A palynological investigation of some Lower Kimmeridgian deposits from Spain

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ABSTRACT—The present paper provides the first palynological data from two ammonite controlled sections from the Lower Kimmeridgian (Sutneria platynota Ammonite Zone) in Spain. The Segura de la Sierra sequence is located in the Betic Cordilleras and the Hontanar sequence is located in the Iberian Chain. The palynological assemblages, dominated by dinoflagellate cysts and sporomorphs, include taxa which are well known from other areas to be long-ranging throughout the major part of the Mesozoic. Most noteworthy is the presence of Cicatricosisporites spp. in the material investigated. The impact of this on the assumption that a strong diachronous south-north migration of this taxon existed during Middle and Late Jurassic times is discussed.

INTRODUCTION
Age assessments of Jurassic sedimentary rocks from the Iberian Peninsula have generally been based on faunal evidence, especially ammonites, although occasionally, due to the absence of palaeontological control, assessments have also been established on lithostratigraphical criteria. So far few Jurassic palynological records are available from this area. Most of these concern Portugal (Riley, 1974; Adloff et al., 1977; Adloff & Doubinger, 1978; Williams & Bujak, 1985; Davies, 1985; Van Erve & Mohr, in press) and little is known about the Jurassic microfloral development in Spain.

To increase the palynological information on the Jurassic of the Iberian Peninsula two Lower Kimmeridgian ammonite controlled sections from different structural units in Spain have been investigated: (1) the Segura de la Sierra section of the Betic Cordilleras and (2) the Hontanar section of the Iberian Chain (Fig. 1). In both sequences some samples were taken from ammonite bearing strata which have been assigned to the Sutneria platynota Ammonite Zone. This zone represents the earliest Kimmeridgian of the Tethyan realm and is generally assumed to be time-equivalent to the Pictonia baylei Ammonite Zone of the Boreal realm (Fig. 2).

THE SEGURA DE LA SIERRA SECTION
Location. The Segura de la Sierra section is located north-east of the village of Segura de la Sierra (province of Jaén) along the road to Siles (Lopez Garrido, 1971; Fig. 1).

Geological setting. In the province of Jaén, the Prebetic Zone is one of the structural units of the Betic Cordilleras, the Alpine fold-belt of southern Spain (Hermes, 1978; Alvarado, 1980). Lopez Garrido (1971) recognized three distinct structural sub-units in this area which approximately correspond to palaeogeographical domains: (1) Unit of Beas de Segura, (2) Unit of Sierra de Cazorla and (3) Unit of Sierra del Segura.

In the former two units only Jurassic deposits are present, whereas in the latter Cretaceous sediments are also encountered. The Segura de la Sierra section is part of the Unit of Sierra del Segura and represents predominantly shallow marine Jurassic-?Cretaceous deposits, uncomfortably overlain by the continental Cretaceous sediments of the so-called “Utrillas” (Lopez Garrido, 1971).

Stratigraphy (Figure 3). No formal lithostratigraphical subdivision has been established in the Unit of Sierra del Segura. However, Lopez Garrido (1971) distinguished several lithological intervals, which, on the basis of their stratigraphical position or fossil content, have been recognized throughout the province of Jaén. The Jurassic-?Cretaceous intervals exposed in the Segura de la Sierra section can be briefly summarized in ascending order (Lopez Garrido, 1971):
Interval 1: 80–100 m of massive grey non-fossiliferous dolomites. It is considered to represent the Lias and ?Dogger.

Interval 2: 8–10 m of grey-yellow nodular limestones containing a rich ammonite fauna. The basal part contains numerous Divisosphinctes spp. and Euaspidoceras sp., Ochetoceras marantianus (D’Orbigny), Taramelliceras flexuosus pinguis (Quenstedt), Taramelliceras flexuosus auritus (Quenstedt), Taramelliceras sarasani Loriol, Taramelliceras pictus costatus (Quenstedt). In the upper part Perisphinctes (Orthosphinctes) tiziani (Oppel), Lithacoceras (Prog- eronia) pseudopolyplacoides Geyer and Glochiceras (Lingulaticeras) lingulatus (Quenstedt) are also present. The lower part of this interval is considered to represent the Late Oxfordian (Epipeltoceras bimammatum Ammonite Zone), whereas the upper part represents the transition to the basal Kimmeridgian.

Interval 3: 50–60 m of alternating limestones, marly limestones and marls. Three sub-units have been recognized: the lowermost 15 m comprise marly limestones with marl intercalations. Abundant ammonites

![Location Map](image-url)

Fig. 1. Location Map. A: Hontanar section. B: Segura de la Sierra section.
have been recorded: e.g. *Sutneria platynota* (Reinecke), *Sowerbyceras silensus* (Fontannes), *Haploceras tenuifalcatum* (Neumayr), *Ataxioceras* sp., *Ataxioceras polyplacous breviceps* (Quenstedt), *Ataxioceras* (Parataxioceras) cf. *schneidi* Geyer, *Ataxioceras* (Parataxioceras) sp., *Lithacoceras* sp. and *Phylloceras* sp. This part is assigned to the Early Kimmeridgian (*Sutneria platynota* Ammonite Zone, Fig. 2). The middle 27 m are formed of marly limestones with marl intercalations. Ostracods, radiolarians, echinoderms and globochaetes have been recorded. The uppermost 13–15 m comprise an alternation of marls, limestones and marly limestones. Ostracods, radiolarians, foraminifera and sponge spicules have been recorded.

