rhaetian assemblage is considered exotic based on geo-

logical observations (pers. comm. M. Erlström & U. Sivhed 2004). The presence of few Cretaceous dinoflagellates supports, that contamination of the analysed material did take place either as caving (despite the casing) or from recycling of the drilling mud. The analysed lithologies comprise red and green coloured sediments, which generally are unfavourable for preservation of palynomorphs due to primary oxidation.

DCS 2535 m

Organic matter: Brown and black woody material dominates together with abundant palynomorphs.

Palynomorphs: Degraded spores and pollen are abundant. Dinoflagellates are rare.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica* occurs commonly. Very few dinoflagellates caved from both Lower and Upper Cretaceous do occur; *Lagenorhytis delicata*, *Oligosphaeridium asterigium*, *Spiniferites* spp. and *Xenascus* sp.

Acritarchs: Very few *Veryhaccium* spp. and *Micrhystridium* spp. are recorded but are considered caved.

Spores and pollen: An overall Rhaetian, Upper Triassic assemblage has been recorded. Trilete spores dominate the assemblage e.g. *Calamospora* spp., *Cingulizonates* sp., *Deltoidospora toralis*, *Densosporites fissus*, *Limbosporites lundbladii*, *Neochomotriletes triangularis* and *Uvaesporites argenteaeformis*. The pollen assemblage comprises *Alisporites robustus*, *Corollina* spp., *Pinuspollenites minimus* and *Ricciisporites tuberculatus*.

Depositional environment: Not identified

Age: Not identified.

Biozone: Not identified.

Comments: The Rhaetian assemblage is considered exotic based on the arguments above. The presence of very few Cretaceous dinoflagellates supports that contamination did take place.

DCS 2565 m

Organic matter: Brown and black woody material dominates together with bisaccate sporomorphs.

Palynomorphs: Bisaccate sporomorphs dominate totally, trilete spores are common and dinoflagellate cysts are rare.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica* is common, all other dinoflagellates are rare e.g. *Chatangiella* sp., *Oligosphaeridium asterigerum*, *Spiniferites* spp., *Spinidinium* spp. and *Xenascus* sp.

Acritarchs: Rare *Micrhystridium* spp. and *Veryhaccium* spp. have been recorded and are considered caved.

Spores and pollen: An overall Rhaetian, Upper Triassic assemblage has been recorded. The trilete spores comprise cf. *Carnisporites spiniger*, *Cibotiumspora jurienensis*, *Deltoidospora toralis*, *Limbosporites lundbladii*, cf. *Polycingulatisporites bicollateralis* and *Triancoraesporites ancorae*.
The species of pollen comprise *Alisporites robustus*, *Chasmatosporites apertus*, *Chasmatosporites hians*, *Corollina* spp., *Quadraeculina anelliformis*, *Ovalipollis ovalis*, *Ricciisporites tuberculatus*, *Taniaesporites rhaeticus*.

Depositional environment: Not identified.

Age: Not identified.

Biozone: Not identified.

Comments: The Rhaetian assemblage is considered exotic based on the arguments above. The presence of very few caved Cretaceous dinoflagellates supports that contamination did take place.

DCS 2605 m

Organic matter: Very low content of organic matter dominated of black and brown woody material.

Palynomorphs: Dominated of dark orange to brown bisaccate pollen and spores.

Dinoflagellate cysts: Rare, caved dinoflagellate cysts do occur, *Rhaetogonyaulax rhaetica* (Upper Triassic), *Hystrichosphaeropsis tubiferum* (Upper Cretaceous), and *Spiniferites* spp. (Lower Cretaceous to Recent).

Acritarchs: None recorded

Spores and pollen: Species, well known from Rhaetian/Lower Jurassic strata, are common e.g. the spores *Calamospora* sp., *Densosporites* sp., and *Porcellispora longdonensis* and the pollen *Alisporites robustus*, *Chasmatosporites elegans*, *Corollina* spp., *Pinuspollenites minimus*, *Ricciisporites tuberculatus*.

Depositional environment: Not identified.

Age: Not identified.

Biozone: Not identified.

Comments: Several of the recorded species appear in the Upper Triassic earlier than the Rhaetian, but no exclusively pre-Rhaetian species has been recorded in this sample. Due to the rare presence of Rhaetian and Cretaceous dinoflagellates all sporomorphs are considered exotic.

DCS 2645 m

Organic matter: Brown and black woody material dominates the organic matter together with degraded plant material. Dinoflagellates are present.

Palynomorphs: Common dinoflagellates.

Dinoflagellate cysts: Rare *Rhaetogonyaulax rhaetica* do occur but mixed Lower and Upper Cretaceous dinoflagellates dominates the assemblage e.g. *Alterbidinium* spp., *Chatangiella* sp., *Microdinium* sp., *Tanyosphaeridium* sp., *Muderongia simplex*, *Oligosphaeridium asterigium*, *Palaeohystrichophora infusorioides*, *Spinidinium* spp., *Spiniferites* spp., *Systematophora* spp. and *Xenascus*? sp.

Acritarchs: Rare *Micrhystridium* spp. and *Veryhaccium* spp. have been recorded and are considered caved.

Spores and pollen: Pollen and spores are not common. The Rhaetian assemblage recognised above does not appear clearly but *Ricciisporites tuberculatus* is recorded. However, the spore *Gleichenitidtes senonicus* appears in lowermost Jurassic and has a long range through Cretaceous. Brown, laevigate trilete spores and the few *Corollina* spp. may come from Cretaceous strata as the dinoflagellates.
No black spores and pollen have been recognised.

Depositional environment: Not identified

Age: Not identified

Biozone: Not Identified

Comments: Some of the dinoflagellates are much darker (brown) than in the samples above. However, in the same sample other dinoflagellates are not thermally affected and without colour. The dinoflagellates are considered exotic, possibly present due to contamination from drilling mud.

DCS 2665 m

Organic matter: Poor organic content dominated by black and brown woody material and degraded plant material (amorphous).

Palynomorphs: Trilete spores dominate, rare pollen and dinoflagellates.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica* is present. Few caved Cretaceous dinoflagellates do occur e.g. *Senoniasphaera* sp., *Spiniferites* spp. and *Spinidinium* spp.

Acritarchs: None recorded.

Spores and pollen: Species, well known from Rhaetian/Lower Jurassic strata, are common e.g. *Deltoidospora toralis*, *Densosporites* sp., *Limbosporites lundbladii*, cf. *Semiretispora* sp., *Cibotiumspora jurienensis*, *Stereisporites* sp. and the pollen *Alisporites* spp., *Chasmatosporites apertus*, *Corollina* spp., *Ovalipollis ovalis*, *Pinuspollenites minimus*, *Platysaccus keuperianus*, *Rhaetopollis germanicus*, *Ricciisporites tuberculatus*.

Depositional environment: Not identified.

Age: Not identified.

Biozone: Not identified.

Comments: The Rhaetian/Lower Jurassic assemblage is considered caved.

DCS 2680 m

Organic matter: Low content of organic matter. Fungal hyphae and hyphae-like particles are abundant and associated with degraded organic sheets of cuticlular? origin.

Palynomorphs: Few dinoflagellates, pollen and spores are present.

Dinoflagellate cysts: Caved Cretaceous dinoflagellate cysts are present e.g. *Chatangiella* sp., *Florentinia tenera* and *Spiniferites* spp.

Acritarchs: Rare *Veryhaccium* spp. have been recorded and are considered caved.

Spores and pollen: Very few, caved Rhaetian/Lower Jurassic spores and pollen are present e.g. *Alisporites* sp., *Cibotiumspora jurienensis*, *Corollina* spp., *Deltoidosporites toralis*, *Pinuspollenites minimus* and *Quadraeculina anelliformis*. *In situ* spores and pollen are not recorded with certainty. Some orange spores are not identified yet, but no black sporomorphs have been recorded.

Depositional environment: Not identified.

Age: Not identified.

Biozone: Not identified.

Comments: The organic content in this sample deviates from higher and lower strata by abundant fungi hyphae and hyphae-like particles, associated with degraded sheets of cuticlular? origin. This fungal organic matter has an orange colour, similar to the dominating organic matter in samples above and below. It may therefore be caved as the majority of organic content in these samples.

