SVERIGES GEOLOGISKA UNDERSÖKNING

SER. Ca AVHANDLINGAR OCH UPPSATSER I A4 NR 72

DOROTHY GUY-OHLSON AND ERIK NORLING

UPPER JURASSIC LITHO- AND BIOSTRATIGRAPHY OF NW SCANIA, SWEDEN

UPPSALA 1988

SVERIGES GEOLOGISKA UNDERSÖKNING

SER Ca AVHANDLINGAR OCH UPPSATSER NR 72

DOROTHY GUY-OHLSON AND ERIK NORLING

UPPER JURASSIC LITHO- AND BIOSTRATIGRAPHY OF NW SCANIA, SWEDEN

UPPSALA 1988

ISBN 91-7158-451-X
ISSN 0348-1352

Textkartorna är från sekretessynpunkt godkända för spridning
Lantmäteriverket 1988-10-12

Tryck: Offsetcenter AB, Uppsala 1988

CONTENTS

ABSTRACT

Upper Jurassic sediments of the Ängelholm Trough, NW Scania, southern Sweden, represent a remnant of deposits once laid down in a large sedimentary depression at the margin of the Fennoscandian Shield. The deposits, which have been differentially eroded in connection with Kimmerian block faulting and Late Cretaceous-Cainozoic movements are described and investigated litho- and biostratigraphically. Upper Jurassic lithostratigraphical units (members of the Annero Formation) which have been identified in this investigation in NW Scania are the Fortuna Marl (Upper Bathonian - Oxfordian), the Fyledal Clay (Oxfordian - Kimmeridgian), the Nytorp Sand (Kimmeridgian - Portlandian) and the Vitabäck Clays (Portlandian - basal Cretaceous). Two boreholes, Åstorp No. 20 and Karindal No. 1 have been examined in detail. The microfloras (83 palynomorph species) and faunas (31 foraminiferal species) have been documented and the former have been illustrated with scanning electron micrographs. From the known stratigraphical ranges of the palynomorphs and foraminifers found it is possible to date different intervals of the examined cores as representing late Middle Jurassic to late Late Jurassic. The foraminiferal fauna also shows that the Upper Jurassic deposits in one of the boreholes, Karindal No. 1, rest on Liassic (Pliensbachian) uplift. Comparison of the Swedish microfossils has been made with other relevant palynofloras and foraminiferal faunas. Reworked spores of Carboniferous age have also been recorded both at Karindal and at Åstorp. Interpretations have been made concerning the palaeoenvironment, sedimentary deposition and organic maturation of the investigated sediments.

KEY WORDS: Upper Jurassic, lithostratigraphy, biostratigraphy, palynomorphs, foraminifers, Sweden.

Introduction

On the Swedish mainland, Upper Jurassic deposits are known from Scania, the southernmost province (Fig. 1). Outcrops of Upper Jurassic strata are found at one locality only i.e. at Eriksdal in the Vomb Trough (Fig. 2). Subsurface studies (borehole geology and geophysics) have shown, however, that Upper Jurassic sediments, beneath a cover of Quaternary, Paleogene and Cretaceous deposits have a fairly wide distribution in Scania (Fig. 2). Concerning some parts of Scania, the knowledge of Upper Jurassic geology is fairly new (Norling, 1981).

In connection with survey mapping in NW Scania (sheet 3B Höganäs NO/3C Helsingborg NV), investigation of samples from boreholes drilled for water supply in the Ängelholm Trough (at Kvidinge, Vallaröd, and Åstorp, Fig. 3) revealed the presence of Upper Jurassic rocks (Norling 1981). Before this discovery Upper Jurassic deposits were unknown in this area. The youngest pre-Quaternary deposits previously known from NW Scania (apart from the Båstad Basin) were of Middle Jurassic age (Guy 1971).

To receive more complete documentation than had resulted from the water drillings mentioned above, the Geological Survey of Sweden (SGU) financed a core-drilling, which was located to Karindal (Fig. 3). The Karindal No. 1 borehole was drilled in 1977 by TGB (Tung Geoteknisk Borrning, Gothenburg) to a depth of 206 m and penetrated almost 90 m of Upper Jurassic strata with a fairly good core recovery, except for completely uncemented parts of the sequence.

The main aim of this investigation is to improve the knowledge of Upper Jurassic litho- and biostratigraphy within the border zone between two geological regimes: the East European Platform and the NW European area of subsidence (including the North Sea and adjacent land masses). It is also hoped to improve the understanding of structurally rather complicated subsurface geology of the Ängelholm Trough in NW Scania. This is not of local interest only. The trough contains a remnant of Upper Jurassic deposits, once laid down in a fairly vast sedimentary depression at the margin of the Fennoscandian Shield. The deposits have been differentially eroded in connection with Kimmerian blockfaulting and late Cretaceous - Cainozoic movements.

The palynological investigation aims to document and determine the palynomorphs found and thereafter biostratigraphically confirm and, if possible, narrow the age determinations of the examined intervals.

Previous foraminiferal studies of Upper Jurassic strata in Scania (Norling 1970, 1972, 1981) have shown that the content of foraminifers in these deposits is usually fairly meagre. They do occur, however, seemingly in varying frequencies in different parts of the province. The aim of the present foraminiferal study is to document the fauna obtained and use it, if possible, to complement the biostratigraphical and palaeoecological conclusions of the palynological investigation.

MATERIAL AND METHODS

Thirteen samples from the interval 90-152 m of the Karindal borehole No. 1 and twenty-one samples from the cored interval 160.58-169.09 m of the Åstorp borehole No. 20 were selected for palynological investigation. The exact depths at which the samples were taken are to be found in Fig. 8.

The samples were prepared partly using standard palynological techniques (Mädler, 1964) and partly using a somewhat adapted version involving ultrasonic cleaning. Slides were prepared for examination in the light microscope and so called strew stubs for routine control in the scanning electron microscope (SEM).

For foraminiferal analyses thirty-two samples were selected from the Karindal borehole No. 1, 90.0–204.5 m interval of core drilling. The Åstorp borehole No. 20 was drilled with a cable tool method down to a depth of 160.1 m, and only the deepest part of the sequence penetrated, 160.1–169.3 m, was actually cored. From the interval 88–160 m seven ditch samples were selected, and thirteen core samples from the interval 160.1–169.3 m for the foraminiferal investigation.

The foraminiferal samples were disaggregated by washing and dry sieving using a standard micropalaeontological technique (Brasier, 1979). The dried residues were then scanned on a picking tray, and the foraminifers were separated from the mineral grains and placed in cells for examination in the light microscope.

The boring core is the property of SGU, but the illustrated specimens are kept for reference at the Section of Palaeobotany, Swedish Museum of Natural History, Stockholm.

GEOLOGICAL SETTING

The Upper Jurassic of Scania, subdivided into four lithostratigraphical units (regionally correlative over fairly vast areas), is preserved in several downfaulted blocks. Originally, the Upper Jurassic sediments of Scania were mainly deposited in one and the same depression, as indicated by lith-

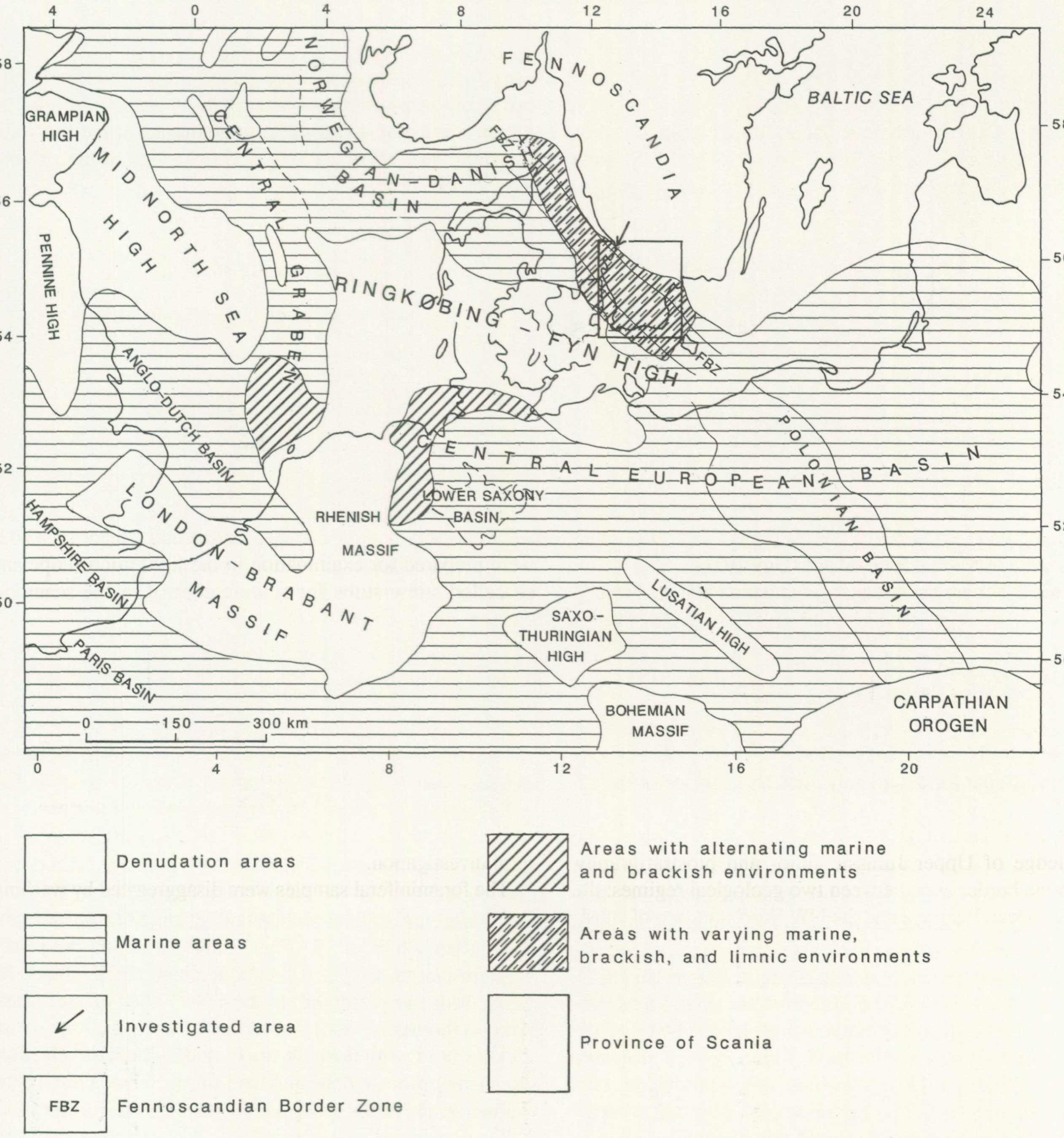


Fig. 1. Upper Jurassic palaeogeography of NW Europe (partly based on the lithological-palaeogeographical map of the Oxfordian compiled by Jubitz, Michelsen, Norling and others 1986 for the IGCP project SW Border of the East European Platform).

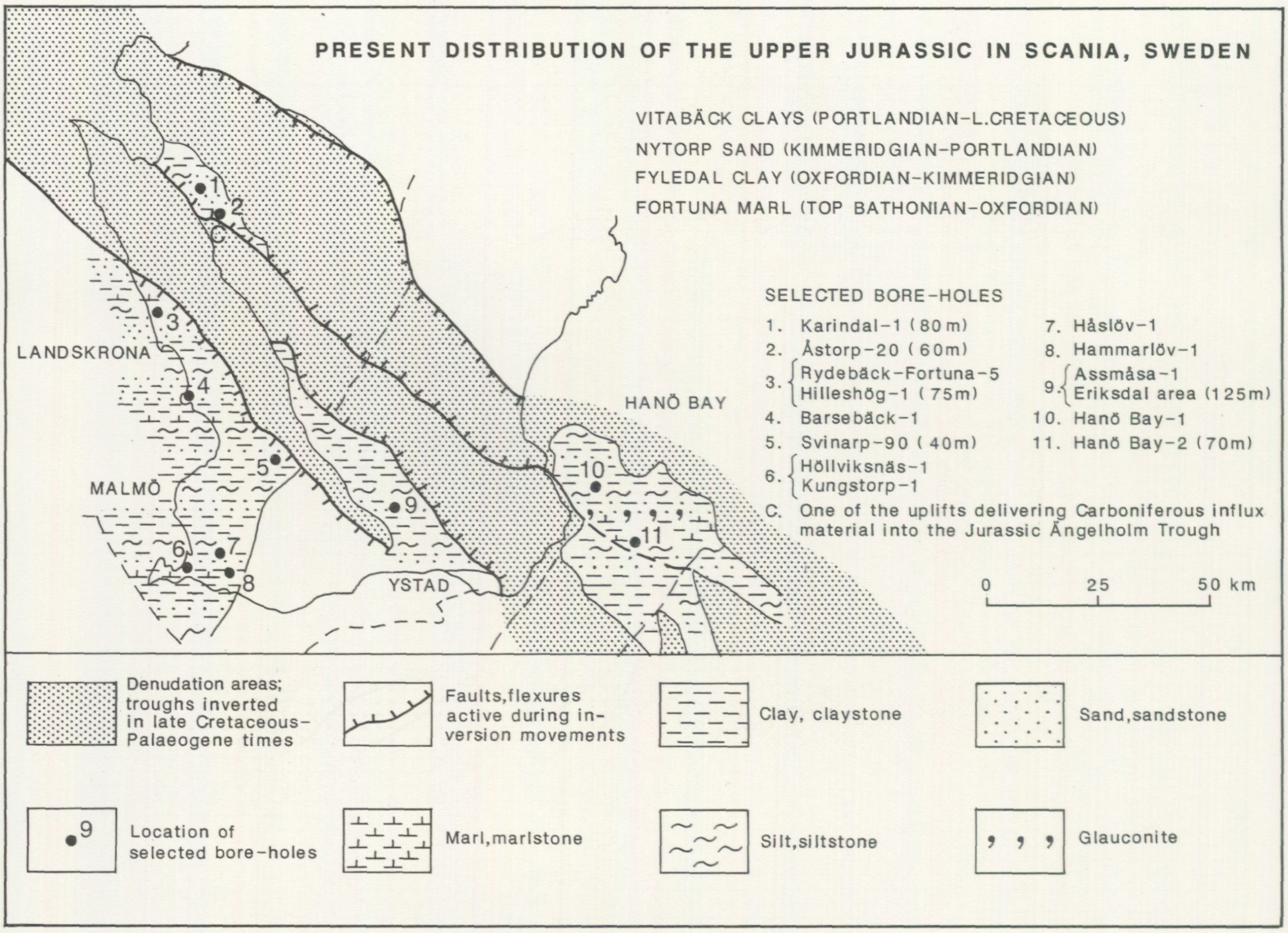


Fig. 2. Upper Jurassic geology of Scania, Sweden. Present distribution of sedimentary rocks.

ological similarities between sections now isolated from each other. Parts of this depression continued to subside during the Cretaceous. During Late Santonian/Campanian time, however, an inversion process started as a consequence of compressional deformation (Norling & Bergström 1987), a process which continued during the Cainozoic. Transgraded areas became land and previously deeply submerged deposits were subjected to erosion. Inversion is a structural process whereby a basin becomes a structural high, or a high becomes a basin, the key principle being that of recurrent vertical movements. Inverted structures may range in width from several kilometres to tens or hundreds of kilometres. Examples at relatively small scales are observed near transcurrent faults, and have been attributed to alternating compression-tension accompanying changes in sense of motion of these faults (Grant 1987). Inverted structures are also reported where transcurrent faulting is absent. In the North Sea and Eurasia, inversion is attributed to plate collision (Ziegler 1981, 1987; Sengor 1984), although the collision front may be distant.

The Upper Jurassic of NW Scania is preserved in a downfaulted area named the Ängelholm Trough, located to the northeastern margin of an inverted tectonic block traversing Scania from NW to SE (Figs. 2 and 3). Along the southwestern margin too, of the same tectonic block, Upper Jurassic beds are preserved. In the Fyle Valley of the Vomb-Trough (north of Ystad) and further towards the west, in the flexure-fault zone forming the boundary between the Fennoscandian Border Zone and the Danish Embayment, Upper Jurassic strata occur beneath the Quaternary cover (Fig. 2).

