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Dinoflagellates of the Callovian-Oxfordian boundary of the "Liesberg-Dorf" quarry (Berner Jura, Switzerland)

By

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With 7 figures and 1 table in the text

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Abstract: A rich dinoflagellate flora (47 genera and more than 70 species) contains a new genus based on a new species *(Liesbergia* n. g. *liesbergensis* n. sp.). The genus *Eodinia* is emended and two new combinations are proposed. Late Callovian to early Oxfordian zonations based on dinoflagellates and ammonites are discussed.

Key words: Dinoflagellate, New genus *Liesbergia,* Callovian, Oxfordian, Schweizer Jura, Liesberg, Biostratigraphy, Dinoflagellate zones, Ammonite zones.

Résumé: Les sédiments callovo-oxfordiens de Liesberg-Dorf (Anceps-Athleta Schicht, Eisenoolitischer Tonmergel, Renggeritone et Terrain à chailles) ont fourni une riche flore de dinoflagellés comprenant 47 genres et plus de 70 espèces. Un nouveau genre, *Liesbergia* n. g.), une nouvelle espèce *(Liesbergia liesbergensis* n. sp.), une nouvelle émendation *(Eodinia* Eisenack émend. Gocht émend. n.) et deux nouvelles combinaisons *(Liesbergia scarburghensis* (Sarjeant) n. comb. et *Eodinia mosaicum* (Dodekova) n. comb.) sont proposées. La répartition des dinoflagellés de Liesberg-Dorf par rapport aux zones d'ammonites *(P. coronatum, P. athleta, Q. lamberti, Q. mariae, C. cordatum* et *C. densiplicatum)* est discutée de même que les corrélations entre zone d'ammonites et zones de dinoflagellés du Callovien supérieur/Oxfordien inférieur européen.

Zusammenfassung: In den Callovo-Oxfordien-Sedimenten von Liesberg-Dorf (Anceps-Athleta Schicht, Eisenoolitischer Tonmergel, Renggeritone und Terrain à chailles) wurde eine reiche Dinoflagellatenflora (47 Gattungen und mehr als 70 Arten) entdeckt. Eine neue Gattung (*Liesbergia* n. g.), eine neue Art *(Liesbergia liesbergensis* n. sp.), eine neue Emendation *(Eodinia* Eisenack emend. Gocht emend. n.) und zwei neuen Kombinationen *(Liesbergia scarburghensis* (Sarjeant) n. comb. und *Eodinia mosaicum* (Dodekova) n. comb. werden vorgeschlagen. Die stratigraphische Verteilung der Dinoflagellaten von Liesberg-Dorf wird mit den Ammonitenzonen verglichen *(P. coronatum, P. athleta, Q. lamberti, Q. mariae, C. cordatum* und *C. densiplicatum)* sowie mit der Korrelation zwischen Ammoniten- und Dinoflagellatenzonen im europäischen Obercallovien und Unteroxford.

Introduction

Following the recent biostratigraphical progress of palynology for the Middle and Late Jurassic, several zonations based on the dinoflagellates were proposed, most of them resulting from the investigations in the English and North Sea Jurassic (RAYNAUD 1978; RILEY & FENTON 1982; WOOLLAM & RIDING 1983). In order to compare these results with Swiss Jurassic palynofloras, a first study concerning the early Oxfordian (Zone of *Q. mariae)* was undertaken; the choise of this zone and of the Liesberg quarry was determined by the following advantages:

- The base of the Oxfordian is generally well known for its rich flora of dinoflagellates.
- The sediments of the Zone of *Q. mariae* are very sparse in the Swiss and German Jurassic, where there is a generalized hiatus at the basis of the Oxfordian (Zones of *Q. mariae* and *C. cordatum*), unlike the "Liesberg-Dorf" quarry which shows a continuous outcrop of these layers (Renggeritone, cf. FISCHER 1965).
- Because of their lithology (grey marls) the "Renggeritone" were expected to contain rich palynomorph assemblages.
- This quarry has been the object of numerous paleontological and biostratigraphical investigations (DE LORIOL 1896–1899; FISCHER 1965; GYGI 1977; GRÜN & ZWEILI 1980; GYGI & MARCHAND 1982; BERNOULLI & GYGI 1983), which should allow a correlation between ammonite and dinoflagellate zones.

Biostratigraphical frame

The "Liesberg-Dorf" quarry, known and studied since the last century (cf. Fig. 1), was visited in 1965 by the IXth European Colloquium of Micropaleontology. On this occasion, FISCHER (1965) published a detailed study of the quarry (location, map, sections, sketches) with a short historic account and the list of the sampled faunas; for further information, the reader should refer to this study.

It also was on the occasion of this colloquium that MILLIOUD (1965) described 10 species of dinoflagellates (with *Gonyaulax areolata* SARJEANT and *Wanaea fimbriata* SARJEANT), 2 species of acritarchs and 8 species of spores and pollens from the "Renggeritone" of Liesberg.

During his numerous studies of the Oxfordian sediments, R. GYGI repeatedly mentioned the stratigraphical position based on the ammonites of the Liesberg-Dorf quarry (GYGI 1977, GYGI & MARCHAND 1982, BERNOULLI & GYGI 1983).

Finally, in 1980, GRÜN & ZWEILI published a study of the nannofossils of Liesberg; the sample taken in the "Renggeritone" (and containing 57 species of nannofossils) indicated an early Oxfordian age.

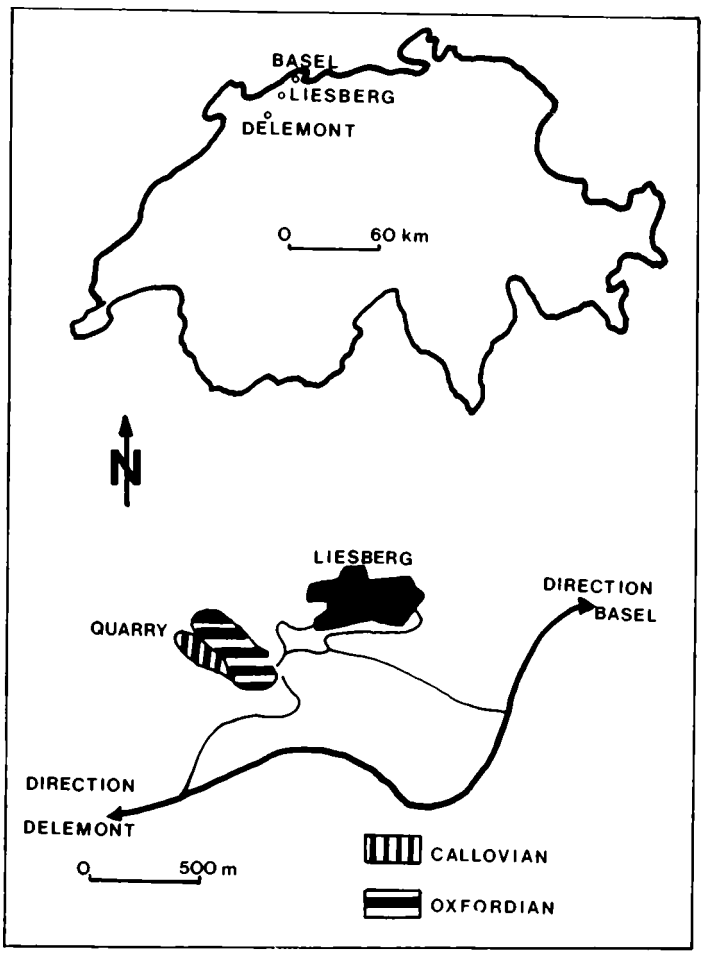

Fig. 1. Location map.

Sampling and Methods

Sixteen samples were prepared (following the usual palynological methods) at the "Geologisch-Paleontologisches Institut der Universität Tübingen". Eight samples were taken in the "Renggeritone" (including the Eisenoolitischer Tonmergel") and the others in the adjacent stratigraphical levels (3 samples in the "Anceps-Athleta Schichten" and 5 samples in the Terrain à Chailles"). The detailed section with the position of the samples is given in Fig. 2.

All of the prepared samples were prolific in palynomorphs; they generally contained spores, pollens, acritarchs and tasmanitaceae, as well as a rich flora of dinoflagellates (e. g. sample 6 contained a few hundred individuals belonging to 50 species on only 4 slides).