DCS 2700 – 2785 m

The samples from 2700 to 2785 metres have a low organic content of similar composition. The uppermost sample is the richest and it comprise the most diverse and abundant spores and pollen assemblage

DCS 2700 m

Organic matter: Organic content dominated of rounded, angular to lath shaped, black woody material. Brown woody material and sporomorphs are common. Fragments of degraded plant tissue do occur.

Palynomorphs: Trilete spores and bisaccate pollen dominate. Rare caved dinoflagellate cysts.

Dinoflagellate cysts: Caved dinoflagellates, *Spiniferites* spp.

Acritarchs: None recorded.

Spores and pollen: *Alisporites grauvogeli*, *Alisporites aequalis*, *Aratrisporites granulatus, Aratrisporites scabratus, Aratrisporites paraspinosum*, *Cyclotriletes* sp., cf. *Doubingerispora filamentosa*, *Parvisaccites triassicus*, *Podosporites amicus*, *Protodiploxypinus fastidiosus?*, *Protodiploxypinus gracilis, Protodiploxypinus potoniei, Protodiploxypinus* sp., *Striatoabieites aytugii*, *Strotersporites* sp. α Scheuring 1978, *Triadispora crassa* and *Umbrosaccus keuperianus*, *Retisulcites perforatus*, *Verrucosisporites* spp.,
Orange to yellow, caved Rhaetian sporomorphs e.g. *Cingulizonates rhaeticus*, *Limbosporites lundbladii*, *Ricciisporites tuberculatus*, *Stereisporites* sp. and *Trianchoraesporites anchora*.

Depositional environment: Terrestrial.

Age: Ladinian, Early Keuper, Middle Triassic.

Biozone: None recorded

Comments: The overall composition of the present assemblage indicates a spore and pollen flora of transitional strata from Upper Muschelkalk to Lower Keuper, uppermost Middle Triassic. *Aratrisporites scabratus* appears in uppermost Muschelkalk and flourish in Lower

Keuper in Poland (Orlowska-Zwolinska 1979). *Umbrosaccus keuperianus* is described from Lower Keuper, Upper Middle Triassic in Germany (Mädler 1964). *Retisulcites perforatus* occurs in Lower Keuper and higher strata (Mädler 1964, Scheuring 1970). *Podosporites amicus* appears at the Middle/Upper Triassic boundary (Scheuring 1978). Several characteristic genera that should appear in basal Upper Triassic, have not been recorded e.g. *Echinatisporites iliacoides*, *Ovalipollis* spp. *sensu stricto*, *Camerosporites* spp. and *Duplicisporites* spp.

DCS 2735 m

Organic matter: Black and brown woody material dominates.

Palynomorphs: Relatively abundant spores, pollen and dinoflagellate cysts.

Dinoflagellate cysts: *Rhaetogonyaulax rhaetica* is caved from higher strata.

Acritarchs: None.

Spores and pollen: Dominated by bisaccate pollen, only few trilete spores. *Alisporites aequalis*, *Alisporites* sp. A, *Aratrisporites* sp., *Cyclotriletes microgranifer*, *Calamospora* sp., *Ovalipollis brutus*, *Podosporites amicus*, cf. *Porcellispora longdonensis*, *Protodiploxypinus gracilis* is common*, Protodiploxypinus fastidiosus*? and *P. poteniei* are rare, *Striatoabieites sp.*α Scheuring 1978 and *Umbrosaccus keuperianus*.
Caved Rhaetian–Hettangian spores and pollen dominate the assemblage: e.g. *Chasmatosporites* sp., *Corollina* sp., *Ricciisporites tuberculatus.*

Depositional environment: Terrestrial.

Age: Ladinian, Early Keuper, Middle Triassic.

Biozone: Not recorded.

Comments: The age determination is based on very few sporomorph taxa. *Protodiploxypinus gracilis* and *P. potoniei* flourish from Upper Muschelkalk to Keuper (Mädler 1964). *Alisporites aequalis*, *Striatoabieites sp.* α Scheuring 1978 and *Umbrosaccus keuperianus* are described from Keuper Mädler 1964, Scheuring 1978). *Podosporites amicus* appears in the basal Upper Triassic at the Lower – Middle Keuper boundary (Scheuring 1978). *Protodiploxypinus fastidiosus* should not occur this high in the succession (Orlowska-Zwolinska 1979).

DCS 2760 m

Organic matter: Very poor content of organic matter.

Palynomorphs: Degraded black woody material dominates. Sporomorphs are common.

Dinoflagellate cysts: Caved dinoflagellates are common e.g. *Oligosphaeridium* spp. and *Spiniferites* spp.

Acritarchs: None.

Spores and pollen: Dominated of bisaccate, non-striate pollen in combination with few trilete spores; *Alisporites aequalis*, *Alisporites grauvogeli*, *Alisporites* sp., *Aratrisporites paraspinosus, Podosporites amicus*, *Protodiploxypinus gracilis*, *Striatites aytugii* and *Umbrosaccus keuperianus.*
Caved Rhaetian/Lower Jurassic spores and pollen occur in the assemblage; *Chasmatosporites* sp., *Corollina* sp. and *Ricciisporites tuberculatus.*

Depositional environment: Terrestrial.

Age: Ladinian, Early Keuper, Middle Triassic.
Biozone: None recorded.

Comments: The age determination is based on very few sporomorphs. *Protodiploxypinus gracilis* described from Upper Muschelkalk to Lower Keuper (Mädler 1964). *Alisporites aequalis* and *Umbrosaccus keuperianus* are described from Keuper (Mädler 1964).

DCS 2785 m

Organic matter: Very poor content of organic matter.

Palynomorphs: Black woody material (angular – rounded) dominates. Sporomorphs are common but mainly caved.

Dinoflagellate cysts: Caved dinoflagellates are common e.g. *Cantulodinium speciosum*, *Chatangiella granulifera*, *Hystrichosphaeridium* cf. *stellata*, *Oligosphaeridium* spp., *Oligosphaerium asterigium*, *Spiniferites* spp. (common), *Trityrodinium* sp., *Xenascus* spp. and further unidentified species. The caved material originates from Lower and Upper Cretaceous strata.

Acritarchs: None recorded.

Spores and pollen: A poor assemblage of spores and pollen are recorded. Caved spores and pollen from Rhaetian/Lower Jurassic strata e.g. *Cibotiumspora jurienensis*, *Corollina* spp., *Alisporites* spp., *Chasmatosporites* spp., *Ovalipollis ovalis* and *Quadraeculina anelliformis* dominate the assemblage.
The limited assemblage of Triassic spores and pollen comprises *Alisporites aequalis*, *Aratrisporites* sp., *Aratrisporites paraspinosus*, *Protodiploxypinus gracilis*, *Protodiploxypinus potoniei, Retisulcites perforatus* and *Triadispora* sp.

Depositional environment: Not identified.

Age: The Triassic assemblage suggests a Ladinian, Early Keuper, Middle Triassic age but is probably caved.

Biozone: None

Comments: No evidence has been found for the presence of an *in situ* flora in this sample, whereas caved spores, pollen and dinoflagellates are abundant. The age, which is indicated by the Triassic flora, is therefore probably representative for the higher strata only.

