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Biostratigraphic correlation of the Middle Oxfordian sediments in the Iberian Chain, eastern Spain

ABSTRACT: Recent studies on Middle Oxfordian ammonite successions in southern Europe, Submediterranean province, based mainly on perisphinctids have led to the elaboration of a detailed biostratigraphic scheme for the Transversarium and Bifurcatus Zones. A correlation scheme is presented for the eastern part of the Iberian Chain (eastern Spain) on the base of representatives of the family Perisphinctidae, which is intended to serve as a basis for the setting of a standard zonal scheme for the Tethyan Oxfordian, one of the main items in the current work of the *Oxfordian Working Group*. In the Iberian Chain the Middle Oxfordian is widely represented under sponge limestone facies. With few exceptions, carbonate sedimentation in the whole studied area starts, as a rule, at the middle part of the Transversarium Zone (Luciaeformis Subzone). Several new biohorizons, widely recognized at a basin scale, are tentatively proposed, to refine the zonal scheme which is characterized now by: the Iberica horizon at the middle part of the Schilli Subzone, the Jelskii and Wartae horizons within the Rotoides Subzone, and the Grossouvrei, Bifurcatus and Ariniensis horizons within the Grossouvrei Subzone.

INTRODUCTION

The biostratigraphic subdivision of the classical zones of the Middle Oxfordian in southern Europe (Submediterranean Province) has undergone a remarkable progress in the recent years in relation to the standard zonal scheme proposed by the Jurassic French Group (CARIOU & *al.* 1971) since the detailed study carried out by one of the present authors in Eastern Iberia (MELÉNDEZ 1989). The major progress in refining the biostratigraphic scheme has mainly affected the Transversarium and Bifurcatus Zones (CALLOMON 1988; MELÉNDEZ 1989; CARIOU & MELÉNDEZ 1990; FONTANA & MELÉNDEZ 1990; FONTANA 1991, 1992; CARIOU & *al.* 1991; MELÉNDEZ & FONTANA 1991, 1992; ATROPS & MELÉNDEZ 1993). The main results in the Plicatilis Zone concern the identification of the classical Vertebrale and Antecedens Subzones in wider areas throughout Europe, and the recognition of their successive homogeneous ammonite assemblages (BOURSEAU 1977, MARCHAND & BROCHWICZ-LEWIŃSKI 1980, CALLOMON 1988, FORTWENGLER 1989).

The purpose of this paper is to report the recent findings of the new successive *Perisphinctes* assemblages from the Middle Oxfordian of the Iberian Chain in order to show their general extent and stratigraphic range accross a wide sedimentary basin. The correlation of the successive profiles has been carried out along three general transversal lines of roughly NW-SE direction (Text-figs 1-3): the first one along the so-called Aragonese Branch of the Iberian Chain, southern margin of the Ebro basin, from the classical locality of Ricla to that of Calanda. Transverse sections *II* and *III* have been carried out in

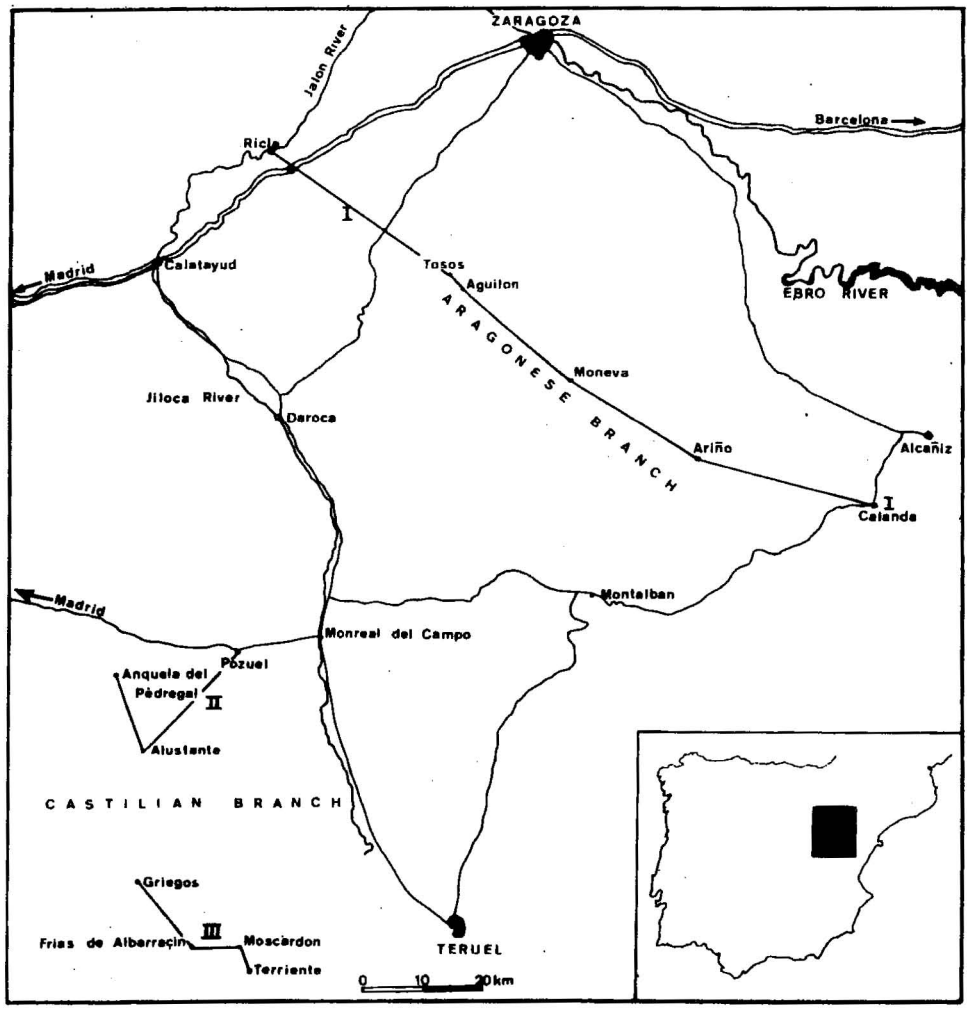


Fig. 1. Geographic setting of the study area (inset shows its location in Spain)

The main transversal correlation lines across the Aragonese and Castilian branches of the Iberian Chain (I, II, III), corresponding to Text-figs 2 and 3, are indicated; the localities on these lines correspond to the studied sections

the so-called Castillian Branch, at the central part of the Iberian Chain, in the areas, respectively, of Sierra Menera (profiles of Anquela del Pedregal, Alustante, and Pozuel del Campo) and Sierra de Albarracín (profiles of Griegos, Frías de Albarracín, and Moscardón).