The chief purpose of this study being biostratigraphy, the acritarchs, spores, pollens and tasmanitides will not be described here, whereas the

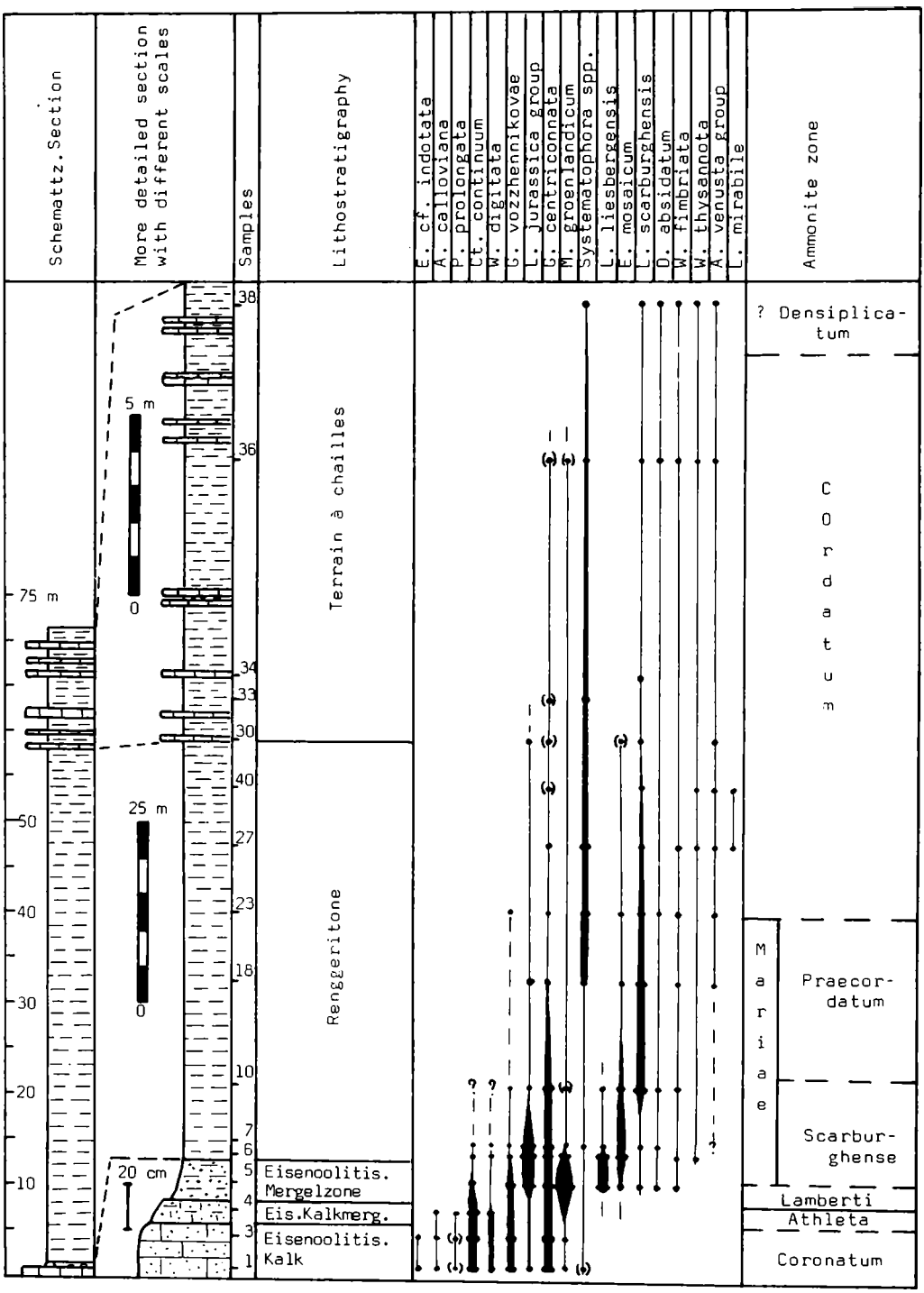

Fig. 2. Studied section with ranges of some dinoflagellates and ammonite zones.

Table 1. Range chart. The numbers correspond to the samples.

	1	3	4	5	6	7	10	19	23	27	40	30	33	34	36	38
"Adnatosphaeridium" caulleyri	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Ambonosphaera calloviana	x	x	x													
Apteodinium nuciforme	x					x	x		x	x				x		
Belodinium cf. asaphum	x				x			x							x	
Chytroeisphaeridia chytroeides	x	x	x	x	x	x	x		x	x	x	x	x		x	x
Cleistosphaeridium ehrenbergii	x	x		x	x	x	x		x	x				x		
Cleistosphaeridium lumectum	x			x	x	x	x	x		x	x	x	x		x	
Cleistosphaeridium polycanthum	x		x		x			x							x	x
Cleistosphaeridium tribuliferum	x	x		x	x	x		x	x	x	x	x	x		x	x
Compositosphaeridium polonicum	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Ctenidodinium continuum	x	x	x	x	x	x	?									
Ctenidodinium ornatum	x	x	x	x	x	x	x	x		x	x	x			x	x
Ctenidodinium stauromatos	x	x				x		x	x	x	x	x	x	x	x	x
"Diacanthum" filapicatum	x	x														
Ellipsoidictyum cinctum group	x	x				x				x			x			x
Energlynia cf. indotata	x	x														
Epiplosphaera + Histiophora	x			x	x	x	x	x	x	x	x		x		x	x
Escharisphaeridia pocockii	x	x			x	x	x	x		x	x	x			x	x
Escharisphaeridia spp.	x	x		x	x	x	x	x	x	x	x	x	x		x	x
Gonyaulacysta centriconnata	x	x		x	x	x	x	x	x	x	x	x	x		x	
Gonyaulacysta eisenackii	x	x		x	x	x	x	x	x	x	x	x			x	x
"Gonyaulacysta jurassica s.l."	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Gonyaulacysta vozzhennikovae	x	x		x	x	x	x		?							
"Hystrichogonyaulax" cladophora	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
"Korystocysta" pachyderma	x	x			x	x	x	x	x	x	x	x	x		x	x
Korystocysta spp.	x	x			x	x	x	x	x	x	x	x	x			x
Lithodinia jurassica group	x			x	x	x	x	x				x				
Meiourogonyaulax spp.	x					x		x	x	x	x				x	x
Mendicodinium groenlandicum	x	x		x	x	x	x								x	
Pareodinia ceratophora	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Pareodinia prolongata	x	x	x													
Sentusidinium spp. pilosum group	x	x		x	x	x	x		x	x	x	x	x	x	x	x
Sentusidinium spp. rioultii group	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stephanelytron scarburghense	x	x														
Surculosphaeridium cribrotubiferum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Surculosphaeridium vestitum	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Systematophora spp.	x					x		x	x	x	x	x	x		x	x
Tubotuberella apatela	x					x		x	x			x			x	x
Tubotuberella dangeardii	x	x		x	x	x	x	x	x	x	x	x	x		x	x
Valensiella ovulum	x	x	x		x			x	x	x						?
Wanaea digitata	x		x		x	x	?									
Dissiliodinium sp.		x														
Hystrichosphaerina orbifera		x											?			
Nannoceratopsis pellucida		x		x	x	x				x	x	x	x		x	x
Aldorfia dictyophora				x	x	x	x	x	x	x	x	x	x		x	x
Atopodinium prostatum				x	x											
Chlamydophorella spp.				x	x		x	x		x		x	x			
Ctenidodidium sellwoodii				x		x		x			x					
Dinopterygium absidatum				x		x	x		x						x	x
Endoscrinium galeritum				x		x	x	x	x	x	x	x	x		x	x
Eodinia mosaicum				x	x		x	x	x			x				
Liesbergia liesbergensis				x	x		x									
Liesbergia scarburghensis				x		x	x	x	x	x	x	x		x	x	x
Prolixosphaeridium mixtispinosum group				x	x	x		x		x						
Rigaudella aemula				x	x	x	x		x	x	x	x	x		x	x
Sirmiodinium grossi				x	x	x	x	x	x	x	x				x	x
Stephanelytron caytonense				x		x	x				x	x				x
Wanaea fimbriata				x	x	x	x	x	x	x	x				x	x
Cleistosphaeridium polytrichum					x	x	x	x			x	x	x			x
Eodinia cf. mosaicum					x	x	x	x	x			x				
Netrelytron stegastum					x	x										
Polystephanephorus spp.					x				x	x						
Stephanelytron redcliffense					x	x	x			x	x				x	x
Wanaea thysannota					x					x	x				x	x
Sirmiodiniopsis orbis						x		x		x						
Scriniodinium crystallinum						x		x	x	x	x	x	x		x	x
Acanthaulax venusta						?		x	x	x	x	x			x	x
Endoscrinium luridum									x	x			x			
Leptodinium mirabile										x	x					
? Leptodinium sp. A													x			

dinoflagellates (70 species distributed in 47 genera) were studied in detail (cf. Table 1).