The FFC-2 *Protodiploxypinus* Assemblage

The most abundant and diverse *in situ* assemblage is recorded highest in the succession. These samples are characterised by *Aratrisporites* spp. and *Protodiploxypinus* spp. (*Minutosaccus* spp. of (Mädler 1964). This assemblage is referred to the *Protodiploxypinus* Assemblage and correlated to similar assemblages in FCC-1 and Höllviken-2. Bisaccate pollen are common and especially represented by *Alisporites*, *Triadispora* and *Voltziaceaesporites*. Striate bisaccates are rare e.g. *Striatoabieites.* Trilete spores are also common but most of the recorded species are not stratigraphic significant.
Both the *Aratrisporites* and *Protodiploxypinus* species suggest an age equivalent to the latest Muschelkalk and Early Keuper. *Ovalipollis brutus* and *Porcellispora longdonensis* appears in the uppermost Middle Triassic, Lower Keuper (Scheuring 1978). *Umbrosaccus keuperianus* is only recorded in FCC-2, it is described from Keuper strata (Mädler 1964). This is supported by the occurrence of *Retisulcites perforatus* that appears first in Lower Keuper and reaches into lowermost Middle Keuper (Scheuring 1978). *Podosporites amicus* appears in the basal Upper Triassic, Middle Keuper (Scheuring 1978).
P. amicus occurs mainly in the uppermost sample at 2700 m and is indicative for lowermost Upper Triassic strata. Therefore, presence of *P. amicus* suggests that some other species judged here to be caved from Rhaetian strata, may also be *in situ* e.g. *Ovalipollis ovalis*. However, no other characteristic sporomorphs from lowermost Upper Triassic are present. This illustrates very well the problem of biostratigraphic dating of ditch cuttings samples.
In contrast to FFC-1 and Höllviken, the present assemblage includes common *Umbrosaccus keuperianus* and *Podosporites amicus*. This may reflect local variation in composition of the palaeo-vegetation.
No *in situ* acritarchs or other algae have been recorded in this assemblage. The depositional environment is therefore considered terrestrial.

Höllviken-2

CS 1761,2 m

Organic matter: Low organic content, dominated by black, angular to lath shaped woody material and abundant pollen and spores.

Palynomorphs: Trilete and monolete spores dominate the assemblage and bisaccate pollen are abundant.

Dinoflagellate cysts: None recorded.

Acritarchs: None recorded.

Spores and pollen: *Alisporites aequalis*, *Anapiculatisporites telephorus*, *Aratrisporites coryliseminis*, *Aratrisporites* cf. *fischerii*, *Aratrisporites granulatus*, *Aratrisporites scabratus*, *Annulispora microannulata*, *Calamospora keuperiana*, *Carnisporites* sp. (*C.* cf. *hercynicus*), *Lunatisporites* cf. *acutus*, *Nevesisporites lubricus*, *Ovalipollis brutus*, *Platysaccus* cf. *papilionis*, *Protodiploxypinus gracilis*, *Triadispora* ?*barbata*, *Striatoabieites* sp.α Scheuring 1978, *Voltziaceaesporites* sp.

Depositional environment: Terrestrial

Age: Ladinian / Early Keuper, Middle Triassic (see comments and discussion below).

Biozone: Not identified.

Comments: This sample is from the fossiliferous “zone” f (Brotzen 1950). The recorded assemblage is abundant and diverse. Most of the *Aratrisporites* spp. and *Protodiploxypinus gracilis* indicate an age equivalent to latest Muschelkalk – Early Keuper (Orlowska-Zwolinska 1979). *Nevesisporites lubricus* occurs in Early Keuper (Orlowska-Zwolinska 1979).

CS 1769,29 m

Lundblad (1949) recorded cuticles and sporomorphs from this level.

Organic matter: Cuticle F, conifer, cf. *Voltzia* (Lundblad 1949).

Palynomorphs: Common Sporomorph A (Lundblad 1949) – *Alisporites* spp.

Comments: This sample is from the fossiliferous “zone” f (Brotzen 1950).

CS 1798,15 m

Organic matter: Relatively high content of black, angular coal and woody fragments.

Palynomorphs: Poor assemblage dominated of trilete and monolete spores. Bisaccate pollen are abundant.

Dinoflagellate cysts: None recorded.

Acritarchs: None recorded.

Spores and pollen: *Alisporites grauvogeli*, *Alisporites* sp., *Anapiculatisporites telephorus*, *Aratrisporites* spp. (*Aratrisporites coryliseminis*, *Aratrisporites fimbriatus* and most common *Aratrisporites paraspinosus*, *Camarozonosporites* sp. (non *rudis*), *Nevesisporites lubricus*, *Ovalipollis brutus*, *Protodiploxypinus gracilis*, *Retisulcites perforatus* and *Striatoabietites aytugii.*

Depositional environment: Terrestrial

Age: Late Ladinian / Early Keuper, Middle Triassic (se discussion below)

Biozone: None

Comments: This sample is from lowermost “zone” e, which is considered one of the barren “zones” (Brotzen 1950).
Most of the *Aratrisporites* spp. and *Protodiploxypinus gracilis* indicate an age equivalent to latest Muschelkalk – Early Keuper (Orlowska-Zwolinska 1979). However the presence of *Nevesisporites lubricus*, *Ovalipollis brutus* and *Retisulcites perforatus* restricts the age to Early Keuper and (Orlowska-Zwolinska 1979, Scheuring 1970).

CS 1805 m

Lundblad (1949) recorded cuticles from this level.

Organic matter: Cuticle of Pteridosperm/pre-Bennettitalean affinity, Cuticle E of possible Cycadealean affinity and G of unknown affinity (Lundblad 1949).

Palynomorphs: No sporomorphs were recorded.

Comments: This sample is from the upper fossiliferous “zone” d (Brotzen 1950).

CS 1824,69 m

Lundblad (1949) recorded cuticles and sporomorphs from this level.

Organic matter: Cuticle A–C of Pteridosperm/pre-Bennettitalean affinity and H–I of unknown affinity (Lundblad 1949).

Palynomorphs: Sporomorph B and C (Lundblad 1949) – ?*Alisporites* spp.

Comments: This sample is from the basis of fossiliferous “zone” d (Brotzen 1950).

CS 1845,2 m

Organic matter: Very low content of black angular coal and woody fragments

Palynomorphs: Rare, fragmented specimens.

Dinoflagellate cysts: None recorded.

Acritarchs: None recorded.

Spores and pollen: Few, unidentified relicts of trilete spores and bisaccate pollen

Depositional environment: Not identified

Age: Not identified; no identified sporomorphs available for interpretation.

Biozone: Not identified; no identified sporomorphs available for interpretation.

Comments: This sample is from the fossiliferous “zone” a (Brotzen 1950).

CS 1865,8 m

Organic matter: Very low content of angular, black coal fragments.

Palynomorphs: Barren.

Dinoflagellate cysts: None recorded.

Acritarchs: None recorded.

Spores and pollen: Barren

Depositional environment: Not identified

Age: Not identified; no sporomorphs available for interpretation.

Biozone: Not identified; no sporomorphs available for interpretation.

Comments: This sample is located just below the barren “zone” a of the presumed Keuper/Muschelkalk succession (Brotzen 1950).

Höllviken-2 *Protodiploxypinus* Assemblage

Two samples out of four new analyses were productive and the recovered assemblages in both samples are characterised by *Aratrisporites* spp. and *Protodiploxypinus* spp. (*Minutosaccus* spp. of Mädler (1964)). Bisaccates are common, especially represented by *Alis-*

porites, *Triadispora* and *Voltziaceaesporites*. Striate bisaccates are rare e.g. *Striatoabieites* and *Striatites.* Trilete spores are common but most of the recorded species are not stratigraphic significant. The assemblage is referred to the *Protodiploxypinus* Assemblage and correlates with similar assemblages in FFC-1 and -2.

Both the *Aratrisporites* and *Protodiploxypinus* species suggest an age equivalent to the latest Muschelkalk and Early Keuper. *Nevesisporites lubricus*, *Retisulcites perforatus* and *Ovalipollis brutus* appear in Early Keuper (Middle Triassic) (Scheuring 1970). These species are present in the lower sample (1798,15 m).

In conclusion, the age of the succession represented by the samples 1761,2 – 1798,15 m in Höllviken-2 is considered Early Keuper, Middle Triassic.

Discussion

The analysed material from the FFC-1 and -2 wells is sampled from the sub-Rhaetian succession. The very low content of organic material in the analysed sediments increase the relative abundance of caved material and mud contamination. In the extreme, the exotic material and fossils is the only organic material in the samples and this is the case in several of the studied samples. Upper and Lower Cretaceous dinoflagellates are present to common in most samples, together with dominating Rhaetian/Lower Jurassic dinoflagellates, spores and pollen. The discrimination of a limited, potentially *in situ* palynomorph flora is therefore difficult. Furthermore, several of the species that are well known from Rhaetian floras in Scania, do occur stratigraphic lower in the Upper Triassic and could therefore actually be *in situ* although classified here as caved. All Rhaetian/Lower Jurassic assemblages recorded here are considered caved.