Difficulties in refining the biostratigraphic subdivision are due to various reasons, as recently summarized by CALLOMON (1988): (*1*) the particular character of representatives of the genus *Perisphinctes*, a group classically used as index-fossils for the Middle Oxfordian, and characterized by a wide and still poorly systematized horizontal variability; (*2*) the apparently gradual and smooth character of evolutive morphological changes udergone by the representatives of *Perisphinctes* throughout the Transversarium Zone, leading often to confusions and misinterpretations of different species of that genus when the precise stratigraphic position is not accurately known; (*3*) the presence of gaps and non-sequences of different range at the Callovian/Oxfordian boundary in southern Europe. This fact has made traditionally difficult the recognition of ammonite successions and biostratigraphic correlations between distant areas. A further, fourth point may be added: the existence of a slight provincialism between perisphinctids of NW and S Europe. Such provincialism is more evident from the Bifurcatus Zone onwards and is still a handicap for detailed correlations between these two European areas.

Gaps and non-sequences, provincionalism and horizontal variability, as well as a high rate of evolution in the perisphinctids, have hindered the biostratigraphic correlation and impeded the progress in establishing biostratigraphic successions. The zonal schemes proposed by different authors (*see* Text-fig. 5) in the last half-century for the Middle and Upper Oxfordian display a slow, although stable progress in refining the biostratigraphic subdivisions of the Middle Oxfordian (*see* Text-fig. 4). For the purpose of comparison the first three zonal schemes are referred to northwestern Europe (Great Britain) and the rest to southern Europe. A correlation between both areas for the upper Bifurcatus Zone has been proposed by CALLOMON (1988), according to whom the Grossouvrei Subzone would comprise the British Cautisnigrae and Variocostatus Subzones. The non-sequence located at the boundary between Transversarium and Cautisnigrae Zones may be evaluated by comparing the tables given by CALLOMON in 1964, 1969 and in 1988 (*see* Text-fig. 5).

THE CURRENT STATE OF PROGRESS

Recent progress in refining the biostratigraphic subdivisions of the Middle Oxfordian by different authors has focused preferently on the recognition of subzones and ammonite horizons within the Transversarium Zone. The main attempts to subdivide the classical zonal scheme were due to BROCHWICZ-LEWIŃSKI (1976), MELÉNDEZ & *al.* (1985), MELÉNDEZ (1989), and

CALLOMON (1988). In all these cases the Transversarium Zone was subdivided into three main subzones: the Parandieri (or Buckmani) Subzone, the Wartae Subzone, and the Schilli Subzone.

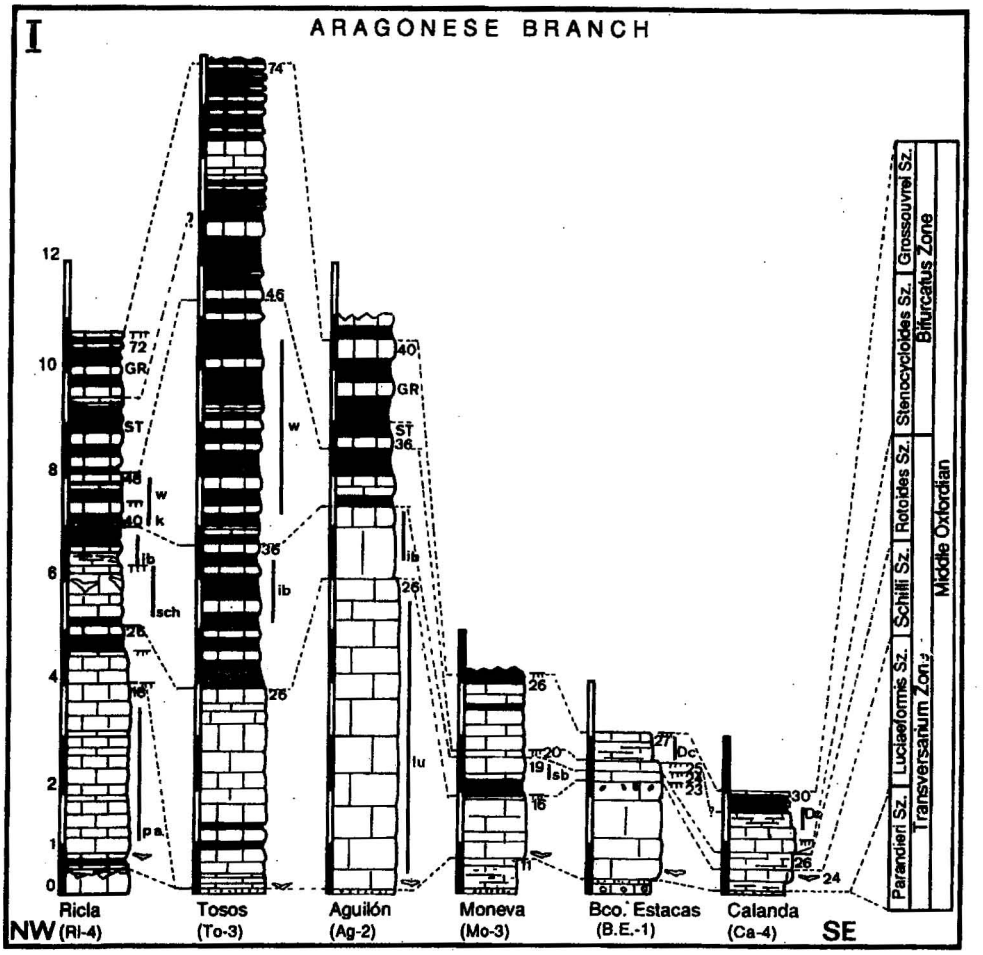


Fig. 2. Middle Oxfordian correlation along the transversal line I—I in the Aragonese Branch of the Iberian Chain

Numbers on the logs indicate the number of beds

Some key perisphinctid genera and species are marked on vertical bars to show their recorded vertical range: **pa** — *Perisphinctes parandieri* DE LORIOL; **lu** — *Perisphinctes luciaeformis* ENAY; **sch** — *Larcheria schilli* OPPEL, **ib** — *Larcheria iberica* FONTANA; **sb** — *Larcheria subschilli* LEE; **k** — *Perisphinctes jelskii* SIEMIRADZKI; **w** — *Perisphinctes wartae* BUKOWSKI; **ro** — *Perisphinctes rotoides* RONCHADZE; **Dc** — *Dichotomoceras bifurcatoides* ENAY — *stenocycloides* SIEMIRADZKI group