Taxonomical Remarks

The following list of taxa contains those cited in the text and in the range chart, and includes, where appropriate, brief comments on important aspects of taxonomy. A new genus, a new species, two new combinations and a new emendation are proposed. All the material is deposited at the "Geologisch-Paleontologisches Institut der Universität Tübingen" under no 1636.

Class Dinophyceae Fritsch 1929
Order Peridiniales Haeckel 1896
Family Pareodiniaceae Gocht 1957

Genus *Netrelytron* Sarjeant 1961

N. stegastum Sarjeant 1961; Fig. 6/12. Often cited with the genus-name *Kalyptea.*

Genus *Pareodinia* Deflandre 1947, emend. Stover & Evitt 1978

P. ceratophora Deflandre 1947.

P. prolongata Sarjeant 1959.

Family Gonyaulacaceae Lindemann 1928

Following the classification proposed by Stover & Evitt (1978), I subdivided this family into 4 groups.

1. Gonyaulacaceae with apical archeopyle.

Genus *Adnatosphaeridium* Williams & Downie 1966

"A." caulleryi (Deflandre 1938) Williams & Downie 1966

Following the recent works of Below (1982), many species were transfered from the genus *Adnatosphaeridium* to the genus *Rigaudella* Below. However, this author thinks (written communication) that *A. caulleryi* is neither an *Adnatosphaeridium* nor a *Rigaudella*. Because I will not discuss this point here, I retain, for the moment, the attribution of *A. caulleryi* (i. e. *Adnatosphaeridium*) but with some reservations. On the other hand, the affinities between *"A. caulleryi"* and a few *Systematophora (S. valensi,* for example) or *Polystephanephorus* often cause some difficulties. In this study, all the specimens considered as *"A." caulleryi* are only those without proximal *(Systematophora)* or distal ring *(Polystephanephorus).* Many intermediate forms probably exist between these different species.

Genus *Ambonosphaera* Fensome 1979

A. calloviana Fensome 1979.

Genus *Belodinium* Cookson & Eisenack 1960

B. cf. *asaphum*, Fig. 7/6.

Only some rare specimens of this genus were observed. A complete form shows the absence of an apical horn, differentiating this species from *B. dysculum* C. & E. 1960 and *B. obsoletum* Dodekova 1975. There are many affinities with *B. asaphum* Drugg 1978, but the paratabulation is not so neat as for the Drugg's species.

Genus *Chlamydophorella* Cookson & Eisenack 1958

Chlamydophorella spp.

Some forms probably belong to this genus, but they are too rare to be determined specifically.

Genus *Cleistosphaeridium* Davey, Downie, Sarjeant & Williams 1966

The different species of this genus are not always easy to determinate; in this study, distinguished:

- The *Cleistosphaeridium* with simple processes:
  - *C. polytrichum* (Valensi 1947) D. D. S. & W. 1969, (> 100 processes, often short)
  - *C. polyacanthum* Gitmez 1970 (48–72 processes, often short)
  - *C. ehrenbergi* (Deflandre 1947) D. D. S. & W. 1969 (30–52 processes, a little longer than those of *C. polyacanthum*).
- The *Cleistosphaeridium* with processes rather bifurcate:
  - *C. lumectum* (Sarjeant 1960) D. D. S. & W. 1969
- The *Cleistosphaeridium* with processes rather stellate:
  - *C. tribuliferum* (Sarjeant 1962) D. D. S. & W. 1969

Genus *Compositosphaeridium* Dodekova 1974

C. polonicum (Gorka 1965) Erkmen & Sarjeant 1980

Genus *Ellipsoidictyum* Klement 1960

"*E. cinctum* group"

I regroup here, with *E. cinctum* Klement 1960, a few forms with sparse reticulation, belonging to *Ellipsoidictyum* but probably different from *E. cinctum*.

Genus *Epiplosphaera* Klement 1960

Epiplosphaera spp., very sparse

Genus *Escharisphaeridia* Erkmen & Sarjeant 1980

Escharisphaeridia spp.

I regroup here many forms belonging probably to different species of *Escharisphaeridia*; some are smooth, others reticulate (like *E. dictyidia* (Sarjeant 1972) E. & S. 1980).

Genus *Histiophora* Klement

Histiophora spp., very sparse.

Genus *Hystrichosphaerina* Alberti 1961

H. orbifera Klement 1960.

Genus *Lithodinia* Eisenack 1935 emend. Gocht 1975

"*L. jurassica* group", Fig. 5/11.

This group contains the typical *L. jurassica* Eisenack 1935 emend. Gocht 1975 and some *Meiourogonyaulax* which are morphologically close such *M. caytonensis* (Sarjeant 1959) Sarjeant 1969, *M. callomonii* Sarjeant 1972 or *M. cristullata* (Sarjeant 1959) Sarjeant 1969. This "group" fits with the "*Meiourogonyaulax caytonensis* group" in Woollam & Riding 1983.

Genus *Meiourogonyaulax* Sarjeant 1966

Meiourogonyaulax spp.

Several species belonging to the genus *Meiourogonyaulax* but different from those of the "*Lithodinia jurassica* group". Some forms seem close to *M. deflandrei* Sarjeant 1968, others may be close to *M. rioultii* Sarjeant 1968.

Genus *Polystephanephorus* Sarjeant 1961

Polystephanephorus spp.

Regrouping *P. calathus* (Sarjeant 1961) Downie & Sarjeant 1965 and *P. paracalathus* (Sarjeant 1960) Downie & Sarjeant 1965.

Genus *Rigaudella* Below 1982

R. aemula (Deflandre 1938) Below 1982

Genus *Sentusidinium* Sarjeant & Stover 1978

In spite of the few species described in the literature (cf. Erkmen & Sarjeant 1980,

In spite of the few species described in the literature (cf. ERKMEN & SARJEANT 1980, COURTINAT & GAILLARD 1980), I regrouped all the *Sentusidinium* into 2 groups, following WOOLLAM & RIDING (1983):

Sentusidinium spp. *"pilosum* group"
- Elongate form, with thin processes, often pointed distally.

Sentusidinium spp. *"rioultii* group"
- Rounded form, with thick processes, bifurcate distally.

Genus *Sirmiodiniopsis* DRUGG 1978

orbis DRUGG 1978

Genus *Surculosphaeridium* DAVEY, DOWNIE, SARJEANT & WILLIAMS 1966

vestitum (DEFLANDRE 1938) D. D. S. & W. 1966.
cribrotubiferum (SARJEANT 1960) D. D. S. & W. 1966.

These two species are not always easy to distinguish.

Genus *Systematophora* KLEMENT 1960

ystematophora spp.

Diverse forms with proximal ring of which some are close to *S. valensi* (SARJEANT 960) DOWNIE & SARJEANT 1965, to *S. orbifera* KLEMENT and to *S. fasciculigera* KLEMENT 960.

Genus *Valensiella* EISENACK 1963

. ovulum (DEFLANDRE 1947) EISENACK 1963

2. Gonyaulacaceae with precingular archeopyle

Genus *Acanthaulax* SARJEANT 1968

. venusta (KLEMENT 1960) SARJEANT 1968, Fig. 5/9–10.

Genus *Aldorfia* STOVER & EVITT 1978

. dictyophora (DEFLANDRE 1938) STOVER & EVITT 1978, Fig. 6/9–10.

The numerous specimens clearly show the wall structure of *Aldorfia* and agree xactly with the description by DEFLANDRE (1938). The species could be conspecific ith *Endoscrinium galeritum reticulatum* POCOCK 1972 and *Endoscrinium subvallare* ARJEANT 1962. Furthermore, it is possible that forms as described here were sometimes onfused with *Scriniocassis dictyotus* (COOKSON & EISENACK 1960) BEJU 1971.

