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Lower Jurassic biostratigraphy of the Oppegård Bore No. 1, NW Scania, Sweden

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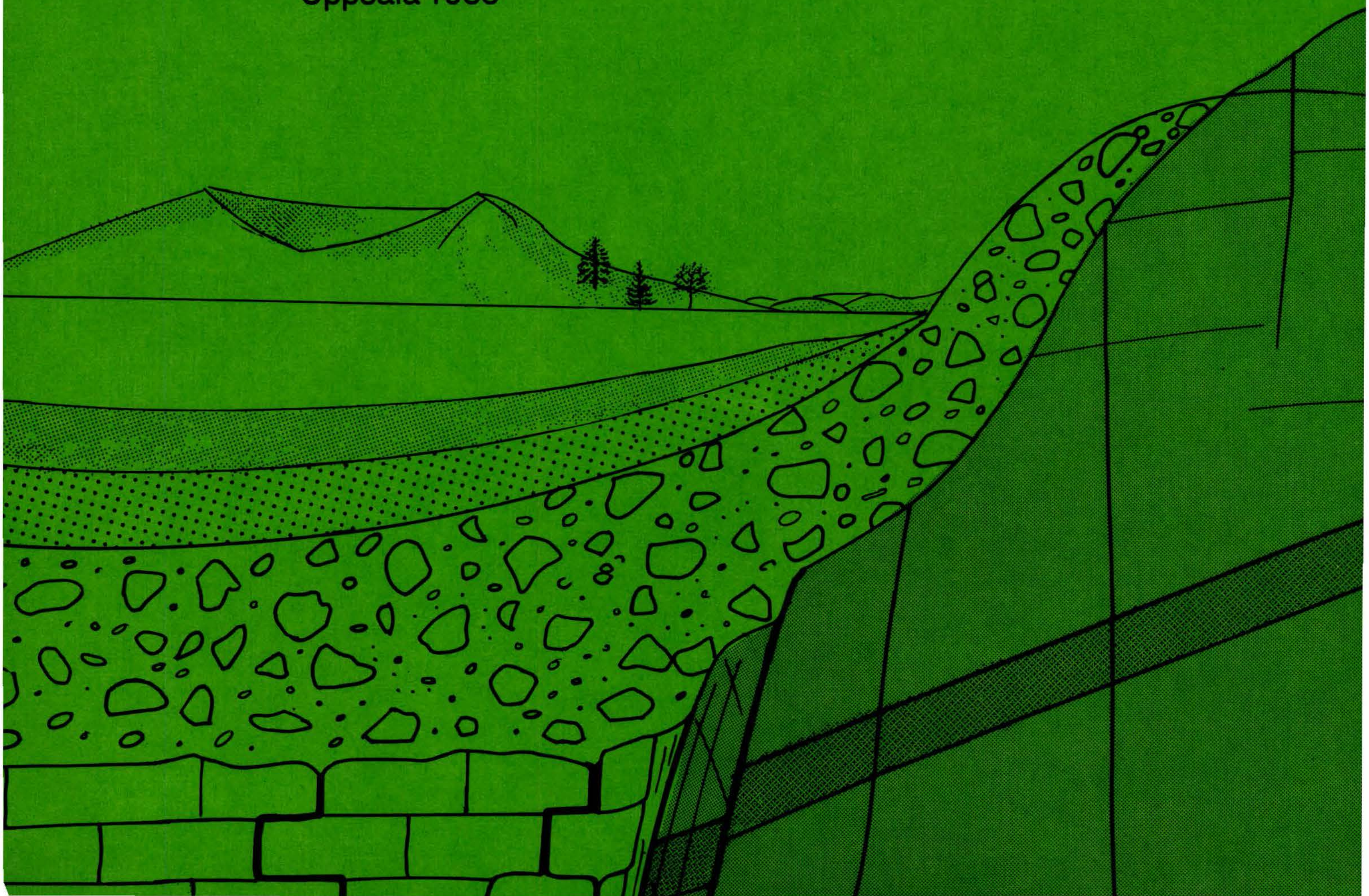

LOWER JURASSIC BIOSTRATIGRAPHY OF THE OPPEGÅRD BORE NO. 1, NW SCANIA, SWEDEN

A contribution to PROJECT TORNQUIST

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FOREWORD

The Phanerozoic rocks of NW Scania have recently been mapped on the scale 1:50,000 (Norling et al. 1981: Berggrundskartan 3B Höganäs NO / 3C Helsingborg NV, SGU Ser. Af No. 129). To a great extent correlation and biostratigraphical dating of Rhaetian, Lower and Middle Jurassic strata in the eastern part of the map district, including the Ängelholm Trough, have been based on palynological studies (Guy 1971, Guy-Ohlson 1976, 1978, 1981). Further micropalaeontological investigations must be carried out within the map area, however, in order to solve some stratigraphical problems connected with the presence of some structural anomalies.

Geophysical surveys, viz. gravity and airborne geomagnetic mapping carried out by the Geological Survey of Sweden (SGU), and reflection seismic profiling by Oljeprospektering AB (OPAB), have revealed the presence of tectonic disturbances in the central part of the Ängelholm Trough (Norling 1981, Norling in Bergström et al. 1982). Such structural anomalies have been recorded in the core drillings Karindal-1, drilled by SGU in 1977, Höjatorp-1 and Oppegård-1, drilled by OPAB in 1979. They include unconformities, diverging lithologies and stratigraphical gaps. These conditions have made attempts to base bore correlations on lithostratigraphy only, very difficult and risky. In Karindal-1, for instance, the Upper Jurassic sequence rests directly on Pliensbachian strata, a fact which could not have been stated without micropalaeontological analyses (Norling 1981, pp 254-255, Fig. 5).

With these difficulties in mind, as well as a noticeable disagreement between the tentative Jurassic stratigraphy proposed by SGU for certain wells in the area in question compared with that proposed by OPAB for the Höjatorp-1 and Oppegård-1 wells, I found further biostratigraphical studies necessary. For that reason I proposed that the authors of the present publication, Dorothy Guy-Ohlson and Elisabet Malmquist of the Department of Palaeobotany, Swedish Museum of

Natural History, carry out a palynological investigation of a specific interval of Oppegård-1, for which OPAB kindly released core material.

When presented with the age of the older palynomorph assemblage *described by Guy-Ohlson and Malmquist in the present paper, it seems obvious that the sandstone with coal sequence (at 271-280 m) in Oppegård-1 corresponds to the middle part of the three-fold Pankarp Member. The lithology of the sequence which has yielded the* younger palynomorph assemblage *of Guy-Ohlson and Malmquist apparently corresponds fairly well with the upper part of the Rydebäck Member, at least as to the colours of these, in part, variegated beds.*

The interesting results given below speak for themselves. They contribute to an improved understanding of the Jurassic stratigraphy of the Ängelholm Trough and will be, without doubt, of use in the further interpretation of the Kimmerian tectonics and eustatic movements in NW Scania.

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ABSTRACT

Guy-Ohlson, D. and Malmquist, E., 1984: Lower Jurassic Biostratigraphy of the Oppegård Bore No. 1, NW Scania, Sweden.

Selected samples from the Oppegård Bore No. 1 between 170-280 metres have been investigated palynologically. Examination in the light and scanning electron microscopes revealed the presence of two distinct Lower Jurassic palynomorph assemblages. On the basis of palynomorph content, comparison with other Lower Jurassic palynofloras, lithostratigraphical/biostratigraphical correlation and palaeoenvironmental comparisons a Toarcian-Aalenian age is *tentatively* suggested for the *younger assemblage* and Sinemurian for the *older assemblage*. The biostratigraphical results contradict the previously presented litho-stratigraphical results for the Oppegård Bore No. 1.

INTRODUCTION

The bore-hole at Oppegård (map reference 56° 10'35 N 12° 55' 05 E) is located 2 km NE of Ausås church in NW Scania in the area known as the Ängelholm trough or Ängelholm basin (Fig.1). The company known as Oljeprospektering AB (OPAB) acquired concession for exploration in northwestern Scania in 1975. This was prolonged until 1977 with an expiration date of 31st December, 1982 being stipulated. According to Linder (1979) 207.15 km of reflection seismic, carried out in an attempt to define drillable prospects in the deeper parts of the Ängelholm basin, identified a number of *weak* structures. OPAB decided that having ascertained the presence of reservoir rocks and encountered gas shows in shallow water wells they would test two of the weak structures. One of these, the Oppegård-1 well, was thus drilled in 1979 to test an elongated structure in the deepest part of the Ängelholm basin.