ST — Stenocycloides Subzone, **GR** — Grossouvrei Subzone

However, the recent finding by GYGI (1986, 1990) of true representatives of the species *Perisphinctes rotoides* RONCHADZE in the region Canton Aargau, Switzerland, at the top of the Transversarium Zone, and the identification by CARIOU & MELÉNDEZ (1990) of the species *Perisphinctes* (*Dichotomosphinctes*) *wartae* BUKOWSKI at the right stratigraphic position, in the same levels, at the top of the Transversarium Zone, led the last authors to propose a new

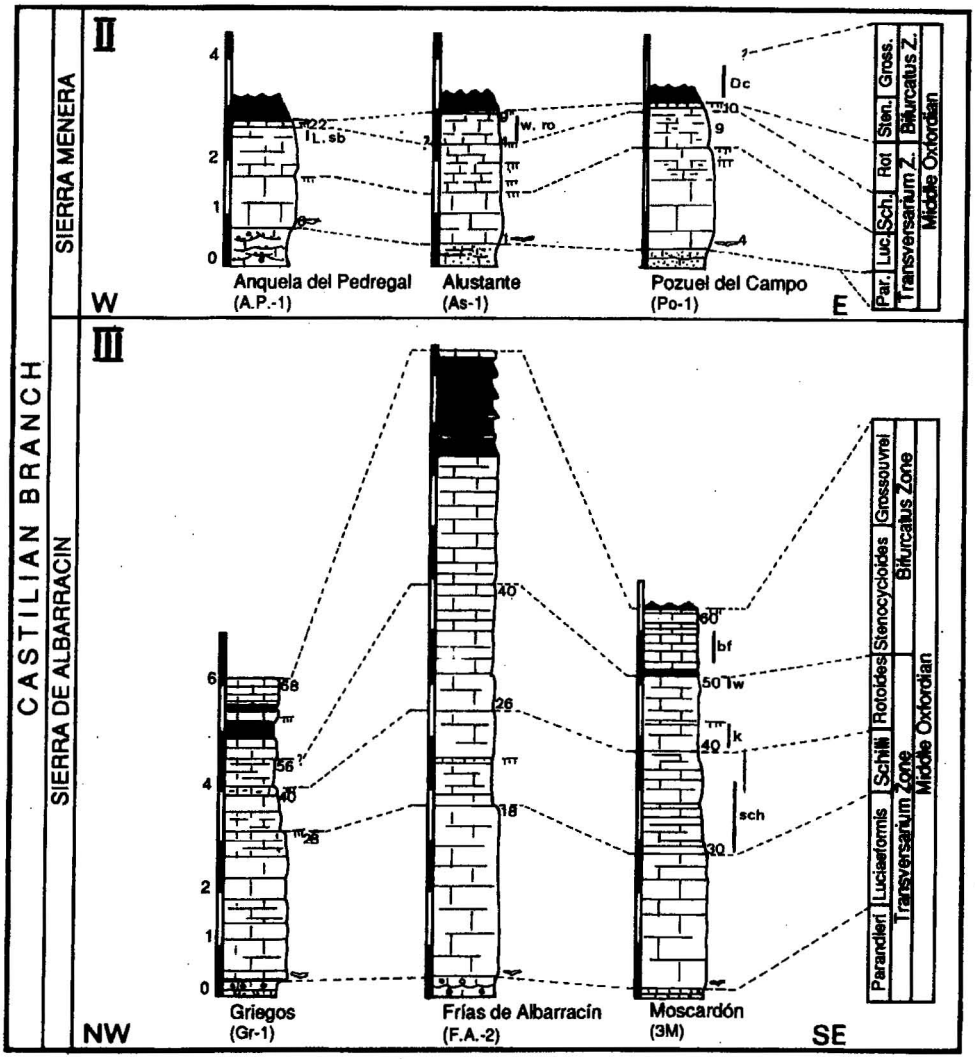


Fig. 3. Middle Oxfordian correlation along the transversal lines II — II (Sierra Menera) and III — III (Sierra de Albarracín), across the Castilian Branch, at the central part of the Iberian Chain

Bed numbers and initial letters for the perisphinctid species and subzones as in Text-fig. 2

biostratigraphic subdivision, the Rotoides Subzone, above the Schilli Subzone and below the Bifurcatus Zone (CARIOU & MELÉNDEZ 1990, CARIOU & *al.* 1991). These authors also proposed to change the name of the classical Wartae Subzone by the Luciaeformis Subzone, with the index species *Per.* (*Dichotomosphinctes*) *luciaeformis* ENAY, which is widely expanded throughout this stratigraphic interval, below the Schilli levels. A result of these changes is that most of the previous references to *Per. rotoides* at lower part of the Plicatilis Zone should be considered as misidentifications, and redetermined as early representatives of *Per. antecedens* SALFELD, or a close form. Similarly, the many specimens classically assigned to *Perisphinctes wartae* BUKOWSKI by different authors at the middle part of the Transversarium Zone, below the *Larcheria schilli* occurrences, should rather be redetermined as *Per.* (*Dichotomosphinctes*) *luciaeformis* ENAY, or any related form.

Up to the present, this stratigraphic interval, the Rotoides Subzone, has been unambiguously identified in the Iberian Chain (eastern Iberia), Aquitaine, Castellane (SE France), Burgundy, the Swiss Jura, and the Polish Jura Chain (*cf.* CARIOU & *al.* 1991). References to the Polish Jura are due to BROCHWICZ-LEWIŃSKI (1970, p. 240) who recognized the assemblage with *Perisphinctes* (*Dichotomosphinctes*) *wartae* BUKOWSKI between the beds *21* and *23* of the Zawodzie section at Częstochowa. A recent revision of this section, thanks to the kind help of E. GŁOWNIAK (University of Warsaw), has allowed the precise recognition of this assemblage right below the levels with *Dichotomoceras* of the *bifurcatoides-stenocycloides* group.

DESCRIPTION OF THE AMMONITE ASSEMBLAGES AND BIOHORIZONS

Detailed descriptions of the current biostratigraphic subdivisions have been given by the present authors (MELÉNDEZ 1989, CARIOU & MELÉNDEZ 1990, FONTANA 1991) and by CARIOU & *al.* (1991). Therefore, in this chapter only a few comments will be added on those aspects of the ammonite assemblages needing revision and on possible new biohorizons (*see* Text-fig. 4).

THE CALLOVIAN/OXFORDIAN BOUNDARY

In the studied area the Oxfordian sediments are represented by sponge limestones facies. The Callovian/Oxfordian boundary is usually located within a thin irregular, iron-oolitic limestone level. In some localities (*e.g.*, Ricla), this boundary level is represented by a thin, irregular, non-oolitic limestone bed

showing several erosional surfaces inside (MELÉNDEZ & *al.* 1983). The Callovian/Oxfordian transition is marked by a huge stratigraphic gap, ranging from the Upper or Middle (sometimes even Lower) Callovian to the Middle Oxfordian, Transversarium Zone.