Geological and geophysical surveys in connection with coal and fire-clay prospecting by the Höganäs Company (HB), and recent mapping and hydrocarbon exploration by SGU and OPAB (Oljeprospektering AB, Stockholm) respectively, have resulted in a considerable amount of subsurface data from the Ängelholm Trough. The geological and geophysical missions carried out include gravity and airborne geomagnetic surveys, refraction and reflection seismic profiling by Compagnie General De Geophysique (CGG) on behalf of OPAB, and bore-hole geology published by Bölau

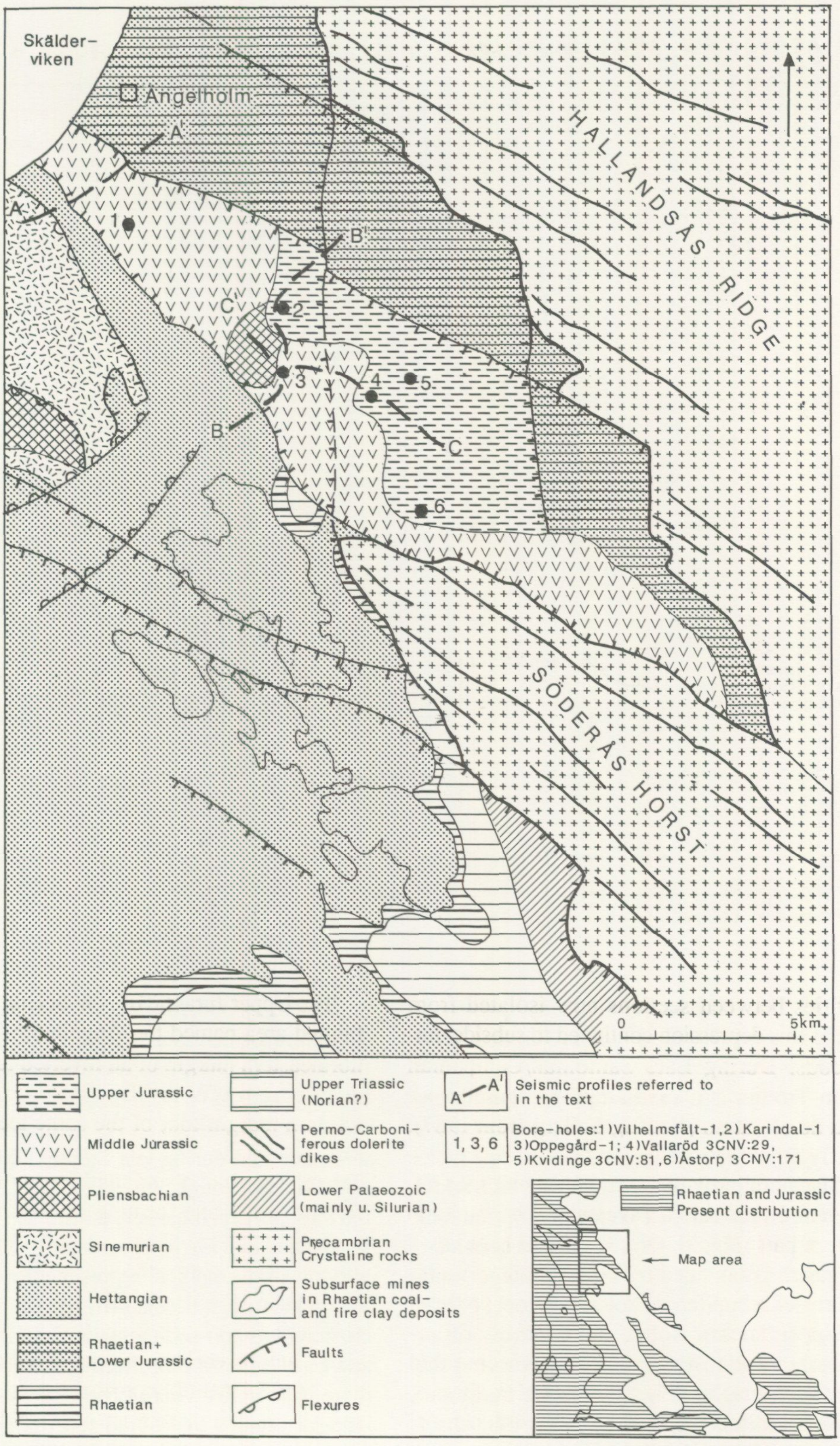


Fig. 3. Geological map of the Ängelholm area, NW Scania. The Ängelholm Trough *sensu strictu* is a narrow trough with Middle and Upper Jurassic bedrocks (beneath the Quaternary). After Wikman & Norling 1981, Wikman & Sivhed 1985, Sivhed & Wikman 1986.

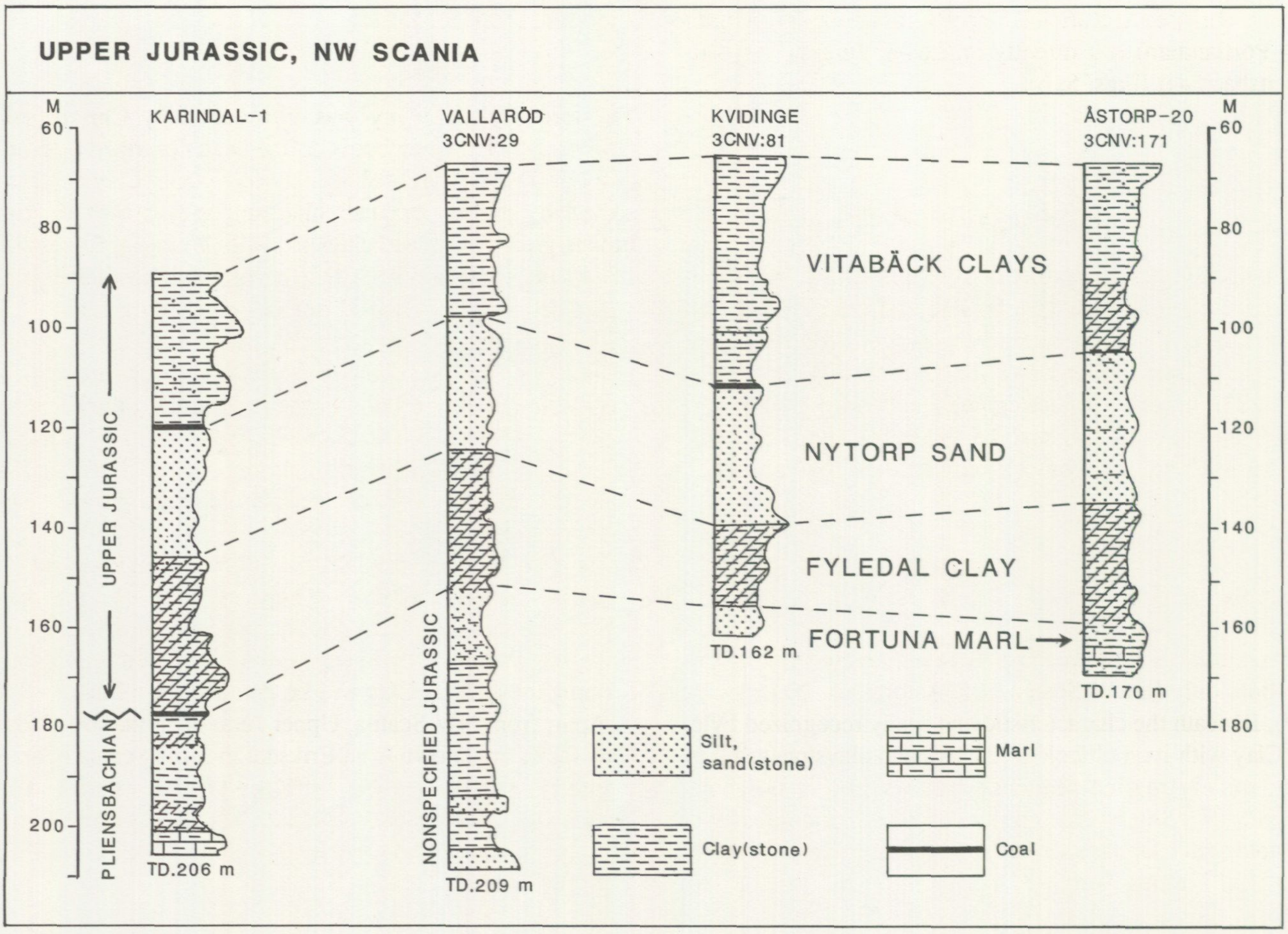


Fig. 4. Four borehole sequences in the Upper Jurassic of the Ängelholm Trough, NW Scania. Oblique line ornament in the lithological columns indicates multicoloured strata.

(1959), Guy (1971), Guy-Ohlson (1985), Guy-Ohlson & Malmquist (1985), Norling (1972, 1978, 1981), and Wikman & Sivhed (1985).

The Ängelholm Trough is a shallow graben hardly exceeding 600 m in depth. Beneath a fairly thick Quaternary overburden (mainly 50–90 m), the prevailing surface rocks in the central and western parts of the trough are of Middle Jurassic age, whereas Upper Jurassic deposits form the rock surface in its eastern part (Fig. 3). On its southwestern side, the Ängelholm Trough is bounded by Precambrian crystalline rocks with Permo-Carboniferous dolerite dikes (Söderås Horst), a minor Upper Triassic uplift, and a narrow rib of Hettangian rocks extending towards the northwest into the Skälderviken Bay of Kattegatt (Fig. 3). To the north and east the Ängelholm Trough is bounded by rather thin Rhaetian - Lower Jurassic deposits (usually < 75 m) beneath a thick Quaternay cover (up to 110 m have been recorded). In the few bore-holes which have reached the basement north and east of the trough, Rhaetian sediments rest on deeply weathered Precambrian crystalline rocks.

Generally speaking, the NW-SE trending Ängelholm Trough is located to a narrow down-faulted zone in between two major tectonic blocks, traversing the whole of Scania, blocks which have been affected by strong inversion movements (uplifts) (Fig. 2). As mentioned above, these uplifts were initiated during late Santonian/Campanian times. The Ängelholm Trough, however, was repeatedly affected by movements much earlier, during the Kimmerian tectogenesis (Rhaetian - Early Cretaceous). This is indicated by the varying stratigraphical representation in different boreholes within the trough. Local differential movements have caused erosion (and non-sedimentation) during Sinemurian, Middle and Late Jurassic times in the trough. In its centre (Fig. 3), there is an uplift where Lower Jurassic deposits form an island surrounded by Middle and Upper Jurassic rocks. As indicated by the biostratigraphical investigation of the Karindal borehole, in combination with interpretation of seismic profiles (Figs. 4, 5) parts of the Lower Jurassic and the Middle Jurassic sequences are eroded in the north-eastern central part of the trough, where the Upper Jurassic forms the rock surface. At Karindal Upper Jurassic strata (Oxfordian - Portlandian) rest directly on Lower Jurassic deposits (Pliensbachian) (Figs. 5, 6).

LITHOSTRATIGRAPHY

The Upper Jurassic deposits of NW Scania are lithostratigrahically correlative with units known from other parts of the province. The Fortuna Marl (in its type section ranging from the Upper Bathonian to the Oxfordian), the Fyledal Clay (Oxfordian - Kimmeridgian), the Nytorp Sand (Kimmeridgian - Portlandian), and the Vitabäck Clays (Portlandian - basal Cretaceous) have been identified (Norling 1972, 1981).

Fortuna Marl

Strata referrable to this member have been recorded from one borehole only in SW Scania, viz. Åstorp No. 20 (Figs. 3, 4, 7). Beneath the characteristic and easily recognized Fyledal Clay with its multicoloured clays and claystones, a 9 m thick mainly marine sequence follows in this borehole, which briefly can be described as follows. For comparison, a lithological characterisation of the type section of the Fortuna Marl is also given:

Åstorp No. 4	Fortuna Marl, type section
160.3-169.1 m (8.8 m)	*Rydebäck - Fortuna No. 5* 135.2-161.3 m (core length) 26.1 m of steeply dipping strata. Estimated actual thickness: 9.7 m). Claystone, partly silty and calcareous, dark-grey and brown with thin layers of ferruginous claystone and silty limestone. Conglomerate at 160.1 m. The sequence contains calcareous foraminifers (dominating), and arenaceous forms as well.
Clay, sandstone, calcareous siltstone (marl) and shale interbedded, grey, brown and black. Arenaceos foraminifers dominating in the upper part of the sequence, calcareous foraminifers at several levels throughout the sequence, dominating in the lower part.	

The foraminiferal fauna of the Fortuna Marl at Åstorp, and its biostratigraphical bearing is treated in page 18. Dominantly marine strata in Fortuna Marl facies are known from boreholes in western Scania (Rydebäck-Fortuna No. 5), southern Scania (Hammarlöv-1, Håslöv-1, Höllviksnäs-1 and Kungstorp-1), and from offshore wells drilled SE of Scania (Hanö Bay 104/13-1 and 104/14-2). The occurrences are documented in Fig. 2 (see also Norling 1981).

Fyledal Clay

The term Fyledal Clay was introduced by Christensen (1969, p. 8). This member is defined and described by Norling (1972, 1981). In NW Scania, the Fyledal Clay is represented by green, greenish blue and grey-brown to iron brown, greasy clays and claystone with a varying content of silt. Its thickness in NW Scania, according to available data, varies between 16 m and 31 m (Kvidinge, 16 m; Åstorp, 25 m; Vallaröd, 28 m, and Karindal, 31 m, see Fig. 4). A renewed study of the lithology of the boreholes in question has resulted in a correction of the Fyledal Clay thickness in Vallaröd 3C NV:29. The thickness 80 m given by Norling (1981, p. 255) and by Norling & Bergström (1987, p. 13) is not correct. 28 m only can be referred to the Fyledal Clay with certainty.

The Fyledal Clay has yielded a rather poor fauna of mainly arenaceous foraminifers in material from Karindal and Åstorp. Its stratigraphical significance will be discussed at some length later. An interpretation of the environments forming the Fyledal Clay will be given in page 21.

Apart from NW Scania, Upper Jurassic strata in Fyledal Clay facies are known from Eriksdal in south Scania (Christensen 1968; Norling 1972, 1981), and from western Scania (Hilleshög-1, Rydebäck-Fortuna-5), which was reported by Oertli, Brotzen & Bartenstein (1961) and Norling (1970, 1972, 1981).

Nytorp Sand

In NW Scania, the Nytorp Sand of Kimmeridgian – Portlandian age (Norling 1972, 1981) has been recorded from the same boreholes as the Fyledal Clay, that is from Karindal, Vallaröd, Kvidinge, and Åstorp (Figs. 3, 4).

The Nytorp Sand is characterised by whitish, greyish and brownish (ferruginous), partly clayey, coarse and fine-grained sandstones, uncemented sand, silt and siltstones interbedded. Its thickness is fairly constant from one borehole to the other: 26 m, 27 m, 28 m, and 25 m in Karindal-1, Vallaröd, Kvidinge, and the Åstorp boreholes respectively. The type Nytorp Sand in Rydebäck-Fortuna No. 5 has a thickness of 35.7 m, a figure which should be reduced considerably to represent the actual thickness, since the layers are steeply dipping. From Eriksdal in south Scania a thickness of c. 18 m of beds corresponding to the Nytorp Sand has been reported (Christensen 1968).

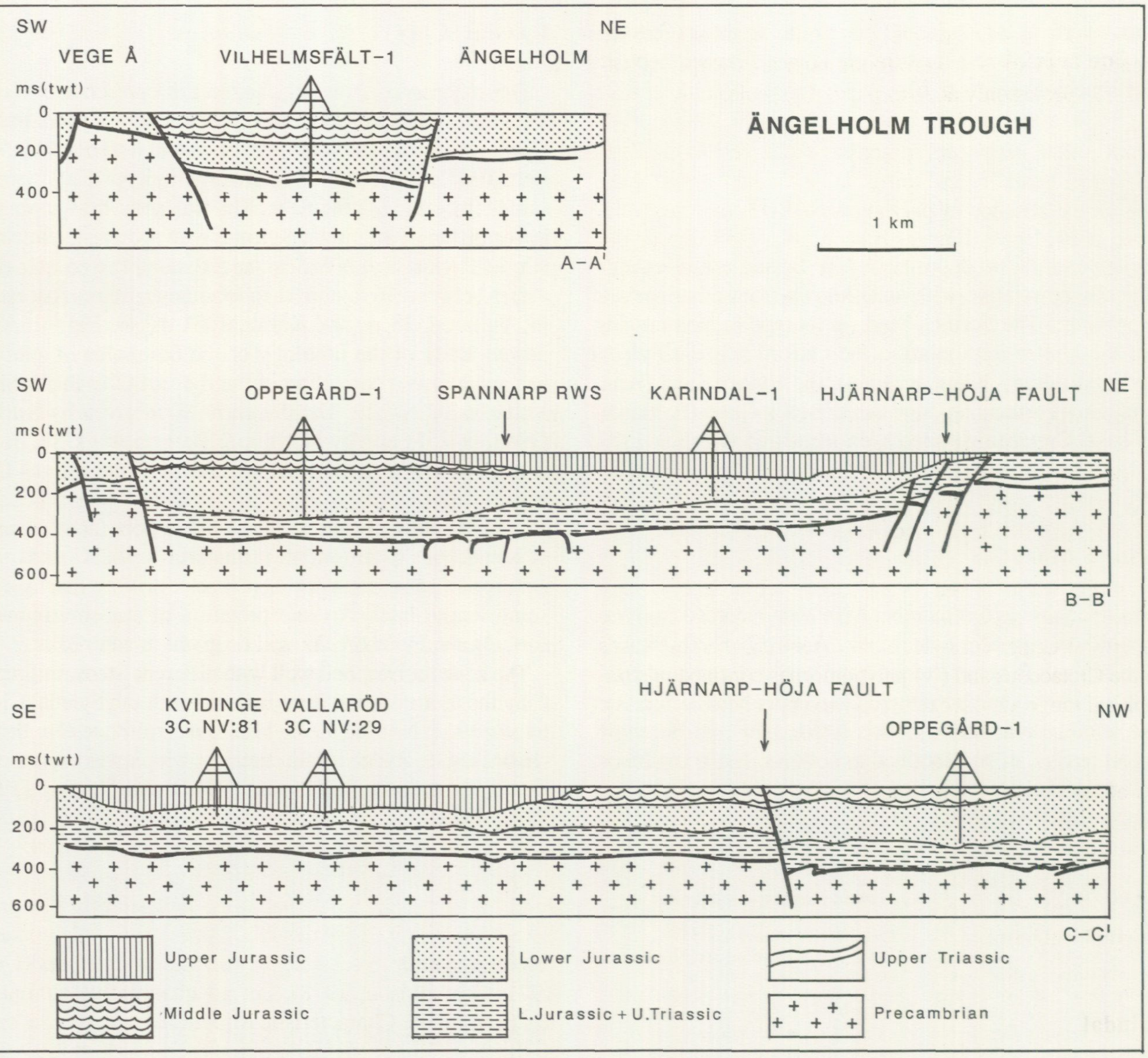


Fig. 5. Cross sections through the Ängelholm Trough based on reflection seismic profiles. For location see Fig. 3. The abbreviation ms (twt) = milliseconds two way time.