**Interval 4:** 35 m of well-bedded grey dolomites. Although no fossils have been recorded, a Kimmeridgian age has been assigned to this unit on lithostratigraphical considerations.

**Interval 5:** 1–3 m of whitish coloured limestones. A few fragments of gastropods and charophytes have been observed.

Lithostratigraphical correlations with adjacent areas suggest this unit represents the Portlandian-Neocomian.

This sequence is unconformably overlain by Cretaceous green marls and white sands of the “Utrillas” of Interval 6 and the yellowish sandy dolomites of Interval 7.
THE HONTANAR SECTION

Location. The Hontanar section is located along the road Teruel-Cuenca (province of Teruel) between kilometer poles 185–186 (Viallard, 1973; Fig. 1).

Geological setting. The section is part of the Sierra de Albaracín, one of the structural units of the Iberian Chain (Viallard, 1973). In this unit the Precambrian and Palaeozoic Hercynian basement is covered by thick more or less complete sequences of Mesozoic and Palaeogene sediments. As a result of tectonics, major differences are apparent in the palaeogeographical configuration of the Jurassic and Cretaceous sedimentary basins.

Stratigraphy (Figure 4). No formal lithostratigraphical subdivision of the Jurassic has been established in this area and the lithostratigraphy, as in the Segura de la Sierra, is discussed in terms of Liassic, Dogger and Malm. In the Hontanar section the Malm is exposed. The Callovian to Middle Oxfordian sequence is very condensed and the Lower Oxfordian seems to be missing. Within the Hontanar section 7 lithological units have been distinguished. These units will be briefly discussed in a ascending order (Viallard, 1973):

- **Unit 1**: approximately 0.30 m of oolithic limestone. Viallard (1973) assigned a Middle-Late Callovian to possibly Middle Oxfordian age for this unit.
- **Unit 2**: 25 m of cryptocrystalline limestones. The fossil record contains ammonites, e.g. *Ochetoceras mariantianum* (D'Orbigny), *Orthosphinctes polygyratus* (Quenstedt) and *Orthosphinctes tiziani* (Oppel), protoglobigerinas and sponges. Based on the ammonites,
the upper part of this unit has been assigned to the Late Oxfordian Epipeltoceras bimammatum Ammonite zone (Fig. 2).

Unit 3: 10m of grey marls. Ammonites have been recorded from this unit, e.g. Idoceras sp. and Sutneria platynota (Reinecke). Based on the latter taxon this unit has been assigned to the Early Kimmeridgian Sutneria platynota Ammonite zone (Fig. 2).

Unit 4: 100m thick sequence of cryptocrystalline limestones with intercalations of marly limestones. Ammonites have been recorded from this unit: Perispinctes (Lithacoceras) aff. riberoi Choffat, Lithacoceras cf. subachilles Wegele and Lithacoceras cf. virgatoides Wegele. Based on the fossil content, Viallard (1973) assigned an Early Kimmeridgian age.

Unit 5: 50m of thick bedded sub-lithographical or oolitic, microcrystalline limestones. The fossil record contains a variety of echinoderms (Cidarids).

Unit 6: 35m of fine sands and silty marls with intercalations of microcrystalline limestone beds. On the basis of the foraminifera taxa Alviseptia jaccardi (Schrodt) a Kimmeridgian age has been assigned.

Unit 7: 70m of fine micaceous sands and silty marls. Based on lithostratigraphical considerations a Late Kimmeridgian to Portlandian age has been assigned.

The Malm sequence is uncomfortably overlain by Cretaceous (Albian) deposits which constitute argilaceous sands with quartz pebbles of the “Utrillas”.

**PALYNOLOGY**

**Sampling.** Twelve samples from the two sections described were taken and prepared, using standard palynological techniques. Eight samples are from Interval 3 of the Segura de la Sierra section (Figure 3); three samples from unit 3 and one sample from unit 4 of the Hontanar section (Figure 4). From the Hontanar section only samples HON 01 and HON 03 provided palynological assemblages, whereas samples HON 02 and HON 04 proved to be barren.

The samples were collected during a field excursion of the Laboratory of Palaeobotany and Palynology of the Utrecht State University, The Netherlands, in the early spring of 1979.

**Annotated species list.** The following taxa have been recognised in the palynological assemblages investigated. The taxonomical classification of the palynomorphs was mainly based on publications by Couper (1958), Burger (1966), Vigran & Thusu (1975), Dörhöfer (1979), Herngreen et al. (1980), Hunt (1985) and Thusu & Vigran (1985). For genera identification the Genera File of Jansonius & Hills (1976) was consulted. Therefore, no other papers are included in the reference list. Full references to the dinoflagellate cysts cited can be found in Lentin & Williams, 1985. Those taxa marked by an asterisk are further discussed in the systematics section.