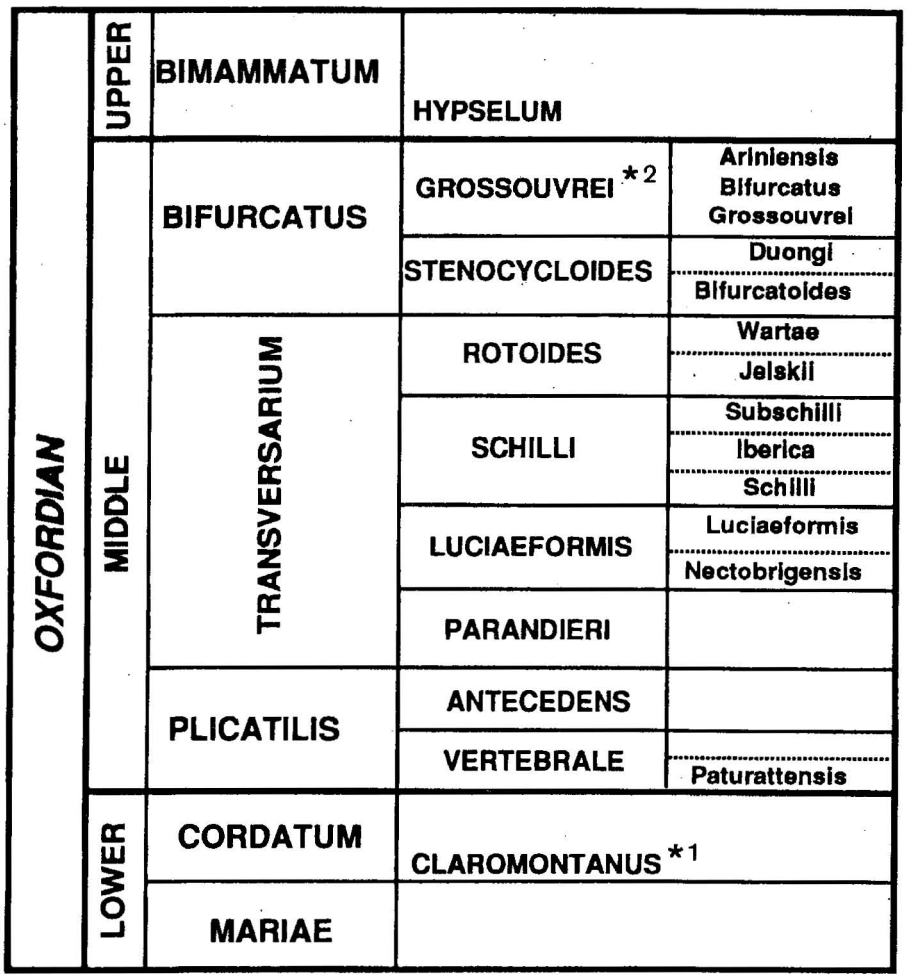


Fig. 4. Proposed biostratigraphic scheme for the Middle Oxfordian of southern Europe

*1 Claromontanus Subzone of BROCHWICZ-LEWIŃSKI (1981), approximately equivalent to the Bukowskii Subzone, lower Cordatum Zone, in the Boreal Realm and a part of the Submediterranean Province.

*2 Subdivisions of the Grossouvrei Subzone into biohorizons should be taken as still provisional, and recognized so far in the Iberian Chain.

LOWER OXFORDIAN, CORDATUM ZONE

The Lower Oxfordian is scarcely represented in the Iberian Chain except for some ammonite specimens, recorded at the Callovian/Oxfordian boundary level, just below the first sponge limestone bank, which characterizes the lower part of the Cordatum Zone (Claromontanus Subzone). These specimens form a well defined assemblage which was previously studied by MELÉNDEZ & *al.* (1993): *Neocampylites delmontanus* (OPPEL), *Prososphinctes claromontanus* (BUKOWSKI), *Passendorferia* (*Enayites*) *czestochowiensis* (SIEMIRADZKI), *Perisphinctes* (*Otosphinctes*) *moeschi* SPATH, *Perisphinctes* (*Otosphinctes*) *spathi* MELÉNDEZ (=*Properisphinctes bernesis* ARKELL, *non* DE LORIOL).

The age of the oolitic iron level is, however, difficult to assess since in many cases Lower Oxfordian ammonites from this level show clear evidence of taphonomic reworking according to the criteria defined by FERNÁNDEZ-LÓPEZ (1984, 1985), and may appear mixed with younger ammonites from the Plicatilis Zone (*see below*). The result is a condensed ammonite association formed by diachronous elements. A detailed discussion on the processes involved in the origin of this bed has recently been made by one of the present authors (*in*: AURELL & *al.* 1993).

MIDDLE OXFORDIAN, PLICATILIS ZONE

The Plicatilis Zone is largely absent in the studied area. Only few specimens of *Perisphinctes* (*Otosphinctes*) of the *paturattensis-montfalconensis* DE LORIOL group, probably characteristic of the lower Vertebrale Subzone (=Paturattensis horizon) are sporadically recorded as a part of a condensed association within the Callovian/Oxfordian boundary level. This association corresponds partly to the Vertebrale Subzone as characterized by several authors in different parts of Europe (BOURSEAU 1977, MARCHAND & BROCHWICZ-LEWIŃSKI 1980, FORTWENGLER 1989), or the Tenuicostatum Subzone as characterized by ENAY (1966) and BROCHWICZ-LEWIŃSKI (1976). The Antecedens Subzone is probably missing in most of the studied localities, except perhaps in the sections of Moscardón and, most of all, Ariño, where some rare specimens of *Tornquistes*, *Kranaosphinctes* and *Arisphinctes* close to the *helenae* group are known from the iron-oolite boundary level.

MIDDLE OXFORDIAN, TRANSVERSARIUM ZONE

The Transversarium Zone is well represented throughout the studied area at the lower part of the Yátova Formation, representing the general beginning of the carbonate sedimentation in the Iberian basin.

PARANDIERI SUBZONE

The lowermost, Parandieri Subzone, has only been identified in Ricla (outcrop *Ri.4*, beds *2-18*), where the succession is more complete, by the presence of *Per.* (*Perisphinctes*) *parandieri* DE LORIOL (M), *Per.* (*Dichotomosphinctes*) *buckmani* ARKELL (m), and *Per.* (*Otosphinctes*) *siemiradzkii* ENAY (m) (*see* FONTANA 1991). As a general rule, representatives of this assemblage are evolute, somewhat coarsely ribbed serpenticones, characterized by their large size, and rounded to subquadrangular whorl section. Some scarce, compressed, finely ribbed specimens can also be occasionally found in this assemblage.