Genus *Apteodinium* EISENACK 1958

. nuciforme (DEFLANDRE 1938) STOVER & EVITT 1978

Genus *Chytroeisphaeridia* SARJEANT 1962 emend. DAVEY 1978

C. chytroeides (SARJEANT 1962) DOWNIE & SARJEANT 1965 emend. DAVEY 1979

Genus *Diacanthum* HABIB 1972

"D." filapicatum (GOCHT 1970) STOVER & EVITT 1978

According to BELOW (1981), the genus *Diacanthum* is a junior synonym of *Occisucysta* GITMEZ 1970. This would imply the transfer of *D. filapicatum* to the genus *Occisucysta*. However, *Occisucysta* has a 2P archeopyle, while *D. filapicatum* has a combined one, with 3" + 4" + the cingular plates and sometimes other precingular plates (H. GOCHT and W. WILLE, oral communication). Thus, the attribution of the species *"filapicata"* to the genus *Gonyaulacysta* (cf. GOCHT 1980) *Diacanthum* (cf. STOVER & EVITT 1978) or *Occisucysta* does not seem justified. The erection of a new genus (which could be the phylogenetic "ancestor" of *Liesbergia*) would be desirable, but this is beyond the scope of this study.

Genus *Dissiliodinium* DRUGG 1978

Dissiliodinium spp.

One ore two specimens can be attributed to this genus, notably on the base of the archeopyle (1", 2", 3", 4", 5"). Different from *D. globulum* DRUGG 1978 because of their thin and fine wall, they cannot be determinated specifically because of their scarcity.

Genus *Endoscrinium* (KLEMENT 1960) VOZZHENNIKOVA 1967

This genus is sometimes considered as a synonym of *Scriniodinium* KLEMENT 1957.

E. galeritum (DEFLANDRE 1938) VOZZHENNIKOVA 1967
E. luridum (DEFLANDRE 1938) GOCHT 1970

Genus *Gonyaulacysta* DEFLANDRE 1964, ex NORRIS & SARJEANT 1965, emend. SARJEANT 1982

G. centriconnata RIDING 1983, Fig. 7/9–10: Before: *"Endoscrinium* MUIR & SARJEANT" *"G. jurassica* s. l.".

Includes the subspecies *G. jurassica* (DEFLANDRE 1938) subsp. *jurassica* DEFL. 1958 emend. SARJEANT 1982 and *G. jurassica* (DEFL. 1938) subsp. *adecta* SARJEANT 1982. These very frequent forms represent sometimes more than 30% of the dinoflagellates in one sample.

G. vozzhennikovae SARJEANT 1982
G. eisenackii (DEFLANDRE 1938) DODEKOVA 1967, emend. SARJEANT 1982.

According to SARJEANT 1982, this species is probably closer to the genus *Gonyaulacysta* than to the genus *Tubotuberella* to which it is often attributed.

Genus *Hystrichogonyaulax* SARJEANT 1969

"H." cladophora (DEFLANDRE 1938) STOVER & EVITT 1978.

The attribution of the species *cladophora* to the genus *Hystrichogonyaulax* is generally accepted, but BELOW (1981) estimates that the genus is no longer valid and proposes to range this species in the genus *Rhynchodiniopsis* DEFLANDRE 1935 emend. BELOW 1981. This species is the most frequent form after *G. jurassica.*

Genus *Leptodinium* KLEMENT 1960, emend. STOVER & EVITT 1978, emend. SARJEANT 1982

L. mirabile KLEMENT 1960, Fig. 6/7, 2 specimens only, but very well preserved.
L. sp. *A*, Fig. 6/6–8.

A single specimen showing a very well preserved paratabulation and probably belonging to *Leptodinium* is very distinct from the known species by the presence, on the parasutures, of spinose ridges.

Liesbergia n. g.

Diagnosis: Cysts relatively large and bearing a precingular (P = 3'' or 2 P = 3'' + 1'') archeopyle. Ornamentation consists of small spines, more or less dense. Paratabulation standard gonyaulacoid.

A very characteristic apical horn is formed by anastomosing fibres (cf. Fig. 3). In the apical area, a small vaulting is normally formed just under the horn (cf. Fig. 3).

Differential diagnosis: This genus can be distinguished from the genus *Acanthaulax* in having a very characteristic apical horn which is only formed by a development of the external ornamentation and not by the entire periphragma as in *Acanthaulax* (cf. Fig. 3).

Derivatio nominis: From the Liesberg-quarry (Swiss Jura).

Type-species: *L. liesbergensis* n. sp.

Other species: *L. scarburghensis* (SARJEANT 1964) n. comb.

Remarks: *"D." filapicatum* (GOCHT 1970) STOVER & EVITT 1978 has great affinities with *Liesbergia.* However, the combined archeopyle and the more massive apical horn would put this species rather in a genus close to *Liesbergia* than in *Liesbergia* s. str.

Liesbergia liesbergensis n. sp., Fig. 5/1–7.

Diagnosis: Cysts relatively large and bearing a precingular (P 3'' or 2 P 3'' + 4'') archeopyle. The ornamentation consists of very sparse spines forming sometimes a small reticulation on the plate surface. The parasutures are underlined by numerous spines which are generally connected by trabeculae. The paratabulation is very well expressed (including the sulcal and cingular area) and is standard gonyaulacoid. An apical horn is formed by elongate anastomosing fibres.

Description and discussion: This species is very close to *Liesbergia carburghensis* (SARJEANT 1964) n. comb. from which it can be distinguished

by its less dense ornamentation and a very well paratabulation; comparing with *"D." filapicatum* (Gocht 1970) Stover & Evitt 1978, *L. liesbergensis* is different by its archeopyle, its apical structure an especially the apical horn (cf. Fig. 3).

Holotype: Sample 6 d, coord. 6.0 x 108.2 (WW). Fig. 5/1–4.
Deposit: Univ. Tübingen, No 1636/6 d 506.
Dimensions of the holotype: 82 µm ∅, 100 µm long + 18 µm (horn).
Derivatio nominis: From the Liesberg-quarry.
Locus typicus and stratum typicum: Renggeritone from Liesberg Dorf, Lower Oxford (*Cardioceras scarburgense* subzone).

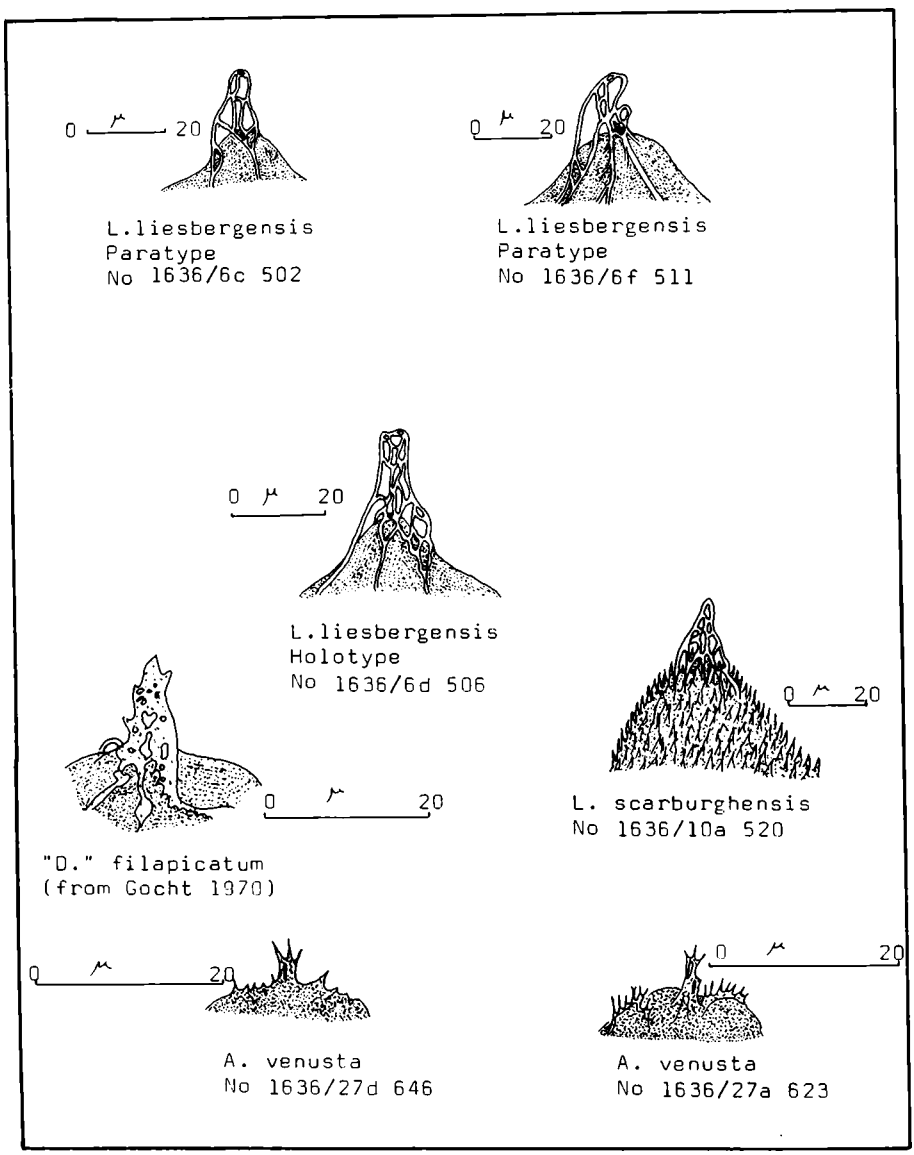

Fig. 3. Comparison between the apical horns of *Liesbergia*, *Acanthaulax* and *Diacanthum*.