NW Scania, and in particular the Ängelholm basin, has been the subject of extensive geological studies for more than a hundred years. The interest in this region has been intensified, naturally over the years, due to the mining of coal and clay by the company known as Höganäs AB. Thus the general geology of the area is already relatively well known. Details of earlier geological investigations of this area and of its Jurassic stratigraphy are to be found in Norling (1972) and further orientation in the geology of the area may be obtained from examination of the survey map, SGU Ser. Af.nr 129, Berggrundskartan 3B Höganäs NO/3C Helsingborg NV.

During the past sixteen years it has been possible to complement the geological knowledge of this area with biostratigraphical results obtained from palynological investigations of specific boring-cores, e.g. Nya Vilhelmsfält No. 1 (Middle Jurassic) Guy, 1971, Guy-Ohlson 1976, Härninge Nos 64 & 159 and Rosenhäll No 62 (Middle

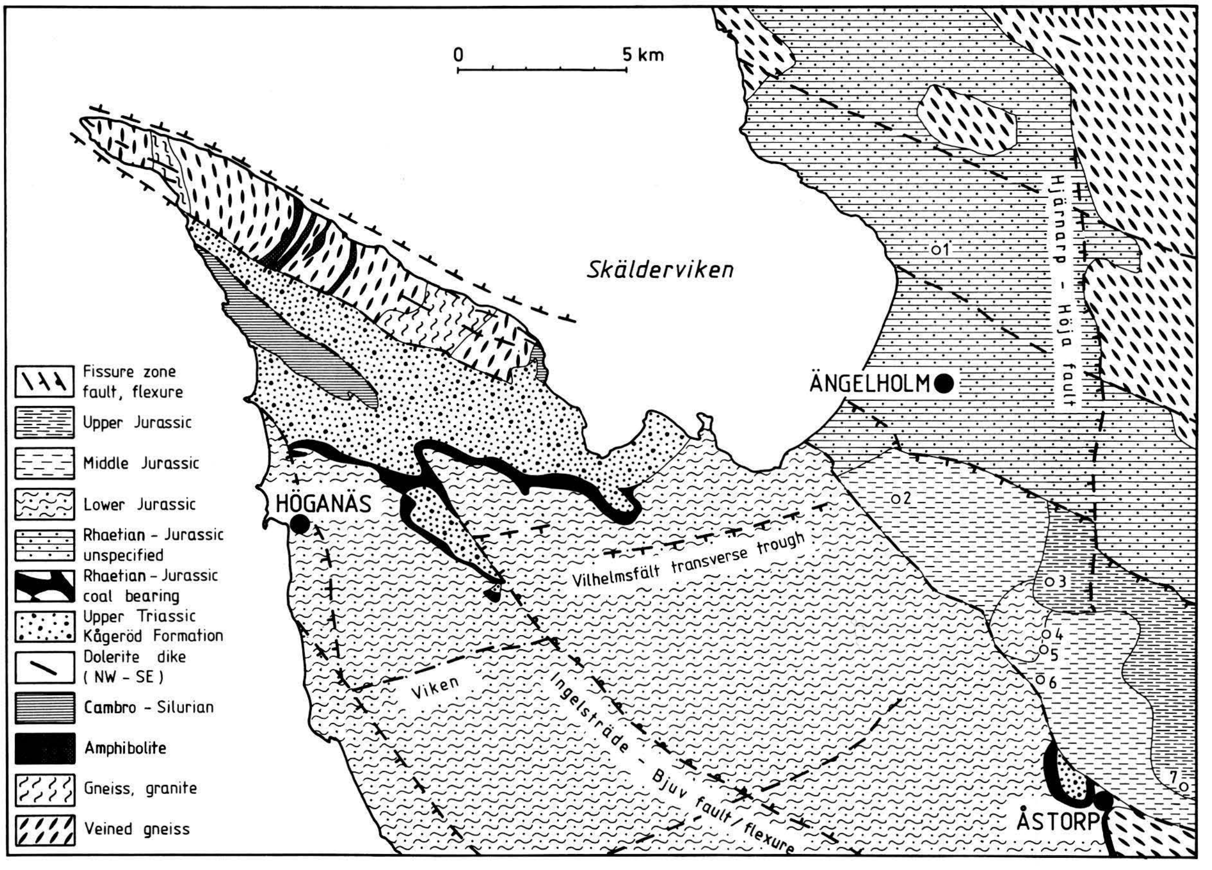

Fig. 1. Geological sketch map of NW Scania (after Wikman, Norling, Sivhed & Karis,1981). Figures refer to the following boreholes: 1) Valhall-1, 2) Nya Vilhelmsfält-1, 3) Karindal-1, 4) Härninge Nos 159 and 64, 5) Oppegård-1, 6) Rosenhäll-62 and 7) Åstorp.

Jurassic) Guy-Ohlson, 1978 and Valhall No.1 (Rhaeto-Liassic) Guy-Ohlson, 1981.

In 1979, Linder in Fig. 6 of his report, summarizes his results and findings by presenting the lithology and stratigraphy of what he termed as being the "actual geological section" of the boring core from Oppegård-1. These results were not in full agreement with what was already known and believed geologically for this specific area. The suggestion that a palynological investigation should be carried out was made by Dr. Erik Norling, who at that time was the head of the Division for Stratigraphy and Palaeontology at the Geological Survey of Sweden. Thus the purpose of the present investigation is the examination of the microfossil content of the boring core from Oppegård-1 in the hope of being able thereafter to help elucidate the existing biostratigraphical controversies.

MATERIALS AND METHODS

Eleven samples from the interval 174.53-275.37 metres were removed from the recovered core and prepared for palynological investigation according to Mädler's method (Guy, 1971, pp.9-12). In certain cases (Malmquist, 1983) ultrasonic cleaning replaced and/or complemented different stages in the preparation of the samples. The exact depths at which the eleven samples were taken are given in Fig. 2 (inside back cover). Slides from each of the eleven samples were prepared for examination in the light microscope and in addition three samples, namely from 275.30, 191.70 and 189.81 metres were also prepared for examination in the scanning electron microscope. The lithological descriptions of the investigated samples are to be found in Fig. 3. Due to poor core recovery and removal of samples for previous investigation it was only possible to select eleven samples for palynological investigation.

The photographs illustrating this report were taken under oil immersion at a magnification of x 1000. Two microscopes at the Section of Palaeobotany were used, namely nos 940229 and 442052. The figures in brackets after the slide number of the illustrated palynomorphs refer to the reference co-ordinates on one of the above-mentioned microscopes. Exactly which microscope was used is indicated in the figure-texts. The scanning micrographs have been taken at the Swedish Museum of Natural History using the Jeol JSM 35 C scanning electron microscope.

The slides containing the recorded as well as photographed palynomorphs are the property of the OPAB, but are kept for reference at the Section of Palaeobotany of the Swedish Museum of Natural History.