LUCIAEFORMIS SUBZONE

The Luciaeformis Subzone appears well developed in all the studied sections, at the lower part of the Yátova Formation, representing the general beginning of the carbonate sedimentation in the Iberian basin. In Ricla, where the succession is more complete, the boundary between the Parandieri and Luciaeformis Subzones is placed between the beds *18* and *20* of the outcrop *Ri.4* in an interval characterized by the local abundance of *Per.* (*Dichotomosphinctes*) *elisabethae* DE RIAZ. The Subzone is characterized by the presence of *Per.* (*Dichotomosphinctes*) *luciaeformis* ENAY and the macroconchs of the *Per. martelli* (OPPEL) group. The basal, Nectobrigensis horizon, characterized by the presence of *Per.* (*Otosphinctes*) *nectobrigensis* MELÉNDEZ is recognized in all the studied localities.

Sediments of this subzone appear well exposed in all the studied localities, as white to gray limestones in massive compact banks (fossiliferous wackestone) with large sponges. Ammonites in this interval are not abundant, the exception being the numerous outcrops between Ricla, Tosos and Aguilón. The Subzone is characterized by the species *Per.* (*Dichotomosphinctes*) *luciaeformis* ENAY, showing a wide variability, from evolute, coarsely ribbed specimens, close to the holotype, to more involute, densely ribbed forms.

Nectobrigensis horizon

The lowermost levels of this interval are characterized by the presence of evolute and large size representatives of *Per.* (*Otosphinctes*) and *Per.* (*Dichotomosphinctes*). The species *Per.* (*Otosphinctes*) *nectobrigensis* MELÉNDEZ, is locally abundant in these levels in Ricla (the type locality of the holotype), allowing to define a lower horizon, the Nectobrigensis horizon, within this subzone. This horizon, however, can be further followed throughout the whole Iberian Chain and has been recognized as well in SE France (Castellane). The ammonite assemblage comprises:

Subfamily Perisphinctinae

Per. (*Otosphinctes*) *nectobrigensis* MELÉNDEZ, 1984. (m)
Per. (*Kranaosphinctes*) n.sp. *A*, in MELÉNDEZ 1989, p. 221, Pl. 21, Figs 4-5 (M)

Subfamily Passendorferiinae

Passendorferia (*Enayites*) *birmensdorfensis* (MOESCH, 1867) (m)
Pass. (*Passendorferia*) *ziegleri* (BROCHWICZ-LEWIŃSKI, 1973) (M)

Luciaeformis horizon

This assemblage includes numerous forms reported by CALLOMON (1988 p. 439, Table 1, assemblage *IV*) from the so-called "Wartae Subzone". Macroconchs of this assemblage correspond to the *Per. martelli* group OPPEL, comprising specimens ranging from some evolute, coarsely ribbed ones, close to those described as *Kranaosphinctes* n.sp.*A* by MELÉNDEZ (1984) and *Per. martelli* OPPEL, to the densely ribbed *Per. aguilonensis* MELÉNDEZ and *Subdiscosphinctes* spp. The involute, densicostate morphology typical of *Subdiscosphinctes* is scarcely represented in the studied area. The assemblage comprises:

Subfamily Perisphinctinae

Per. (*Dichotomosphinctes*) *luciaeformis* ENAY, 1966 (m)
Per. (*Otosphinctes*) *vermicularis* LEE, 1905 (m)
Subdisc. (*Subdiscosphinctes*) sp. in FONTANA (1991; and MELÉNDEZ & FONTANA 1993) (m)
Per. (*Kranaosphinctes*) sp. (M)
Per. (*Perisphinctes*) *aguilonensis* MELÉNDEZ, 1984 (M)
Per. (*Perisphinctes*) aff. *martelli* (OPPEL, 1863) (M)

Subfamily Passendorferiinae

Passendorferia (*Enayites*) *birmensdorfensis* (MOESCH, 1867) (m)
Pass. (*Passendorferia*) *ziegleri* (BROCHWICZ-LEWIŃSKI, 1973) (M)
Sequeirosia (*Gemmellarites*) *trichopocus* (GEMMELLARO, 1875) (m)[1]
Seq. (*Sequeirosia*) *brochwiczi* (SEQUEIROS, 1973) (M)

SCHILLI SUBZONE

The Schilli Subzone is also widely represented in the Iberian Chain. It is characterized by the presence of numerous representatives of the genus *Larcheria*. This genus has been recently shown to present a well-defined sexual dimorphism. It has been possible to recognize the macroconchs (M) and microconchs (m) in most of the currently known species from Western Europe (FONTANA 1991; MELÉNDEZ & FONTANA 1992, 1993).

[1] Representatives of these Mediterranean "*Dichotomosphinctes*" and "*Arisphinctes*" (=*Sequeirosia* MELÉNDEZ) are common throughout the Transversarium Zone. However, the precise position of the species *Sequeirosia trichoplocus* and *S. brochwiczi* appears to be at the Luciaeformis horizon, in the upper Luciaeformis or lower Schilli Subzone.

Some of the typical species of this interval have been listed by CALLOMON (1988) and by CARIOU & MELÉNDEZ (1990). Further details on the geographic and stratigraphic extent of this subzone in the Iberian Chain, and on its paleontological content are given by FONTANA & MELÉNDEZ (1990) and FONTANA (1991). The list of characteristic morphospecies can be summarized as follows:

Larcheria schilli (OPPEL) (m & M)
Larcheria iberica FONTANA (m & M)[2]
Larcheria subschilli (LEE) (m & M)
Passendorferia tenuis sensu MELÉNDEZ 1984, 1989 (*non* ENAY, 1966)
[="*Passend.* (m & M) n.sp. aff. *birmensdorfensis* (MOESCH)" *in* FONTANA (1991, p. 60, Pl. 5, Figs 3-4) (M)]
Per. (*Otosphinctes*) *vermicularis* LEE (m)
Per. (*Otosphinctes*) *sorlinensis* DE LORIOL (m)[3]
Per. (*Dichotomosphinctes*) *marnesiae* DE LORIOL (m)
Per. (*Dichotomosphinctes*) *luciae* DE RIAZ (m)[4]
Per. (*Dichotomosphinctes*) *ultimus* ENAY (m)
Per. (*Kranaosphinctes*) sp. (M)[5]
Per. marcoui DE LORIOL (?M)[6]

The proposed biohorizons

The subdivision of this subzone into biohorizons has been made on the basis of the successive species of *Larcheria*. It was first proposed by MELÉNDEZ (1989) for the Iberian Chain as the lower, Schilli horizon, and the upper Subschilli horizon. However, the recent recognition of a new form, *Larcheria iberica* FONTANA, morphologically and stratigraphically intermediate between the well-known species *Larcheria schilli* (OPPEL) and *Larcheria subschilli* (LEE) would make it possible to distinguish a new, intermediate, Iberica horizon within this subzone (FONTANA 1991, MELÉNDEZ & FONTANA 1993).