Vitabäck Clays

From the same four boreholes which have penetrated the Fyledal Clay and the Nytorp Sand, the Vitabäck Clays have also been recorded (Fig. 4).

The Vitabäck Clays in NW Scania vary in thickness between 31 m and 47 m. It should be noted , however, that these strata are truncated by Quaternary glacial deposits. Thus the figures given do not necessarily represent primary thicknesses. In its type area the Vitabäck Clays Member has a thickness of 70 m according to Christensen (1968).

PALYNOSTRATIGRAPHY

The palynomorph content

The investigated samples from both boreholes contained well preserved palynomorphs, mainly pollen grains and spores, though certain other species representing dinoflagellates, acritarchs and other organic-walled microalgae were also found. At Åstorp 49 species were recorded and at Karindal 66 species. A complete list of the species recorded is to be found in Fig. 8. Their known published stratigraphical ranges are also recorded there along with the number of individuals per species found during the light microscope slide examination for each sample. Of the 83 species listed in Appendix I, 35 species were found both at Åstorp and Karindal, 17 species only at Åstorp and 31 species only at Karindal.

Many pollen grains and spores have relatively long stratigraphical ranges often spanning e.g. several ammonite biozones. In the absence of palynomorphs with narrow, well-defined stratigraphical ranges it is necessary to examine the whole palynomorph assemblage. It is the incoming and outgoing of taxa and the changes within certain groups which enable the establishment of assemblage biozones based on the palynomorphs found present.

From the total palynomorph content it is possible to order, generally speaking, the species present into 4 different groups according to their known stratigraphical ranges: (i) palynomorphs with their known stratigraphical ranges in the Lower and Middle Jurassic sediments, but terminating at the top of the Middle Jurassic or the very base of the Upper Jurassic, (ii) palynomorphs with long stratigraphical ranges through the whole of the Jurassic, (iii) palynomorphs with stratigraphical ranges extending from the Middle Jurassic through the Upper Jurassic, even extending in some cases into the Cretaceous and (iv) palynomorphs confined in stratigraphical range almost exclusively to upper Middle Jurassic - Upper Jurassic sediments. The individual numbers found for each species reflect what would be expected for a palynoflora of late Jurassic age. Small number of individuals are found for the first group and much greater for the second group. Somewhat less, but still considerably greater than that of the first group, is found for the third group and for the last group only a few individuals with a rather narrow stratigraphical range.

Karindal

From closer examination of Fig. 8 it is also possible to observe the following points for the Karindal borehole. (a) Several palynomorphs are distributed throughout the whole sample interval examined, e.g. *Callialasporites dampieri, Araucariacites australis, Botryococcus* sp., *Cerebropollenites mesozoicus, Classopollis classoides* and *Cyathidites australis*. These palynomorphs belong to the second stratigraphical group, i.e. the long-ranging. These vary in representation throughout the sample interval. (b) Certain species are restricted to the uppermost part of the interval examined, e.g. *Callialasporites segmentus, Leptolepidites major, Leptolepidites rotundus, Stereisporites antiquasporites, Leptolepidites crassibalteus, Dictyophyllidites equiexinus* and *Coronatispora valdensis*. (c) Some species are found only in the middle part of the interval, e.g. *Lycopodiacidites rugulatus, Callialasporites trilobatus* and *Leptolepidites equatibissus*. (d) The bottom part of the interval is also characterised in the same way e.g. by *Cycadopites deterius*.

These observed groupings suggest the presence of 3 different assemblages and an interval devoid of palynomorphs. Zone A from 151.71–149.81 m, zone B from 147.95–146.60 m, an interval zone from 146.32–140.32 m and zone C from 113.92–90.12 m. The palynomorphs comprising the different assemblage groups belong to different stratigraphical groups. Examining the palynomorph constituents of each zone in the light of their known stratigraphical ranges (Fig. 8) certain points may be noted. Zone A and Zone B are very similar in number of species and number of individuals per species being characterised by *Alisporites robustus, Araucariacites australis, Cerebropollenites mesozoicus, Classopollis classoides* and *Cyathidites australis*. The presence in Zone A, however, of *Cycadopites deterius* distinguishes it from Zone B. The interval zone between Zone B and C is barren. The presence in large numbers of *Araucariacites australis* in Zone C contrasts greatly with Zone A and B. The assemblage in Zone C is otherwise characterised by the presence of *Alisporites robustus, Callialasporites dampieri, Cyathidites australis* and *Callialasporites turbatus*.

The zones correspond well with different lithostratigraphical units. Zones A and B correspond with the Fyledal Clay, the interval zone with the Nytorp Sand and Zone C with the Vitabäck Clays. The stratigraphical ranges (Fig. 8) of the palynomorphs suggest a late Middle - Late Jurassic age for the interval examined.

Though some species with older Jurassic stratigraphical ranges are present the proportion of species with younger stratigraphical ranges favours a late Jurassic age. The presence of a variety of species of *Callialasporites* is reminiscent of Scanian lower Middle Jurassic microfloras (Guy, 1971; Guy-Ohlson, 1978), but no quantitative similarity has been found. Characteristic Middle Jurassic species such as those of *Neoraistrickia* have not been found in the investigated interval. Neither those characteristic Jurassic (Portlandian)/Lower Cretaceous palynomorphs such as *Pilosisporites, Trilobosporites* and *Cicatricosisporites* have been recorded, though the presence of *Coronatispora valdensis* suggests an approach to the Lower Cretaceous.

It may well be that the two assemblages A and B found in the Fyledal Clay represent Oxfordian, respectively Kimmeridgian ages, the interval zone a Kimmeridgian - Portlandian age and Zone C a Portlandian age, but this cannot be directly inferred from the stratigraphical ranges known for palynomorphs found in the present investigation.

Åstorp

At Åstorp similar observations within the studied sample interval were made with reference to assemblage composi-

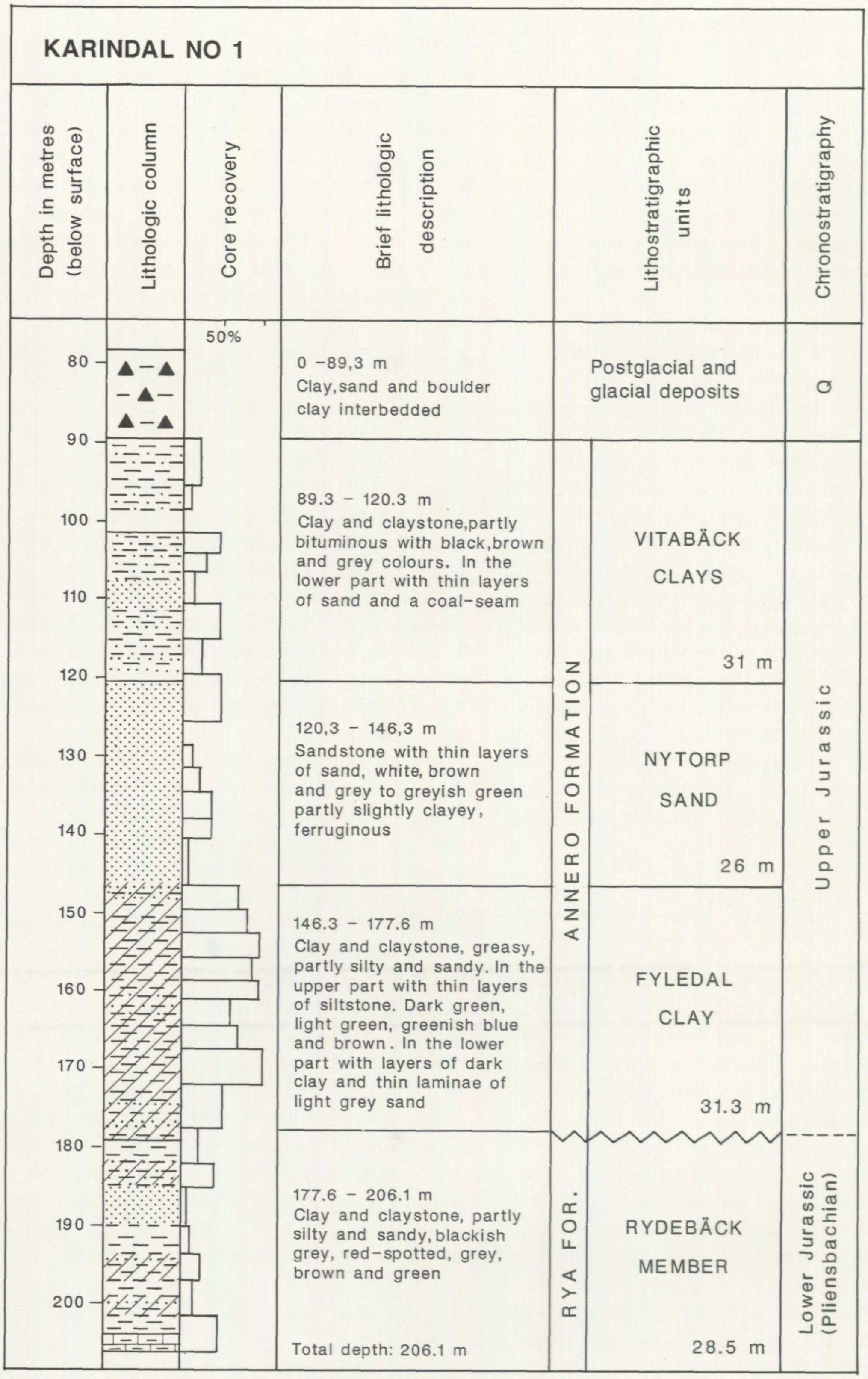


Fig. 6. Karindal No. 1. Well log showing lithology, litho- and stratigraphy.

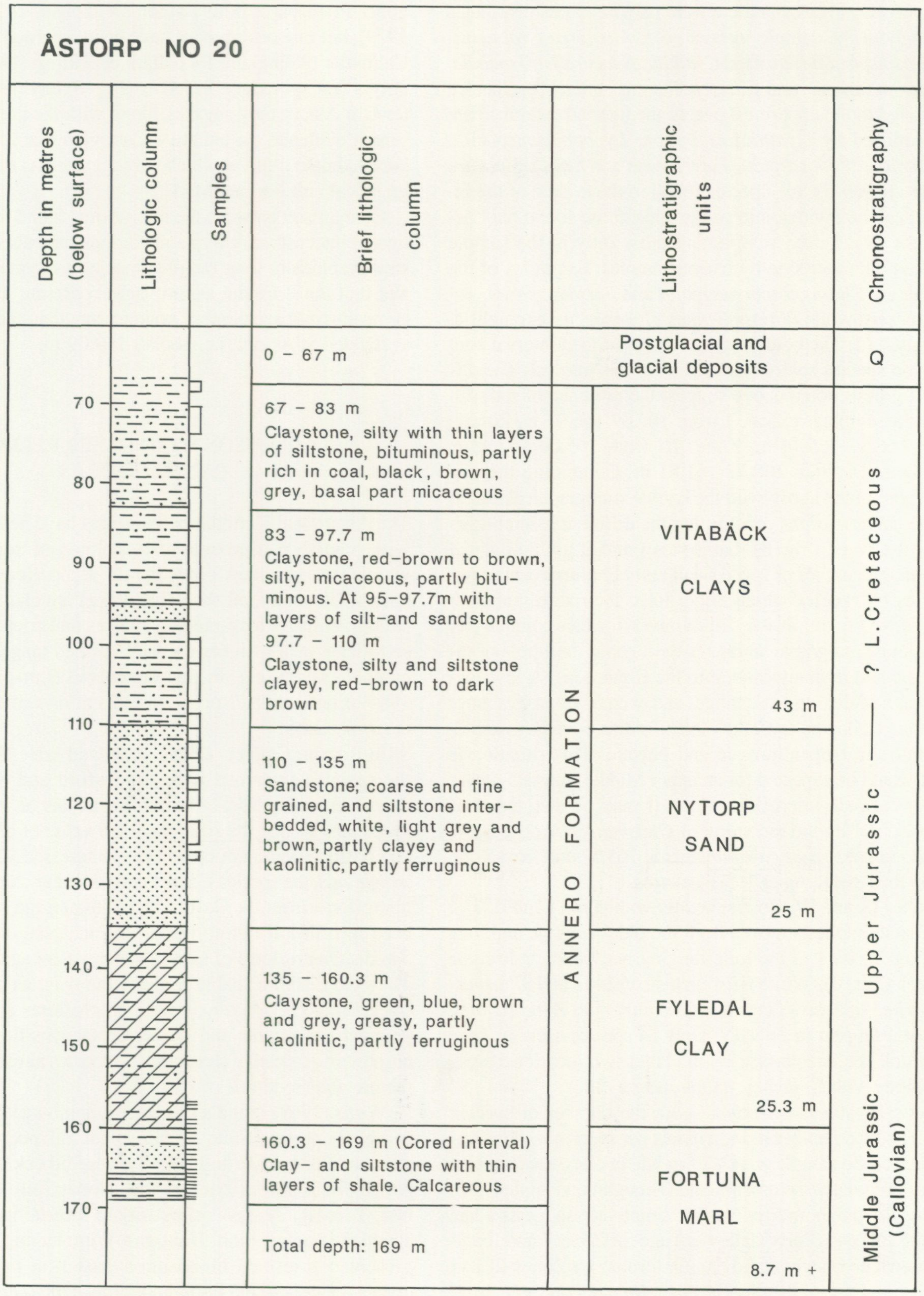


Fig. 7. Åstorp No. 20. Well log showing lithology, litho- and chronostratigraphy.

tion. (a) As in Karindal there were palynomorphs distributed throughout the sample interval, e.g. *Alisporites robustus, Cibotiumspora jurienensis, Cyathidites australis, Osmundacidites wellmanii* and *Classopollis classoides*. (b) Species restricted to the uppermost part of the interval examined are exemplified by *Cyathidites minor, Lycopodiumsporites clavatoides, Podocarpidites verrucosus* and *Rugulatisporites* cf. *neuquenensis*. (c) Species found in the middle of the interval can be divided into two groups: those found only below the first barren sample and those only in the sample flanked on either side by barren samples. Examples of the former are *Chasmotosporites major* and *Baculatisporites comaumensis*, while *Pinuspollenites globosaccus* exemplifies the latter. (d) The bottom part of the examined interval contains no species solely recorded from this interval. The different groups noted above suggest the presence of four different assemblages: Zone I from 169.09-166.77 m, Zone II from 166.57-165.14 m, Zone III from 165.00-162.98 m and Zone IV from 160.58-161.81 m. Combining the evidence presented above with the known stratigraphical ranges of the palynomorphs constituting the different assemblages it can be noted (Fig. 8) that Zones I and II are dominated both in the number of species and number of individuals per species by species which either have their stratigraphical ranges which end at the Callovian/Oxfordian boundary or have long stratigraphical ranges throughout the whole of the Jurassic and in many cases into the Cretaceous. A few species have Middle Jurassic ranges and even fewer have a range from the Callovian or Callovian/Oxfordian boundary extending into the Upper Jurassic and beyond. This situation is what would be expected for an upper Middle Jurassic - lower Upper Jurassic microflora. Zone II may be distinguished from Zone I by the incoming of *Chasmatosporites major* and *Baculatisporites comaumensis* at 165.57 and from Zone III by their outgoing at 165.14 metres.

Zones III and IV contrast greatly with zones I and II. The dominant emphasis moves from the older Jurassic and long ranging Jurassic to the long ranging and younger Jurassic species (Fig. 8). While *Alisporites robustus* and *Chasmatosporites apertus* occur in high numbers in Zone III they almost disappear in Zone IV. Only 24 species occur in Zone III which is characterised by the latter two mentioned species along with *Ginkgocycadophytus nitidus*.