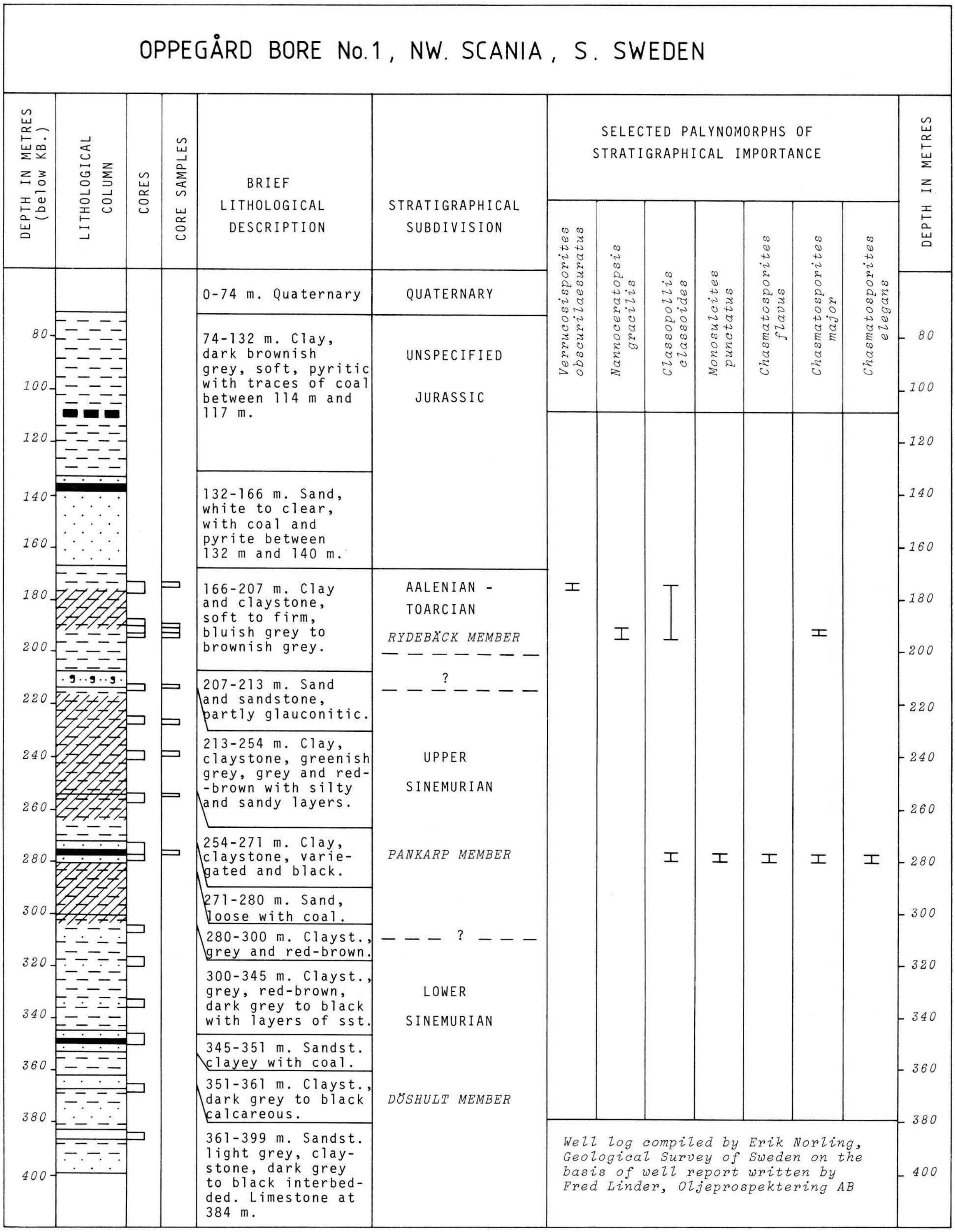
OPPEGÅRD BORE No.1, NW. SCANIA, S. SWEDEN
DEPTH IN METRES (below KB.)
LITHOLOGICAL COLUMN
CORES
CORE SAMPLES
BRIEF LITHOLOGICAL DESCRIPTION
STRATIGRAPHICAL SUBDIVISION
SELECTED PALYNOMORPHS OF STRATIGRAPHICAL IMPORTANCE
DEPTH IN METRES
Verrucosisporites obscurilaesuratus
Nannoceratopsis gracilis
Classopollis classoides
Monosulcites punctatus
Chasmatosporites flavus
Chasmatosporites major
Chasmatosporites elegans
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
0-74 m. Quaternary
74-132 m. Clay, dark brownish grey, soft, pyritic with traces of coal between 114 m and 117 m.
132-166 m. Sand, white to clear, with coal and pyrite between 132 m and 140 m.
166-207 m. Clay and claystone, soft to firm, bluish grey to brownish grey.
207-213 m. Sand and sandstone, partly glauconitic.
213-254 m. Clay, claystone, greenish grey, grey and red-brown with silty and sandy layers.
254-271 m. Clay, claystone, variegated and black.
271-280 m. Sand, loose with coal.
280-300 m. Clayst., grey and red-brown.
300-345 m. Clayst., grey, red-brown, dark grey to black with layers of sst.
345-351 m. Sandst. clayey with coal.
351-361 m. Clayst., dark grey to black calcareous.
361-399 m. Sandst. light grey, claystone, dark grey to black interbedded. Limestone at 384 m.
QUATERNARY
UNSPECIFIED
JURASSIC
AALENIAN - TOARCIAN
RYDEBÄCK MEMBER
?
UPPER
SINEMURIAN
PANKARP MEMBER
?
LOWER
SINEMURIAN
DÖSHULT MEMBER
Well log compiled by Erik Norling, Geological Survey of Sweden on the basis of well report written by Fred Linder, Oljeprospektering AB

Fig. 3.

PALYNOMORPH CONTENT AND BIOSTRATIGRAPHICAL RESULTS

Examination in the light microscope of slides from the eleven samples (and also in the scanning electron microscope) revealed the presence of a relatively well preserved "microflora" of which it was possible to determine some eighty-one species. In Fig.2 the species are listed in tabular form according to their stratigraphical (mainly European) ranges. The number of individuals recorded per sample for each species is also given in Fig.2 along with the total number of palynomorphs for each sample.

The palynomorphs recorded are of varying stratigraphical distributions. From examination of the table in Fig. 2 it is possible to detect the presence of *two* separate palynomorph assemblages, a *younger* being represented by the palynomorphs found for example in samples from 189.81 and 175.24 metres and an *older* being represented by the sample from 275.37 metres.

According to the bore protocol macrofossil evidence (in the form of belemnites and shell fragments) was found at the interval between 212.55-212.65 metres. Linder's report (1979) makes no reference to any determination being made of the recorded macrofossils.

THE YOUNGER ASSEMBLAGE

Palynomorphs from this assemblage may be generally grouped according to their stratigraphical distribution in the following way:

a) those that have a distribution ranging from or before the Rhaetian to the end of the Lower Jurassic inclusive Aalenian,
b) those that are long-ranging from or before the Rhaetian through the whole of the Jurassic,
c) those that are restricted to the Lower Jurassic inclusive Aalenian, for example *Acanthotriletes ovalis, Entylissa reticulata, Entylissa tecta, Chasmatosporites rimatus and Inaperturopollenites globulus*,

CHRONOSTRATIGRAPHICAL UNITS					LITHOSTRATIGRAPHICAL UNITS		ENVIRONMENT
S.	SERIES	STAGE			FORMATION	MEMBER	
LOWER CRETACEOUS					NOT ESTABLISHED	VITABÄCK CLAYS	ALTERNATING LIMNIC AND BRACKISH
JURASSIC	UPPER	PORTLANDIAN			NOT ESTABLISHED	NYTORP SAND	ALTERNATING LIMNIC AND BRACKISH
JURASSIC	UPPER	KIMMERIDGIAN			NOT ESTABLISHED	NYTORP SAND	ALTERNATING LIMNIC AND BRACKISH
JURASSIC	UPPER	OXFORDIAN			ANNERO FORMATION	FYLEDAL CLAY	BRACKISH-MARINE
JURASSIC	MIDDLE	CALLOVIAN			ANNERO FORMATION	FORTUNA MARL	MARINE
JURASSIC	MIDDLE	BATHONIAN			VILHELMSFÄLT F. (NW Scania) / NOT ESTABLISHED (SE Scania)	GLASS SAND	NEAR SHORE
JURASSIC	MIDDLE	BAJOCIAN			VILHELMSFÄLT F. (NW Scania) / NOT ESTABLISHED (SE Scania)	FUGLUNDA MEMBER	DELTAIC-LIMNIC
JURASSIC	MIDDLE	AALENIAN			VILHELMSFÄLT F. (NW Scania) / NOT ESTABLISHED (SE Scania)	FUGLUNDA MEMBER	DELTAIC-LIMNIC
JURASSIC	LOWER	TOARCIAN	LIASSIC	ζ	RYA FORMATION	RYDEBÄCK MEMBER	MARINE
JURASSIC	LOWER	TOARCIAN	LIASSIC	ε	RYA FORMATION	RYDEBÄCK MEMBER	MARINE
JURASSIC	LOWER	PLIENSBACHIAN	LIASSIC	δ	RYA FORMATION	RYDEBÄCK MEMBER	MARINE
JURASSIC	LOWER	PLIENSBACHIAN	LIASSIC	γ	RYA FORMATION	KATSLÖSA MEMBER	MARINE
JURASSIC	LOWER	SINEMURIAN	LIASSIC	β	RYA FORMATION	PANKARP MEMBER	MARINE
JURASSIC	LOWER	SINEMURIAN	LIASSIC	α_3	RYA FORMATION	DÖSHULT MEMBER	MARINE
JURASSIC	LOWER	HETTANGIAN	LIASSIC	α_{1-2}	HÖGANÄS FORMATION	HELSINGBORG MEMBER	LIMNIC-DELTAIC
UPPER TRIASSIC		RHAETIAN			HÖGANÄS FORMATION	BJUV MEMBER	LIMNIC-DELTAIC
UPPER TRIASSIC		RHAETIAN			HÖGANÄS FORMATION	VALLÅKRA MEMBER	LIMNIC-DELTAIC

Fig. 4. Jurassic stratigraphy of Scania. Compiled after Norling, 1972, Norling in Bergström et al., 1982 and Sivhed, personal communication.

d) those that are long-ranging, commencing their distribution in the Hettangian and continuing through the whole of the Jurassic,

e) those that are restricted in distribution to the upper part of the Lower Jurassic and in some cases reaching into the lowermost Middle Jurassic for example *Ceratosporites spinosus*, *Nannoceratopsis gracilis*, *Verrucosisporites obscurilaesuratus*, *Nannoceratopsis spiculata and Todisporites minor*.