Sediments of the Schilli Subzone appear bounded by small gaps of different range and extent (MELÉNDEZ & FONTANA 1993, Fig. 8.4).

The lower gap, affecting the Schilli horizon, shows a maximum range in the external part of the platform, while the upper one, affecting the Subschilli

[2] Some earlier references to *Larcheria subschilli* (LEE) by one of the present authors (MELÉNDEZ 1989) from such sections as Ricla, Aguilón and Moscardón, should be reinterpreted as *Larcheria iberica* FONTANA.

[3] *Per. sorlinensis* DE LORIOL is mostly localized at the upper part of the Schilli Subzone, Subschilli horizon.

[4] Representatives of these medium-sized, densicostate *Dichotomosphinctes* can also be found in the underlying, Luciaeformis assemblage. They do persist, however, in this Subzone, and show a progressive reduction in the adult size.

[5] Macroconchs of *Per.* (*Otosphinctes*) *vermicularis* and *Per.* (*Otosphinctes*) *sorlinensis* are involute rounded serpenticones, finely ribbed in the inner whorl, and only slightly variocostate in the adult stage. They may be assigned, on pure morphological grounds, to *Kranaosphinctes*.

[6] The original type-specimen of *Per. marcoui* DE LORIOL is an involute, compressed, densicostate specimen which most probably is the nucleus of a *Per.* (*Perisphinctes*) (M), and could be interpreted as a late representative of the former *Per. martelli* (OPPEL).

horizon, extends throughout the more proximal areas. The geographic spread of the different horizons appears therefore asymmetrical across the Iberian basin.

Schilli horizon (MELÉNDEZ 1984)

The Schilli horizon has been better recognized in the more proximal areas, such as the profiles of Ricla and Tosos (Aragonese Branch) and in the profiles of Moscardón and Frías in Sierra de Albarracín (*see* Text-figs 2-3). It is characterized by the sudden appearance of *Larcheria* and the presence of common representatives of *L. schilli* (OPPEL) (M & m). This species is characterized by somewhat involute, platycone coiling with oval, thick whorl section and the "larcherioid" strong ribbing from the early stages of the development. The available data also suggest that, besides the Iberian Chain, this horizon can be extended to other areas of western Europe, such as Aquitaine and Burgundy (CARIOU & *al.* 1991).

Iberica horizon, nov.

This new horizon is defined by the species *Larcheria iberica* FONTANA, 1991 (M & m), widespread throughout the Iberian Chain. The species is characterized by the compressed platycone shape with moderately evolute coiling and the "larcherioid" (multidivided with distant primaries) ribbing on the whorl sides. This horizon can be recognized in the French Jura, as well as in Trept, and in the Swiss Jura, as good specimens of this species are recognized among the material figured by ENAY (1966), DE RIAZ (1898) and RONCHADZÉ (1917)(*see* MELÉNDEZ & FONTANA 1993, p. 180). Its presence in the Polish Jura Chain is still doubtful, although the specimen figured by BROCHWICZ-LEWIŃSKI (1972, Pl. 13) as *Larcheria* cf. *latumbilicata* (TINTANT) could, in fact, represent the macroconch counterpart of this species.

Subschilli horizon (MELÉNDEZ 1984)

Unlike the Schilli horizon, in the studied area the Subschilli horizon has been recognized only in the more distal areas, i.e. the sections of Moneva, Ariño (Barranco de las Estacas) and in the numerous outcrops of Calanda wherefrom come the best specimens of this species. It is defined by the species *Larcheria subschilli* (LEE) (M & m), a form characterized by the inner whorls, reaching the "larcherioid" aspect in later stages of the ontogeny. Some other *Perisphinctes* species typical of the Subzone can also be common; for instance, *Per.* (*Dichotomosphinctes*) *luciae* DE RIAZ, *Per.* (*Dichotomosphinctes*) *ultimus* ENAY, *Per.* (*Otosphinctes*) *sorlinensis* DE LORIOL, etc.

ROTOIDES SUBZONE (CARIOU & MELÉNDEZ 1990, CARIOU & *al.* 1991)

This subzone forms a well defined stratigraphic interval in SW Europe between the last levels with *Larcheria* and the first record of typical representatives of *Per.* (*Dichotomoceras*). It corresponds to the "horizon à *Proscaphites colleti* (LEE)" of CARIOU (1966). In Poitou this stratigraphic interval is represented by a highly diversified and not yet described ammonite assemblage. The index species, *Per.* (*Dichotomosphinctes*) *rotoides* RONCHADZÉ has been identified so far in different areas throughout western Europe, between the Swiss Jura and Aquitaine (*see* CARIOU & *al.* 1991, p. 707 for references). In the studied sections, at the Iberian Chain, this species has been reported from the localities of Moneva and Ariño (Barranco de las Estacas Section, *see* FONTANA 1991), although it is not particularly abundant in the area.

Jelskii horizon, nov.

The identification of several well-defined successive ammonite associations in the studied area allows the recognition of at least two biohorizons within this subzone: a lower one, composed by a homogeneous assemblage first identified and described by one of the authors (MELÉNDEZ 1989, p. 307, Pl. 50) as *Per.* (*Dichotomosphinctes*) sp.n. *A*, which can be properly assigned to *Perisphinctes jelskii* SIEMIRADZKI. This species has been reported so far, in the Iberian Chain from the localities of Ricla (outcrop *Ri.1*) and Aguilón, just above the last levels with representatives of the genus *Larcheria*. In Aquitaine this species appears also well localized in comparable levels, in constant association with its presumable macroconch, a larger involute, finely ribbed form identified as *Per. kreutzi* RONCHADZÉ (*non* SIEMIRADZKI). The assemblage comprises:

Perisphinctes(?) *jelskii* SIEMIRADZKI, 1899 (m)
Perisphinctes(?) *kreutzi* RONCHADZÉ, 1917 (*non* SIEMIRADZKI, 1891
Per. (*Perisphinctes*) ex gr. *panthieri* ENAY, 1966; as *in* MELÉNDEZ (1989, p. 242, Pl. 28, Figs 1-4 and Pl. 29, Fig. 2, *non* Fig. 1) (M)

Wartae horizon, nov.

The second, higher biohorizon, is characterized by the sudden appearance of *Per.* (*Dichotomosphinctes*) *wartae* BUKOWSKI. The index species of the Subzone, *Per.* (*Dichotomosphinctes*) *rotoides* RONCHADZÉ seems to have similar stratigraphic range. However, further evidence is still needed to show whether these two species actually form a part of a single assemblage or are, on the contrary, stratigraphically successive. This upper stratigraphic interval can be proposed as a new unit, the Wartae horizon, at the upper part of the Subzone.