Zone IV shows poverty in both the number of species found and the number of individuals per species with the exception of the sample at 161.19 m where *Classopollis classoides* dominates the assemblage. Though the complete picture of the palynomorph content tentatively suggests a late Middle Jurassic (Early Callovian) age for Zones I and II and a somewhat younger Callovian-Oxfordian for Zones III and IV, the presence of the dinoflagellate *Nannoceratopsis gracilis* in Zones I, III and IV should be mentioned. The main stratigraphical range for this species has been established as upper Pliensbachian to Bathonian (Thusu, 1978; Sarjeant, 1979), but rare occurrences have been recorded in the lower Callovian of England (Woollam & Riding, 1983). Even if only a few sporadic specimens (Fig. 8) have been encountered at Åstorp they suggest, along with the previously presented evidence, a tentative Callovian age for the whole cored sample interval which is recognised as the lithostratigraphical unit Fortuna Marl.

Comparison between the microfloras found for the investigated intervals at Åstorp and Karindal reveals that only the stratigraphically long ranging species are common to both and that the Karindal assemblages represent a microflora, comparatively speaking of younger age than the interval investigated at Åstorp, i.e. 160.58-169.09 m.

COMPARISON WITH OTHER RELEVANT PALYNOFLORAS

The Åstorp and Karindal palynofloras have been compared with other NW European palynofloras of similar age in which the dominant constituents are pollen grains and spores. Generally, all the palynofloras are characterised by stratigraphically long-ranging species and contain very few significant taxa with narrow well-defined ranges. In certain cases, however, e.g. in east Greenland (Lund & Pedersen 1984) dinoflagellates occur and this allows much finer age determinations.

In Britain, Couper (1958, p. 94 and table 9) noted that the samples examined from the Oxford and Kimmeridge clays were not particularly rich in species or in number of specimens so that the stratigraphical value of differences in composition could not be accurately assessed. *Foveotriletes irregulatus*, the species Couper considered to characterise the microfloras from the Oxford and Kimmeridge clays has not been recorded at Åstorp nor at Karindal, but otherwise the Swedish microfloras of supposed equivalent age are similar. They are distinguishable in the same way, as already outlined, from the Middle Jurassic microfloras and from the younger Purbeckian and Lower Cretaceous floras by their absence of respective characteristic species already named in the previous section.

Norris (1969) found a restricted assemblage composition in what he termed Suite A (equivalent to Upper Kimmeridgian, the Portlandian and basal Lower Purbeck Beds). Comparison of Karindal Zone C with Norris suite A (1969, p. 604, Text-fig. 3) shows similarity to a certain extent in assemblage composition. Hunt and Wimbledon (1984) have presented a refined biozonation based on palynological events for the marine Portlandian rocks of southern Britain. Their assemblages from marine rocks reflect low diversity dominated by gymnosperm pollen of genera found also at

Karindal, e.g. *Classopollis, Spheripollenites, Araucariacites, Callialasporites* and *Alisporites*. The assemblages from non-marine rocks are more diverse (up to 90 species) and though dominated also by gymnosperm pollen contain some samples dominated by trilete spores similar to those found in zone C of Karindal with the exception that the 'typical younger elements' such as *Trilobosporites* and *Cicatricosisporites* have not been recorded at Karindal.

The dominant gymnosperm pollen grain species, e.g. *Araucariacites australis, Cerebropollenites mesozoicus, Perinopollenites elatoides, Spherinopollenites* spp., *Callialasporites* and *Classopollis* recorded by Batten (in Thusu, 1978) for the NW European continental shelf area are present at Karindal. Likewise the majority of genera and species, e.g. *Gleicheniidites, Lycopodiumsporites, Sestrosporites pseudoalveolatus* and *Staplinisporites caminus* named as occurring in the restricted pteridophyte spore assemblages have been recorded at Karindal. The long-ranging gymnosperms and the difficulties in finding significant taxa to characterise specifically the Callovian and Oxfordian are also mentioned.

The work of Lund and Pedersen (1984) in East Greenland further exemplifies the difficulties in obtaining significant correlation based on spores and pollen grains. The genera listed in Lund & Pedersen (1984, p. 392, Fig. 5) for assemblages C3 to D (58), equivalent to Early Callovian - Early Kimmeridgian respectively, are also recorded at Åstorp, respectively Karindal. Similar assemblages have also been recorded for N. Norway (Vigran & Thusu, 1975). The usefulness and significance of dinoflagellates is well illustrated in this Greenland study where they permit not only a well-defined narrow age determination but also facilitate refined correlation with e.g. Svalbard (Bjaerke 1977 and 1980).

In his studies of spore-pollen assemblages from France (Normandy) and Germany, Srivastava (1987) names *Callialasporites, Cerebropollenites* and *Exesipollenites* as the dominating genera for the otherwise poor spore/pollen contents of the Callovian samples. *Araucariacites, Callialasporites, Cerebropollenites* and *Classopollis* genera dominated the Oxfordian samples studied and species such as *Leptolepidites major* and *Staplinosporites caminus*, familiar from Karindal are also named. The Kimmeridgian samples were dominated by taxa of earlier stages with *Densoisporites perinatus* (not recorded at all in the Swedish samples) named as an additional species of interest.

Comparison with microfloras from other geographical regions such as Canada (Pocock, 1970), Argentina (Volkheimer and Quattrocchio, 1981), Australia (Filatoff, 1975) and Libya (Thusu & Vigran, 1985) shows similar assemblage composition, even if the similarity is more at the generic rather than the species level.

Summing up the comparison with the most relevant assemblages it may be said that there are general similarities of assemblage composition, but detailed correlation without the presence of dinoflagellates or other significant taxa appears difficult if not impossible.

REWORKED PALYNOMORPHS

Reworked Carboniferous spores have been recorded both at Karindal and at Åstorp. From Fig. 8 it can be seen that they are more numerous at Åstorp. Those recorded at Åstorp were extremely well preserved for reworked spores and show little sign of damage or long distance transport (Pl. 4: 10-12).

The occurrence of reworked Carboniferous spores in Swedish Mesozoic sediments have been reported and studied by Guy-Ohlson *et al.* (1987). One of the possible source areas suggested for supposed Carboniferous deposits in close association with Precambrian bedrock was the northernmost tip of 'Söderåsen' (Guy-Ohlson *et al.* 1987, p. 297, Fig. 2). The proximity of the Åstorp bore-hole to Söderåsen, the increase in the number of reworked Carboniferous spores found compared to previous records and the relatively better preservation appear to endorse the first tentative proposal of Söderåsen being, in Jurassic times, an uplifted block directly or indirectly overlain by Carboniferous deposits and thus a possible source area.

FORAMINIFERAL STRATIGRAPHY

The foraminiferal content

Only 6 of 32 selected samples from Karindal No. 1 core drilling, and 11 of 20 samples from Åstorp No. 20 contained definable foraminifers. A complete list of foraminiferal species (and non-specified forms referred to different genera) is to be found in Fig. 9, where also their known stratigraphical ranges in Europe are given (see also Index of Foraminifera, p. 27). The occurrences of different foraminifers in pre-Quaternary strata at Karindal and Åstorp are marked with dots in Fig. 9 (the number of individuals of each species is generally so small in the material studied that information of frequences or relative frequences is regarded to be of little value).

NUMBER OF PALYNOMORPHS IN SAMPLES EXAMINED (LIGHT MICROSCOPE ANALYSIS)

ÅSTORP

LIST OF PALYNOMORPHS PRESENT	STRATIGRAPHICAL RANGE (JURASSIC L / M / U – CRETACEOUS)	169.09	167.68 - 167.70	167.05 - 167.07	166.77 - 166.78	166.56 - 166.57	166.45 - 166.46	165.95 - 165.96	165.83 - 165.85	165.66 - 165.67	165.42 - 165.43	165.14 - 165.16	164.98 - 165.00	164.89 - 164.92	164.52 - 164.55	163.22 - 163.24	162.98	161.76 - 161.81	161.31	161.19	160.93	160.58
Chasmatosporites major	Hettangian – Bajocian					1		1	2	6	17	3										
Lycopodiacidites rugulatus	Hettangian – Bathonian	2	3	3	3	2	2	2				5								2	1	1
Lycopodiumsporites semi-muris	Hettangian – Bathonian																					
Conbaculatisporites mesozoicus	Hettangian – Bathonian	1			1	1		1	1			1		2						1		
Alisporites robustus	Hettangian – Callovian	40	18	44	65	35	52	61	75	59	70	53		72					1	10	1	
Chasmatosporites apertus	Hettangian – Callovian	18	13	14	21	16	35	27	16	11	12	20		35				1		9		
Calamospora mesozoica	Hettangian – Callovian	3	8	12	10	9	28	28	15		8	6		5					1	8		3
Contignisporites dunrobinensis	Hettangian – Callovian																					
Todisporites major	Hettangian – Callovian																					
Pityosporites scaurus	Hettangian – Callovian																					
Protopinus scanicus	Hettangian – Callovian	1	1	2	10	3	6	3	3		4	4								1		
Brachysaccus microsaccus	Hettangian – Portlandian	6	5	6	3	10	10	6	4	15	9	7		9				1	2			
Callialasporites dampieri	Hettangian – Portlandian																					
Cibotiumspora jurienensis	Hettangian – Portlandian		1	3		1	1	5	4	7	5	3		6				4	5	17		7
Callialasporites minus	- - - Aalenian – Portlandian																					
Callialasporites trilobatus	- - - Toarcian – Portlandian																					
Callialasporites segmentus	- - - Toarcian – Portlandian																					
Araucariacites australis	Hettangian – Cretaceous	2		1								2								1		
Baculatisporites comaumensis	Hettangian – Cretaceous					1	1	5	2	8	3	11										
Cerebropollenites mesozoicus	Hettangian – Cretaceous	8	1		18	9	12	6	12		6	9		6					6	32		7
Classopollis classoides	Hettangian – Cretaceous	39	21	20	52	24	33	36	35	20	26	27		12				3	7	130	7	41
Contignisporites problematicus	Hettangian – Cretaceous	1		1			2	2		1				1						2		1
Cyathidites australis	Hettangian – Cretaceous	14	8	20	41	26	22	21	32	18	6	19		19				9	3	37	2	12
Cyathidites minor	Hettangian – Cretaceous																			1	4	4
Cycadopites minimus	Hettangian – Cretaceous																					
Densoisporites velatus	Hettangian – Cretaceous				3					2												
Eucommiidites troedsonii	Hettangian – Cretaceous																					
Ginkgocycadophytus nitidus	Hettangian – Cretaceous	18		21	24	3	31	18	14	16	18	9		38				6	5	22		4
Gleicheniidites senonicus	Hettangian – Cretaceous																				1	
Ischyosporites variegatus	Hettangian – Cretaceous	3	2			1	2		1									1		4	1	3
Lycopodiumsporites clavatoides	Hettangian – Cretaceous																					1
Osmundacidites wellmanii	Hettangian – Cretaceous	1	7	7	18	22	13	8	18	13	8	4		15			1	1	2	6		1
Marattisporites scabratus	Hettangian – Cretaceous							4				3		2				1		2		
Perinopollenites elatoides	Hettangian – Cretaceous	1								1	1			5				1	1			2
Podocarpidites ellipticus	Hettangian – Cretaceous											3								11	1	6
Uvaesporites argenteaeformis	Hettangian – Cretaceous																					
Vitreisporites pallidus	Hettangian – Cretaceous	1		2					3	4	4			6						2		
Spheripollenites scabratus	• Sinemurian; Pliensbachian – Cretaceous																					
Callialasporites turbatus	Toarcian – Portlandian							1	2		6	1		2						2		

KARINDAL

LIST OF PALYNOMORPHS PRESENT	151.10 - 151.71	149.81 - 149.89	147.91 - 147.95	146.60 - 146.66	140.32 - 146.32	113.92	112.09	110.52	103.81	98.27	95.22	91.26	90.12
Chasmatosporites major													
Lycopodiacidites rugulatus			3										
Lycopodiumsporites semi-muris										1			
Conbaculatisporites mesozoicus													
Alisporites robustus	9	21	20	2		8	17	12	5	14	12	1	22
Chasmatosporites apertus													1
Calamospora mesozoica													
Contignisporites dunrobinensis			1			1	1						1
Todisporites major						1	1		2	3			
Pityosporites scaurus	1	1	2										
Protopinus scanicus		1	2										
Brachysaccus microsaccus	1		4			1	6			1			
Callialasporites dampieri	1		4	1		19	9	11	26	27	14	5	4
Cibotiumspora jurienensis		2	3			7			1	1	2		4
Callialasporites minus		1				1	3	2	7	2			
Callialasporites trilobatus			1										
Callialasporites segmentus								1	1	1	1		
Araucariacites australis	17	6	27	3		25	215	143	169	171	70	3	72
Baculatisporites comaumensis		1	1	1		1		3		4			
Cerebropollenites mesozoicus	26	13	22	5		4	11	11	6		3		2
Classopollis classoides	23	8	56	9			12	11	5	14	13	6	74
Contignisporites problematicus		1	1				1		1				1
Cyathidites australis	17	9	17	4		37		6	21	36	19	8	39
Cyathidites minor	5	1	1	4		14		2		3			3
Cycadopites minimus	1		1			4	4	5	8	2	7		
Densoisporites velatus	7	3						1		1			
Eucommiidites troedsonii	1	1	1	1			7	4	3		1		
Ginkgocycadophytus nitidus	2		2	2		3	5	7		1	1	6	14
Gleicheniidites senonicus	1	1								1			1
Ischyosporites variegatus			2			2	1	1	3	2			
Lycopodiumsporites clavatoides			2					1		1			5
Osmundacidites wellmanii			2			2				1			
Marattisporites scabratus	2	1	5			3	1	1	1		1		2
Perinopollenites elatoides													
Podocarpidites ellipticus													
Uvaesporites argenteaeformis		1						1		1			
Vitreisporites pallidus													1
Spheripollenites scabratus						6	6	1					
Callialasporites turbatus	1	1	3			10	2	12	5	2			

Fig. 8. Table recording the palynomorphs found in the borehole intervals studied palynologically at Karindal and Åstorp. The species are arranged according to their known (published) stratigraphical range and the number of individuals per species found during the light microscope slide examination is recorded for each sample.

Sestrosporites pseudoalveolatus																							1	1						2	1	1		
Leptolepidites major																														1	1			1
Podocarpidites verrucosus																			9															
Rugulatisporites neuquenensis																		1	15															
Matonisporites crassiangulatus																						3	5		1					2				
Parvisaccites enigmatus	2	4	9	2	1	5	3	1		3	3								6		2	3	3	5	1		7	7	2	2	6	5	2	3
Cyathidites concavus																								2				19						1
Leptolepidites equatibossus																								1										
Leptolepidites paverus	1	2		1	2						2												1	1						1				
Leptolepidites rotundus			2			2		1											1											1				1
Lycopodiumsporites vilhelmii																							1	1				2	1	1	1			1
Monolites couperi											1												1	1								1		
Densoisporites crassus													1																					
Densoisporites scanicus						1	1	1																										
Pityosporites nigraeformis	4		5	11	3	8	12	15	11	9	8												1											4
Pinuspollenites globosaccus													7																					
Lycopodiumsporites reticulumsporites	5	4	8	5	4	4	8	12	9	4	5							1	6		2													
Concavissimisporites variverrucatus																					1	2						3	1	6				
Stereisporites antiquasporites	1	3	5	4	1	2	6	2		2	2		4				2	1	1		2													1
Cycadopites deterius																						1	1											
Leptolepidites crassibalteus																																		1
Dictyophyllidites equiexinus		1	4	2	2		1	1											9		1													1
Coronatispora valdensis																																		2
Camarazonosporites sp.																																		1
Ceratosporites sp.																											1							
Leptolepidites sp.																		1	1		1													
Lycopodiumsporites sp.																						1								1				
Ovalipollis ?																								1										
Pinuspollenites sp.											1		12																					
Podocarpidites sp.																								3										
Schizosporis sp.																								1										
Spheripollenites sp.					3	1		1											2		8	1	1	1	2						1	1		
Stereisporites sp.																															1			
Todisporites sp.																														1				
Tri-saccite pollen grain																														1				
Sp. indet.	4	3	4	4	1					1	8		5				2	4	2		1	4	2	5				1			3	2		4
Densosporites spp. (reworked)	10	15	9	8	14	9	7	1	5		1		1				2		6												1			
Lycospora (reworked)		1	1										1																					
Murospora (reworked)	1		1	1				1			1												15											
Tripartites (reworked)			1																															
Botryococcus sp.		1	1	1	1		1	1		1	4		11					1	6			4	1		1			4	1	1	1		1	1
Canningia sp.																																		1
Micrhystridium spp.						1			1	2																								
Nannoceratopsis gracilis			2	2									1						1															
Tasmanites sp.		5	1	1	3		1	1			3							1	1		1						1					1		
Total	159	127	178	305	199	283	275	278	209	206	229		212			1	34	43	363	18	111	132	107	207	37		158	338	248	280	312	155	32	273

N.B: 1. The stratigraphical ranges given above are mainly taken from Filatoff 1975, Guy-Ohlson 1986, Srivastava 1987, Thusu 1978 and Woollam & Riding 1983.
2. Rare occurrences, range outside Europe and/or uncertain ranges are marked by a dashed line (------).