A limited, in situ spore-pollen assemblage has been recorded in the lower samples from both wells (FFC-1 in 2029 – 2080 m and FFC-2 in 2700–2785 m) and named the *Protodiploxypinus* Assemblage, se later). This assemblage is rather uniform in composition in all samples but most abundant and diverse in the uppermost samples of its occurrence i.e. 2029 m in FFC-1 and 2700 m in FFC-2 respectively. In both wells the flora appears downwards diluted and may therefore be derived from the upper part of the succession only or mainly.

The *Protodiploxypinus* Assemblage is also recorded in cores from the Höllviken-2 well. Old reports indicate occurrence of bisaccate pollen and cuticles in samples from 1769,29 – 1824,69 m (Lundblad 1949). Two new samples from this depth interval (1761,2 and 1798,15 m) provided brown to black palynomorphs of the *Protodiploxypinus* Assemblage, whereas two other samples from below this interval (1845,2 and 1865,8 m) were barren.

Colours of palynomorphs reflect burial depth by downwards increasing thermal metamorphosis of the organic material. The Cretaceous dinoflagellates are colourless and not thermally affected. The Rhaetian flora is dominantly yellow to dark-orange, whereas the *Protodiploxypinus* Assemblage is dark orange, brown to black. The rather wide colour range of the *Protodiploxypinus* Assemblage may reflect a mixture of caved and *in situ* specimens. The dark-orange colours dominate in the upper part of the flora whereas the brown to black colours dominate in the lower part. This colour change may reflect a high thermal gradient for this succession.

Palyno-stratigraphy of mid- to Upper Triassic successions varies significantly between regions (Warrington *et al.* 1980) so stratigraphic reports from nearby regions are the most reliable for dating and correlation of the recorded flora. Studies of palynofloras from Poland (Orlowska-Zwolinska 1979), Germany, Austria and Switzerland (Mädler 1964, Schulz 1965, Visscher 1966, Scheuring 1970, 1978, Reitz 1985) and the North Sea region (Lundblad 1949, Clarke 1965, Geiger & Hopping 1968) have been used. However, due to the considerable range in time of printing of these publications, both the taxonomy and the stratigraphic significance of species and genera vary significantly.

The inferred age of the *Protodiploxypinus* Assemblage is rather precise due to the content of stratigraphic significant species. *Minutosaccus* spp. (Mädler 1964), later transferred to *Microcachryidites* and subsequently to *Protodiploxypinus* (Scheuring 1970), is a group of small bisaccate pollen with minute sacci in relation to the central body. *Protodiploxypinus potoniei* and *P. gracilis* from this morpho-group appear in uppermost Muschelkalk and reach through Lower Keuper (Lettenkeuper) (Mädler 1964, Orlowska-Zwolinska 1979, Reitz 1985). The genus *Aratrisporites* occurs abundant and diverse in uppermost Muschelkalk and is common in Lower Keuper (Mädler 1964, Orlowska-Zwolinska 1979, Reitz 1985). *Ovalipollis brutus* is present in Höllviken-2 (but very rare in FFC-1 and FFC-2). *O. brutus* appears in Lower Keuper (Scheuring 1978). *Nevesisporites lubricus* is stratigraphical limited to Lower Keuper (Orlowska-Zwolinska 1979).

Some stratigraphically characteristic species occur associated with the *Protodiploxypinus* Assemblage but are limited to one or two of the studied wells. *Aratrisporites fimbriatus* occurs in FFC-1 and Höllviken-2 and confirms that the assemblage correlates to strata no higher than Lower Keuper (Orlowska-Zwolinska 1979). *Umbrosaccus keuperianus* is confined to FFC-2 and indicates strata no lower than Lower Keuper (Mädler 1964). *Parvisaccites triassicus* is recorded in FFC-2 and is restricted to Lower Keuper (Scheuring 1970). *Retisulcites perforatus* is recorded sporadic in FFC-2 and Höllviken-2 and is reported to occur in Lower Keuper – lowermost Middle Keuper (Lettenkeuper and lower Gipskeuper; Scheuring 1970). *Podosporites amicus* occurs in FCC-2 and is supposed to appear in lowermost Middle Keuper (basal Gipskeuper, Scheuring 1978).
Lettenkeuper, Lower Keuper is equivalent to upper Ladinian, upper Middle Triassic in the international stratigraphy and Gipskeuper, lower Middle Keuper is equivalent to lower Carnian, lower Upper Triassic (figure 2).

The data presented above clearly indicate a late Ladinian, latest Middle Triassic age for the *Protodiploxypinus* Assemblage in all three wells. However, vague stratigraphic variation is indicated within the limits of the *Protodiploxypinus* Assemblage. The assemblage in FFC-2 may include slightly younger strata than in the other wells possibly in form of caved cuttings. This is indicated partly by the stratigraphic significance of *Podosporites amicus* that occur only in this well and partly by the presence of other species limited to this well.
In contrast, *Aratrisporites fimbriatus* occurs only in FFC-1 and Höllviken and may then indicate slightly older strata. This differentiation of the assemblage could also reflect regional variation in the palaeo-vegetation or a random recovery from the cuttings mixture.

The stratigraphically important and morphologically characteristic Upper Triassic taxa *Echinatisporites iliacoides*, *Camerosporites* spp. and *Duplicisporites* spp. do not occur in any of the analysed samples. In Poland and Germany, these sporomorphs appear in the basal Carnian, basal Upper Triassic (Orlowska-Zwolinska 1979, Reitz 1985). This absence supports the upper Ladinian age assignment above.

Results

Most palynologically analysed, sedimentary samples from the Triassic, pre-Rhaetian succession of the FFC-1 and -2 wells are barren probably due to depositional environments hostile to preservation of organic material and fossils.

However, a new spore-pollen flora of limited diversity and abundance is recognised in the Triassic succession of southwest Scania. The new flora is preliminary named the *Protodiploxypinus* Assemblage after some of the prominent sporomorphs. An equivalent flora is identified in 2 core-samples of the Höllviken-2 well.

The *Protodiploxypinus* Assemblage may be limited to the highest strata in FFC-1 and -2 where the assemblage appears first (downhole) and the records below may be due to caving of these strata.

The most characteristic spores and pollen are species of *Alisporites*, *Aratrisporites* and *Protodiploxypinus* and limited occurrence of striate bisaccate pollen.

A morphologically characteristic algae (acritarch?) occurs in the *Protodiploxypinus* Assemblage of the FFC-1 and indicates a limnic–brackish depositional environment for the assemblage at this locality.

The age of the *Protodiploxypinus* Assemblage is late Ladinian, latest Middle Triassic. Few species limited to the assemblage in the FFC-2 well indicate that strata of earliest Late Triassic age may be present here, but this is not convincing due to the absence of a typical Late Triassic flora.

The Ladinian, Middle Triassic age is in accordance with earlier biostratigraphic datings of the fossiliferous Höllviken-2 succession based on ostracods and characean (algae) but favours a correlation to Lower Keuper rather than Upper Muschelkalk for the upper part of the Höllviken succession.

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Plates

Plate 1

Two magnifications are used for all illustrations and each are represented by a short (low magnification) and a longer (high magnification) 50 μm bar. Plate 1, figures 10, 14 and 15 are of low magnification.

Figures 1–2: *Nevesisporites lubricus*, Höllviken-2, CS 1761,2 m.
Figure 3: *Calamospora* sp., Höllviken-2, CS 1761,2 m.
Figures 4–5: *Calamospora* sp., Höllviken-2, CS 1761,2 m.
Figures 6 & 9: *Anapiculatisporites telephorus*, Höllviken-2, CS 1761,2 m.
Figures 7–8: *Annullispora microannulata*, Höllviken-2, CS 1761,2 m.
Figures 10–12: *Anapiculatisporites telephorus*, Höllviken-2, CS 1761,2 m.
Figures 13–16: *Anapiculatisporites telephorus*, Höllviken-2, CS 1761,2 m.
Figures 17–18: *Anapiculatisporites telephorus*, Höllviken-2, CS 1798,15 m.