In the studied area the Wartae horizon is specially well developed in the sections of Ricla (outcrop *Ri.4*, beds *42-48*), Tosos (outcrop *To.3*, beds *40-44*; *see* FONTANA 1991), Aguilón (outcrop *AG.2*, beds *34-35*), Ariño (outcrop *Ar.1*, beds *18-19*) and Moscardón (outcrop *3M*), where it appears specially well exposed at beds *48*, *50*, and *52* (*see* MELÉNDEZ 1989, CARIOU & *al.* 1991). Attention should be paid to the close morphological similarity between representatives of *Per.* (*Dichotomosphinctes*) *wartae* BUKOWSKI and the first specimens of *Per.* (*Dichotomoceras*) *bifurcatoides* ENAY, leading frequently to misidentifications. Therefore, the specimens figured by MELÉNDEZ (1989, Pl. 52, Fig. 1; Pl. 53, Fig. 2; Pl. 54, Fig. 2 and 4) coming from levels *50*, and *52* of Moscardón, should be rather determined as *Per.* (*Dichotomosphinctes*) *wartae* BUKOWSKI. The assemblage comprises:

Per. (*Dichotomosphinctes*) *wartae* BUKOWSKI, 1887 (m)
Per. (*Dichotomosphinctes*) *rotoides* RONCHADZE, 1917 (m), *non* ARKELL (1935-48), *nec* ENAY (1966), *nec* BROCHWICZ-LEWIŃSKI (1976)[7]
Per. (*Perisphinctes*) *cuneicostatus* ARKELL (M) *Per.* (*Perisphinctes*) ex gr. *panthieri* ENAY, 1966; as *in* MELÉNDEZ (1989, Pl. 29, Fig. 1).

MIDDLE OXFORDIAN, BIFURCATUS ZONE

STENOCYCLOIDES SUBZONE

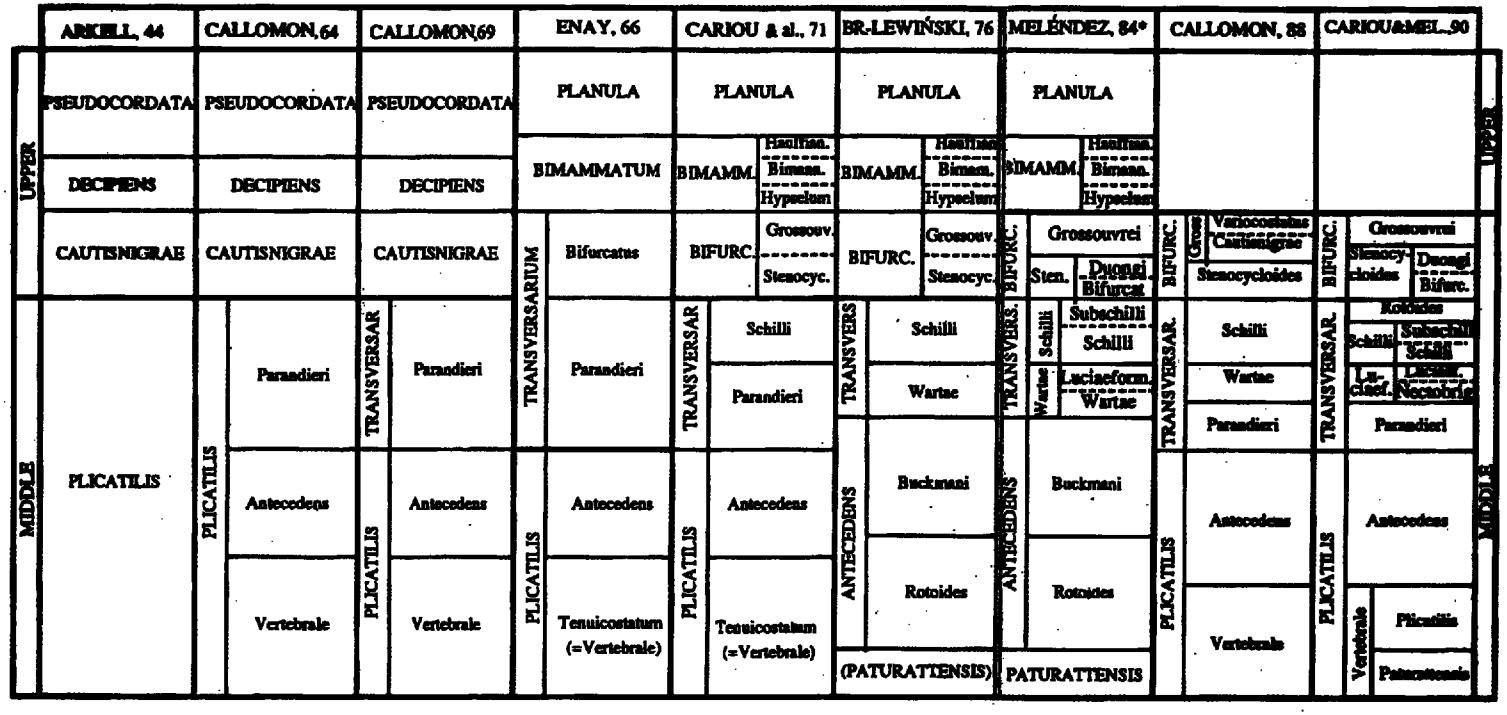
The onset of the Bifurcatus Zone, the Stenocycloides Subzone, is marked by the appearance of the first representatives of true *Per.* (*Dichotomoceras*) of the *bifurcatoides* ENAY — *stenocycloides* SIEMIRADZKI groups and their corresponding macroconchs, *Per.* (*Perisphinctes*) *panthieri* ENAY.

Bifurcatoides horizon (MELÉNDEZ 1984)

The lower, Bifurcatoides horizon, can be recognized at the base of this subzone characterized by the presence of large-sized, first representatives of *Per.* (*Dichotomoceras*) and their corresponding macroconchs, the early representatives of *Perisphinctes* (s.str.). These forms are characterized by the finely ribbed inner whorls and *U*-shaped initial part of rib curve, the quadratic whorl section and large, cuneiform modified adult ribs. This horizon has been

[7] *Per.* (*Dichotomosphinctes*) *rotoides* RONCHADZÉ, a late representative of *Dichotomosphinctes*, transitional to *Dichotomoceras*, is a compressed serpenticone characterized by the evolute coiling with rounded whorl section and coarsely ribbed ornamentation in the inner whorls, turning into involute compressed serpenticone with fine, sharp, *Dichtomoceras*-like ribs at the end of the adult body chamber.