Liesbergia scarburghensis (SARJEANT 1964) n. comb., Fig. 5/12.

SARJEANT 1961: *"Gonyaulax areolata"*, p. 95–97, Pl. 13, Fig. 13, Text-Fig. 5.
SARJEANT 1964: *G. scarburghense*, p. 472–473.
DRUGG 1978: *Acanthaulax senta*, p. 62, Pl. 3, Fig. 13; pl. 4, Fig. 1–3.

Because of the elements already discussed (notably the structure of the apical horn), the species *G. scarburghensis* SARJEANT 1964 is now put in the genus *Liesbergia*. On the other hand it is confirmed that *A. senta* DRUGG and *G. scarburghense* SARJEANT (holotype reexamined by W. Wille) are synonymous. Consequently, the forms described as *A. senta* or *G. scarburghensis* in the literature must be considered now as *Liesbergia scarburghensis* (SARJEANT 1964) n. comb.

Genus *Scriniodinium* KLEMENT 1957

S. crystallinum (DEFLANDRE 1938) KLEMENT 1957, Fig. 6/11.

Genus *Tubotuberella* VOZZHENNIKOVA 1967, emend. SARJEANT 1982

T. dangeardii (SARJEANT 1968) STOVER & EVITT 1978, emend. SARJEANT 1982.

This species was sometimes attributed to *Dimidiadinium* BRIDEAUX 1977, but the recent studies of SARJEANT (1982) seem to justify its return to the genus *Tubotuberella*.

T. apatela (COOKSON & EISENACK 1960) IOANNIDES, STAVRINOS & DOWNIE 1976, emend. SARJEANT 1982, Fig. 5/8.

According to SARJEANT (1982) who rejects the genus *Glabridinium* BRIDEAUX 1977, I retain the species *apatelum* in the genus *Tubotuberella*. The affinities between *dangeardii* and *apatelum* confirm that they belong to the same genus.

B. Gonyaulacaceae with epicystal archeopyle

Genus *Ctenidodinium* DEFLANDRE 1938

C. continuum GOCHT 1970. Fig. 7/11.
C. ornatum (EISENACK 1935) DEFLANDRE 1938, Fig. 7/13.
C. sellwoodii (SARJEANT 1975) STOVER & EVITT 1978, Fig. 7/2.
C. stauromatos (SARJEANT 1976) STOVER & EVITT 1978, Fig. 7/1.

Remarks: *C. sellwoodii* and *C. stauromatos* are often considered as *Dichadogonyaulax* SARJEANT 1966 (cf. especially WOOLLAM 1983).

Genus *Dinopterygium* DRUGG 1978

D. absidatum DRUGG 1978, Fig. 7/3.

Energlynia SARJEANT 1976

E. cf. *indotata*, Fig. 6/1-2.

Forms of the "*Energlynia-Wanaea* group" in which the form and the frange of the paracingulum seem closer to *E. indotata* (DRUGG 1978) FENSOME 1981 than to *E. acollaris* (DODEKOVA 1975) SARJEANT 1978 or *W. spectabilis* (DEFLANDRE & COOKSON 1955) COOKSON & EISENACK 1968.

Genus *Eodinia* EISENACK 1936 emend. GOCHT 1975, new emendation

Emended diagnosis: polygonal or ovoid body, with small apical horn. The widest part of the test is in the lower part of the paracingulum. Paratabulation standard gonyaulacacean 4', 1 a, 6'', ?6 c, 6''', 1 p., 1'''', 6 s. Parasutures often underlined by spines. Double wall with endophragma and periphragma joined by massive elements giving a mosaical aspect. Archeopyle epicystal.

Differential diagnosis: *Eodinia* can be distinguished from *Ctenidodinium* DEFLANDRE 1938 and *Korystocysta* WOOLLAM 1983 by the double wall connected by massive or fibrous elements and by the growth of the postcingular plates on both sides.

Type-species: *Eodinia pachytheca* EISENACK 1936 emend. GOCHT 1975.

Other species: *E. mosaicum* (DODEKOVA 1975) nov. comb.
E. cf. *mosaicum.*

The problem of *K. pachydermum* will be discussed with the genus *Korystocysta.*

E. mosaicum (DODEKOVA 1975) n. comb., Fig. 7/7.

DODEKOVA 1975: *Ctenidodinium mosaicum,* p. 18-19, Pl. I, fig. 1-6, Pl. II, fig. 1, 3, 6.

The double wall (underlined by the mosaic aspect), the epicystal archeopyle and the apical horn justify the transfer from the genus *Ctenidodinium* to the genus *Eodinia.*

E. cf. *mosaicum*, Fig. 7, /4, 5, 8.

This species differs from *E. mosaicum* by its "mosaic" only visible by phase contrast. With normal light, these forms seemed very close to *Korystocysta pachyderma* (DEFLANDRE 1938) WOOLLAM 1983.

Genus *Korystocysta* WOOLLAM 1983

Korystocysta spp.

Forms very close to *K. kettonensis* (SARJEANT 1976) WOOLLAM 1983, but different from *K. pachyderma* (DEFLANDRE 1938) WOOLLAM 1983.

The numerous specimens attributed to *"K." pachyderma* possess (at least partially) the structure of the wall of *Eodinia.* It is possible that this species should be transferred to the genus *Eodinia.* However, only the examination of the holoypte of *K. pachyderma*

with phase contrast would permit to answer this question. Further, the postcingular plates of *K. pachyderma* show a growth in both sides as by *Eodinia*. However, the plate configuration seems closer to *Ctenidodinium* than to *Eodinia*.

Genus *Mendicodinium* Morgenroth 1970

M. groenlandicum (Pocock & Sarjeant 1972) Davey 1979

Genus *Wanaea* Cookson & Eisenack 1958

W. digitata Cookson & Eisenack 1958 emend. Woollam 1982, Fig. 6/3.

Although Woollam (1982) estimates that *W. digitata* is restricted to Australia, some specimens which seem to belong to this species (and not to *W. thysanota*) were observed.

W. thysanota Woollam 1982, Fig. 6/4.

W. fimbriata Sarjeant 1961, Fig. 6/5.

4. Gonyaulacaceae with combined archeopyle

Genus *Sirmiodinium* Alberti 1961 emend. Warren 1973

S. grossii Alberti 1961 emend. Warren 1973.
Family Stephanelytraceae Stover, Sarjeant & Drugg 1977.

Genus *Stephanelytron* Sarjeant 1961 emend. Stover, Sarjeant & Drugg 1977.

S. caytonense Sarjeant 1961, emend. Stover, Sarjeant & Drugg 1977.
S. redcliffense Sarjeant 1961, emend. Stover, Sarjeant & Drugg 1977, Fig. 7/12.
S. scarburghense Sarjeant 1961, emend. Stover, Sarjeant & Drugg, 1977.

Remarks: Representatives of the genus *Stephanelytron* are very rare in my samples. Only *S. redcliffense* is slightly more frequent.

Peridiniales, genus incertae sedis.

Genus *Atopodinium* Drugg 1978

A. prostatum Drugg 1978

Genus *Prolixosphaeridium* Davey, Downie, Sarjeant & Williams 1966, emend. Davey 1969

"P." mixtispinosum group"

Includes *P. mixtispinosum* (KLEMENT 1960) DAVEY, DOWNIE, SARJEANT & WILLIAMS 1966 and some forms belonging probably to *P. deirense* DAVEY, DOWNIE, SARJEANT & WILLIAMS 1966 and *P. anasillum* ERKMEN & SARJEANT 1980.