Plate 1

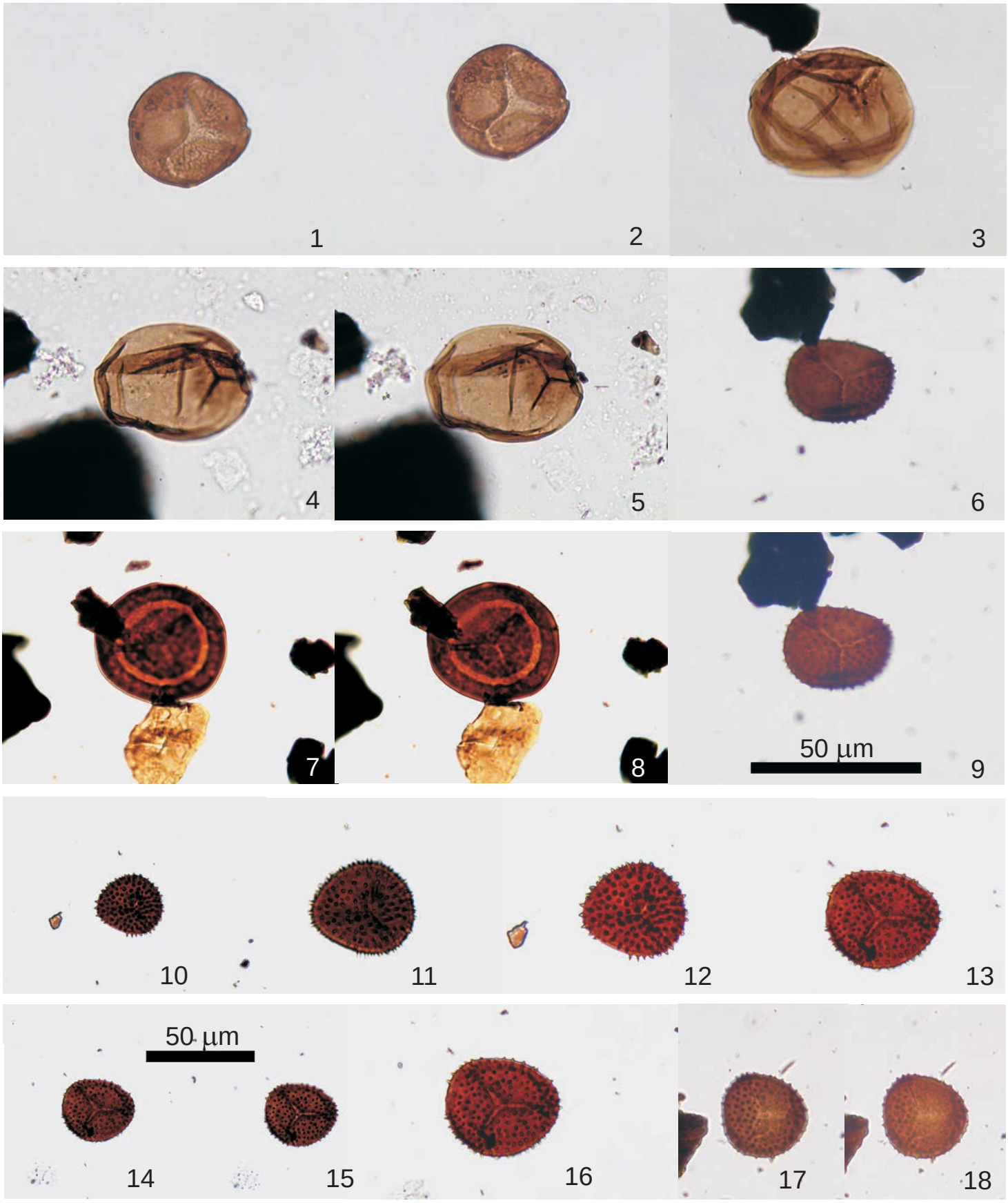


Plate 2

Two magnifications are used for all illustrations and each are represented by a short (low magnification) and a longer (high magnification) 50 μm bar. Plate 2, figures 7, 10 and 13–16 are of low magnification.

Figures 1–2 & 4–5: *Aratrisporites paraspinosus*, FFC-2, DCS 2785 m.
Figures 3 & 6: *Aratrisporites granulatus*, Höllviken-2, CS 1761,2 m
Figures 7–9: *Aratrisporites fimbriatus*, FFC- 1, DCS 2029 m.
Figures 10–12: *Aratrisporites paraspinosus*, FFC- 1, DCS 2080 m.
Figures 13–14: *Aratrisporites* sp., Höllviken-2, CS 1761,2 m.
Figures 15–16: *Aratrisporites* sp., Höllviken-2, CS 1761,2 m.

Plate 2

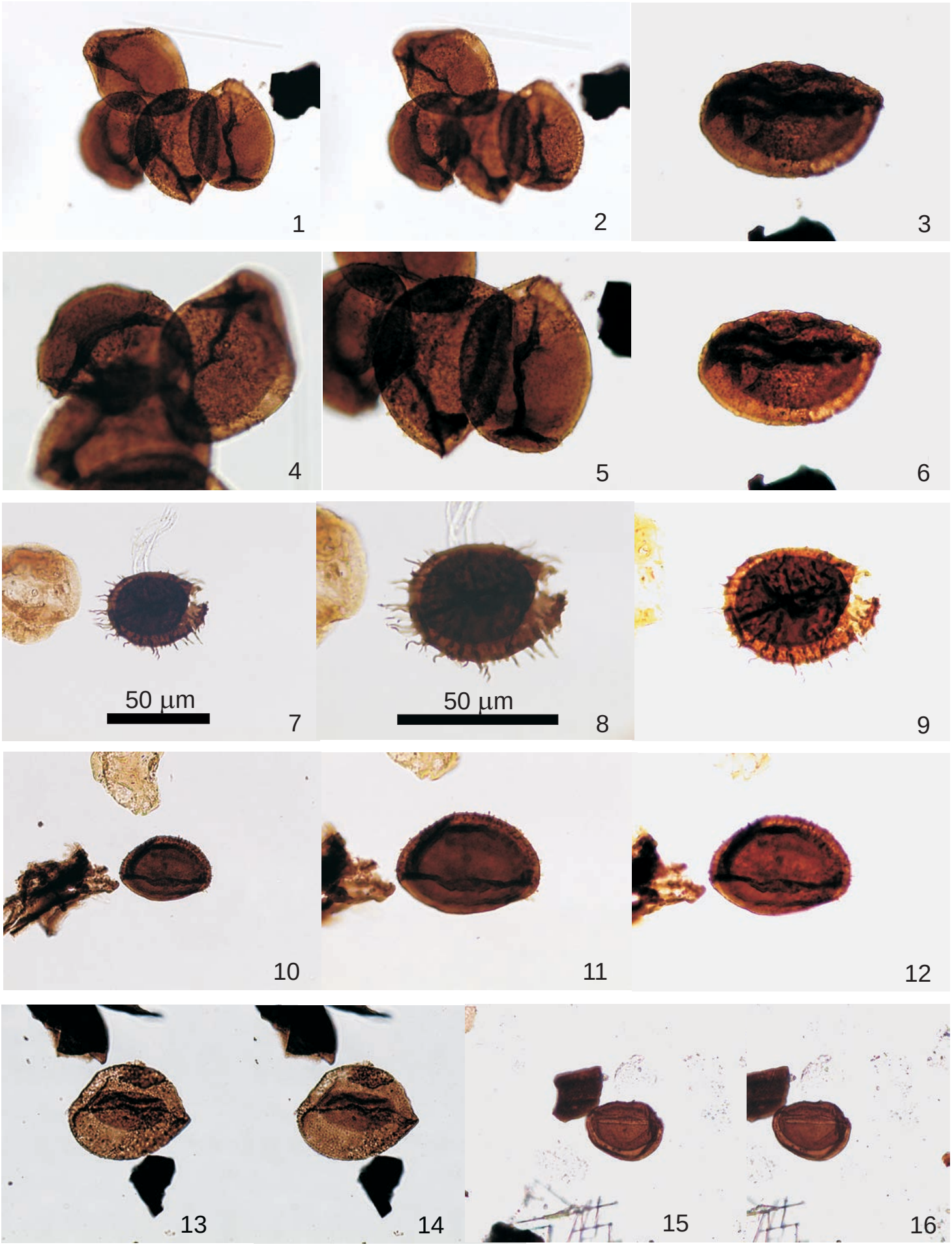
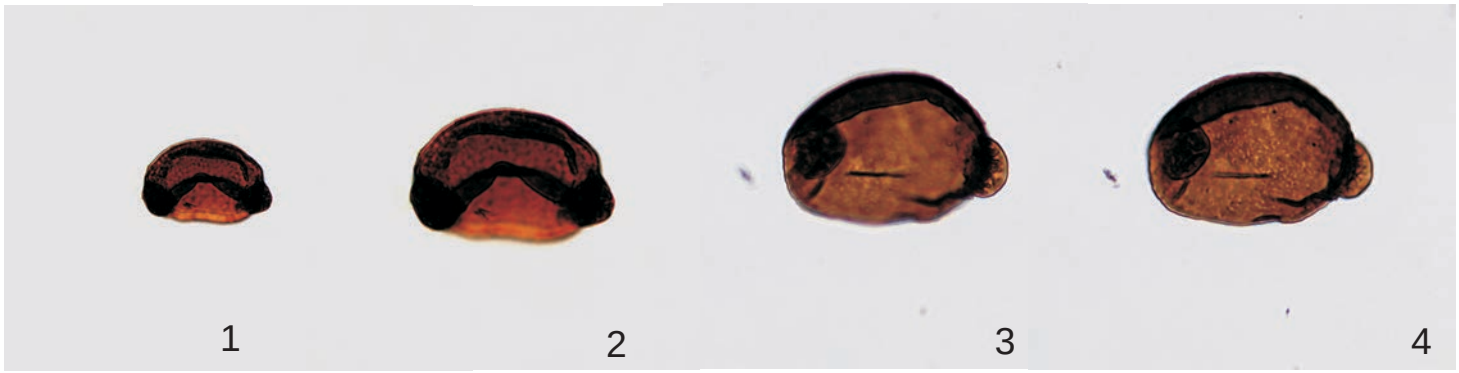


