BULLETIN DE L'ACADÉMIE
POLONAISE DES SCIENCES
Série des sciences de la terre
Volume XXX, No. 3-4, 1982
Publié en cotobre 1983

GEOLOGY

Lower Oxfordian in the Iberian Chain, Spain; Part I. Biostratigraphy and Nature of Gaps

by

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Presented by W. POŻARYSKI on November 12, 1982

Summary. The studies have shown a general trend of the rate of sedimentation to decrease at the turn of the Callovian and Oxfordian in the Iberian Range and several gaps have been recorded in the studied sections. The Lower Oxfordian has been recorded in either ferruginous oolite layer with distinct traces of condensation or in infillings of corrosional pockets. The above phenomena appear traceable throughout vast areas in Europe and they cannot be explained by marine regression and related erosion as there is growing evidence for just the opposite trend. The Ricla and other sections displaying traces of advanced submarine corrosion make it possible to explain the above phenomena in terms of repeated rises of the CCD (calcite compensation depth) at the turn of the Callovian and Oxfordian.

In the Iberian Chain, Callovian and Middle Oxfordian and younger rocks have been known since the end of the 19th c. [11] whereas first references to fossils possibly indicative of the Lower Oxfordian were not given before the 1960's [27]. This is connected with the question of a specific layer or layers of ferruginous oolite limestone, developed in this region at the Callovian–Oxfordian boundary. The nature of this horizon has been the subject of vivid discussions in the last years. Besides ferruginous ooids, the limestones display ferruginous coatings around skeletal fragments, especially ammonite shells, as well as crusts and hardgrounds. Ammonites recorded in that horizon were found to range in age from the Upper Callovian to Middle Oxfordian. Such features of the horizon were explained in terms of regression and emergence at the Dogger–Malm boundary [7, 8] and the resulting large break in sedimentation [8–10, 25]. According to other authors [27, 15, 1] we are not dealing here with emergence and the boundary sequence is highly reduced but not missing.

The last years witnessed steadily growing evidence for the presence of Lower Oxfordian fossils in the oolite horizon in this region [31, 25, 15]. Special attention should be paid to the record of Lower oxfordian peltoceratids

in that horizon at Moscardon near Teruel [14], similar forms and those of the genus *Prososphinctes* at the neighbouring Pozuel del Campo locality [19], and several ammonites indicative of the uppermost Callovian and/or Lower Oxfordian at Aguilón, about 40 km south of Zaragoza [29], and *Creniceras renggeri, Grossouvria sulcifera,* several *Clambites (Euaspidoceras), Campylites* and others from several localities throughout the region [1].

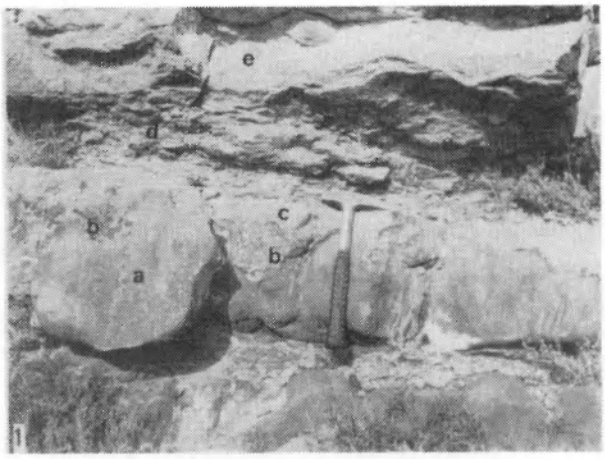
Systematic studies on the Oxfordian in central and northern parts of the Iberian Chain, carried out by the senior author (GM), and supplementary field work made it possible to collect some data casting a new light on the character of the Dogger–Malm boundary in this region. The paper presents the results of surveys of sections which appeared best for reconstructing succession of events from the turn of the Callovian and Oxfordian. Detailed descriptions of these and other sections will be given in D.Sc. thesis of G. Melendez, recently in preparation. The selected sections (Fig. 1) include Anquela del Pedregal and Pozuel del Campo, west of Teruel, close to the western boundary of distribution of ferruginous oolite limestones as shown by Gomez [18], Aguilón and Ventas de San Pedro near Ariño, SE of Zaragoza, as well as Ricla, where the oolite limestones are missing.

Description of the sections.

Ventas de San Pedro locality. The section, displayed in escarpment of the Rio Martin river between Arino and Oliete, about 100 km SE of Zaragoza, is the classic one, as rich Callovian and Oxfordian ammonite fauna from that locality has been known since the end of the 19th c. [11] and studied by several authors, especially since the 1960's [8–10, 25, 15, 26, 18, 1]. In the last five of these papers, there may be noted references to ammonites referable to the uppermost Callovian and Lower Oxfordian.

The section begins with a bank of massive ferruginous orange-beige limestone, the top part of which yields numerous Upper Bathonian–Lower Callovian (Macrocephalus Zone) ammonites. The bank is overlain by yellow--grey limestone layer about 40 cm thick, somewhat irregularly stratified and very rich in ammonites of the Lower Callovian (Macrocephalus and Gracilis Zones), bivalves (mainly pectinids) and belemnites. The next layer of light gray limestone (No. 108 in Fig. 2) displays small (usually 0.5 to 1.0 mm in size) ferruginous ooids randomly scattered throughout the rock and a distinct crust at the top. This first layer with ooids yields fairly rich assemblage of ammonites referable to the Lower Callovian (Gracilis Zone). The crust separates it from the next one (No. 109 in Fig. 2), about 40 cm thick yellow limestone layer rich in ferruginous ooids markedly varying in size (from 0.5 to 5 mm).