From detailed examination of the above mentioned groups in the table in Fig. 2 it may be observed that the assemblage is dominated, in numbers at least, by palynomorphs with long-ranging stratigraphical distributions. Thereafter, it is possible, considering points (c) and (e) along with the exact distributions of the palynomorphs concerned, to narrow the age of this younger assemblage to the upper part of the Early Jurassic, namely the Toarcian-Aalenian.

THE OLDER ASSEMBLAGE

It is possible to group the palynomorphs in this assemblage in a similar way as was done for the younger assemblage, namely:

a) those that have a stratigraphical range from the Rhaetian into the lowermost part the Lower Jurassic, for example *Monosulcites punctatus, Monocolpopollenites magnus and Monocolpopollenites fusiformis,*
b) those that have a stratigraphical range from the Rhaetian through the Lower Jurassic up to and through at least part of the Middle Jurassic,
c) those that are long-ranging from the Rhaetian through the whole of the Jurassic,
d) those commencing their stratigraphical range at the end of the Rhaetian and continuing on through the Lower Jurassic and in some cases into the Middle Jurassic, and
e) those commencing their distribution in the Hettangian and ranging through the whole of the Lower Jurassic and part the Middle Jurassic, and in some cases through the whole of the Middle Jurassic and Upper Jurassic.

This assemblage, like the younger, is dominated by palynomorphs with long-ranging distributions, but can be differentiated from it by the presence of such palynomorphs as, for example *Chasmatosporites flavus, Crassipollenites diffusus, Crassipollenites rugosus, and Entylissa pyriformis,* with stratigraphical ranges restricted to the Hettangian and Sinemurian.

The results of the palynological investigation (summarized biostratigraphically in Fig. 3 show that the samples examined contain 2 palynomorph assemblages which can be distinguished from each other. The *younger assemblage,* characterized by a dominance of stratigraphically long-ranging palynomorphs, the presence of certain palynomorphs of restricted stratigraphical range and the absence of numerous typical Middle Jurassic species or index fossils, contains palynomorphs whose stratigraphical range appears to indicate a Toarcian-Aalenian age, at least for the sample interval 191.70-175.24 metres. The *older assemblage* is represented by the sample from 275.37 metres and is characterized by a dominance of stratigraphically long-ranging species and the presence of certain species with restricted stratigraphical range. The latter have their distribution restricted to the Hettangian and Sinemurian.

Thus on the grounds of the palynomorph content of the samples it is possible to suggest a Toarcian-Aalenian age for the samples from 191.70-175.24 metres and an age of Hettangian - Sinemurian for the sample at 275.37 metres. (On lithological grounds Hettangian is not an actual possibility for consideration.) These results stand somewhat in contradiction to those of Linder (1979, p.6) who suggested that the former interval should be regarded as a "Fyledalen Clay Formation", (that is Upper Jurassic) and Döshult Formation (Lower Sinemurian) for the latter sample of 275.37 metres. Further discussion of this follows in the next chapter.

In addition it should be noted that according to Linder (1979, Fig.6) an unconformity exists at approximately 270 metres below KB (KB = Kelly Bushing). This uncomformity is also reflected to some extent in the results obtained from the palynological investigation, in that two distinct assemblages (see above) differing in age could be determined. These assemblages are separated by the interval between 191.70 and 275.37 metres. Palynological examination of 5 samples from this intervening interval was carried out. This examination revealed the presence of very few palynomorphs (Fig.2). Thus it is impossible to pin-point or verify the exact positions of the unconformities on the basis of palynological evidence. All that can be concluded is that there exists an interval zone which is almost barren between the two assemblage biozones. The few palynomorphs encountered there are almost exclusively bisaccate pollen grains which have presumably been transported by wind long distances from the nearest source. No palynomorphs indicating marine environmental deposition have been recorded in this interval.

COMPARISON WITH OTHER LOWER JURASSIC "PALYNOFLORAS"

Swedish Lower Jurassic (in particular Rhaeto-Liassic) floras, including both so called macrofloras and microfloras, have been the subject of many different studies during the past decades. A brief survey of the work done is to be found in Guy-Ohlson (1981, pp. 233-234). Of particular interest to this present investigation is the palynostratigraphy of the Rhaeto-Liassic of the Valhall Bore No.1, Guy-Ohlson 1981, and that of the Toarcian-Aalenian of the Nya Vilhelmsfält Bore No. 1 (as yet unpublished).

THE OLDER ASSEMBLAGE

When the older assemblage at Oppegård is compared with the assemblages found at Valhall (Guy-Ohlson, 1981), it is noted that it is most comparable with the so called *younger assemblage* at Valhall, that is the assemblage forming the *Pinuspollenites* - *Trachysporites* zone and *Pinus - pollenites* and *Trachysporites*. It differs from it, however, by the presence of *Cerebropollenites (mesozoicus) macroverrucosus and Corollina torosus, (Classopollis classoides)*. In fact it bears greater resemblance to the palynostratigraphical zone (not present at Valhall) established by Lund (1977, pp. 41-49) and designated as the "unnamed zone above the *Pinuspollenites* - *Trachysporites* zone".

This zone was established by Lund for the dark clay samples taken from the Gantofta Brick Pit in Scania and representing an age of Early Sinemurian (Lias α 3) and Late Sinemurian (Lias β), the latter age having been verified by the presence of ammonites (Reyment, 1969). Despite the similarity of palynomorph content no lithological similarity can be observed, however, between Lund's dark clay samples (Lund 1977, p.47), and Linder's lithological description (Linder, 1975, appendix A, p.2) of the interval 271-280 metres, namely, "sand, loose quartz, generally medium, locally coarse, subangular, and sandstone, grey, hard very fine grading to siltstone, well cemented, quartzitic, traces of coal".

It should be mentioned, however, that such lithology is known for an interval in the Pankarp Member of the Sinemurian (Norling 1972, p.9 and 1982, pp. 31-32 and Fig. 9, p.30). Thus, at least, lithologically there exists the possibility that the sediments of the older assemblage may, in fact, belong to the Upper Sinemurian.

Thus only on the grounds of similarity of palynomorph content is it suggested that the *older assemblage* at Oppegård is equivalent to Lund's palynostratigraphical zone known as the "unnamed zone with *Cerebropollenites macroverrucosus* above the *Pinuspollenites - Trachysporites* zone", and as such according to Lund is of Sinemurian (Lias $\alpha 3$ - β) age. From actual assemblage composition at Oppegård and with direct comparison with Lund's table 4 (Lund, 1977, pp. 94-95) a tentative Sinemurian age is suggested for the Oppegård sample at 275.37 metres.

THE YOUNGER ASSEMBLAGE

Toarcian-Aalenian sediments from the Nya Vilhelmsfält Bore No.1 have been investigated palynologically (results as yet unpublished) revealing a rich and extremely well preserved "microflora". The *younger assemblage* in the Oppegård Bore No.1 can in no way "rival" the Vilhelmsfält "microflora", which is superior not only in state of preservation but also in the variety and diversity of the palynomorph species present as well as in the total number of individuals representing the species. On comparison, however, certain similarities may be observed among others:

a) the presence in both of stratigraphically long-ranging palynomorph species such as *Cyathidites australis, Cyathidites minor, Ginkgocycadophytus nitidus, Classopollis classoides, Perinopollenites elatoides, Araucariacites australis, Spheripollenites subgranulatus and Spheripollenites scabratus,*
b) the presence of a variety of species of *Chasmatosporites,* thus indicating, the typical Liassic character of the assemblage,
c) the presence of certain so called index dinoflagellate species for the upper Lower Jurassic, for example *Nannoceratopsis gracilis,*
d) the absence of species indicating a charcteristic Middle Jurassic assemblage.

On the basis of direct comparison it would appear that the *younger* Oppegård *assemblage* is of the same age as those sediments previously mentioned as being investigated from the Nya Vilhelmsfält Bore No.1, i.e. Toarcian-Aalenian.

Sediments from the Bagågraven clay pit, on the island of Bornholm, Denmark, have been investigated palynologically by Hoelstad (1983). He established three biozones based on the seventy palynomorph species (only spores and pollen grains) found. The lowest zone he dated as uppermost Toarcian, the middle zone to lowermost Aalenian and the upper zone he referred to the Middle Jurassic.