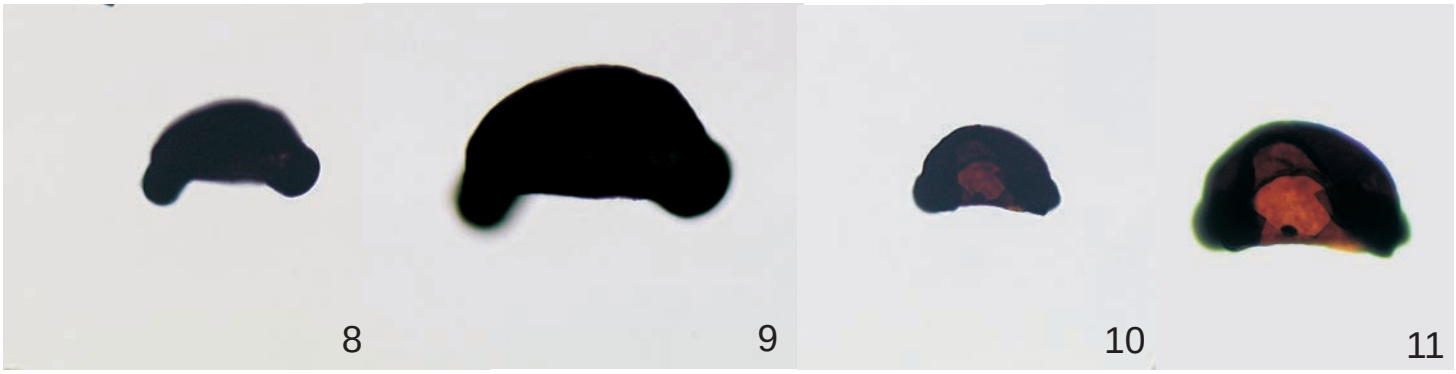
Plate 3

Two magnifications are used for all illustrations and each are represented by a short (low magnification) and a longer (high magnification) 50 µm bar. Plate 3, figures 1, 5, 10, 12–13, and 15 are of low magnification.

Figures 1–2: *Protodiploxypinus gracilis*, FFC-1, DCS 2029 m.
Figures 3–4: *Protodiploxypinus gracilis*, Höllviken-2, CS 1761,2 m.
Figures 5–7: *Protodiploxypinus gracilis*, FFC-1, DCS 2029 m.
Figures 8–9: *Protodiploxypinus potonie*?, FFC-1, DCS 2029 m.
Figures 10–11: *Protodiploxypinus gracilis*, FFC-1, DCS 2029 m.
Figures 12–14: *Protodiploxypinus gracilis*, FFC-2, DCS 2700 m.
Figures 15–16: *Protodiploxypinus gracilis*, FFC- 1, DCS 2029 m.

Plate 3





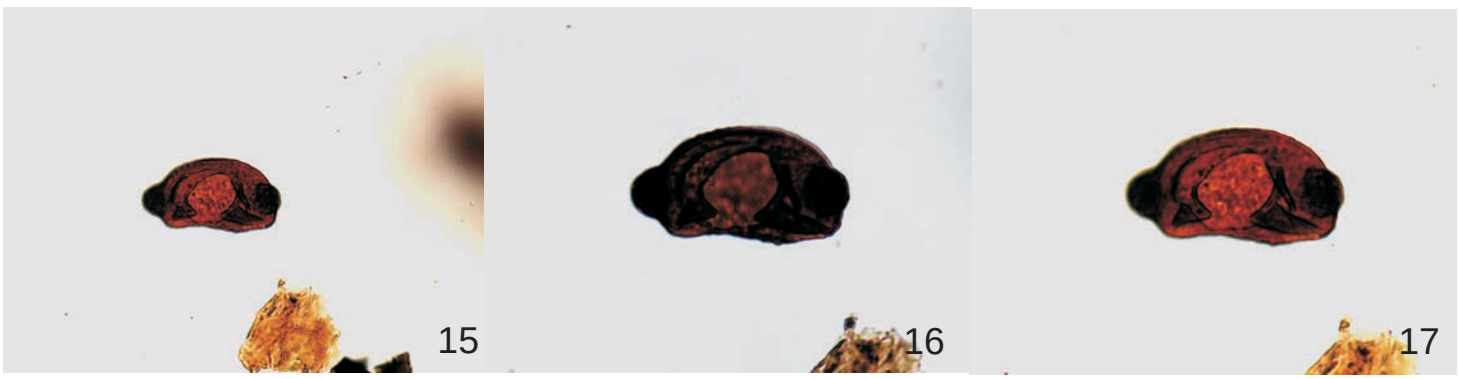


Plate 4

Two magnifications are used for all illustrations and each are represented by a short (low magnification) and a longer (high magnification) 50 μm bar. Plate 4, all figures are of low magnification.

Figures 1–3: *Paravisaccites triassicus*, FCC-2, DCS 2700 m.
Figures 4–5: *Paravisaccites triassicus*, FCC-2, DCS 2700 m.
Figures 6–7: *Alisporites aequalis*, FFC-, DCS 2700 m.
Figures 8–9: *Alisporites aequalis*, FFC-, DCS 2700 m.
Figures 9–10: *Alisporites aequalis*, FFC-, DCS 2700 m.
Figures 12 & 15: *Alisporites aequalis*, Höllviken-2, CS 1761,2 m.
Figures 13–14: *Alisporites grauvogeli*, Höllviken-2, CS 1798,15 m.