Fig. 8 cont.

Karindal

Most of the foraminiferal species at Karindal are obtained from the basal part of the sequence penetrated. The major part of the pre-Quaternary sequence (90-170 m, see Fig. 6) has not yielded any definable foraminifers at all. In some samples internal moulds are the only remnants of calcareous foraminiferal tests once present in the sediment. Such observations indicate that certain intervals of the Upper Jurassic sequence at Karindal represent marine decalcified sediments. As will be demonstrated in the following, however. the major part of the Upper Jurassic deposits in NW Scania is interpreted to have been formed in non-marine environments.

The foraminifers obtained from Karindal-1 can be subdivided into three stratigraphical range groups: 1) forms mainly restricted to the Lower Jurassic, 2) long-ranging forms, and 3) forms ranging from the Middle Jurassic to the Upper Jurassic.

Group 1 includes foraminifers recorded in samples from 177.6-190.6 m interval of the drilling. The assemblage represents a characteristic Middle Liassic fauna including several forms restricted to the Pliensbachian in Europe, e.g. *Brizalina liasica amalthea, Lenticulina turbiniformis, Marginuina spinata interrupta, Saracenaria sublaevis,* and *Geinitzinita tenera carinata* (see Fig. 9 and p. 27).

Group 2 (the long-ranging forms) includes mainly calcareous (nodosariid) foraminifers, but also arenaceous forms: *Pseudonodosaria vulgata, Astacolus varians, Lenticulina muensteri* (calcareous forms), and *Ammodiscus tenuissimus* (arenaceous form). These foraminifers vary in representation within the drilling sequence of Karindal-1 which has yielded definable foraminifers (170-190 m).

Group 3 represents a fauna obtained from the uppermost sample (at 172 m), of those which have yielded any foraminifers. Along with long-ranging forms the foraminiferal assemblage from 172 m includes *Dentalina guembeli, Marginulina nytorpensis*, and *Lenticulina quenstedti. Dentalina guembeli* has a stratigraphical range from the Callovian to the Oxfordian in Europe. *Marginulina nytorpensis* has previously been described from western Scania, where it was recorded from strata given Callovian and Oxfordian ages (Norling 1972, 1981). *Lenticulina quenstedti* has a range from the Bajocian to the Kimmeridgian.

The foraminiferal analyses of Karindal-1 suggest that strata of late Middle Jurassic or early Late Jurassic age rest on an uplift of Early Jurassic, seemingly Pliensbachian age. This is supported by the lithostratigraphical interpretation of the deepest 30 m core interval of Karindal-1, suggesting: a) the 177.7-206.1 m interval of drilling has penetrated the Rydebäck Member (Middle to Upper Lias); b) characteristic Middle Jurassic strata are missing, viz. the Vilhelmsfält Formation; c) from 146.3 m to 177.6 m the lithology is characteristic of the Fyledal Clay, given an Oxfordian-Kimmeridgian age in other parts of Scania (Christensen 1968; Norling 1972, 1981).

Åstorp

The foraminiferal fauna obtained from the Åstorp samples (Figs. 7, 9) is rather poor, most records being concentrated to certain levels separated from each other by barren intervals. In terms of local lithostratigraphical units, the basal member of the sequence penetrated, the Fortuna Marl, has yielded the major part of the foraminiferal fauna, including both calcareous and arenaceous forms. The succeeding Fyledal Clay Member has yielded arenaceous foraminifers only, whereas the Nytorp Sand (Fig. 7) has not yielded any foraminifers at all. From the uppermost member of the sequence, the Vitabäck Clays, individuals of one arenaceous genus, and three genera of calcareous foraminifers have been recorded. The latter include forms indicating that the Vitabäck Clays may span the Jurassic-Cretaceous boundary. The foraminiferal taxa recorded from Åstorp No. 20 are listed in Fig. 9.

The Åstorp foraminifers can be given the following subdivision: 1) short-ranging forms restricted to the Middle Jurassic - Upper Jurassic transition; 2) long-ranging, and 3) post-Jurassic forms.

Group 1 mainly includes forms recorded from the 160.3-169.1 m interval of drilling. This assemblage contains calcareous foraminifers such as *Dentalina guembeli, Frondicularia franconia, Lingulina lingulaeformis*, and arenaceous foraminifers such as *Valvulina* cf. *fusca, Haplophragmoides canui, Gaudryina heersumensis*, and *Reophax suprajurassica. Dentalina guembeli*, also recorded from Karindal-1 (p. 18) and from other Scanian localities as well (Norling 1972, 1981), is restricted to the Callovian and Oxfordian Stages in Europe. In Åstorp No. 20 this form has been found in samples from 162 m and 165.8-168.4 m. *Frondicularia franconica*, recorded from 165.8-168.4 m interval of drilling, ranges from the Upper Bathonian to the Lower Oxfordian in Europe.

Lingulina lingulaeformis has been recorded from the same samples as *Frondicularia franconica*, but also from other levels (160.3 m and 169.1 m). Its stratigraphical range in Europe is Bathonian-Oxfordian. In samples of the Fortuna Marl from other localities in Scania, *Lingulina lingulaeformis* and *Frondicularia franconica* frequently occur together. They may represent forms of one and the same species, *Lingulina lingulaeformis* being the juvenile (and perhaps adolescent) form, and *Frondicularia franconica* the adult form. Their alleged relation has previously been discussed by Norling (1972, pp. 64, 95-96).

The specimens referred to as *Valvulina* cf. *fusca*, obtained from 164.5-165.8 m core interval in Åstorp No. 20, show a close affinity to forms described and illustrated by Lutze

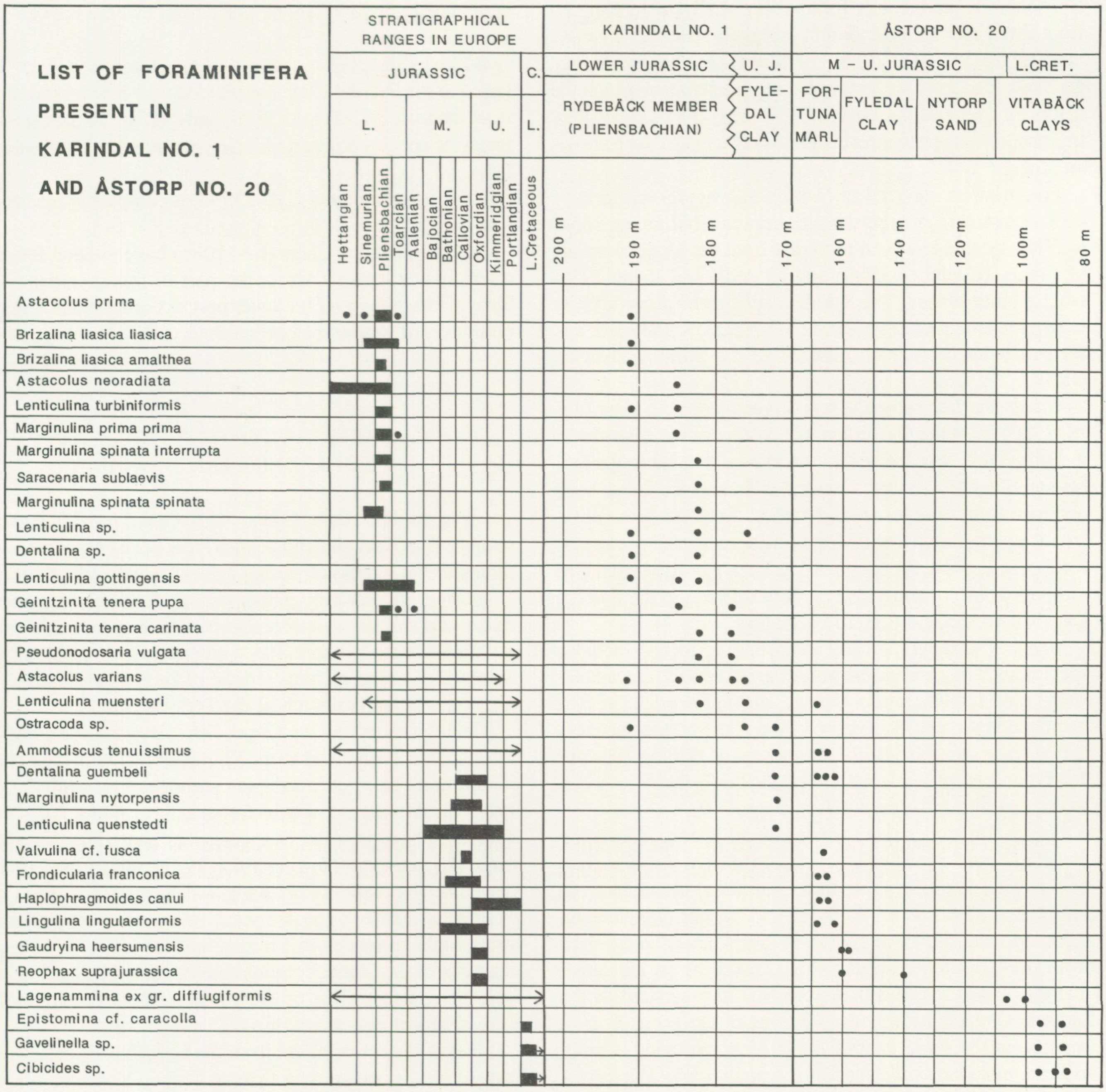


Fig. 9. List of foraminifers obtained from the Karindal and Åstorp pre-Quaternary sequence and their stratigraphical ranges..

(1960) under this specific name. This form is a low and flat trochospiral, arenaceous foraminifer easily differentiated from the Upper Jurassic (Kimmeridgian) species *Valvulina meentzeni* KLINGER 1955. *Valvulina fusca* has previously been recorded from western and south-western Scania and the Hanö Bay, east of the province (Norling 1981). Elsewhere in Europe, this species seems to be restricted to the Callovian Stage.

Foraminifers referred to *Haplophragmoides canui* have been obtained from core samples between 162 m and 165.8 m. This species has been recorded from the Upper Jurassic of France (Cushman 1930) and N. Alaska (Tappan 1955) among other places. The Swedish specimens show affinity to *Haplophragmoides volgensis* MYATLIUK 1939 too, described from the Upper Jurassic of the Saratov District, USSR.

Gaudryina heersumensis was originally described by Lutze (1960) from the Oxfordian of NW Germany. Elsewhere in Europe too, this species seems to be restricted to the Oxfordian Stage. At Åstorp, *Gaudryina heersumensis* has been obtained from samples around 160 m. *Reophax suprajurassica* is another arenaceous foraminifer restricted to the Oxfordian in Europe. At Åstorp it has been recorded from two samples at 140 m and 160.3 m, both referred to the Fyledal Clay Member of the Annero Formation.

Group 2 (stratigraphically long-ranging forms) includes species such as *Lenticulina muensteri*, *Ammodiscus tenuissimus*, and *Lagenammina* ex gr. *difflugiformis*. The first mentioned two species, recorded from Karindal too, were obtained from the 160.3-169.1 m interval of drilling (Fortuna Marl), and *Lagenammina* ex gr. *difflugiformis* from the lower part of the Vitabäck Clays (Figs. 7, 9).

Group 3 includes three foraminiferal genera: *Cibicides*, *Gavelinella* and *Epistomina*, all recorded from the upper part of the Vitabäck Clays. Neither *Cibicides*, obtained from samples at 85 m, 88 m, 90 m, and 95 m, nor *Gavelinella*, recorded from the 85 m and 95 m levels has been reported from pre-Cretaceous strata. This is taken as an indication that the Vitabäck Clays in Åstorp No. 20 may straddle the Jurassic-Cretaceous boundary. Forms of the genus *Epistomina* from the same interval of drilling, showing affinity to *Epistomina caracolla* support this stratigraphical interpretation. *E. caracolla*, including the two subspecies *E. caracolla caracolla* and *E. caracolla anterior*, is restricted to the Lower Cretaceous in Europe. The first mentioned subspecies ranges from the Upper Valanginian to the Lower Barremian, the latter from the Middle to the Upper Valanginian ("Leitfossilien" 1962; Norling 1981).

The foraminiferal analyses of the pre-Quaternary sequence in Åstorp. No. 20 suggest the following:

A) The 160.3-169.1 m interval of drilling, lithologically correlative with the Fortuna Marl (page 9), has yielded a foraminiferal assemblage containing forms stratigraphically restricted to the Middle Jurassic - Upper Jurassic transitional beds. The boundary may be placed somewhere betwen 160 m and 165 m .

B) The 135-160.3 m interval of the Åstorp sequence, referred to the Fyledal Clay, has yielded very few foraminifers from samples at 140 m, 156 m, and 160 m, all arenaceous forms of species stratigraphically restricted to the Oxfordian.

C) The Nytorp Sand (110-135 m) is completely devoid of foraminifers.

D) The Vitabäck Clays (67-110 m) have yielded foraminifers indicating that the upper part of this member is of Early Cretaceous age. Its lower part has not yielded any foraminifers of stratigraphical bearing.

COMPARISON WITH OTHER RELEVANT FORAMINIFERAL FAUNAS

The foraminiferal faunas obtained from the pre-Quaternary sequences at Karindal and Åstorp have been compared with foraminiferal faunas of similar age elsewhere in Europe.

Among the nineteen genera recorded, thirteen represent calcareous and six arenaceous forms. Among the calcareous genera nodosariid foraminifers dominate (nine genera), a predominance which is characteristic of Jurassic shelf sea faunas north, as well as south of the Tethyan Sea.

The interval below the Upper Jurassic sequence cored at Karindal has been dated to the Pliensbachian with the aid of foraminifers from core samples within the interval 177.6-190.6 m. Almost the whole foraminiferal fauna from this interval, including some 15 species, has been found in other parts of Scania too (Norling 1972, 1981), and in the Lias of Denmark (Norvang 1957; Bang in Larsen *et al.* 1968) as well. Most of these species seem to have almost identical stratigraphical ranges in Sweden and Denmark. A strange character of the Liassic foraminiferal fauna at Karindal is the lack of representatives of the genus *Nodosaria*, normally fairly frequent in strata of this age.

Most of the foraminifers from the Liassic beds below the base of the Upper Jurassic Fyledal Clay in Karindal-1 have also been recorded from NW Germany (Bartenstein & Brand 1937; Neuweiler in Bach *et al.* 1959, "Leitfossilien" 1962; Brouwer 1969); Great Britain (Adams 1957; Barnard 1950-56, Brouwer 1969; Copestake & Johnson 1984; Lord & Bown 1987), and from France (Bizon 1960; Ruget & Sigal 1967; Brouwer 1969). Many of the foraminifers in the Liassic assemblage of Karindal seem to be restricted to the Pliensbachian in NW Europe; *Brizalina liasica amalthea*, *Lenticulina turbiniformis*, *Marginulina spinata interrupta*, *Saracenaria sublaevis*, and *Geinitzinita tenera carinata* to be mentioned (Fig. 9).

The meagre foraminiferal fauna obtained from post-Liassic, essentially Upper Jurassic strata in NW Scania includes some 15 species. Apart from the long-ranging species of little biostratigraphical interest, the assemblage includes one species only which is restricted to the Middle Jurassic in Europe, viz. *Valvulina fusca* (Lutze 1960; Norling 1981), whereas the other forms with a limited stratigraphical range either span the Middle Jurassic - Upper Jurassic boundary, or are restricted to the Upper Jurassic in Europe. As a whole, the foraminiferal fauna of the Fortuna Marl and the Fyledal Clay (p. 19) in NW Scania show a striking resemblance not only to faunas in countries adjacent to Scania, but also to foraminiferal assemblages recorded from Jurassic strata in more distant areas such as south Germany, France and Wessex. Many forms listed in a recent publication by Lord & Bown (1987) from the Upper Jurassic of the Dorset coast are also present in NW Scania, forms such as *Frondicularia franconica*, *Lenticulina quenstedti* and *Haplophragmoides canui* along with several long-ranging forms common to Sweden and Wessex (Fig. 9). The bed by bed foraminiferal biostratigraphy of the Dorset Jurassic, correlated with the ammonite zonation, has been of importance for the biostratigraphy of the Swedish Jurassic in this and previous investigations (Norling 1970, 1972, 1981).

Most of the foraminiferal species obtained from Karindal and Åstorp have previously been treated in a more comprehensive publication (Norling 1972), where a list of the main references used for comparison and correlation of the Scanian Jurassic foraminiferal faunas with those of other countries will be found (pp. 105, 116-120). In this respect the list includes literature concerning e.g. Denmark, Germany, Austrian-Swiss Jura, the Netherlands, United Kingdom, France, Italy, Spain, Poland, Czechoslovakia, and the Soviet Union.