When the *younger assemblage* at Oppegård is compared with the palynomorphs found in Hoelstad's first two biozones, i.e. uppermost Toarcian and lowermost Aalenian, some similarity is observed, but identity with neither of the zones can be inferred. From the actual palynomorph content the greater resemblance is to zone one, i.e. that of uppermost Toarcian age, but the *younger* Oppegård *assemblage* differs from it by the presence of dinoflagellates and acritarchs and the absence of such species as *Foraminisporis jurassicus, Heliosporites reissingeri and Ischyosporites variegatus,* which are all of importance in the Bornholm material. Comparison with Lower Liassic palynomorphs described from Holland (Herngreen and De Boer, 1974), England (Couper, 1958) and Germany (Schulz, 1967) has also been made, but though general similarity of palynomorph content is observed no definite identity with any one assemblage can be observed.

Thus comparison of the *younger assemblage* at Oppegård with other Early Jurassic palynofloras substantiates the tentatively suggested Toarcian-Aalenian age but does not permit the establishment of a narrower age definition for the samples examined.

PALAEOENVIRONMENT

The palynomorph content of the *older assemblage* at Oppegård contains no fossil marine organisms such as dinoflagellates or other organic-walled microplankton apart from a few specimens of *Micrhystridium* and even fewer *Botryococcus colonies*. The former are indicative of marine influence, even though very much restricted, on an otherwise continental environment, this being witnessed to by the relatively large numbers of pollen grains of *Araucariacites australis, Alisporites robustus and Perinopollenites elatoides* and the presence of *Classopollis*, while the latter, i.e. the *Botryococcus colonies*, represent fresh water influence. The occurrence of both *Micrhystridium and Botryococcus* in the same sample suggests significant fresh water influence on the depositional environment, for example the site of deposition may have been near-shore, close to a river mouth.

Scanian Sinemurian sediments have accumulated largely under marine depositional environment. The palynological results now obtained suggest a non-marine deposition for the interval 271-280 metres, represented by loose sand with coal.

The *younger assemblage* at Oppegård in contrast to the *older assemblage* contains certain dinoflagellates which indicate a definite marine depositional environment. This is also corroborated by the presence of the acritarch, *Micrhystridium lymensis*. This marine depositional environment is in accordance with what would be expected for sediments of Toarcian-Aalenian age as proposed in the previous chapters.

THERMAL ALTERATION INDEX

The colour of the palynomorphs found varies from light yellow to light brownish yellow. Based on the colour of small unornamented spores through the sample intervals examined it is possible to determine the thermal alteration, i.e. organic maturation, of the samples investigated and in turn suggest the hydrocarbon source potential for these sediments.

A value of 2.0 on the thermal alteration index (TAI) scale (Batten,1981) is obtained for the *younger assemblage* sediments and a value of 2.5 for the *older assemblage* sediments. These values indicate that some chemical change has occurred, but the organic matter is immature, or only very marginally mature, not likely to have potential as a commercial source. These results obtained from the present palynological investigation are in agreement with the report from Geochem Laboratories appendixed to Linder's report, 1979.

CONCLUSION

Palynological investigation of selected samples from the interval 170-280 metres of the Oppegård Bore No. 1 has been unable to confirm the results of Linder's report, 1979, but instead has been able to reveal the presence of two distinct assemblages of palynomorphs. The *younger assemblage* of palynomorphs, deposited under marine environmental conditions, is indicative of a Toarcian-Aalenian age for the sample interval 174.53-191.70 metres and the *older assemblage*, deposited under non-marine conditions, is indicative of a Sinemurian age for the sample at 275.37 metres.

ACKNOWLEDGEMENT

We should like to express our thanks to all those who have helped and encouraged us with this work. Dr Erik Norling of the Geological Survey of Sweden suggested the investigation and has supported us throughout it with his continued interest.
Prof. B. Lundblad has put the staff (Yvonne Arremo, Britta Broberg, Kamlesh Khullar, Olof Haglund and Lars Imby) and facilities of the Section of Palaeobotany at the Swedish Museum of Natural History at our disposal.

We are also indebted to Oljeprospektering AB (OPAB) for allowing us to investigate their core material, giving us access to their own results and for permission to publish our results.

OPPEGÅRD BORE NO.1: LIST OF PALYNOMORPHS PRESENT

(in alphabetical order)

Acanthortriletes ovalis NILSSON
Alisporites robustus NILSSON
Aratisporites fimbriatus (KLAUS) MÄDLER
Araucariacites australis COOKSON
Araucariacites sp.
Baculatisporites comaumensis (COOKSON) POTONIÉ
Botryococcus sp.
Brachysaccus microsaccus (COUPER) MÄDLER
Brachysaccus sp.
Calamospora mesozoica COUPER
Calamospora sp.
Callialasporites dampieri (BALME) DEV
Canningia sp.
Caytonipollenites pallidus (REISSINGER) COUPER
Ceratosporites spinosus SCHULZ
Cerebropollenites mesozoicus (COUPER) NILSSON
Chasmatosporites apertus NILSSON
Chasmatosporites elegans NILSSON
Chasmatosporites flavus NILSSON
Chasmatosporites hians NILSSON
Chasmatosporites major NILSSON
Chasmatosporites minor NILSSON
Chasmatosporites radiatus NILSSON
Chasmatosporites rimatus NILSSON
Chasmatosporites sp.
Classopollis classoides (PFLUG) POCOCK & JANSONIUS
Conbaculatisporites mesozoicus KLAUS
Crassipollenites diffusus NILSSON
Crassipollenites rugosus NILSSON
Cyathidites australis COUPER
Cyathidites concavus (BOLKHOVITINA) DETTMANN

Cyathidites minor COUPER
Densoisporites sp.
Entylissa pyriformis NILSSON
Entylissa reticulata NILSSON
Entylissa tecta NILSSON
Eucommiidites major SCHULZ
Eucommiidites troedssonii ERDTMAN
Exesipollenites tumulus BALME
Exesipollenites sp.
Ginkgocycadophytus nitidus (BALME) DE JERSEY
Inaperturopollenites globulus NILSSON
Inaperturopollenites triangularis NILSSON
Inaperturopollenites sp.
Leiotriletes sp.
Lycopodiacidites rugulatus (COUPER) SCHULZ
Lycopodiumsporites clavatoides (COUPER) TRALAU
Lycopodiumsporites sp.
Marattisporites scabratus COUPER
Micrhystridium lymensis
Micrhystridium sp.
Monocolpopollenites fusiformis NILSSON
Monocolpopollenites magnus NILSSON
Monosulcites minimus COUPER
Murospora sp.
Monosulcites punctatus ORLOWSKA-ZWOLINSKA
Nannoceratopsis gracilis (ALBERTI) EVITT
Nannoceratopsis spiculata STOVER
Osmundacidites wellmanii COUPER
Perinopollenites elatoides COUPER
Pityosporites scaurus (NILSSON) SCHULZ
Platysaccus lopsinensis (MAL) POCOCK
Sestrosporites sp.
Species indet.
Spheripollenites scabratus COUPER
Spheripollenites subgranulatus COUPER
Stereisporites cicatricosus (ROG.) DANZÉ-CORSIN et LAVEINE

Taedaepollenites scaurus NILSSON
Todisporites major COUPER
Todisporites minor COUPER
Trachysporites asper NILSSON
Tripartina cf.T. variablis MALJAVIKINA
Undulatisporites concavus KEDVES
Undulatisporites sp.
Uvaesporites sp.
Verrucosisporites obscurilaesuratus POCOCK
Vitreisporites pallidus (REISSINGER) NILSSON
Zebrasporites interscriptus (THIERG.) KLAUS