Nannoceratopsiales PEEL & EVITT 1980

Family *Nannoceratopsaceae*

Genus *Nannoceratopsis* DEFLANDRE 1938, emend. EVITT 1961, emend. PEEL & EVITT 1980

N. pellucida DEFLANDRE 1938, emend. EVITT 1961.

Biostratigraphical results

Ammonite zones and distribution of dinoflagellates in Liesberg

Thanks to the collaboration of R. GYGI, it was possible to compare the distribution of the dinoflagellates with the ammonite zones established in the area of Liesberg (cf. Fig. 2); the ranges of many of the dinoflagellates exceed the interval studied here (for example *C. polonicum, G. jurassica, H. cladophora,* etc.); nevertheless, beside these long ranging forms, we find some excellent stratigraphical markers which are distributed as follows:

- *Echinoceras coronatum* Zone (Sample 1, 2 3) and *Peltoceras athleta* Zone (Sample 4?). The samples 1, 2, 3 certainly belong to the *E. coronatum* zone; the sample 4 probably belongs to the *P. athleta* zone. The dinoflagellates do not allow to separate these two zones. Three species seem to be typical: *A. calloviana, E.* cf. *indotata* and *P. prolongata.*

- *Quenstedtoceras lamberti* zone (Sample 5 ?). The base of the "Eisenoolitischer Tonmergel" belongs to the *Q. lamberti* zone. It therefore seems probable that sample 5 belongs to this zone, but it could also belong to the basis of *Q. mariae* zone. Most of the numerous first appearances of dinoflagellates observed in this sample are probably due to the facies which has yielded a very rich assemblages. Nevertheless, the following first appearances seem typical: *W. fimbriata, L. scarburghensis, L. liesbergensis.*

- *Quenstedtoceras mariae* zone (Samples 6, 7, 10, 18 and ?23). The samples 6, 7 and 10 belong to the *Cardioceras scarburghense* subzone, the sample 18 belongs to the *C. praecordatum* subzone whereas sample 23 could be situated at the limit between the *Q. mariae* and *C. cordatum* zones. The range of *A. venusta* begins in the middle part of the zone whereas *C. continuum, G. vozzhennikovae, W. digitata, L. liesbergensis* and *E. mosaicum* disappear within this zone.

- *Cardioceras cordatum* zone (Samples 27, 40, 30, 33, 34, 36). *L. mirabile* has its first appearance in this zone. *G. centriconnata* and "*L. jurassica* group"

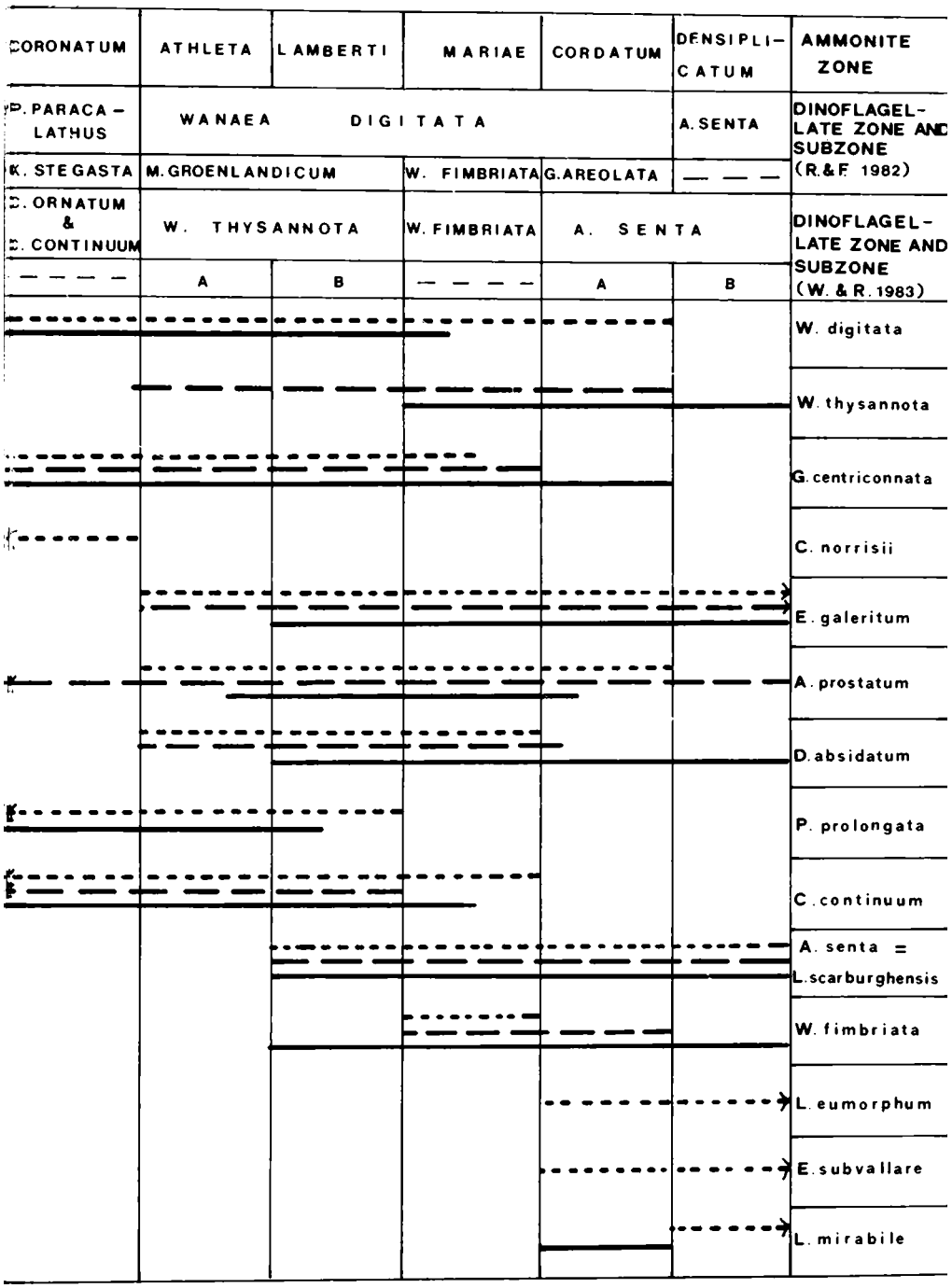

Fig. 4. Stratigraphical distribution of the "zonal-markers" a comparison between the zonation of Woollam & Riding 1983, Riley & Fenton 1982 and the repartition at Liesberg Dorf.