PALAEOENVIRONMENTS, DEPOSITION AND ORGANIC MATURATION

Karindal

No dinoflagellates have been recorded in the Karindal samples, but three other species of organic-walled microplankton are of interest - namely *Botryococcus* sp., indicative of a fresh water influence on the sedimentary deposition, *Tasmanites* sp., the green alga indicative of marine conditions and *Canningia* sp. also indicative of marine environment. Examination of Fig. 8 shows that *Botryococcus* is found in almost all samples, *Tasmanites* in only 2 samples (at 113.92 m and 95.22 m) but never together with *Botryococcus*, and *Canningia* only in one sample (at 90.12 m) and then together with *Botryococcus*. Thus for the Fyledal Clay there is palynological evidence indicating freshwater influence on the depositional environment, none for the Nytorp Sand but again for certain samples of the Vitabäck Clays. Short-lived marine ingressions at 113.92 m and 95.22 m are indicated by presence of *Tasmanites* and absence of *Botryococcus*, while the presence of both at 90.12 m suggests brackish conditions prevailed at the time of deposition.

Basing an evaluation on small unsculptured spores of light brownish yellow colour through the sample series a value of 3 was obtained on the thermal alteration index scale (T.A.I.) of Batten (1980, 1981, 1982), indicating some chemical changes, marginally mature sediments with only a low hydrocarbon energy source potential.

The Jurassic sequence at Karindal has been studied palynologically down to a depth of 152 m. Below this level foraminifers only were examined. As shown above (p. 18, Fig. 6) the deepest 30 m of the Karindal borehole penetrated Liassic deposits. Samples from 177.6 m, 181.8 m, 184.7 m, and 190.4 m represent marine deposits as indicated by their content of calcareous foraminifers. With a few exceptions the number of individuals of different foraminiferal species is small. The exception are *Geinitzinita tenera* and *Brizalina liasica*, species which were found in a relative large number of individuals in samples from 177.6 m, 181.8 m, and 184.7 m and 190.4 m respectively.

In his study of depositional environment of Liassic foraminifers in different parts of NW Europe, Brouwer (1969, p. 20), after statistical treatment of his large material, has recognized a particular succession of foraminiferal assemblages. In this succession assemblages with *Lenticulina gottingensis* (or other unornamented *Lenticulina*) as a main component probably represent the deepest and/or most open marine condition. If comparable with Recent seas, such an assemblage may have occupied a depth interval between 60 m and 1500 m. Towards the other end of Brouwer's assemblage succession *Geinitzinita tenera* dominated assemblages are to be found, indicating shallow marine, nearshore environments. Assemblages with *Brizalina liasica* as the main component occupy the central part of Brouwer's succession, perhaps indicating rather deep marine conditions.

As a whole, the Pliensbachian foraminiferal fauna of Karindal is composed of nodosariid foraminifers with few exceptions (*Brizalina* forms). According to Bielecka & Pozaryski (1954), nodosariids are rare in very shallow marine environments, but become more numerous in marly, argillaceous sediments formed in nearshore but deeper waters. Wall (1960) and Gordon (1970) have reached similar conclusions. The latter stated that the characteristic nodosariid and nodosariid-mixed assemblages in the Jurassic indicate that in general, they are "typical of shelf seas with nearby lands that feed coarse to fine terrigenous sediments into a sea, where carbonate deposition is also progressing. When such seas reach extremes of shallowness, the nodosariid and nodosariid-mixed assemblages seem to disappear."

The Upper Jurassic sequence at Karindal has yielded very few foraminifers, specimens of the genera *Lenticulina, Dentalina, Marginulina* and *Ammodiscus*, all obtained from samples within the 172-176 m interval. The palynological and foraminiferal investigations thus indicate that the Fyledal Clay (146-177 m) was deposited in alternating marine and freshwater environments. There is no foraminiferal evidence concerning the depositional environment for the Nytorp Sand and the Vitabäck Clays at Karindal.

Åstorp

From examination of Fig. 8 it can be seen that several organic-walled palynomorphs (other than pollen grains and spores) have been recorded. *Nannoceratopsis gracilis*, the only dinoflagellate recorded has been found in 4 samples, at 167.05-167.07 m, 166.77-166.78 m, 164.84-164.92 m and 161.19 m and is indicative of a marine sedimentary environment. The same conditions are also indicated by the presence of *Tasmanites* which occur in 9 samples, 3 of which also contained *Nannoceratopsis gracilis. Tasmanites* is known (Wall 1965; Riding 1983) to typify subsaline marine conditions and even characterise brackish water or shallow water often restricted marine environments where the salinity has been reduced due to freshwater run off. The occurrence of *Botryococcus* in many of the samples (Fig. 8) investigated from Åstorp indicates such a fresh water influence on the sedimentary deposition. Thus brackish inshore conditions may be concluded for the deposition of the cored interval studied at Åstorp. The occurrence of *Micrhystridium* spp., which prefer a partly enclosed in-shore environment, in two of the samples where the greatest number of reworked Carboniferous spores occur may well account in part for their present good state of preservation. As for the organic maturation, a somewhat higher value was obtained on the T.A.I. scale indicating mature sediments with a possible hydrocarbon energy source potential, but not sufficient to be of commercial interest.

From the list of Foraminifera (Fig. 9) it can be seen that calcareous forms have been found in the Fortuna Marl (160-169 m) spanning the Middle Jurassic - Upper Jurassic boundary, and within the central part of the Vitabäck Clays (67-110 m), seemingly straddling the Jurassic-Cretaceous boundary. Arenaceous foraminifers have been found in the Fortuna Marl in assemblages dominated by calcareous forms, in the Fyledal Clay (135-160 m), and in the basal part of the Vitabäck Clays. The Nytorp Sand has not yielded any foraminifers at all.

Along with dinoflagellates, pollen grains and spores, the calcareous foraminifers indicate alternating marine and freshwater influence on the deposition of the Fortuna Marl. The succeeding Fyledal Clay has yielded arenaceous foraminifers only. The main cause for the faunal change, where the Fortuna Marl is replaced by the Fyledal Clay has been interpreted as a change in depositional environment from mainly marine to brackish-limnic (Norling 1972, p. 111). With reference to the Vitabäck Clays spanning the Jurassic-Cretaceous boundary, the records of calcareous foraminifers indicate marine ingressions.

CONCLUSIONS

This study has resulted in the identification in NW Scania of the following lithostratigraphical units (members of the Annero Formation), namely, the Fortuna Marl (Upper Bathonian - Oxfordian), the Fyledal Clay (Oxfordian - Kimmeridgian), the Nytorp Sand (Kimmeridgian - Postlandian) and the Vitabäck Clays (Portlandian - basal Cretaceous). From the two boreholes, Åstorp No. 20 and Karindal No. 1, 83 palynomorph species and 31 foraminiferal species have been determined. From their known stratigraphical ranges it has been possible to date different intervals of the examined cores as representing late Middle Jurassic to late Late Jurassic. The foraminiferal fauna also shows that the Upper Jurassic deposits of Karindal No. 1 rest on Pliensbachian uplift.

REFERENCES

Literature used in the palynomorph systematic determinations has not been given in the list below, but can be found mainly in Filatoff 1975, Guy-Ohlson 1986 and/or Pocock, 1970.

ARBEITSKREIS DEUTSCHER MIKROPALÄONTOLOGEN, 1962: Leitfossilien der Mikropaläontologie. 432 pp. 61 plates, 22 tables. Gebruder Borntraeger. Berlin-Nikolassee.

ADAMS, C. G. 1957: A study of the morphology and variation of some Upper Liassic Foraminifera. *Micropalaeontology*, 3: 205—226.

BACH, H., HAGENMEYER, P. & NEUWEILER, F. 1959: Neubeschreibung und Revision einiger Foraminiferenarten und -unterarten aus dem schwäbischen Lias. — *Geol. Jahrbuch* 76: 427—452.

BARNARD, T. 1950 a): Foraminifera from the Lower Lias of the Dorset Coast. *Q. J. Geol. Soc.* London, 105: 347—391.

- 1950 b): Foraminifera from the Upper Lias of Byfield, Northamptonshire. *Q. J. Geol. Soc.* London, 106: 1—36.
- 1952: Foraminifera from the Upper Oxford Clay (Jurassic) of Warboys, Huntingdonshire, *Geol. Assoc., Proc.*, 63(4): 336—350.
- 1953: Foraminifera from the Upper Oxford Clay (Jurassic) of Redcliff Point, near Weymouth, England. *Geol. Assoc., Proc.*, 64(3): 183—197.
- 1956: Some *Lingulinae* from the Lias of England. *Micropaleontology*, 2(3): 271—282.

BARTENSTEIN, H. & BRAND, E. 1937: Mikropaläontologische Untersuchungen zur Stratigraphie des nordwestdeutschen Lias und Doggers. *Senckenberg Naturforsch. Ges. Abh.* No. 439: 1—224.

- 1951: Mikropaläontologische Untersuchungen zur Stratigraphie des nordwestdeutschen Valendis. *Abh. senckenberg. naturforsch. Ges.* 485: 239—336.

BATTEN, D. J. 1978: Early Cretaceous to Middle Jurassic miospores and palynofacies of the northwest European Continental shelf: 97—101. *In* "Distribution of biostratigraphically diagnostic dinoflagellate cysts and miospores from the Nortwest European Continental Shelf and adjacent Areas", Thusu, B. ed. *Continental Shelf Institute* Trondheim, Norway. Publ. No. 100, 111 pp.

- 1980: Use of transmitted light microscopy of sedimentary organic matter for evaluation of hydrocarbon source potential. *IV. Int. Palynol. Conf.*, Lucknow (1976—77) 2: 589—594.
- 1981: Palynofacies, organic maturation and source potential for petroleum. In "Organic maturation studies and fossil fuel exploration", Brooks. J. ed. *Academic Press* (London) Ltd: 202—223.
- 1982: Palynofacies, palaeoenvironments and petroleum. *J. micropal.*, 1: 107—114.

BERGSTRÖM, J., HOLLAND, B., LARSSON, K., NORLING, E. & SIVHED, U. 1982: Guide to excursions in Scania. *Sver. Geol. Unders.* Ser Ca 54., 95 pp. Uppsala.

BIELECKA, W. & POZARYSKI, W. 1954: Stratygrafia Mikropaleontologiczna Gornego Malmu w Polsce Srodkowej. *Inst. Geol. Prace.*, Vol. 12, 206 pp. Warsaw.

BIZON, G. 1960: Revision de quelques especes-types de Foraminiferes du Lias du Basin Parisien de la Collection Terquem. *Rev. Micropaleontol.*, No. 1. Paris.

- 1961: Contributions a l'étude micropaleontologique du Lias du Basin de Paris. *BRGM, Mem.*, 4:111—113. Paris.

BJAERKE, T. 1977: Mesozoic palynology of Svalbard - *II*. Palynomorphs from the Mesozoic sequence of Kong Karls Land. *Norsk Polarinst.* Årsbok 1976: 83—120.

- 1980: Mesozoic palynology of Svalbard - *V*. Dinoflagellates from the Agardfjellet Member (Middle and Upper Jurassic) in Spitsbergen. *Norsk Polarinst.* 172: 146—167.

BRASIER, M. D. 1980: Microfossils. 193 pp. Allen & Unwin. London.

BRADY, H. B. 1879: Notes on some reticularian Rhizopoda of the Challenger Expedition. - *Q. J. Microsc. Sci.* New Ser. 19:1.

BROUWER, J. 1969: Foraminiferal assemblages from the Lias of NW Europe. - *Verh. K. ned. Akad. Wet.* Afd. *Natuurkunde. Eerste Reeks, Deel XXV*, No. 4. Amsterdam.

BÖLAU, E. 1959: Der Südwest- und Südostrand des Baltischen Schildes (Schonen und Ostbaltikum). -*Geol. För. Stockh. Förh.* 81: 167—230.

COPESTAKE, P. & JOHNSON, B. 1984: Lower Jurassic (Hettangian-Toarcian) Foraminifera from the Mochras Borehole, North Wales (UK) and their application to a worldwide biozonation. *Benthos 83* (Ed. H. J. Oertli). *Second International Symposium on Benthic Foraminifera* (Pau, 1983). 183—184. Pau et Bordeaux 1984.

COUPER, R. A. 1958: Britsh Mesozoic microspores and pollen grains. *Palaeontographica*, B (103): 75—179.

CHRISTENSEN, O. B. 1965: The ostracode genus *Dicrorygma* POAG 1962, from the Upper Jurassic and Lower Cretaceous. *Dan. Geol. Unders. 2 Raekke*, 90, 23 pp. Copenhagen.

- 1968: Some deposits and microfaunas from the Upper Jurassic in Scania. *Sver. Geol. Unders.* Ser. C 632, 46 pp. Stockholm.

FILATOFF, J. 1975: Jurassic palynology of the Perth Basin, Western Australia. *Palaeontographica*, B (103): 1—113.

GORDON, W. A. 1970: Biogeography of Jurassic Foraminifera. *Geol. Soc. Am. Bull.*, Vol. 81, pp. 1689—1704.

GRANT, A. C. (1987): Inversion tectonics on the continental margin of east Newfoundland. *Geology*, Vol. 15: 845—848. USA.

GUY, D. J. E. 1971: Palynological investigations in the Middle Jurassic of the Vilhelmsfält boring, southern Sweden. *Publ. Inst. Min. Palaeont. Quatern. Geol.* Lunds Univ. 168: 1—104.

GUY-OHLSON, D. 1978: Jurassic biostratigraphy of three borings in NW Scania. (A brief palynological report). *Sver. Geol. Unders. Rapp. och Medd.* 11: 1—41.

- 1985: Palynology of Swedish Upper Jurassic sediments. *Palynology*, 9: 243—244.
- 1986: Jurassic palynology of the Vilhelmsfält Bore No. 1, Scania, Sweden. Toarcian-Aalenian. *Swed. Mus. Nat. Hist.* Stockholm, Sweden, 127 pp.

GUY-OHLSON, D., LINDQVIST, B. & NORLING, E. 1987: Reworked Carboniferous spores in Swedish Mesozoic sediments. *Geol. För. Stockh. Förh.* 109(4): 295—306.

GUY-OHLSON, D. J. E. & MALMQUIST, E. 1985: Lower Jurassic biostratigraphy of the Oppergård Bore No. 1, NW Scania, Sweden. *Sver. Geol. Unders. Rapporter och Meddelanden* No. 40, 27 pp. Uppsala.

HEUSLER, R. 1881: Untersuchungen über die mikroskopischen Strukturverhältnisse der Aargauer Jurakalke mit besonderer Berucksichtigung ihrer Foraminiferernfauna. Dissertation. Univ. Zürich. 47 pp.

HÄGG, R. 1940: Purbeck eller wealden vid Vitabäck i Skåne. *Geol. För. Stockh. Förh.* 62:303.

LARSEN, G., BUCH, A., CHRISTENSEN, O. & BANG, I. 1968: Øresund. Helsingør-Helsingborglinien. *Geologisk Rapport. Danmarks Geologiske Undersøgelse.* Rapport No. 1: 1-90. Copenhagen.

"LEITFOSSILIEN", 1962: See Arbeitskreis Deutscher Mikropaläontologen.

LOEBLICH, A. R. Jr & TAPPAN, H. 1964: Sarcodina. Chiefly Thecamoebians and Foraminiferida. *Treatise on Invertebrate Paleontology. Part C. Protista*, Vol. 1 and 2. 900 pp.

LORD, A. R. & BOWN, P. R. (ed.) 1987: Mesozoic and Cenozoic stratigraphical micropalaeontology of the Dorset coast and the Isle of Wight, southern England. *British Micropalaentological Society, Guide Book 1.* 185 pp. (Field Guide for the XXth. European Micropalaeontological Colloquium.)

LUND, J. J. & PEDERSEN, K. R. 1984: Palynology of the marine Jurassic formations in the Vardeklöft ravine, Jameson Land, East Greenland. *Bull. geol. Soc. Denmark*, 33: 371—399.

LUTZE, G. F. 1960: Zur Stratigraphie und Palaeontologie des Callovian und Oxfordien in Nordwest-Deutschland. *Geol. Jahrbuch.* 77: 391—532.

MYATLIUK, E. V. 1939: The Foraminifera from the Upper Jurassic and Lower Cretaceous Deposits of the Middle Volga Region and Obschiy Syrt. *Trans. Geol. Oil. Inst.*, A. Vol. 120, 76 pp. (In Russian). Leningrad.

MÄDLER, K. 1964: Die geologische Verbreitung von Sporen und Pollen in der Deutschen Trias. *Beih. geol. Jb.* 65: 1—147.

NORLING, E. 1970: Jurassic and Lower Cretaceous stratigraphy of the Rydebäck-Fortuna borings in Southern Sweden. *Geol. För. Stockh. Förh.* 92: 261—287.

- 1972: Jurassic Stratigraphy and Foraminifera of Western Scania, Southern Sweden. *Sver. Geol. Unders. Ser. Ca 47*, 120 pp. Stockholm.
- 1978: Berggrund. Pp. 20—32, 86. *In:* Esko Daniel: Beskrivning till jordartskartan Höganäs NO/Helsingborg NV. *Sver. Geol. Unders. Ser. Ae* 26, 92 pp. Stockholm.
- 1981: Upper Jurassic and Lower Cretaceous geology of Sweden. *Geol. Fören. Stockh. Förh.* 103: 253—269.