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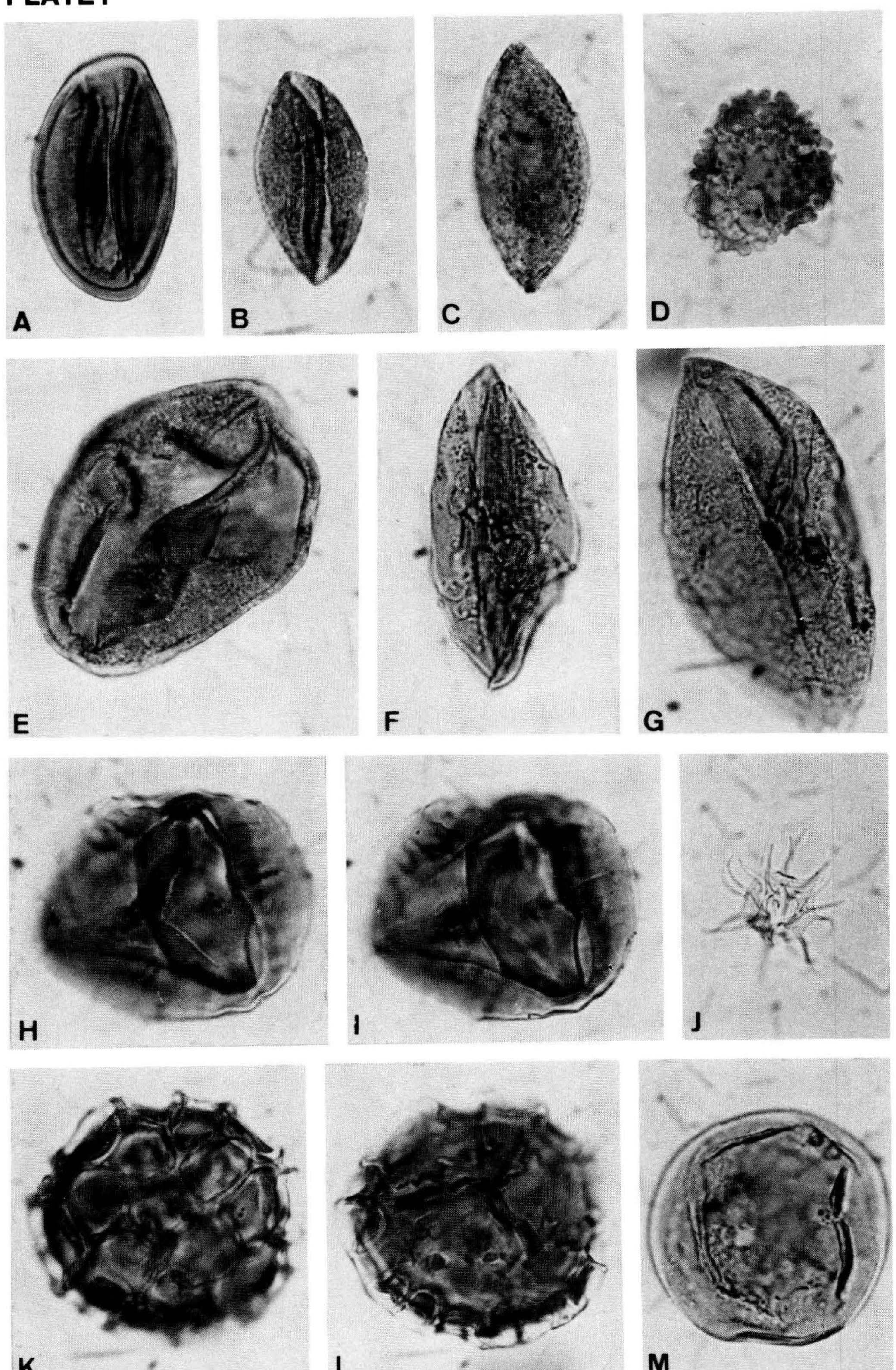
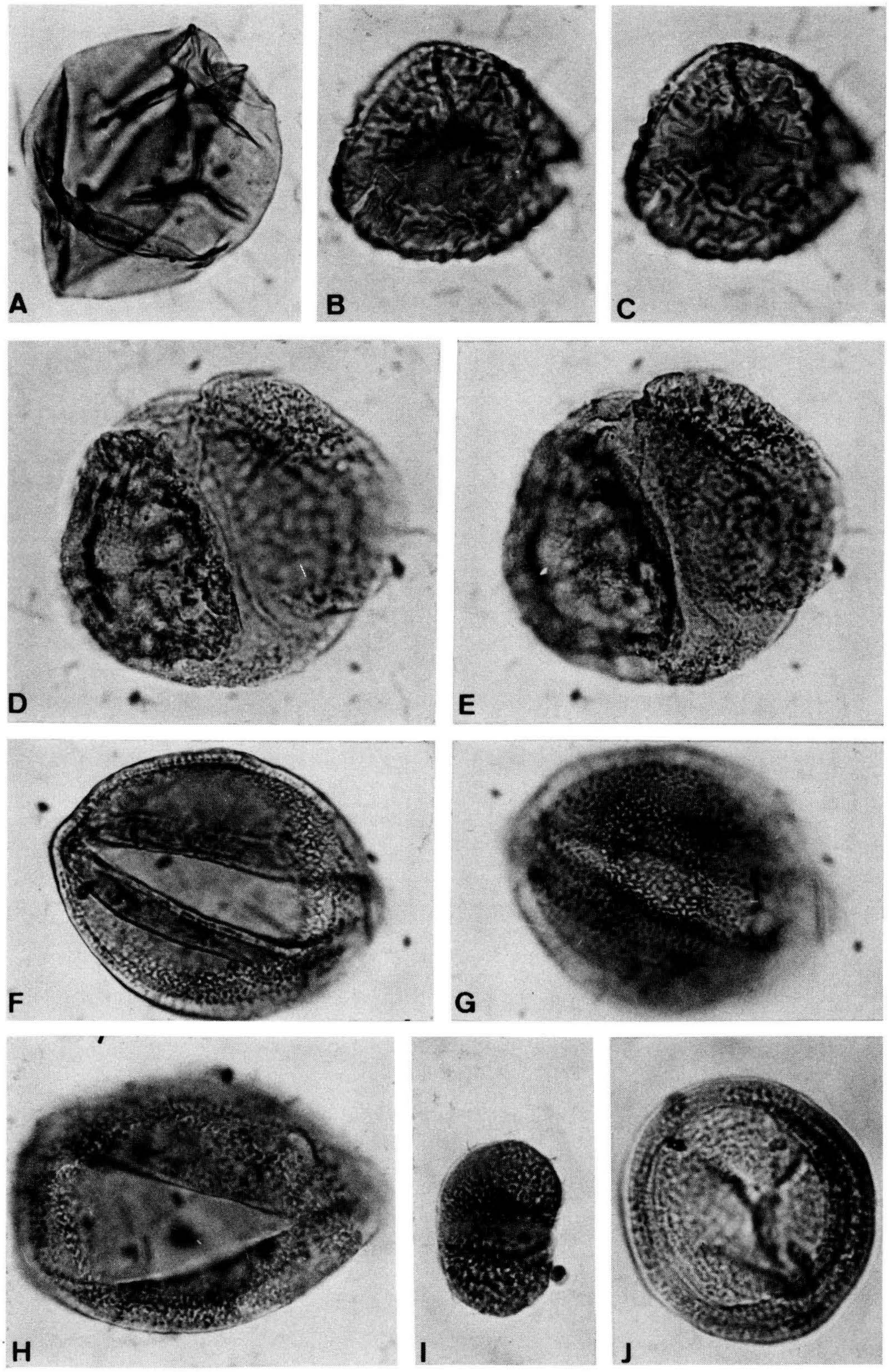
PLATE I