**Spores**

Aequitiradites sp.

Antulsporites clavus (Balme, 1957) Filatoff, 1975.

Araucarioites australis Cookson, 1947.

Baculatisporites caumaensis (Cookson, 1953) Potonié, 1956.

Biretisporites potoniaei (Delcourt & Sprumont, 1955)

Delcourt, Dettmann & Hughes, 1963.

Calamospora mesozoica Couper, 1958.

Cibotiumspora juriensis (Balme, 1957) Filatoff, 1975

(Plate 1, Fig. 1).

Cicatricosisporites spp. (Plate I, Figs. 4–6).

Concavipollisporites spp. (Plate I, Fig. 3).

Concavipollisporites spp.

Contignisporites cooksonii (Balme, 1957) Dettmann, 1963.

Convolutispora spp.

Deltidospora mesozoica (Thiengart, 1949) Schuurman, 1977.

Deltidospora minor (Couper, 1958) Pocock, 1970.

Densoisporites velatus Weyland & Krieger, 1953.

Echinatisporis spp.

Foraminisporis spp.

Gleicheniidites senonicus Ross, 1949 (Plate I, Fig. 2).

Ischyosphorites variegatus (Couper, 1958) Schulz, 1967

(Plate I, Fig. 9).

Kraeusetisporites sp.

Leptolepidites proxigranulatus (Brenner, 1963) Dörhöfer, 1979.

Leptolepidites spp.

Lycopodiacidites intraverrucatus Benner, 1963.

Markitisporites scabratus Couper, 1958.

Osmundacidites wellmanii Couper, 1953.

Reticulatisporites spp.

Retiriterites spp.

Rubinella major (Couper, 1958) Norris, 1969 (Plate I, Fig. 7).

Sphoripollisporites spp. (Plate I, Figs. 11, 12).

Staplinisporites camirzus Couper, 1958.

Stoverisporites segmentatus Stover, 1962.

Todisporites major Couper, 1958.

Todisporites minor Couper, 1958.

Trilobosporites spp.

Tuberositriletes spp.

Uvaesporites argenteaeformis (Balme, 1957) Schulz, 1967 (Plate I, Fig. 8).

Varirugosisporites spp.

**Pollen**

Bisaccate pollen undifferentiated.

Callialasporites dampieri (Balme, 1957) Sukh Dev, 1961 (Plate I, Fig. 10).

Callialasporites microvelatus Schulz, 1966.

Callialasporites minus (Tralau, 1968) Guy, 1971.

Callialasporites trilobatus (Balme, 1957) Sukh Dev, 1961 (Plate I, Fig. 15).

Callialasporites turbatus (Balme, 1957) Schulz, 1967
Van Erve, Besems

Callialasporites segmentatus (Balme, 1957) Srivastava, 1963.
Cerebropollenites macrovellucosus (Thiergart, 1949) Schulz, 1967.
Corollina spp. (Plate I, Fig. 14).
Cycadopites spp.
Ephedripites spp.
Exesipollenites tumulus Balme, 1957 (Plate I, Fig. 13).
Perinopollenites elatoides Couper, 1958.

Dinoflagellate cysts
Apteodinium cf. nuciforrne (Deflandre, 1938b) Stover & Evitt, 1978 (Plate 2, Fig. 5).
Apteodinium nuciforrne (Deflandre, 1938b) Stover & Evitt, 1978.
Chlamydophorella? cf. membranoidea* Vozhennikova, 1967 (Plate 2, Figs. 7, 10).
Chytroeisphaeridia chytroeides (Sarjeant, 1962a) Downie & Sarjeant, 1963 emend. Davey, 1979 (Plate 2, Fig. 8).
Cleistosphaeridium spp.
Cribroperidinium granufatum (Klement, 1960) Stover & Evitt, 1978 (Plate 2, Fig. 9).
Cribroperidinium spp.
Ctenidodinium cf. panneum (Norris, 1965) Lentin & Williams, 1973.
Dichadogonyaulax sellwoodii Group* sensu Woollam, 1983 (Plate 2, Fig. 2).
Dingodinium tuberosum (Gitmez, 1970) Fisher & Riley, 1980 (Plate 2, Fig. 11).
Dinoflagellates indeterminable.
Egmontodinium? ovatum (Gitmez & Sarjeant, 1972) Riley, 1979.