NORLING, E. & BERGSTRÖM, J. 1987: Mesozoic and Cenozoic tectonic evolution of Scania, southern Sweden. *In*: P. A. Ziegler (Editor), Compressional Intra-Plate Deformations in the Alpine Foreland. *Tectonophysics*, 137: 7—19

NORRIS, G. 1969: Miospores from the Purbeck beds and marine Upper Jurassic of southern England. *Palaeontology* 12(4): 574—620.
NØRVANG, A. 1957: The Foraminifera of the Lias Series in Jutland, Denmark. 135 pp., Copenhagen.
OERTLI, H. J., BROTZEN, F. & BARTENSTEIN, H. 1961: Mikropaläontologisch feinstratigraphische Untersuchung der Jura-Kreide-Grenzschichten in Südschweden. *Sver. Geol. Unders. Ser. C* 579, 24 pp. Stockholm.
POCOCK, S. A. J. 1970: Palynology of the Jurassic sediments of western Canada. Part 1. Terrestrial species. *Palaeontographica* B (130) 1—2: 12—72; continued in 3—6: 73—136.
RIDING, J. B. 1983: The palynology of the Aalenian (Middle Jurassic) sediments of Jackdaw Quarry, Gloucestershire, England. *Mercian geol.* 9(2): 111—120.
RUGET, C. & SIGAL, J. 1967: Les Foraminiferes du sondage de Laneuveville-devant-Nancy (Lotharingien de la region type). *Science de la Terre,* 12(1—2): 33—70.
SARJEANT, W. A. S. 1979: Middle and Upper Jurassic dinoflagellate cysts: the world excluding North America. *AASP Contributions Series* 5B: 133—157.
SENGOR, A. M. C. 1984: The Cimmeride orogenic system and the tectonics of Eurasia. *Geological Society of America. Special Paper* 195, 82 pp.
SIVHED, A. & WIKMAN, H. 1986: Berggrundskartan 3C Helsingborg SV (med beskrivning). *Sver. Geol. Unders. Ser. Af* 149, Uppsala.
SRIVASTAVA, S. K. 1987: Jurassic spore-pollen assemblages from Normandy (France) and Germany. *Geobios* 20(1): 5—79.
THUSU, B. 1978: Aptian to Toarcian dinoflagellate cysts in Arctic Norway: 61—95. In "Distribution of biostratigraphically diagnostic dinoflagellate cysts and miospores from the northwest European Continental Shelf and adjacent areas". *Continental Shelf Institute.* Trondheim. Norway. Publ. No. 100, 111 pp.
THUSU, B. & VIGRAN, J. O. 1985: Middle-Late Jurassic (Late Bathonian-Tithonian) Palynomorphs. *J. micropalaeontol.,* 4(1): 113—130.
VIGRAN, J. O. & THUSU, B. 1975: Illustrations and distribution of the Jurassic palynomorphs of Norway. *Roy. Norw. Counc. Sci. Ind. Res., Cont. Shelf Div. Publ.* 65: 1—55.
VOLKHEIMER, W. & QUATTROCCHIO, M. E. 1981: Distribucion estratigrafica de los palinomorfos Jurasicos y Cretacios en la faja Andina y areas adyacentes de America del sur austral con especial consideracion de la cuenca neuquina. *Cuencas sedimentarias del Jurasico y Cretacico de America del Sur,* 2: 407—444.
WALL, D. 1965: Microplankton, pollen and spores from the Lower Jurassic in Britan. *Micropaleontology,* 11: 151—190.
WALL, J. H. 1960: Jurassic microfaunas from Saskatchewan. *Sask. Dep. Min. Resour.* Repr. No. 53, 229 pp.
WIKMAN, H. & NORLING, E. 1981: Berggrundskartan 3B Höganäs NO/3C Helsingborg NV. *Sver. Geol. Unders. Ser. Af* 129. Uppsala.
WIKMAN, H. & SIVHED, U. 1985: Berggrundskartan 3C Helsingborg NO. *Sver. Geol. Unders. Ser. Af* 148. Uppsala.
WILLIAMSON, W. C. 1858: On the Recent Foraminifera of Great Britain. *Roy. Society Publications,* 107 pp. London.
WOOLLAM, R. & RIDING, J. B. 1983: Dinoflagellate cyst zonation of the English Jurassic. *Inst. geol. Sci.* Report 83/2: 1—42.
ZIEGLER, P. A. 1981: Evolution of sedimentary basins in north-west Europe. In Petroleum Geology of the Continental Shelf of North-West Europe. Institute of Petroleum: 3—39.
- 1987: Compressional intra-plate deformation in the Alpine foreland – – an introduction. *Tectonophysics,* Vol. 137(1—4): 1—5.

APPENDIX I

LIST OF PALYNOMORPHS PRESENT

(All species listed below are to be found in Fig. 8)

Alisporites robustus NILSSON, 1958 ... p. 11, 14; pl. 2
Araucariacites australis COOKSON, 1947 ... p. 11, 15
Baculatisporites comaumensis (COOKSON) POTONIÉ ... p. 14; pl. 1
Botryococcus (sp.) KÜTZING, 1849 ... p. 11, 21, 22; pl. 5
Brachysaccus microsaccus (COUPER) MÄDLER, 1964 ... pl. 2
Calamospora mesozoica COUPER, 1958
Callialasporites damperi (BALME) SUKH DEV, 1971 ... p. 11; pl. 2
Callialasporites minus (TRALAU) GUY, 1971
Callialasporites segmentus (BALME) SRIVASTAVA, 1963 ... p. 11
Callialasporites trilobatus (BALME) SUKH DEV, 1961 ... p. 11
Callialasporites turbatus (BALME) SCHULZ, 1967 ... p. 11
Camarazonosporites (sp.) PANT (ex. PONTONIÉ), 1956
Canningia (sp.) COOKSON & EISENACK, 1960 ... p. 21
Ceratosporites (sp.) COOKSON & DETTMANN, 1958
Cerebropollenites mesozoicus (COUPER) NILSSON, 1958 ... p. 11, 15; pl. 2
Chasmatosporites apertus (ROGALSKA) NILSSON, 1958 ... p. 14; pl. 3
Chasmatosporites major (NILSSON) POCOCK & JANSONIUS, 1969 ... p. 14
Cibotiumspora jurienensis (BALME) FILATOFF, 1975 ... p. 14; pl. 1
Classopollis classoides (PFLUG) POCOCK & JANSONIUS, 1961 ... p. 11, 14; pl. 3
Conbaculatisporites mesozoicus KLAUS, 1960 ... pl. 1
Concavissimisporites variverrucatus COUPER, 1958
Contignisporites dunrobinensis (COUPER) SCHULZ, 1967
Contignisporites problematicus (COUPER) DÖRING, 1965 ... pl. 2
Coronatispora valdensis (COUPER) DETTMANN, 1963 ... p. 11
Cyathidites australis COUPER, 1953 ... p. 11, 14; pl. 1
Cyathidites concavus (BOLKHOVITINA) DETTMANN, 1963
Cyathidites minor COUPER, 1953 ... p. 14
Cycadopites deterius (BALME) SUKH DEV, 1959 ... p. 11
Cycadopites minimus (COOKSON) POCOCK, 1970
Densoisporites crassus TRALAU, 1968
Densoisporites scanicus TRALAU, 1968
Densoisporites velatus WEYLAND & KRIEGER, 1953
Densosporites (spp.) (BERRY) BUTTERWORTH, JANSONIUS, SMITH & STAPLIN, 1964 ... pl. 4
Dictyophyllidites equiexinus (COUPER) DETTMANN, 1963 ... p. 11
Eucommiidites troedssonii ERDTMAN, 1948 ... pl. 3
Ginkgocycadophytus nitidus (BALME) de JERSEY, 1962 ... p. 14; pl. 3
Gleicheniidites senonicus ROSS, 1949 ... pl. 1
Ischyosporites variegatus (COUPER) SCHULZ, 1967 ... pl. 2
Leptolepidites crassibalteus FILATOFF, 1975 ... p. 11
Leptolepidites equatibossus (COUPER) TRALAU, 1968
Leptolepidites major COUPER, 1958 ... p. 11, 15; pl. 1
Leptolepidites paverus LEVET-CARETTE, 1964
Leptolepidites rotundus TRALAU, 1968
Lycopodiacidites rugulatus (COUPER) SCHULZ, 1958
Lycopodiumsporites clavatoides (COUPER) TRALAU, 1968 ... p. 14
Lycopodiumsporites reticulumsporites (ROUSE) DETTMANN, 1963

APPENDIX II

INDEX OF FORAMINIFERA

PLATE I

Fig. 01 *Cyathidites australis* Couper
Å-SEM/3: 161.19
Fig. 02 *Cibotiumspora jurienensis* (Balme) Filatoff
Å-SEM/19: 167.05-165.07
Fig. 03 *Gleicheniidites senonicus* Ross
Å-SEM/4: 161.31
Fig. 04 *Sp. indet.*
Å-SEM/3: 161.19
Fig. 05 Cf. *Leptolepidites major* Couper
Å-SEM/5: 161.76-161.81
Fig. 06 *Leptolepidites* cf. *bossus* (Couper) Schulz
Å-SEM/3: 161.19
Fig. 07 *Sp. indet.*
Å-SEM/9: 164.89-164.92
Fig. 08 Cf. *Conbaculatisporites mesozoicus* Klaus
Å-SEM/3: 161.19
Fig. 09 *Baculatisporites comaumensis* (Cookson) Pontonié
Å-SEM/5: 164.89-164.92
Fig. 10 *Neoraistrickia truncata* (Cookson) Pontonié
Å-SEM/1: 160.58
Fig. 11 *Neoraistrickia truncata* (Cookson) Pontonié
Å-SEM/1: 160.58
Fig. 12 *Neoraistrickia* sp. Pontonié
Å-SEM/3: 161.19
Figs. 13, 14 *Rugulatisporites neuquenensis* Volkheimer
Å-SEM/3: 161.19
Figs. 15, 16 *Rugulatisporites neuquenensis* Volkheimer
Å-SEM/2: 160.93

(Bar length = 10 microns in Figs. 1-13, 15 and 1 micron in Figs. 14, 16)

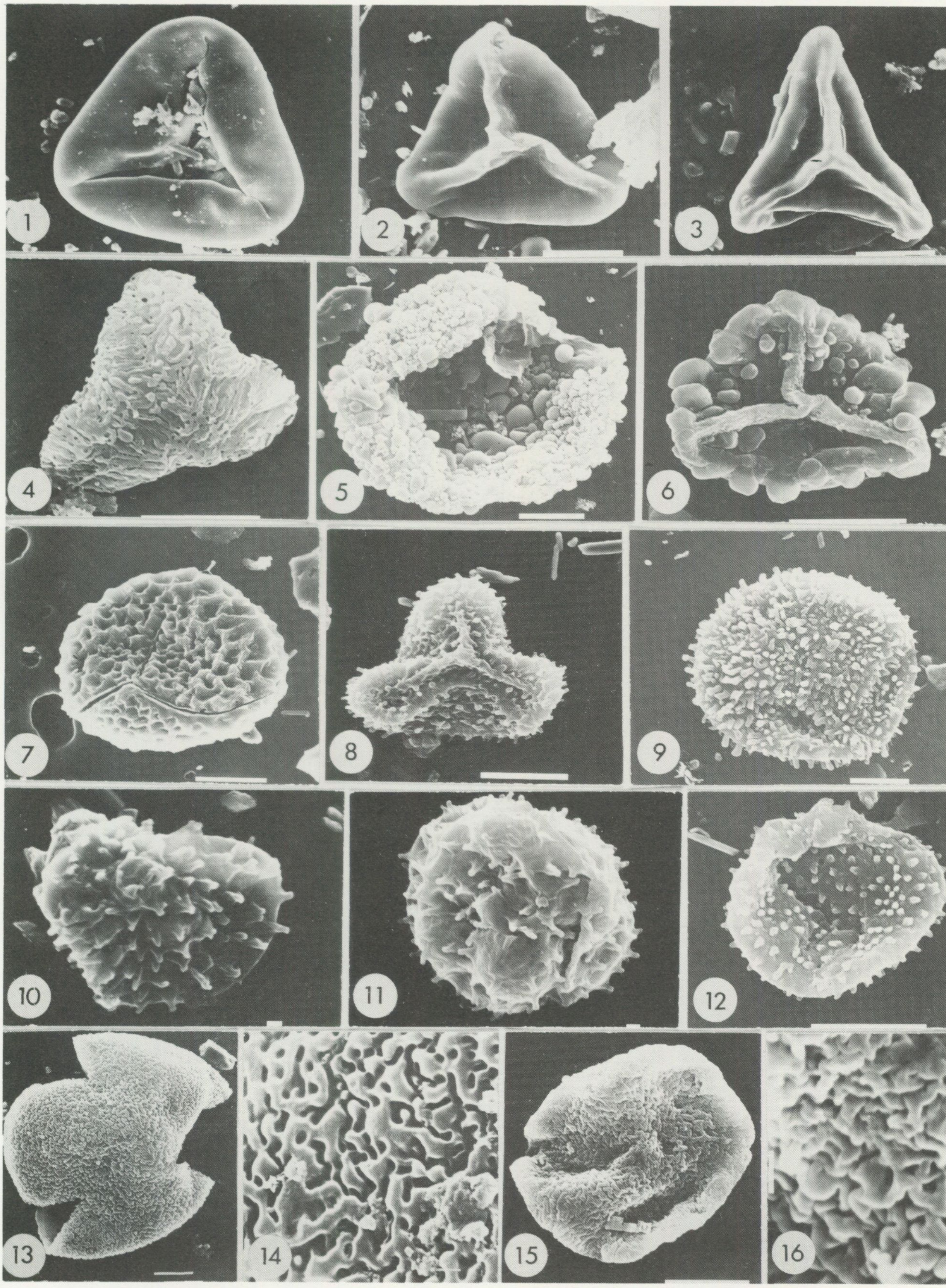

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

PLATE 2

Fig. 01 *Ischyosporites variegatus* (Couper) Schulz
Å-SEM/3: 161.19
Fig. 02 *Contignisporites problematicus* (Couper) Döring
Å-SEM/9: 164.89-164.92
Fig. 03 *Sp. indet.*
Å-SEM/3: 161.19
Fig. 04 *Marattisporites scabratus* Couper
Å-SEM/3: 161.19
Fig. 05 *Cerebropollenites mesozoicus* (Couper) Nilsson
Å-SEM/1: 160.58
Fig. 06 *Callialasporites dampieri* (Balme) Sukh Dev
KD-SEM/9: 110.52
Fig. 07 *Parvisaccites enigmatus* Couper
KD-SEM/8: 112.59
Fig. 08 *Sp. indet.*
Å-SEM/9: 164.89-164.92
Fig. 09 *Alisporites robustus* Nilsson
Å-SEM/19: 167.05-167.07
Fig. 10 *Brachysaccus microsaccus* (Couper) Mädler
Å-SEM/3: 161.19
Fig. 11 *Brachysaccus microsaccus* (Couper) Mädler
Å-SEM/18: 166.77-166.78
Fig. 12 *Pityosporites nigraeformis* (Bolkhovitina) Pocock
Å-SEM/18: 166.77-166.78

(Bar length = 10 microns)