Woollam & Riding 1983: ——— ——— ———

Riley & Fenton 1982: – – – – – – – –

Liesberg: ————————

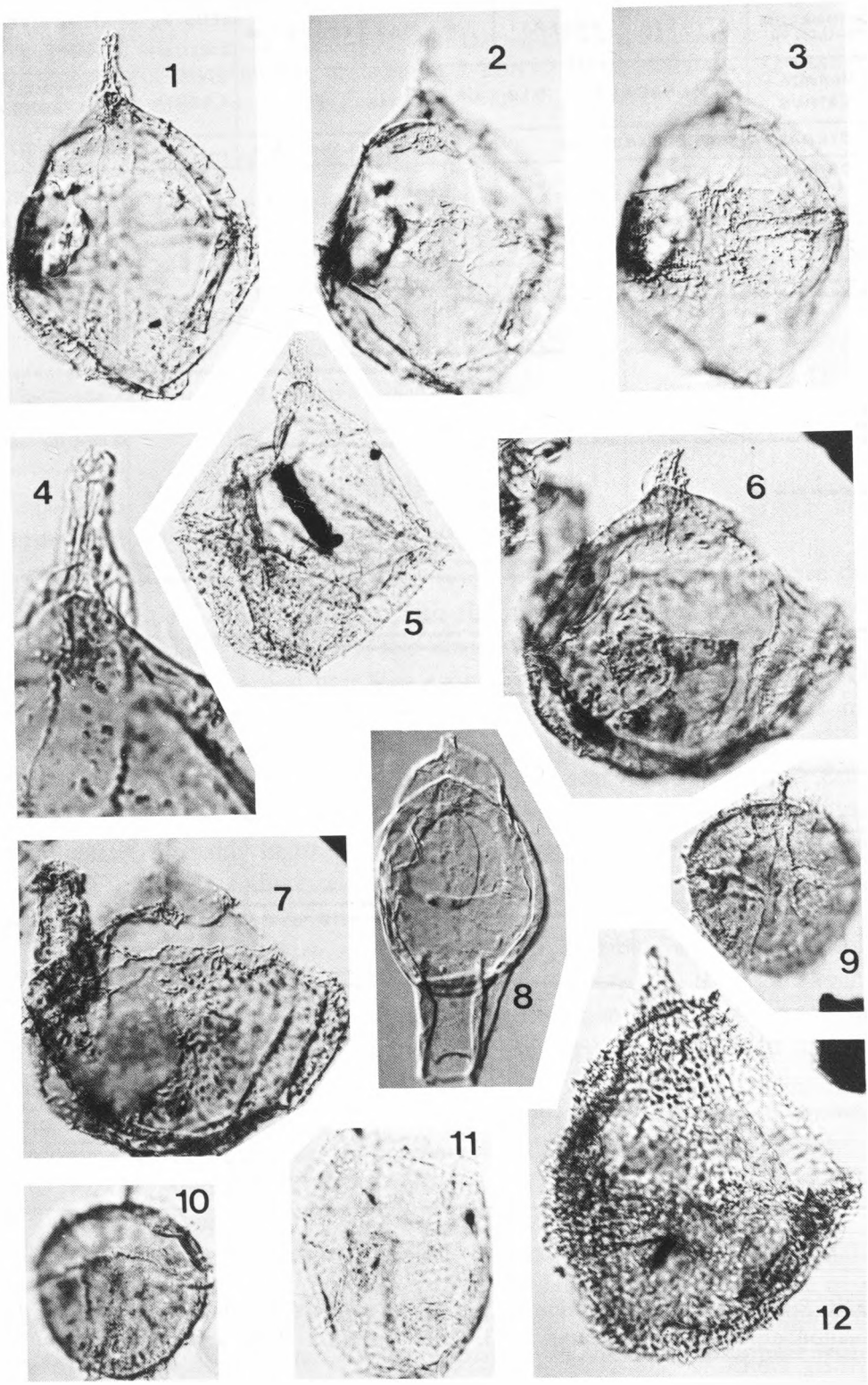

Fig. 5 (Legend see p. 349)

are diminishing and disappear within this zone. *M. groenlandicum* subsists only in some isolated specimens. *W. fimbriata* and *D. absidatum* are still present.

– *Cardioceras densiplicatum* zone (Sample 38?). It seems probable that sample 38 belongs to the base of the *C. densiplicatum* zone; *W. fimbriata, L. scarburghensis* and *D. absidatum* are still present, whereas *G. centriconnata* and *M. groenlandicum* have disappeared.

Comparison with published European dinoflagellate zonations

A comparison of the distribution of the dinoflagellates in Liesberg with the range charts published by SARJEANT 1967, RILEY & SARJEANT 1972, RAYNAUD 1978, FENSOME 1979 & 1981, WOOLLAM 1980, RILEY & FENTON 1982, RIDING 1982 & 1983, WOOLLAM & RIDING 1983 shows that most of the stratigraphical distributions are virtually identical (e. g. *A. calloviana, Energlynia* spp., *P. prolongata, "L. jurassica* gr.", *L. scarburghensis, M. groenlandicum*). However, some species have somewhat different ranges, although the discrepancies are generally of minor importance.

Remarks: The extension of the range of *W. digitata* and *W. thysannota* may be due to the differences in the determination of these two species. The first appearance of *L. mirabile* in the *C. cordatum* zone is surprising; however, the species is only represented by 2 to 3 specimens. The absence of some species is sometimes misleading because it can be due to the fact that certain samples (e. g. 5, 6, 38) are much richer than others (e. g. 1, 3, 4) or can simply be due to facies change. For this reason, the apparently limited ranges of species represented by rare specimens like *D. filapicatum, A. prostatum, Stephanelytron* spp., *Ct. sellwoodii, Belodinium* spp., *Polystephanephorus* spp., *E. luridum, Dissiliodinium* spp., *H. orbifera, Chlamydophorella* spp., *P. mixtispinosum* group, N. stegastum and *S. orbis* may be artifacts. For similar reasons, the absence in the late Callovian samples of forms like *R. aemula, A. dictyophora, E. galeritum, E. mosaicum, S. crystallinum* or *S. grossii*, which are generally well known in this stage, could be due to the facies (the samples of the late Callovian are all from oolitic limestones). However, some absences are more significant:

Fig. 5.

1: *L. liesbergensis* n. sp., holotype No 1636/6 d 506, general side, x 370.
2: *L. liesbergensis* n. sp., holotype, dorsal side. x 370.
3: *L. liesbergensis* n. sp., holotype, ventral side. x 370.
4: *L. liesbergensis* n. sp., holotype, detail of the apical horn, x 920.
5: *L. liesbergensis* n. sp., paratype No 1636/6 c 502. x 370.
6–7: *L. liesbergensis* n. sp., paratype No 1636/6 f 511. x 370.
8: *T. apatela* (COOKSON & EISENACK) IOANN., STAVR. & DOWNIE 1976, em. SARJEANT 1982 No 1636/38 a 1384. x 370.
9: *A. venusta* (KLEMENT 1960) SARJEANT 1968 No 1636/27 a 623 ventral face. x 370.
10: *A. venusta* (KL.) SARJEANT 1968, dorsal face. x 370.
11: *L. jurassica* EISENACK 1935 emend. GOCHT 1975 No 1636/5 II a 2142. x 370.
12: *L. scarburghensis* (SARJEANT 1964) n. comb. No 1636/10 a 520. x 370.

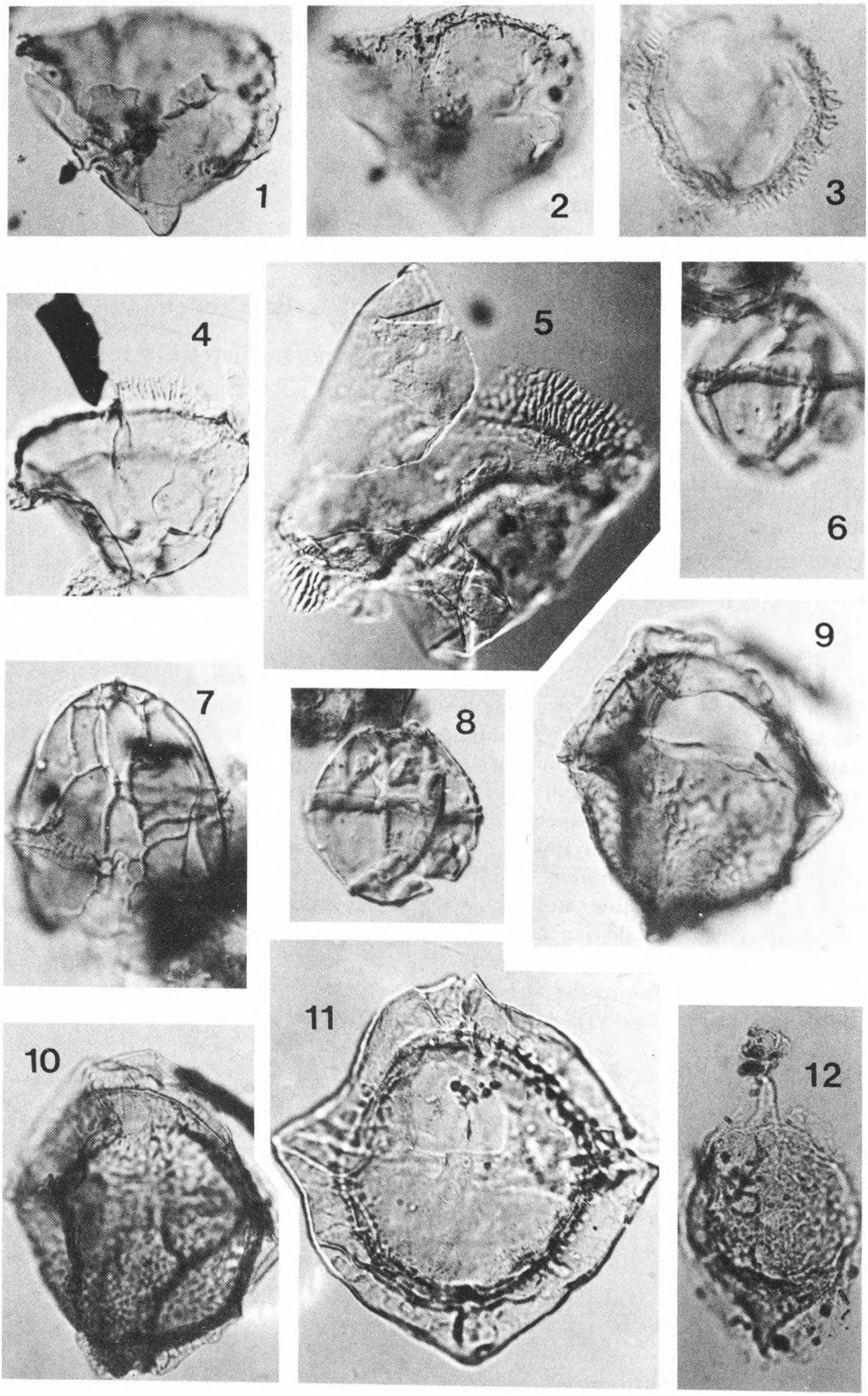

Fig. 6 (Legend see p. 351)

The absence of *A. callovians, P. prolongata* and *Eneglynia* spp. in all of the very rich post-Callovian samples.