Ellipsoidictium spp.
Epiplospheara spp.
Escharisphaeridia pocockii (Sarjeant, 1968) Erkman & Sarjeant, 1980.
"Gonyaulacysta complex"* sensu Jan du Chêne, Masure et al., 1986 (Plate 2, Figs. 1, 4).
Gonyaulacysta jurassica (Deflandre, 1938) Norris & Sarjeant, 1965.
Hystrichosphaerina orbifera (Klement, 1960) Stover & Evitt, 1978.
Leptodinium spp.
Mendicodinium groenlandicum (Pocock & Sarjeant, 1972). Davey, 1979.
Meristaulax cf. granulata (Klement, 1960) Sarjeant, 1984.
Meristaulax granulata (Klement, 1960) Sarjeant, 1984.
Pareodinia ceratophora Deflandre, 1947.
Pareodinia spp.
Scrinodinium crystallinum (Deflandre, 1938) Klement, 1960.
Scrinodinium spp.
Sentusidinium cf. rioulitt (Sarjeant, 1968) Sarjeant & Stover, 1978 (Plate 2, Fig. 6).
Sentusidinium pilosum (Ehrenberg, 1854) Sarjeant & Stover, 1978.
Sirmiodinium grossii Alberti, 1961.
Systematophora areolata Klement, 1960 (Plate 2, Fig. 3).
Tubotubereffa apatefa (Cookson & Eisenack, 1960) Ioannides et al., 1977 emend. Sarjeant, 1982.
Tubotubereffa furida (Deflandre, 1938) Davies, 1983.
Waffodinium cf. glaessneri* (Cookson & Eisenack, 1960) Loeblich & Loeblich, 1968.

Explanation of Plate 1
All Figures approx. ×1000 magnification.

Fig. 1. Cibotiumpora juriensis (Balme, 1957) Filatoff, 1975 sample SIE-08.
Fig. 2. Gleicheniidites senonicus Ross, 1949 sample SIE-08.
Fig. 3. Concavisporites spp. sample SIE-09.
Figs. 4,5,6. Cicatricosisporites spp. Fig. 4: sample SIE-08. Fig. 5: sample SIE-06. Fig. 6: sample SIE-09.
Fig. 7. Rubinella major (Couper, 1958) Norris, 1969 sample SIE-05.
Fig. 8. Uvaesporites argenteaformis (Bolchovitina, 1953) Schulz, 1967 sample SIE-09.
Fig. 9. Ischyosporites variegatus (Couper, 1958) Schulz, 1967 sample SIE-05.
Fig. 10. Callialasporites dampilieri (Balme, 1957) Sukh Dev, 1961 sample SIE-09.
Figs. 11,12. Spheripollenites spp. sample SIE-09.
Fig. 13. Exesipollenites tumulus Balme, 1957 sample SIE-09.
Fig. 14. Corollina spp. (tetrad) sample SIE-05.
Fig. 15. Callialasporites trilobatus (Balme, 1957) Sukh Dev, 1961 sample SIE-09.
Fig. 16. Callialasporites turbatus (Balme, 1957) Schulz, 1967 sample SIE-05.

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Acritarchs
Acantomorphy acritarchs (including *Micrhystridium* spp., *Baltsphaeridium* spp., *Solisphaeridium* spp.).

Algae *sensu lato*
*Circulisporites* parvus De Jersey 1963.
*Botryococcus* spp.

Prasinophytes
*Botryococcus* spp.

Tasmanitids
*Botryococcus* spp.

Scolecodonts
*Schistomeringos expectatus* Szaniawski & Gazdzicki, 1978.

Foraminiferids
*Trochiliascia* spp.

Systematic descriptions
Class Dinophyceae Fritsch, 1929.
Order Peridiniales Haeckel, 1894.
Genus *Dichadogonyaulax* Sarjeant, 1966 emend. Woollam, 1983.
*Dichadogonyaulax sellwoodii* Group sensu Woollam, 1983.

Remarks. Several authors have discussed the taxonomic relationship between *Dichadogonyaulax* and *Ctenidodinium* Woollam (1983, p.193) differentiates the genera “primarily on the asymmetry of the paracingular crests”. Whilst Benson (1985, p.147–8) separates the genera “on the basis of the postventral displacement of the pre-apical paraplate”. The comment of Benson (1985, p.145) that the differentiation of species within the complex is often easier than deciding in which genus the species should be placed is fully supported.

1982 *Chlamydophorella* Cookson & Eisenack 1958 emend.
Duxbury 1983.

*Chlamydophorella? membra-noidea* Vozzhennikova 1967
(Plate 2, Figs. 7, 10)

Remarks. This species is closely related to *C.? membra-noidea* Vozzhennikova 1967. Davey (1982, p.27) in discussing this species notes the occasional presence of a corona, including the holotype, and suggests this is due to intra-specific variability. Davey suggests that *C.? membranoidea* probably ranges from the basal Kimmeridgian to the Late Hauterivian, although notes that specimens possessing a corona have not been observed below the Early Portlandian (*kerbus*) Ammo-

Explanation of Plate 2
All Figures ×650 magnification except Figs. 7, 10 ×1000.

Figs. 1, 4. “Gonyaulacysta complex” sample SIE-08. The specimen figured is probably conspecific with *Meristaulax angulosa* (Gitmez, 1970) Sarjeant & Gocht in Sarjeant 1984, however the species was so rare that it has been recorded under the “Gonyaulacysta complex”.

Fig. 2. *Dichadogonyaulax sellwoodii* Group sensu Woollam, 1983 sample SIE-08.

Fig. 3. *Systematophora arealata* Klement, 1960 sample SIE-08.

Fig. 5. *Apteodinium* cf. *nuciforme* (Deflandre, 1938) Stover & Evitt, 1978 sample SIE-08.