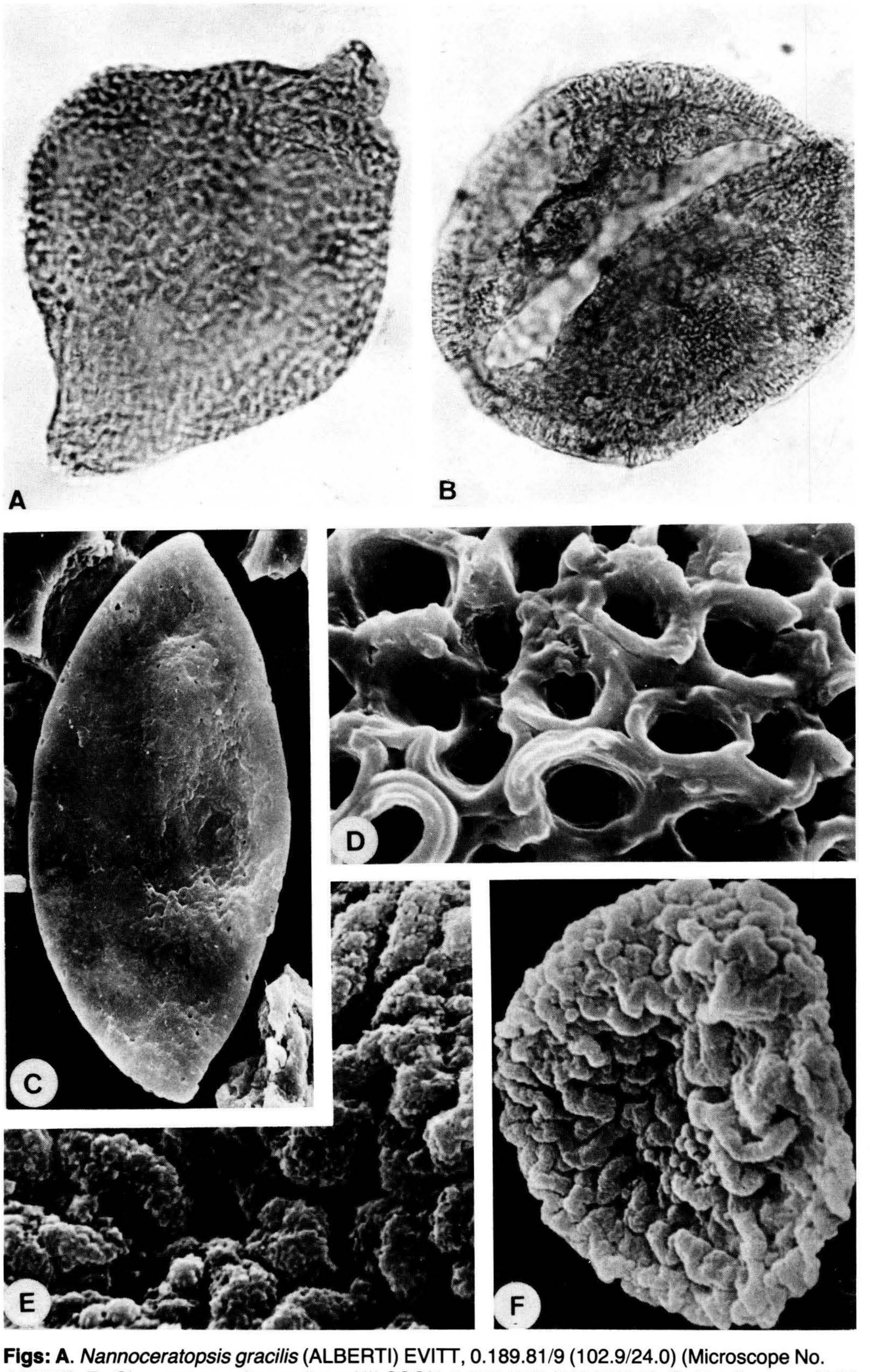
Figs: A. *Eucommiidites troedssonii* ERDTMAN, 0.275.3/4 (93.4/41.7). **B**. *Entylissa pyriformis* NILSSON, 0.275.37/2 (104.9/44.3). **C**. *Monocolpopollenites sp.*, 0.275.37/1 (106.4/21.2). **D**. *Uvaesporites sp.*, 0.174.53/5 (96.9/20.5). **E**. *Monosulcites punctatus* ORLOWSKA-ZWOLINSKA, 0.275.37/1 (93.1/25.3). **F**. *Monocolpopollenites fusiformis* NILSSON 0.275.37/2 (98.7/38.1). **G**. *Monocolpopollenites magnus* NILSSON, 0.275.37/4 (101.7/38.2). **H & I**. *Zebrasporites interscriptus* (THIERG.) KLAUS, 0.275.37/4 (98.4/38.0). **J**. *Micrhystridium sp.*, 0.275.37/2 (107.2/24.8). **K & L**. *Lycopodiumsporites clavatoides* (COUPER) TRALAU, 0.275.37/4 (94.8/24.8). **M**. *Crassipollenites rugosus* NILSSON, 0.275.37/4 (95.4/50.8).

PLATE II



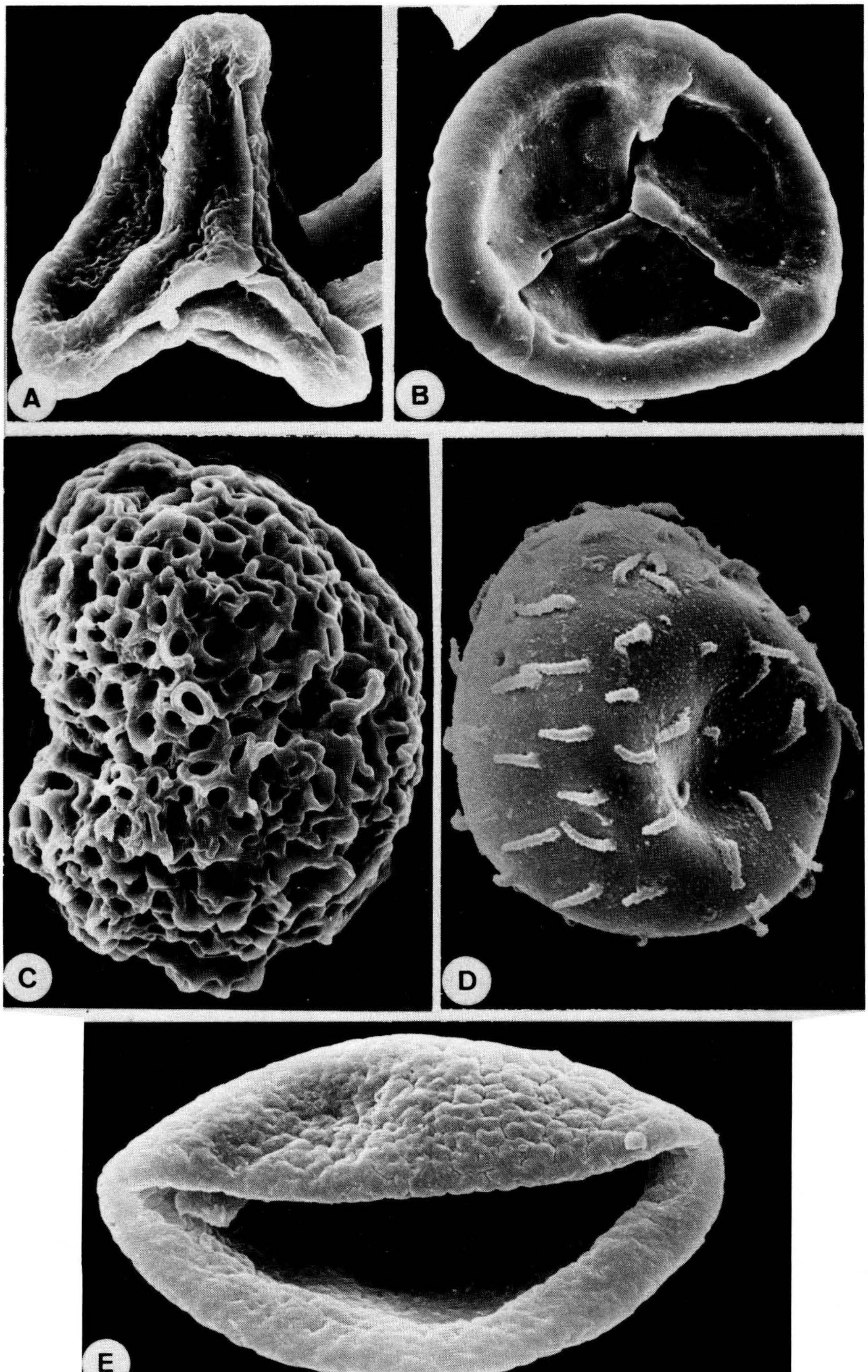
Figs: A. *Calamospora mesozoicus* COUPER, 0.275.37/1 (102.9/30.1). **B & C**. *Lycopodiacidites rugulatus* (COUPER) SCHULZ, 0.275.37/5 (90.9/33.8). **D & E**. *Brachysaccus sp.*, 0.275.37/3 (102.1/34.4). **F & G**. *Chasmatosporites hians* NILSSON, 0.275.37/4 (104.9/48.8).
H. *Chasmatosporites major* NILSSON, 0.275.37/1 (92.9/46.1). **I**. *Vitreisporites pallidus* (REISSINGER) NILSSON, 0.175.24/5 (110.5/48.5) (Microscope No. 442052). **J**. *Classopollis classoides* (PFLUG) POCOCK et JANSONIUS, 0.189.81/8 (116.7/39.9) (Microscope No. 442052).