Ct. continuum is frequent in the Callovian samples (samples 1, 3, 4) becomes rare in samples 6 and 7, and finally disappears with sample 10.

G. centriconnata, frequent in samples 1 to 18, later becomes more and more rare and only subsists as a single specimen in samples 30, 33 and 36; it is not present in sample 38. A similar process (diminution then disappearance) can be observed in the *"L. jurassica* group", *M. groenlandicum, W. digitata, E. mosaicum* (this latter species, e. g., diminishes gradually from sample 18 onward and disappear with sample 30).

Some of the dinoflagellate ranges observed in Liesberg modify details of a few limits of zones proposed by WOOLLAM & RIDING (1983) or RILEY & FENTON (1982). These divergences are shown in Fig. 4. The major divergence concerns the top of the zone of *W. fimbriata* (Limit *Mariae/Cordatum* Zone).

Conclusions

The present study demonstrate that the published dinoflagellate zonation can also be applied to the late Callovian/early Oxfordian succession of the Jura Mountains of northwestern Switzerland. However a few discrepancies with published data exist. Since this study is restricted to a single locality, it would be necessary to extend it to other sections in the Jura Mountains in order to see if these discrepancies are significant of if they are merely due to local particularities.

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Fig. 6.

1-2: *E.* cf. *indotata* No 1636/1 a 1230. x 370.
3: *W. digitata* COOKSON & EISENACK, emend. WOOLLAM 1982 No 1636/10 b 1918. x 370.
4: *W. thysanota* WOOLLAM 1982 No 1636/6 c 2115. x 370.
5: *W. fimbriata* SARJEANT 1961 No 1636/38 b 1400. x 370.
6, 8: *Leptodinium*? sp. A No 1636/33 a 1519. x 370.
7: *L. mirabile* KLEMENT 1960 No 1636/40 b 1662. x 370.
9: *A. dictyophora* (DEFLANDRE 1938) STOVER & EVITT 1978 dorsal side No 1636/30 b 1585. x 370.
10: *A. dictyophora* (DEFLANDRE 1938) STOVER & EVITT 1978 ventral side. x 370.
11: *S. crystallinum* SARJEANT 1961 No 1636/18 b 1857. x 370.
12: *N. stegastum* SARJEANT 1961 No 1636/7 a 1952. x 370.

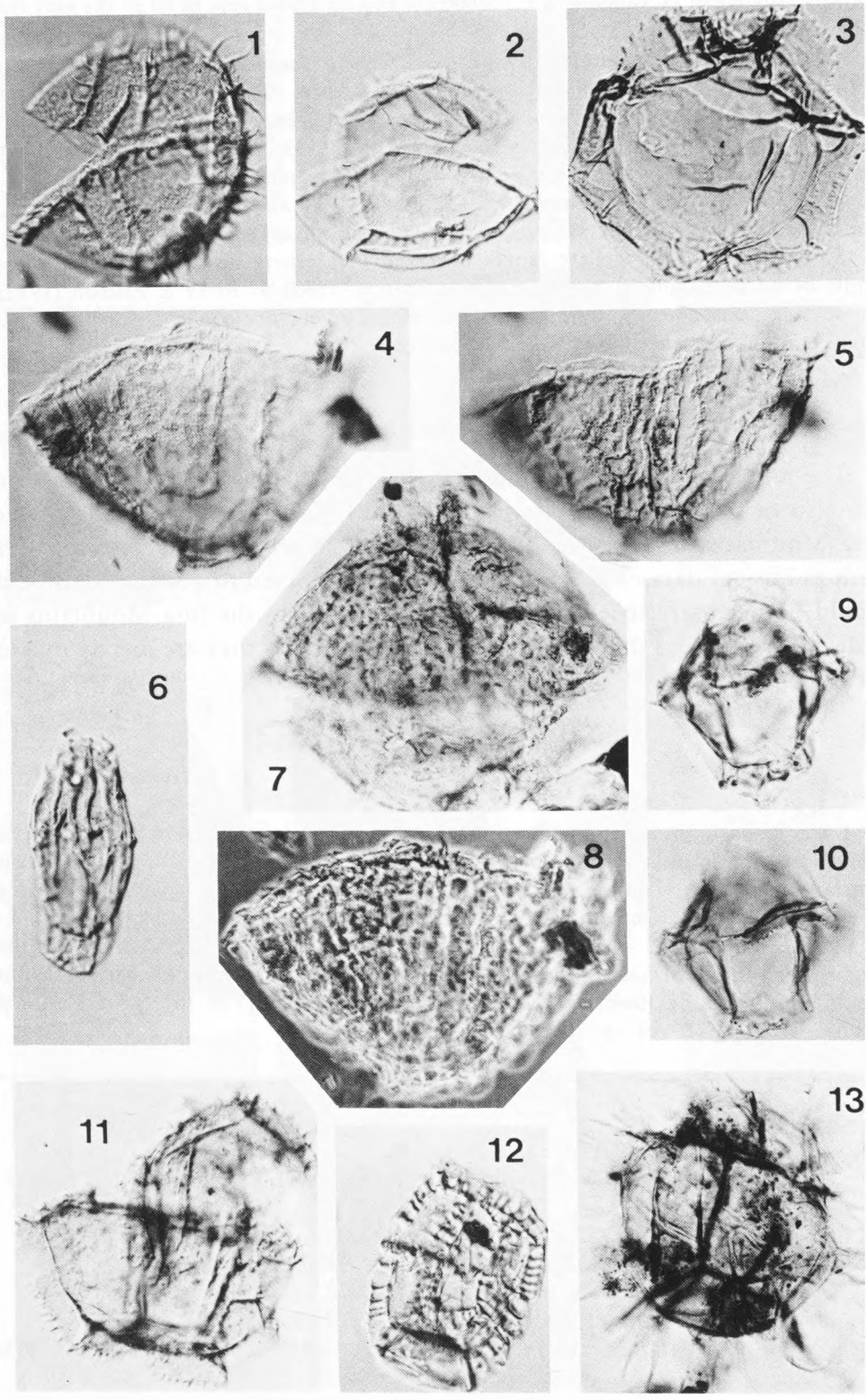

Fig. 7 (Legend see p. 353)

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Fig. 7.

1: *C. stauromatos* (SARJEANT 1976) STOVER & EVITT 1978 No 1636/36 a 363. x 370.
2: *C. sellwoodii* (SARJEANT 1975) STOVER & EVITT 1978 No 1636/7 c 2039. x 370.
3: *D. absidatum* DRUGG 1978 No 1636/38 b 1406. x 370.
4: *E.* cf. *mosaicum*, hypocyst, dorsal side No 1636/6 d 79. x 370.
5: *E.* cf. *mosaicum*, hypocyst, ventral side. x 370.
6: *B.* cf. *asaphum*, complete specimen No 1636/6 c 2114. x 370.
7: *E. mosaicum* (DODEKOVA 1975) nov. comb. No 1636/6 d 73. x 370.
8: *E.* cf. *mosaicum*, hypocyst, dorsal side with phase-contrast No 1636/6 d 79. x 370.
9–10: *G. centriconnata* RIDING 1983 1636/1 a 1217. x 370.
11: *C. continuum* GOCHT 1970 No 1636/6 e. 81 x 370.
12: *S. redcliffense* SARJEANT 1961, emend. STOVER, SARJEANT & DRUGG 1977 No 1636/10 a 1900. x 370.
13: *C. ornatum* (EISENACK 1935) DEFLANDRE 1938 No 1636/6 f 83. x 370.

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