Fig. 6. *Sentusidinium* cf. *rioultii* (Sarjeant, 1968) Sarjeant & Stover, 1978 sample SIE-08.

Figs. 7, 10. *Chlamydophorella? membra-noidea* Vozzhennikova, 1967 sample SIE-08.

Fig. 8. *Chytroeisphaeridia chytroeides* (Sarjeant, 1962) Downie & Sarjeant, 1963 emend. Davey, 1979 sample SIE-08. The operculum can be observed in the cyst interior.

Fig. 9. *Cribroperidinium granuligerum* (Klement, 1960) Stover & Evitt, 1978 sample SIE-08.

Fig. 11. *Dingodinium tuberosum* (Gitmez, 1970) Fisher & Riley, 1980 sample SIE-08.
nite Zone. The species recorded in Spain although not possessing a discernable corona are synonymous with *C.? membranoidea* sensu Davey (1982). It seems likely however, that the presence or absence of a corona, linked to an indication of a stratigraphical element to this variability, would suggest two species are involved. Hence the forms recorded in Spain have not been assigned to *C. membranoidea*, although the poor quality of the material in Spain could not support the erection of a new species.

"Gonyaulacysta complex" sensu Jan du Chêne, Masure et al. 1986. (Plate II, Figs. 1, 4)

**Remarks.** The term "Gonyaulacysta complex" was coined by Stover & Evitt (1978, p.271). Jan du Chêne, Masure et al. (1986 p.15) also adopted this term although incorporating several new genera, including *Apteodinium* and *Meristaulax* (which they synonymize with *Cribroperidinium*). The generally poor preservation of the Spanish material means that many dinocysts could not be positively identified. However, many could clearly be recognised as part of the "Gonyaulacysta complex" and probably are representatives of the genera *Apteodinium, Cribroperidinium, and Meristaulax.*

Genus *Wallodinium* Loeblich & Loeblich, 1968. *Wallodinium* cf. *glaessneri* (Cookson & Eisenack 1960b)

Loeblich & Loeblich 1968.

1980 *Wallodinium* cf. *W. glaessneri* Courtinat & Galliard p. 68, pl. 2, fig. 11.

**Remarks.** The single specimen recorded is comparable with *W. glaessneri* and probably synonymous with that described by Courtinat & Galliard (1980) from the Upper Oxfordian.

**GENERAL COMPOSITION OF THE ASSEMBLAGES**

The samples investigated yielded relatively moderate diversified but rather poorly preserved palynomorphs. The relative frequencies and distribution of the taxa recognised are presented on Figures 5 and 6. The plots were made within S.I.P.M., EPX/36 with the Checklist programme of J. Phillips.

The sporomorph content of the Segura de la Sierra assemblages is generally dominated by *Corollina* spp. and *Spheripollenites* spp. All other sporomorph taxa are minor constituents although occasionally *Concavissimisporites* spp. can be present in higher proportions. Noteworthy is the persistent occurrence of *Cicatricosisporites* spp. Acantomorph acritarchs, dinoflagellate cysts forming part of the "Gonyaulacysta complex", *Sentusidinium* cf. *rivoultii* and *Apteodinium* cf. *nuciforme* are generally the most frequent microplankton constituents.

The sporomorph content of the Hontanar assemblages is dominated by *Spheripollenites* spp. All other sporomorph taxa are minor constituents although *Corollina* spp. and *Exesipollenites tumulus* may occur in higher proportions. It should be noted that due to the overall poor preservation some specimens referred to *Exesipollenites tumulus* may represent inner bodies of *Corollina* spp. (see also Riley, 1974; p.36). *Cicatricosisporites* spp. has been recorded in both assemblages. Microplankton is a minor constituent.

The major difference between the Segura de la Sierra and Hontanar assemblages is that the latter are less diversified and contain fewer microplankton. The Segura de la Sierra assemblages show a general decrease in diversity towards the higher part of Interval 3.

**DISCUSSION**

**Sporomorphs.** The majority of taxa which have been recognised from the sections investigated occur in both Tethyan and Boreal realms. Some of them range throughout the larger part of the Jurassic and Cretaceous of Northwest Europe, e.g. *Deltoidospora* spp., *Gleicheniidites senonicus, Ischyosporites variegatus, Leptolepidites* spp., *Spheripollenites* spp. *Todisporites* spp., *Callialasporites* spp., *Corollina* spp. and *Taurucosporites segmentatus*, while other taxa are known from the Upper Jurassic onwards, e.g. *Cicatricosisporites* spp., *Concavissimisporites* spp., *Leptolepidites proxigranulatus* and *Trilobosporites* spp. (e.g. Couper, 1958; Burger, 1966; Vigran & Thusu, 1975; Dörhöfer, 1979; Herngreen et al., 1980, Hunt, 1985).

Although the bulk of taxa are present in both Tethyan and Boreal areas, the composition of Middle to Late Jurassic assemblages from these areas are quite different. This difference has already been discussed by Thusu & Vigran (1985). Although these authors do not discuss coeval Early Kimmeridgian assemblages, the composition of the Spanish sporomorph fraction in broad terms resembles that of other Jurassic Tethyan assemblages from the Sahara and north-eastern Libya being dominated by *Corollina* spp. and *Spheripollenites* spp. with scarce bisaccate pollen grains. (see also Reyre, 1973; Riley, 1974; Thusu & Vigran, 1985; Van Erve & Mohr, in press.). Assemblages from the Boreal area however show a reverse combination (Thusu & Vigran, 1985).