PLATE III



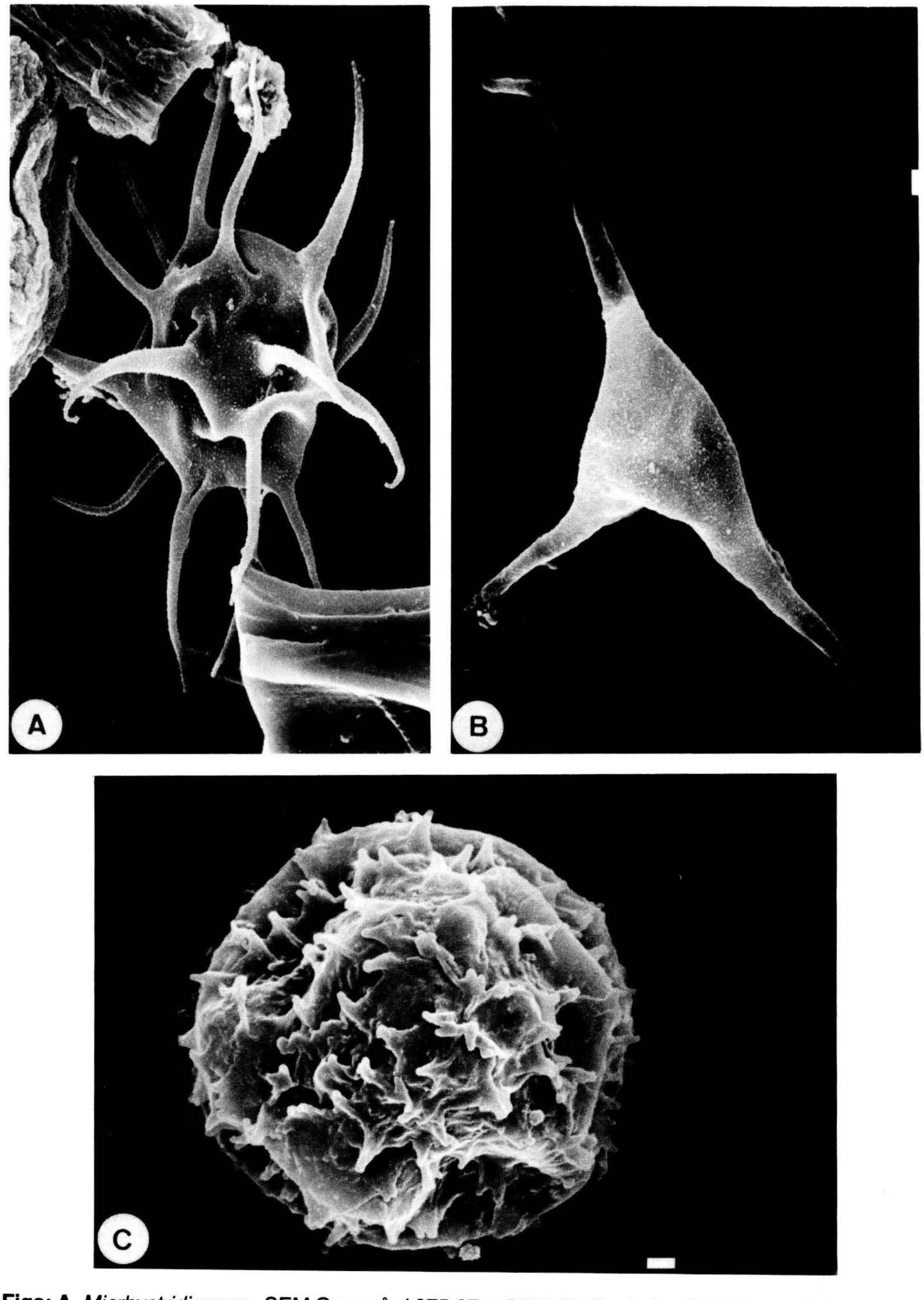
Figs: A. *Nannoceratopsis gracilis* (ALBERTI) EVITT, 0.189.81/9 (102.9/24.0) (Microscope No. 442052). **B**. *Chasmatosporites radiatus* NILSSON, 0.275.37/3 (112.7/43.7). **C**. *Entylissa sp.*, SEM Oppegård 275.37 × 1800. **D**. *Sp. indet.*, SEM Oppegård 275.37 × 1200 (see also Plate IV, Fig. C). **E & F**. *Cerebropollenites sp.*, SEM Oppegård 275.37, E: × 8600, F: × 3200.

PLATE IV



Figs: A. *Sp. indet.*, SEM Oppegård 275.37 × 2000. **B**. *Leiotriletes sp.*, SEM Oppegård 275.37 × 2600. **C**. *Sp. indet.*, SEM Oppegård 275.37 × 1200 (see also Plate III, Fig. D). **D**. *Sp. indet.*, SEM Oppegård 275.37 × 4800. **E**. *Sp. indet.*, SEM Oppegård 275.37 × 3600.

PLATE V



Figs: A. *Micrhystridium sp.*, SEM Oppegård 275.37 × 3000. **B**. *Sp. indet.*, SEM Oppegård 275.37 × 4000. **C**. *Sp. indet.*, SEM Oppegård 275.37 × 4400.

OPPEGÅRD BORE No. 1, SCANIA

Stratigraphical range: RHAETIAN; JURASSIC — L: HETTANGIAN, SINEMURIAN, PLIENSBACHIAN, TOARCIAN; M: AALENIAN, BAJOCIAN, BATHONIAN, CALLOVIAN; U: OXFORDIAN, KIMMERIDGIAN, PORTLANDIAN

LIST OF PALYNOMORPHS PRESENT	No. of palynomorphs present in samples examined													
	275.37 m	254.95 m	239.20 m	226.47 m	212.27 m	192.30 m	191.70 m	191.22 m	189.81 m	175.24 m	174.53 m	SEM: 275.3 m	SEM: 191.70 m	SEM: 189.81 m
Aratisporites fimbriatus									2					
Monosulcites punctatus	1													
Cf Monocolpopollenites magnus	1								1					
Monocolpopollenites fusiformis	1													
Conbaculatisporites mesozoicus										1			1	
Chasmatosporites major	1								5					
Chasmatosporites apertus	4													
Marattisporites scabratus	5								1	1				
Chasmatosporites hians	1								1					
Cf Pityosporites scaurus									1					
Baculatisporites comaumensis	1						1							
Brachysaccus microsaccus	2			3					7					
Botryococcus sp.	2													
Cyathidites australis	31		2	1		2	6	1	12	4				1
Cyathidites minor	5						5		11	2			1	1
Ginkgocycadophytus nitidus							1		6					
Eucommiidites troedssonii	1								3	1			1	
Zebrasporites interscriptus	1													
Chasmatosporites minor	2													
Alisporites robustus	19			2		1	7	1	16	1				1
Lycopodiacidites rugulatus	1											1		
Calamospora mesozoica	8										1			
Osmundacidites wellmanii	2								1	1				
Pityosporites scaurus	4		2											
Vitreisporites pallidus				1						1				
Eucommiidites major	1													
''Chasmatosporites radiatus''	3													
Trachysporites asper	1					1			1					
Chasmotosporites flavus	2													
''Crassipollenites diffusus''	1													
Crassipollenites rugosus	2													
Entylissa pyriformis	1								1					
Chasmatosporites elegans	1													
Inaperturopollenites triangularis	2													
Taedaepollenites scaurus	2													
Cf Acanthotriletes ovalis										2				
Entylissa reticulata						1			1					
Cf Entylissa reticulata							1							
Entylissa tecta							1			1				1
Chasmatosporites rimatus									4	1				
Inaperturopollenites globulus							1		3	1				
Undulatisporites concavus							1					2		
Lycopodiumsporites clavatoides	3												1	1
Micrhystridium lymensis										1				1
Stereisporites cicatricosus	1													
Todisporites major	3					1			2	1				
Classopollis classoides	12					2	31	1	28	35	1			
Perinopollenites elatoides	24						2		11	6				
Araucariacites australis	149	1	3	2	1		5		10					
Spheripollenites subgranulatus							1		2					
Cf Monosulcites minimus							1		1	2				
Spheripollenites scabratus							2		9	37				
Cerebropollenites mesozoicus	5					1	2		3			1		
Callialasporites dampieri	2													
Ceratosporites spinosus				1										1
Nannoceratopsis gracilis							1		15					
Verrucosisporites obscurilaesuratus										1				
Nannoceratopsis spiculata									3					
Todisporites minor							1							
Cyathidites concavus									1					
Cf Tripartina variablis								1	1					
Platysaccus lopsinensis							1		2					
Exesipollenites tumulus								1						
Araucariacites sp.							4		3					
Brachysaccus sp.							1							
Calamospora sp.							1							
Callialasporites sp.	2													
Canningia sp.			1											
Chasmatosporites sp.							2		6	1				
Densoisporites sp.						1					1			
Exesipollenites sp.									1					
Inaperturopollenites sp.				3					1	1				
Leiotriletes sp.												1		1
Leptolepidites sp.										1				
Lycopodiumsporites sp.	1													
Micrhystridium sp.	4											1		
Murospora sp.							1		1					
Spheripollenites sp.	2			1			1		1	5				3
Sestrosporites sp.														1
Undulatisporites sp.	1						1							
Uvaesporites sp.											1			
Sp. indet.	11	0	1	1	0	3	9		15	22	4	6	2	9
Total No. of palynomorphs	329	1	9	15	1	13	91	5	193	130	8	10	8	22

Fig. 2

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