Plate 4

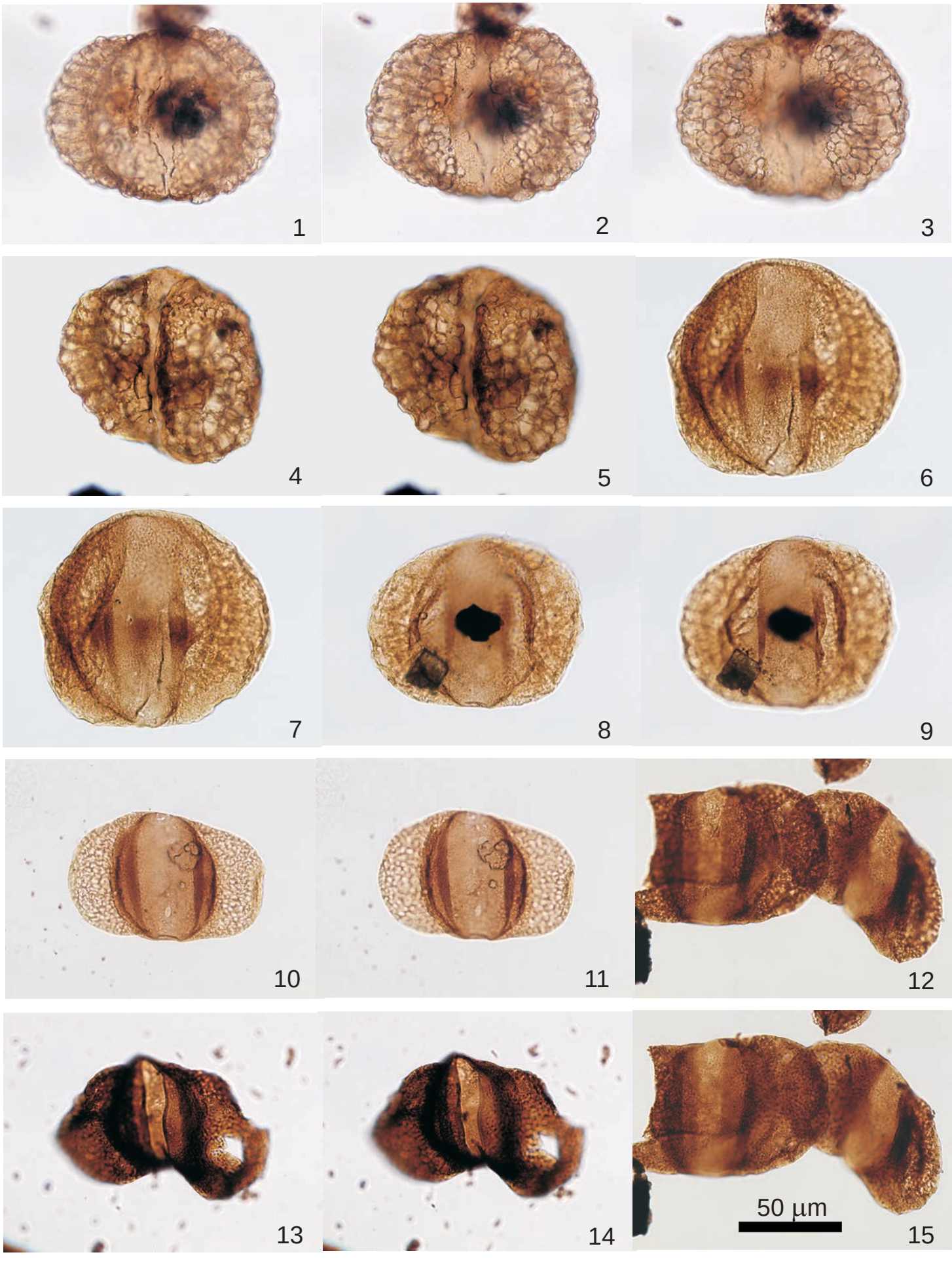
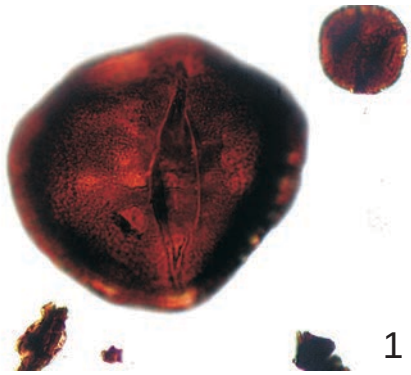


Plate 5

Two magnifications are used for all illustrations and each are represented by a short (low magnification) and a longer (high magnification) 50 μm bar. Plate 5, figures 4–5, 7 and 12 are of low magnification.

Figure 1: *Ovalipollis brutus*, Höllviken-2, CS 1798,15 m.
Figure 2: *Ovalipollis brutus*, Höllviken-2, CS 1798,15 m.
Figure 3: *Ovalipollis brutus*, Höllviken-2, CS 1761,2 m.
Figures 4–6: *Voltziaceaesporites* sp., Höllviken-2, 1761,2 m.
Figures 7–8: *Voltziaceaesporites* sp., Höllviken-2, CS 1761,2 m.
Figure 9: *Podosporites amicus*, FFC-2, DCS 2700 m.
Figure 10: *Podosporites amicus*, FFC- 2, DCS 2735 m.
Figure 11: *Podosporites amicus*, FFC-2, DCS 2735 m.
Figures 12–14: *Retisulcites perforatus*, Höllviken-2, CS 1798,15 m

Plate 5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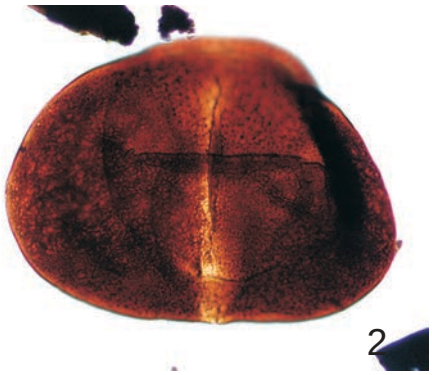
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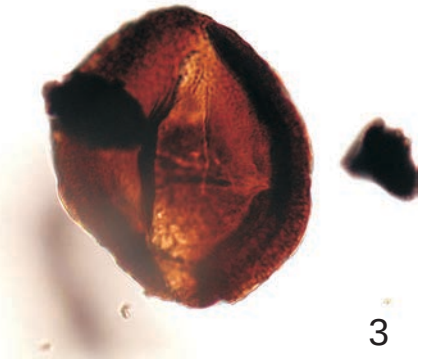
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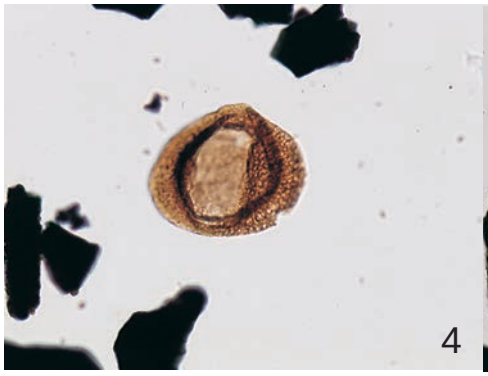
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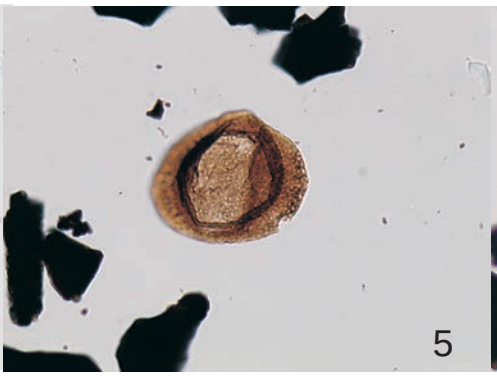
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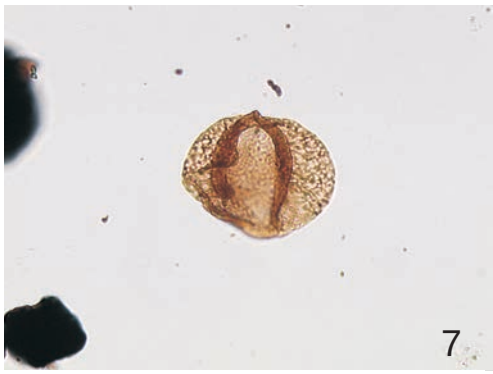
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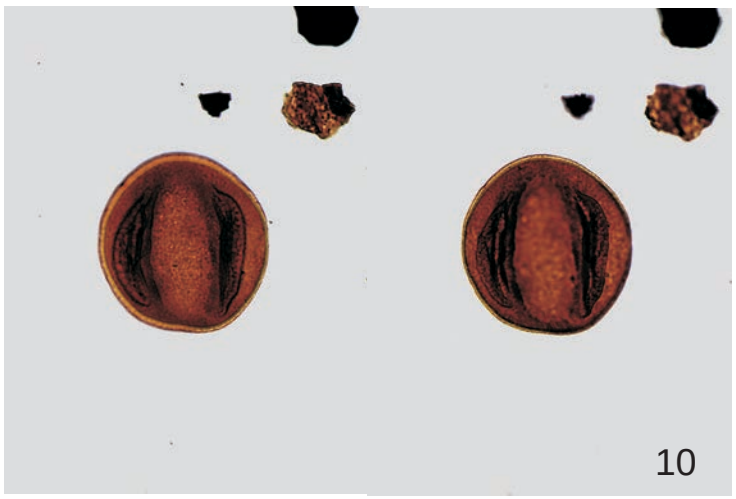
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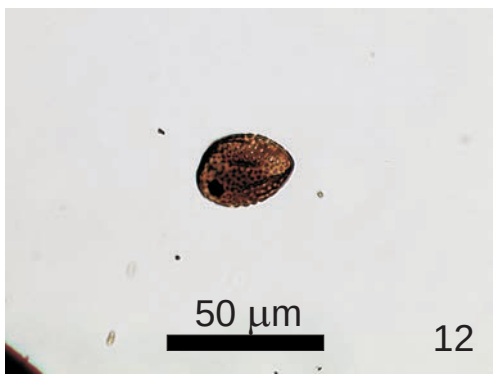