Most noteworthy in the sporomorph content of the samples investigated is the presence of *Cicatricosisporites* spp. According to Dörhöfer (1979, fig. 4), this taxon evolved and migrated from lower palaeolati-
tudes (10 degrees) in the Callovian of North Africa towards the north. At a palaeolatitude of ca 20 degrees (= approx. Iberian peninsula) it would appear in the Oxfordian and at a palaeolatitude of ca 30 degrees (North-west Europe) its first appearance would be in the Upper Kimmeridgian. However, the palynological data available do not support this theory: (1) the presence of indigenous Cicatricosisporites spp. in the “Callovian” of North Africa is rather doubtful. The palynological data from North Africa used by Dorhofer first Callovian to Late Jurassic age. Reyre’s Zone 5B at the base of his zone 5B of presumed Middle Jurassic deposits have been recorded. However, the Lower Kimmeridgian interval is considered in several Upper Jurassic zonal schemes notably Fisher & Riley (1980) (Leptodinium egemenii subzone) and Woollam & Riding (1983) (Gj/Sc(c) subzone). In general the microplankton assemblages described from these publications are all fairly similar being dominated by species of the “Gonyaulacysta complex,” normally with common G. jurassica, Hystrichogonyaulax cladophora, and species of Leptodinium. The assemblages also typically contain Sentusidinium spp. and with varying records of chorote dinocysts.

In some respects the assemblages recorded in Spain are similar to those mentioned above, particularly in the dominance of species of the “Gonyaulacysta complex”. However G. jurassica, which is normally frequent in Northwest European Early Kimmeridgian assemblages, although present in Spain, is only recorded in low numbers and H. cladophora is not recorded at all.

The other apparently major difference is the presence of species of Dichagonyaulax and Ctenidodium with high parasutural ornament in the Spanish material. Ctenidodium chondrum Drugg 1978, which has low parasutural ornament, is the only published species of these genera from the Early Kimmeridgian. This apparent difference is probably a reflection of the lack of published data, since several forms, similar to those recorded in Spain, have been frequently noted to occur in borehole material from the Kimmeridgian of the North Sea (CFL pers. obs.).

Of palynostratigraphical interest is that both the publications on zonal schemes mentioned above note the last stratigraphical occurrence of Scriniodinium crystallinum in the Pictonia baylei zone and significant this form is also recorded in Spain. Equally Woollam & Riding (1983) note the first appearance of Dingodinium tuberosum in the earliest Kimmeridgian Gj/sc(c) subzone, again a species recorded in Spain.
**Fig. 5. Distribution chart Segura de la Sierra section.**
Lower Kimmeridgian Palynology of Spain

| Species Name                                | Abundance |
|---------------------------------------------|-----------|
| ACANTHOMORPH ACritarchs                     |           |
| APTEODINUM CF. NUCIFORME                    |           |
| CRIBROPERIDINUM GRANULIGERUM                |           |
| DICHADOGONYAULAX SELLWOODII Group           |           |
| DINGODINUM TUBEROSUM                        |           |
| SENTSUSIDINUM FILOSUM                       |           |
| BOTRYOCOCUS SPP.                            |           |
| DINOFLAGELLATES INDET.                      |           |
| HSTRICHOSPHAERINA ORBIFERA                 |           |
| LEFTODINUM SPP.                             |           |
| FAREODINIA CERATOPIRA                       |           |
| PTEROSPERMAELLA SPP.                        |           |
| SENTSUSIDINUM CF. RIGULTI                   |           |
| TASHANITES SPP.                             |           |
| CHLAMYDOPHORELLA CF. MEMBRANOIDES           |           |
| CYHTROEISPHAERIDIA CHYTOIDES                |           |
| CTENIODINUM CF. PANNEUM                     |           |
| ESCHARISPHAERIDIA POOCOKII                  |           |
| HERISTHULAX CF. GRANULATA                   |           |
| HERISTHULAX GRANULATA                       |           |
| SYSTEHATOPHORA AREOLATA                     |           |
| TROCHILIASCA SPP.                           |           |
| CRIBROPERIDINUM SPP.                        |           |
| CYNATOSPHAERI SPP.                          |           |
| GONYaulacysta JURASSICA                     |           |
| APTEODINUM NUCIFORME                        |           |
| EGHNODINUM? QUATOM                          |           |
| SCRINIODINUM CRYSTALLINUM                   |           |
| SCRINIODINUM SPY.                           |           |
| MENDICODINUM GROENLANDICUM                  |           |
| SCRINIODINUM GROSSII                        |           |
| TUBOTUBERELLA AFATELA                       |           |
| TUBOTUBERELLA LURIDA                        |           |
| UNLENSIERTA OVALA                           |           |
| HALLUDINUM CF. GLAEONYFR1                   |           |
| CIRCULISPORITES PARVUS                      |           |