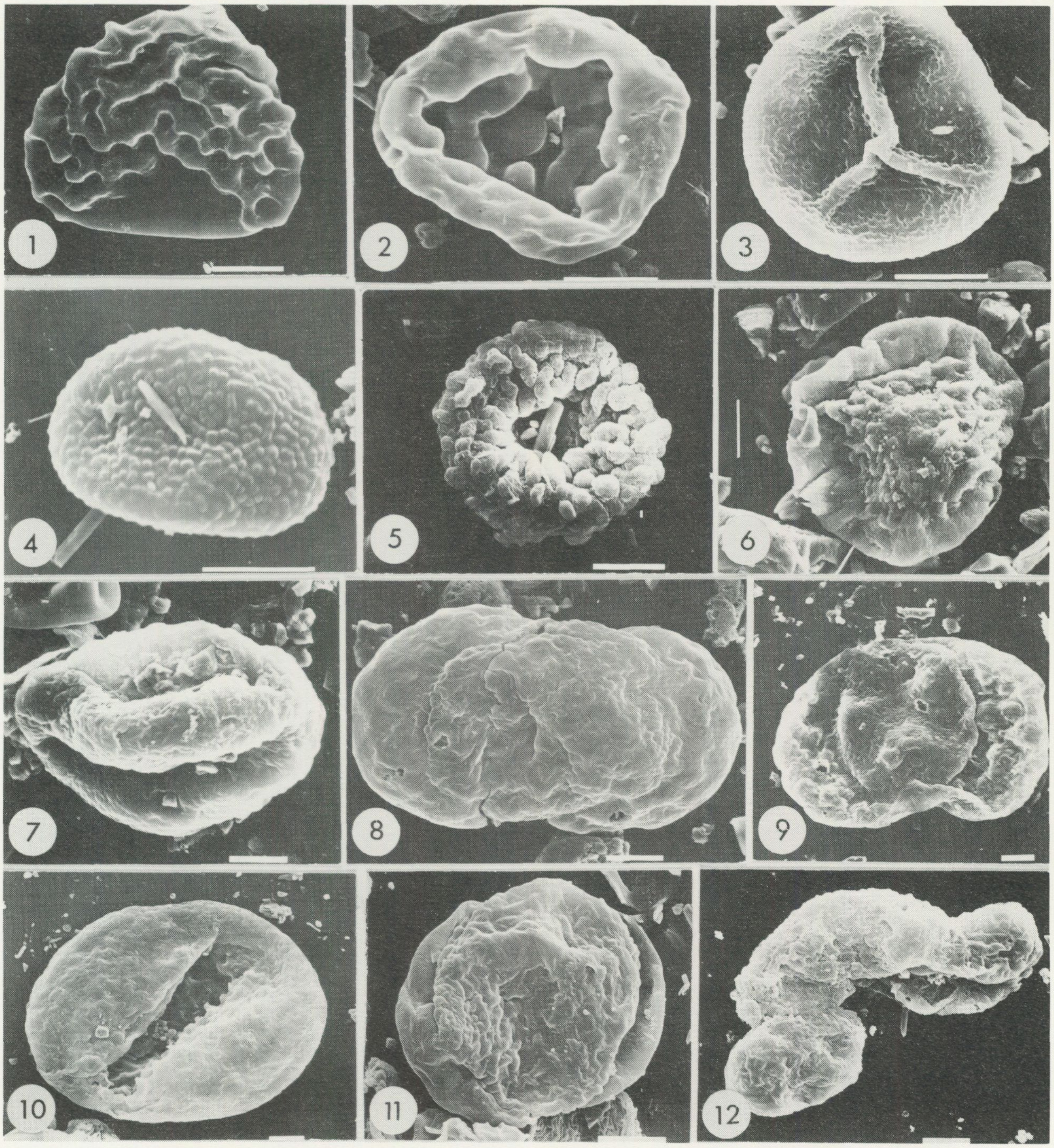

1
2
3
4
5
6
7
8
9
10
11
12

PLATE 3

Fig. 1 *Podocarpidites verrucossus* Volkheimer
Å-SEM/9: 164.89-164.92

Fig. 2 *Podocarpidites* sp.
Å-SEM/3: 161.19

Fig. 3 Reticulate inner structure of bisaccate pollen
Å-SEM/9: 164.89-164.92

Fig. 4 *Chasmatosporites hians* Nilsson
Å-SEM/11: 165.14-165.16

Fig. 5 *Chasmatosporites apertus* (Rogalska) Nilsson
Å-SEM/3: 161.19

Fig. 6 *Ginkgocycadophytus nitidus* (Balme) de Jersey
Å-SEM/18: 166.77-166.78

Fig. 7 *Eucommiidites troedsonii* Erdtman
Å-SEM/17: 166.56-166.57

Figs. 8-13 *Classopollis classoides* (Pflug) Pocock & Jansonius
(8) Å-SEM/1: 160.58, (9) Å-SEM/7: 166.56-166.57, (10) Å-SEM/14: 165.83-165.85, (11) KD-SEM/11: 98.27, (12) & (13) Å-SEM/17: 166.56-166.57

(Bar length = 10 microns in Figs. 1-2, 4-5, 7-12 and 1 micron in Figs. 3, 9, 13)

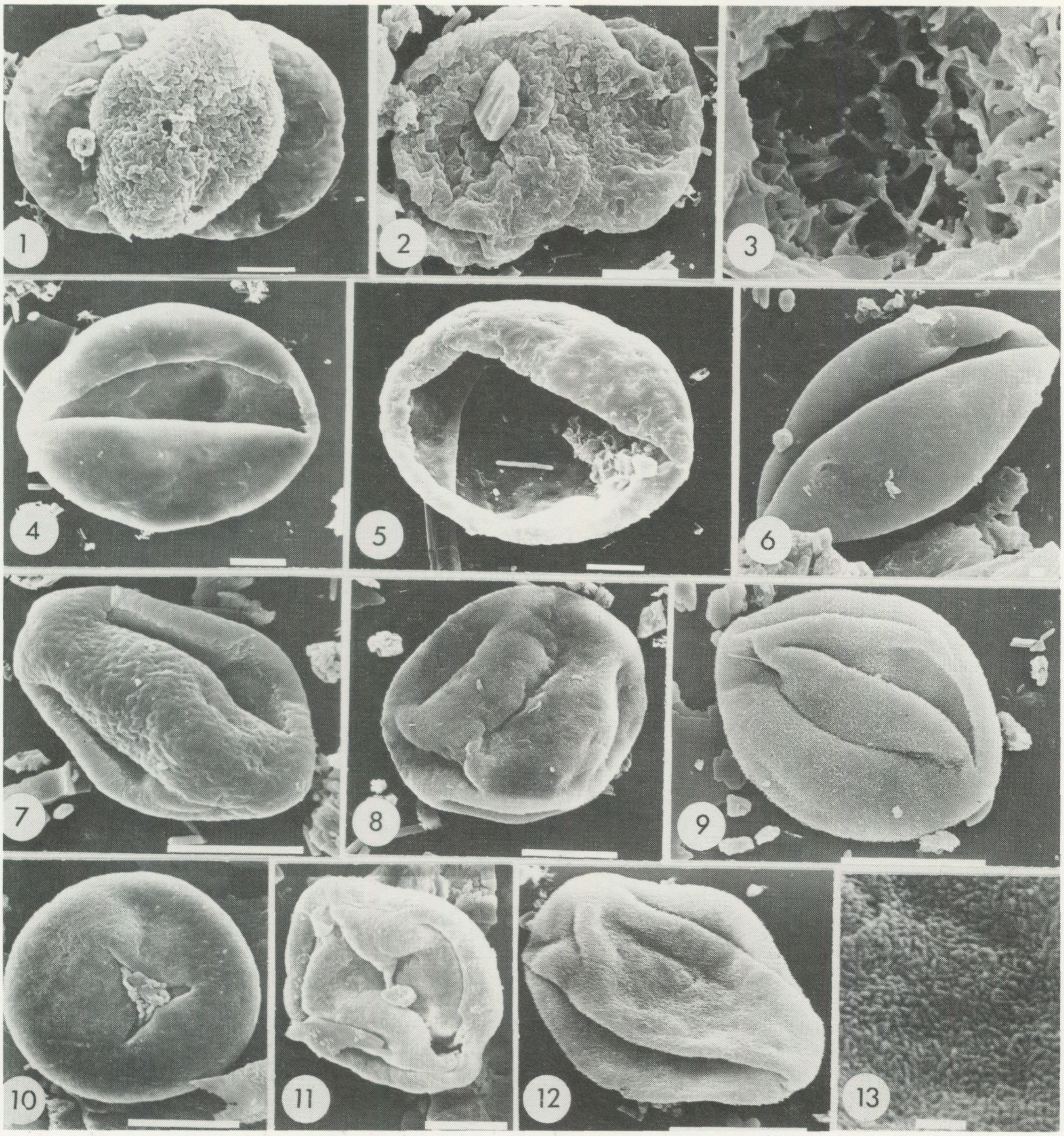

1
2
3
4
5
6
7
8
9
10
11
12
13

PLATE 4

Figs. 1-9 *Sp. indet.*
(1) Å-SEM/12: 165.42-165.43, (2) Å-SEM/18: 166.77-166.78, (3) Å-SEM/11: 165.14-165.16, (4) Å-SEM/9: 164.89-164.92, (5) Å-SEM/5: 166.56-166.57, (6) Å-SEM/3: 161.19, (7) Å-SEM/3: 161.19, (8) Å-SEM/ 164.89-164.92, (9) Å-SEM/19: 167.05-167.07

Figs. 10-12 *Densosporites* sp.
Å-SEM/3: 161.19

(Bar length = 1 micron in Figs. 2, 5-7, 11-12 and 10 microns in all of the others)

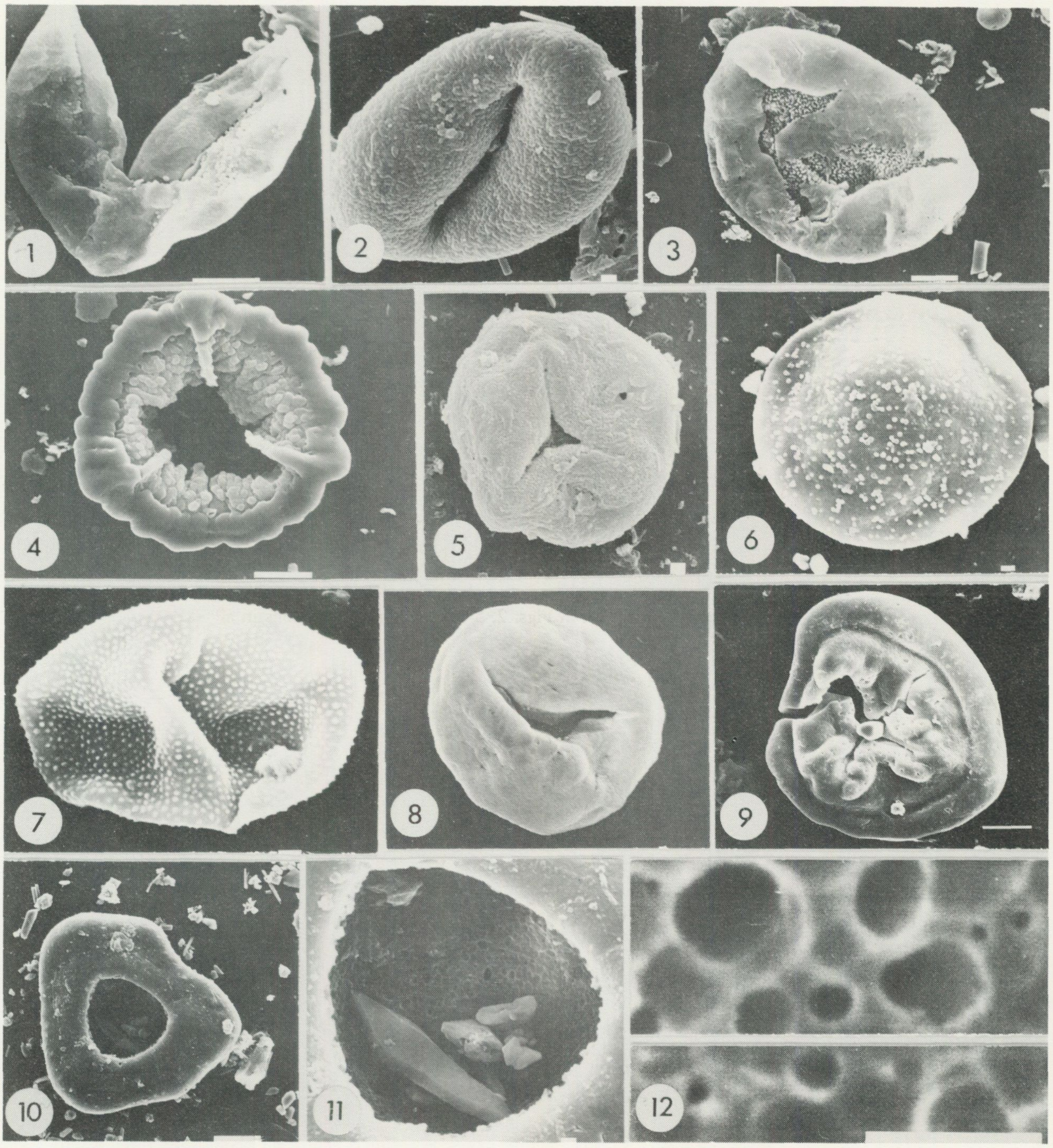

1
2
3
4
5
6
7
8
9
10
11
12

PLATE 5

Fig. 01 *Sp. indet.*
Å-SEM/17: 166.56-166.57

Fig. 02 *Botryococcus* sp.
Å-SEM/17: 166.56-166.57

Fig. 03 *Botryococcus* sp.
Å-SEM/9: 164.89-164.92

Figs. 4-6 *Micrhystridium* spp.
(4) & (5) Å-SEM/17: 166.56-166.57, (6) Å-SEM/18: 166.77-166.78

Figs. 7-8 *Nannoceratopsis gracilis* (Alberti) Evitt
Å-SEM/18: 166.77-166.78

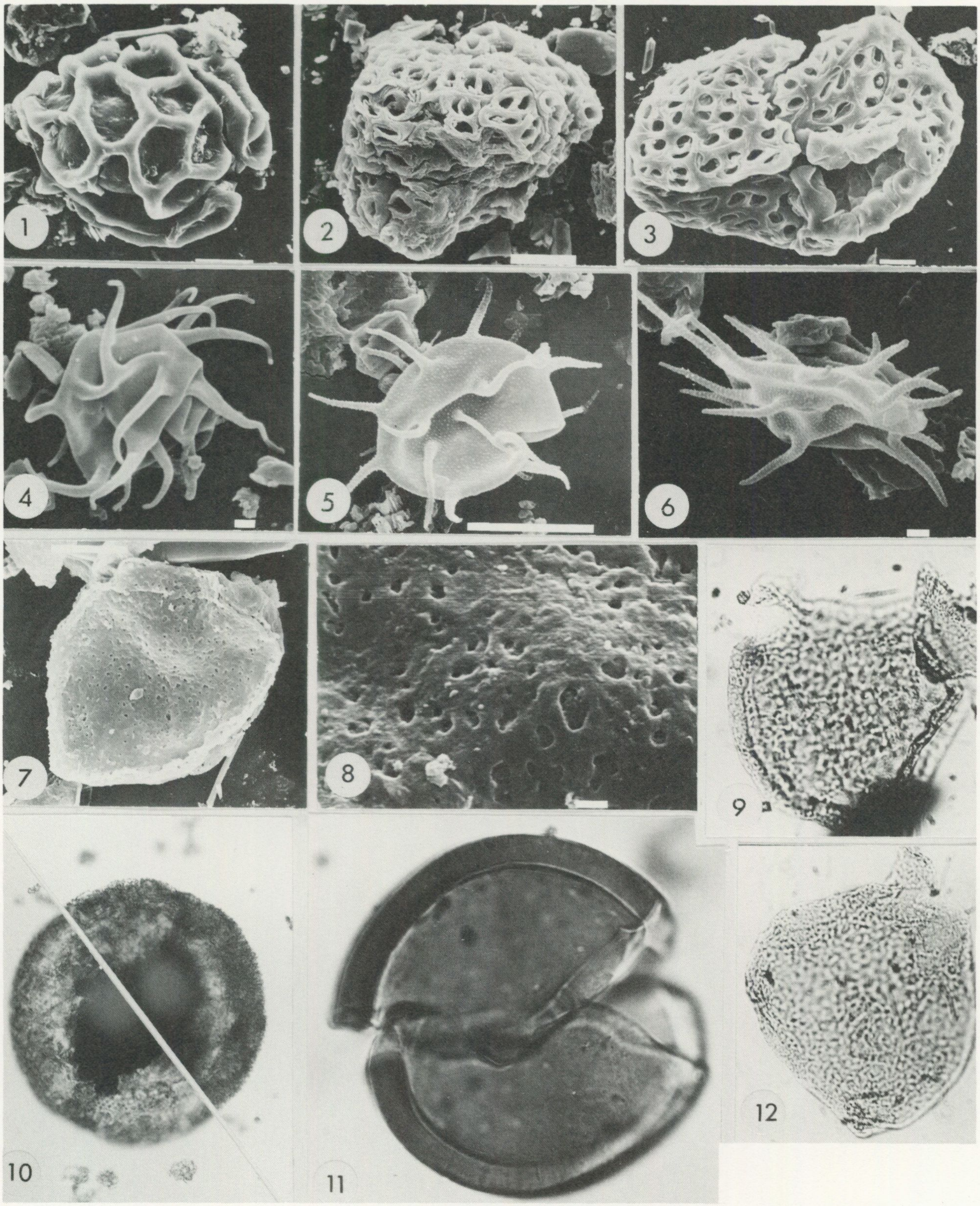
Fig. 09 *Nannoceratopsis gracilis* (Alberti) Evitt
Å 166.77-166.79/1 (92.5/25.6) x 1250

Fig. 10 *Tasmanites* sp.
Å 165.14-165.16/9 (105.6/48.4) x 400

Fig. 11 *Tasmanites* sp.
Å 161.19/2 (105.6/35.6) x 900

Fig. 12 *Nannoceratopsis gracilis* (Alberti) Evitt
Å 167.05-167.07/1 (96.3/20.0) x 1250

(Bar length = 10 microns in Figs. 1-7 and 1 micron in Fig. 8)


1
2
3
4
5
6
7
8
9
10
11
12

PRISKLASS B

Distribution
Liber Distribution
S-162 89 STOCKHOLM
Tel. 08-739 96 60

Tryck: Offsetcenter AB, Uppsala 1988

ISBN 91-7158-451-X
ISSN 0348-1352