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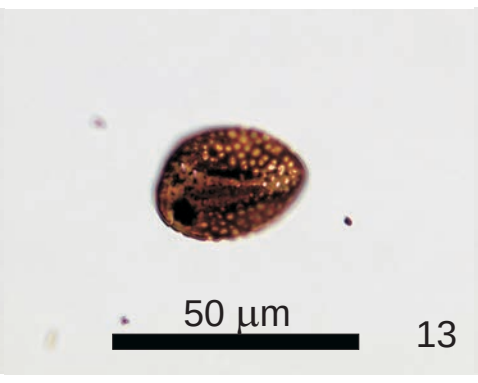

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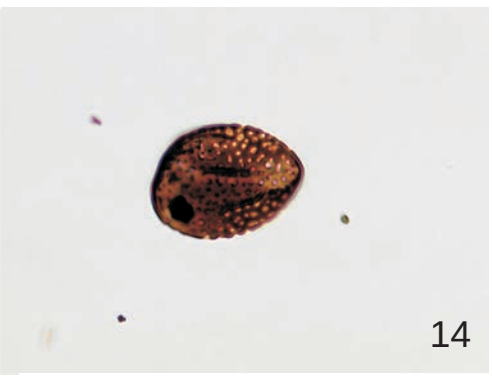
14

Plate 6

Two magnifications are used for all illustrations and each are represented by a short (low magnification) and a longer (high magnification) 50 μm bar. Plate 6, figures 1–4, 7, 10–11 and 13 are of low magnification.

Figure 1: *Striatites aytugii*, FFC-2, DCS 2700 m.
Figure 2: *Lunatisporites acutus*, Höllviken-2, CS 1761,2 m.
Figures 6 & 9: *Striatites* sp. α Scheuring 1978, FFC-1, DCS 1729 m.
Figures 4–5: *Striatites* sp. α Scheuring 1978, Höllviken-2, CS 1761,2 m.
Figures 7–8: *Umbrosaccus keuperianus*, FCC-2, DCS 2700.
Figures 10–12: *Umbrosaccus keuperianus*, FCC-2, DCS 2700 m.
Figures 13–15: *Umbrosaccus keuperianus*, FCC-2, DCS 2700 m.

Plate 6

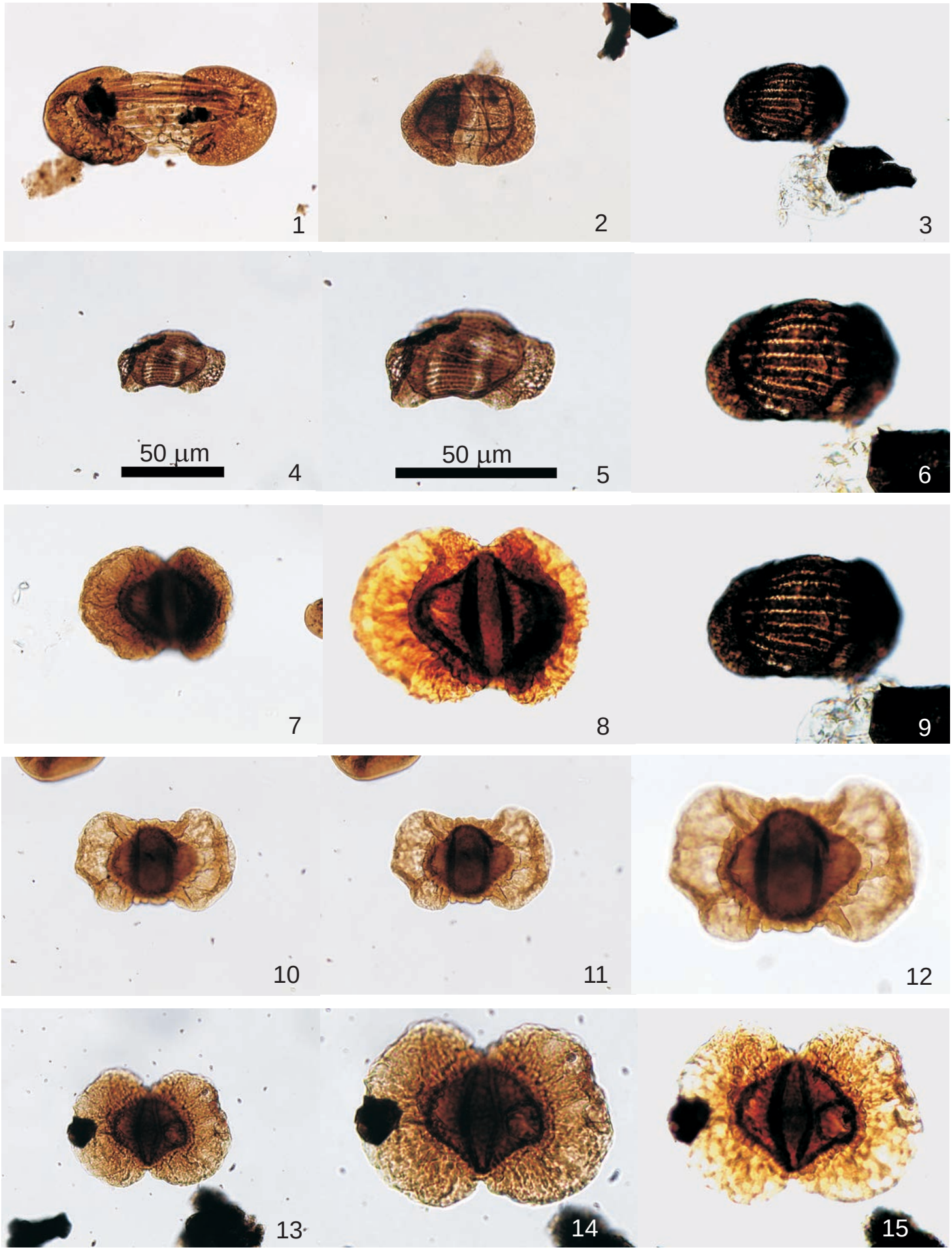

Plate 7

Two magnifications are used for all illustrations and each are represented by a short (low magnification) and a longer (high magnification) 50 μm bar. Plate 7, figures 1, 3 and 7–9 are of low magnification.

Figures 1–2: *Dactylofusa*? sp., FFC-1, DCS 2080 m.
Figure 3: *Dactylofusa*? sp., FFC-1, DCS 2080 m.
Figures 4–5: *Dactylofusa*? sp., FFC-1, DCS 2080 m.
Figure 6: *Dactylofusa*? sp., FFC-1, DCS 2080 m.
Figures 7–8: *Dactylofusa*? sp., FFC-1, DCS 2080 m.
Figure 9: *Dactylofusa*? sp., FFC-1, DCS 2029 m.

Plate 7