Fig. 5. Distribution chart Segura de la Sierra section.
Very Rare (0-2 Percent)
Rare (3-5 Percent)
Few (6-15 Percent)
Common (16-25 Percent)
Abundant (26-100 Percent)
Questionably Present
Not Present

**Key to Symbols**

- **GONVULACYSTA COMPLEX**
- ACANTHOMORPH ACRITARCHS
- APTEODINIUM CF. NUCIFORME
- CHLAMYDOPHORELLA CF. MEMBRANOIDEA
- ELLIPSOIDICIT YM SPP.
- PAREODINI SPP.
- TROCHILIASCIA SPP.
- APTEODINIUM NUCIFORME
- CLEISTOSPHAERIDUM SPP.
- CRIBROPERIDINUM GRANULIGERUM
- CRIBROPERIDINUM SPP.
- CTENIODINUM CF. PANNEUM
- DICHADOGONYAULAX SELLWOODII Group
- DINOFLAGELLATES INDET.
- EPILOSPHAER A SPP.
- ESCHARISPHAERIA POCOCKII
- LEPTODINIUM SPP.
- MENTIDONINIUM GROENLANDICUM
- MERISTUALAX CF. GRANULATA
- PAREODINI CERATOPHORA
- SCHISTOMERINGOS EXPECTATUS
- SCRINIODINUM CRYSTALLINUM
- SCRINIODINUM SPP.
- SENTUSIDINUM CF. KIULTII
- SYSTEMATOPHORA AREOLATA
- TASMANITES SPP.
- ARACUCHRICIDITES AUSTRALIS
- BOREITISPORITES POTONIAE
- BISANGIT PLENUM
- CALANDROPORA MESOZOICA
- CALLIALASPORITES TRILOBATUS
- CEREBROPOLLENITES MACROVERRUCOSUS
- CIBOTIUMSPORA JURINENS
- CICATRICOSISPORITES SPP.
- CONVEXISPORITES SPP.
- CONTIGISPORITES COMKSONII
- CONVOLUTISPORA SPP.
- COROLLINA SPP.
- CYCADOPITES SPP.
- DELTOIDOSPORA MESOZOICA
- DELTOIDOSPORA MINOR
- DERMOSPORITES VELETUS
- EXESIPOLLENITES TUMULUS
- ISCHYRISPORITES VARIEGATUS
- LEPTOLEPIDITES SPP.
- LYCOPODICIDITES INTRAVERrucatus
- PERINOPOLLENITES ELATOIDES
- RUBINELLA MAJOR
- SPHERIPOLLENITES SPP.
- STEPLINISPORITES CAMINUS
- TAURUCOSPORITES SEGMENTATUS
- TODISPORITES MAJOR
- TODISPORITES MINOR
- TRILOBOSPORITES SPP.
- TUBEROSITRILET SPP.
- UVAESPORITES ARGENTEAPOFORMIS
- VARIRUGOSISPORITES SPP.
- AEGITIRIRADITES SPP.
- BACULATISPORITES COMAUNENSIS
- CALLIALASPORITES TURBATUS
- CONVEXISPORITES SPP.
- ECHINATISPORIS SPP.
- EPHEDRIPITES SPP.
- FORAMINISPORIS SPP.
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References

Adloff, M. C. & Doubinger, J., 1978. Associations palynologiques du Trias et du Lias inferieur de l’Ouest de l’Europe (Luxembourg, France, Portugal). Palinologia, n. extraordinaire 1, 21–25.

Adloff, M. C., Doubinger, J. & Palain, C., 1977. Contribution à la palynologie du Trias et du Lias inferieur du Portugal. “Grès de Silves” du Nord du Tage. Comunicaciones do Servicos Geologicas de Portugal, 58 (1974), 91–144.

Alvarado, M., 1980. Introduccion a la Geologia general de Espana. Boletin Geologico y Minero. T. XCI-I, 65 pp.

Benson, D. G., 1985. Observations and recommendations on the fossil dinocyst genera Cenidiodinium, Dichadogonyaulax and Korystocysta. Tulane studies in Geology and Palaeontology Vol. 18, 145–155.

Burger, D., 1966. Palynology of the uppermost Jurassic and lowermost Cretaceous strata in the Eastern Netherlands. Leidsche Geologische Mededelingen, 35, 209–276.

Cookson, I. C. & Eissenack, A., 1960. Upper Mesozoic microplankton from Australia & New Guinea. Palaeontology, 2, (2), 243–261.

Couper, R. A., 1958. British Mesozoic micospores and pollen grains. Palaeontographica, Abt. B., 103 (4-6), 75–179.

Courtinat, R. & Gaillard, C. 1980. Les dinoflagellés des calcaires lites des Trept (Oxfordian Supérieur) inventaire and repartition comparative à celle de la microfaune benthique. Documents des Laboratoires de Geologie de la Faculté des Science de Lyon, 78, 1–123.

Davey, R. J., 1982. Dinocyst stratigraphy of the latest Jurassic to early Cretaceous of the Haldager No. 1 borehole, Denmark. Danmarks Geologiske Undersogelse, Serie B., 6, 1–57.