Correlation chart of biostratigraphic subdivisions proposed by different authors for the Middle and Upper Oxfordian of the western Tethys, Submediterranean, and Subboreal provinces



* *See also* MELÉNDEZ, SEQUEIROS & BROCHWICZ-LEWIŃSKI (1985).

identified by the index species in all the studied localities. The assemblage comprises:

Per. (*Dichotomoceras*) *bifurcatoides* ENAY (m)
Per. (*Dichotomoceras*) *stenocycloides* SIEMIRADZKI (m)
Per. (*Perisphinctes*) *panthieri panthieri* ENAY (M)
Per. (*Perisphinctes*) *panthieri polonicus* MALINOWSKA (M) (a finely ribbed subspecies).

Duongi horizon (MELÉNDEZ 1984)

The upper, Duongi horizon, characterized by the presence of common representatives of *Per.* (*Dichotomoceras*) *duongi* MELÉNDEZ, is recognized at the top of the Subzone (MELÉNDEZ 1984, MELÉNDEZ & *al.* 1985). Macroconchs of this assemblage comprise representatives of *Per.* (*Perisphinctes*) close to *Per. panthieri* ENAY, but showing a smaller size and a reduction of the varicostate stage, such as some forms described as early *Ampthillia* by ENAY (1966) and MELÉNDEZ (1984, 1989). This horizon has been recognized in most of the studied localities, but specially in the sections of Ricla, Tosos, Ariño, Moscardón, and Frías de Albarracín. The assemblage comprises:

Per. (*Dichotomoceras*) *duongi* MELÉNDEZ (m)
Per. (*Dichotomoceras*) *stenocycloides* RONCHADZE (*non* SIEMIRADZKI) (m)
Per. (*Ampthillia*) n.sp. aff. *quadratus* ENAY, 1966; as *in* MELÉNDEZ (1989, Pl. 34, Fig. 1) (M)

GROSSOUVREI SUBZONE

The Grossouvrei Subzone[8] is characterized by the presence of small-sized *Per.* (*Dichotomoceras*) of the *grossouvrei* SIEMIRADZKI, *bifurcatus* QUENSTEDT and *crassus* ENAY groups (= *Divisosphinctes* BEURLEN). This subzone appears so far difficult to subdivide. However, the recorded *Perisphinctes* succession in the Iberian Chain allows recognizing several well-defined assemblages which can be tentatively proposed as documenting the biohorizons for this region. The species *Per.* (*Dichotomoceras*) *grossouvrei* SIEMIRADZKI seems to concentrate at the lower part, in an interval specially well-developed in the area of Ricla-Tosos and Aguilón, whilst such forms as *Per.* (*Dichotomoceras*) *bifurcatus* (QUENSTEDT) and *Per.* (*Dichotomoceras*) *crassus* ENAY occupy successive higher positions in this subzone, roughly coinciding with the presumably corresponding macroconchs: *Per.* (*Perisphinctes*) *variocostatus* (BUCKLAND) and *Per.* (*Ampthillia*) *malinowskae* BROCHWICZ-LEWIŃSKI. This interval is widely developed in all the studied localities. Finally, an upper horizon can be recognized in some

[8] Detailed correlation with the British Cautisnigrae and Variocostatus Subzones (CALLOMON 1988) is still difficult to recognize since the index British species are still poorly known in most of the Submediterranean areas.

localities (Ariño, and the Barranco de las Estacas section), at the very last levels of this Subzone. It is characterized by the species *Per.* (*Ampthillia*) *ariniensis* (MELÉNDEZ 1984). This species could, in fact, constitute the latest representative of subfamily Perisphinctinae in the Iberian Chain and has been found in the same levels as the early representatives of *Orthosphinctes*. As a whole this subdivision of the subzone into three horizons should be taken as preliminary, probably suitable of finer further subdivisions. The ammonite assemblages of these horizons comprise:

Grossouvrei horizon, nov.

Per. (*Dichotomoceras*) *grossouvrei* SIEMIRADZKI, 1899 (m)
Per. (*Dichotomoceras*) *falculae* RONCHADZÉ, 1917 (m)
Per. (*Ampthillia*) aff. *quadratus* ENAY, 1966 (M)

Bifurcatus horizon, nov.

Per. (*Dichotomoceras*) *bifurcatus* (QUENSTEDT, 1847) (m)
Per. (*Dichotomoceras*) *crassus* ENAY, 1966 (m)
Per. (*Perisphinctes*) *variocostatus* (BUCKLAND, 1836) (M)
Per. (*Ampthillia*) *malinowskae* BROCHWICZ-LEWIŃSKI, 1975 (M)

Ariniensis horizon, nov.

Per. (*Ampthillia*) *ariniensis* (MELÉNDEZ, 1984) (M & m)[9]

The proposed biostratigraphic subdivision (*see* Text-fig. 4) contain some units which have already been recognized in distant areas throughout separate basins in southern Europe and are suitable to be taken as full subzones. This is the case of Luciaeformis, Schilli, or Bifurcatoides horizons, which are widely characterized, from Iberia to Aquitaine and from the French Jura to southern Germany, the Swiss Jura or, partly, the Polish Jura. Some other, such as the Iberica, Wartae, or Ariniensis horizons, although identified so far only in the Iberian basin are undoubtedly present in many other distant south European regions. The validity of the perisphinctids as a biostratigraphic tool is demonstrated by the detailed subdivisions they allow and by the good correlation the successive assemblages described herein and recognized across the Submediterranean Province. A detailed network of biostratigraphic correlation is still ahead, but it can only be entailed by the careful collection of homogeneous assemblages and the comparison of successions in separate areas. This should lead to the recognition of successive biospecies and to the comprehension of

[9] First included within the genus *Passendorferia* by the author (MELÉNDEZ 1989, p. 149, Pl. 7, Fig. 3; Pl. 8, Fig. 1).

their vertical evolutionary variation, beyond the morphological approach underlying the vertical classification which has been the classical procedure in the perisphinctids.

CONCLUSIONS

The perisphinctids appear as the most suitable group for biostratigraphic subdivision at the subzone and biohorizon level in the Middle Oxfordian across the Submediterranean Province. The biostratigraphic scheme is slowly being refined as long as the detailed collection of large, homogeneous assemblages allow the recognition of successive horizontal biospecies. Successions identified so far in the Iberian Chain, ranging from the base of the Transversarium Zone to the top of the Bifurcatus Zone, have allowed the identification throughout this area of six subzones and twelve biohorizons characterized by the successive perisphinctid assemblages. The good correlation of some of these subdivisions shown across southern Europe indicates that many of them could be assumed to have full subzone range.

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