Davies, E. H., 1985. The miospore and dinoflagellate cyst opello-zonation of the Lias of Portugal. Palynology, 9, 105–132.

Dörhöfer, G., 1979. Distribution and stratigraphic utility of Oxfordian to Valanginian miospores in Europe and North America. AASP Contribution Series No. 5B, 101–132.

Fisher, M. J. & Riley, L. A., 1980. The stratigraphic distribution of dinoflagellate cysts at the basal Jurassic-Cretaceous boundary. IV International Palynological Conference Lucknow (1976-77), 2, 313–329.

Fritsch, F. E., 1929. Evolutionary sequences and affinities among Pyrophyta. Biological Reviews 4, 103–151.

Gitmez, G. U., 1970. Dinoflagellate cysts and acritarchs from the basal Kimmeridgian (Upper Jurassic) of England, Scotland and Ireland. Bull. Br. Mus. Nat. Hist. (Geol), Vol. 18, 231–331.

Haeckel, E., 1894. Entwurf eines naturlichen Systems der Organismen auf Grund ihrer Stammgeschichte, Erster Teil: Systematische Phylogenie der Protisten und Pflanzen. Berlin, George Rieper, 400 pp.

Hallam, A., 1975. Jurassic environments. Cambridge University Press.

Hermes, J. J., 1978. The stratigraphy of the Subbetic and southern Prebetic of the Velez Rubio-Caravaca area and its bearing on transcurrent faulting in the Betic Cordilleras of southern Spain. Proceedings Koninklijke Nederlandse Akademie voor Wetenschappen, 81, 1–54.

Herngren, G. F. W., Van Hoeken-Klinkenberg, P. M. J. & De Boer, K. F., 1980. Some remarks on selected palynomorphs near the Jurassic-Cretaceous boundary in the Netherlands. IVth International Palynological Conference Lucknow (1976-77), 2, 357–3376.

Hunt, Ch. O., 1985. Miospores from the Portland Stone Formation and lower part of the Purbeck Formation (Upper Jurassic/Lower Cretaceous) from Dorset, England. Pollen et Spores, (3–4), 449–451.

Jan du Chêne, R., Masure, E. et al., 1986. Guide pratique pour la détermination de kystes de Dinoflagellés fossiles: le complexe Gonyaulacysta. Bull. Centres Rech., Explor.-Prod., Elf Aquitaine Mem. 12, 479 pp.

Lentin, J. K. & Williams, G. L., 1985. Fossil Dinoflagellates: Index to Genera and Species, 1985 Edition. Canadian Technical Report of Hydrography and Ocean Sciences. 60, 451 pp.

Lopez Garrido, A. C., 1971. Geologia de la zona prebetic, al NE de la provincia de Jaén. Thesis doctor., Universidad de Granada, España, 91–204.

Rye, Y., 1973. Palynology of the Mesozoisque Saharian. Memoires du Museum National d’Histoire Naturelle, Serie C, Sciences de la Torre, Tome XXVII, 284 pp.

Riley, L. A., 1974. Miospores from the Upper Jurassic of the Cabo Espichel, Portugal. Symposium on stratigraphical palynology. Birbal Sahni Institute of Palaeobotany, Special publication No. 3, 33–39.

Stover, L. E. & Evitt, W. R., 1978. Analyses of pre-Pleistocene organic-walled dinoflagellates. Publ. Geol. Sci. Univ. Stanford 15, 300 pp.

Thusu, B. & Vigran, J. O., 1975. A review of the palynostratigraphy of the Jurassic System in Norway. NTNF’s Continental Shelf Project, Publication No. 67, 1–12.
Van Erve, B. & Vigran, J. O., 1985. Middle-Late Jurassic (Late Bathonian-Tithonian) Palynomorphs. *Journal of Micropalaеontology*, 4 (1), 113–130.

Van Erve, A. W. & Mohr, B. A. R., in press. Palynological investigation in the Upper Jurassic of the vertebrate locality Guimarota (Leiria, Central Portugal).

Viallard, P., 1973. Recherches sur le cycle alpin dans la chaine Iberique sud-occidentale. *Traveaux du Lab. de Geol. Mediteer., Associé au CNRS, Univ. Paul Sabatier, Toulouse*, 130–139.

Vigran, J. O. & Thusu, B., 1975. Illustrations and distribution of the Jurassic palynomorphs of Norway. *NTNF's Continental Shelf Project, Publication No. 65*, 1–54.

Williams, G. L. & Bujak, J. P., 1985. Mesozoic and Cenozoic dinoflagellates. In: Bolli et al. (Eds.): *Planktonic Stratigraphy*, 847–946.

Woollam, R., 1983. A review of the Jurassic dinocyst genera *Ctenidodinum* Deflandre 1938 and *Dichadogonyaulax* Sarjeant 1966. *Palynology* 7, 183–196.

Woollam, R. & Riding, J. B., 1983. Dinoflagellate cyst zonation of the English Jurassic. *Rep. Inst. Geol. Sci.* No. 83/2, 41p.