The second oolite layer appears rather nonuniform. This is due to the development of irregular ferruginous crusts or surfaces, dividing it into some "beds" and accentuating cavity- or pocket-like bodies. Analyses of ammonites recorded in this bed show cooccurrence of individuals differing in size. However,



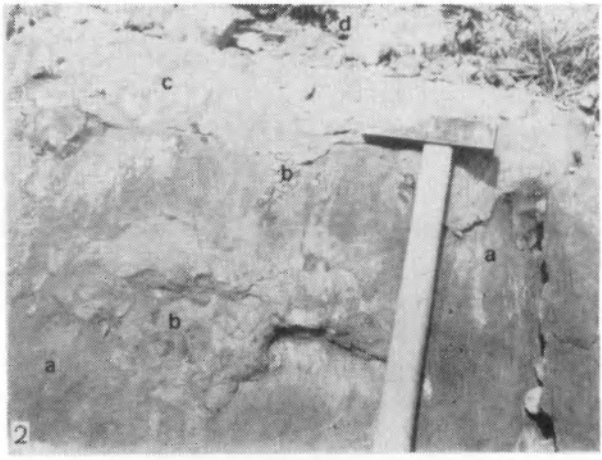


PLATE I

Fig. 1. Callovian-Oxfordian boundary at Ricla; a—Callovian filamentous limestones, b—pockets of the first generation, c—pockets of the third generation, d—Mid-Oxfordian marls, e—Mid-Oxfordian spongy limestones; All photos taken by G. Melendez

Fig. 2. As above; note truncation of pockets of the first generation by those of the third

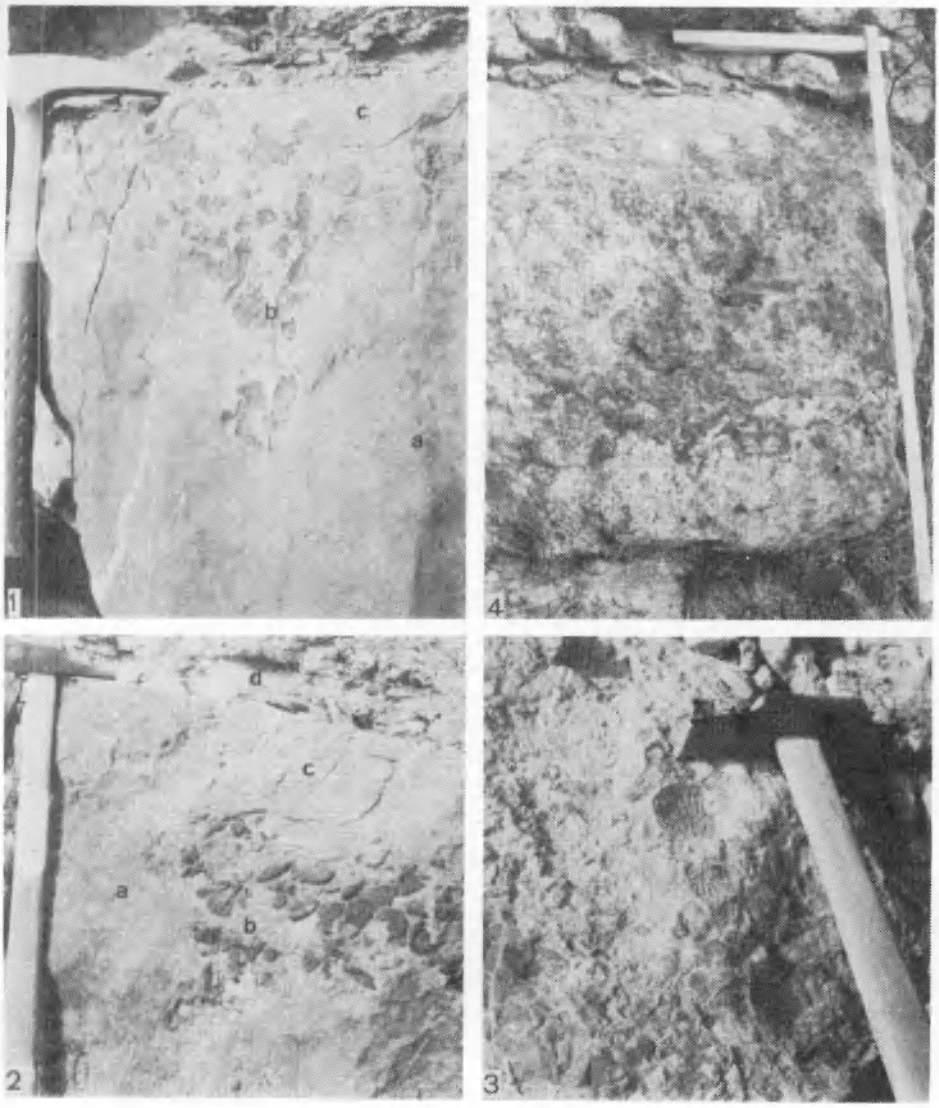


PLATE II

Fig. 1. Almost vertical pocket of the first generation, developed along burrowings; Ricla section. Fig. 2. As above; Ricla section. Fig. 3. Upper surface of limestone layer which forms pockets of the third generation, with imprint of *Neocampylites* cf. *delmontanus* (Oppel); Ricla section. Fig. 4. Upper Fe-oolite level (109) in the Ventas de San Pedro section (Arino), with irregular ferruginous crusts accentuating pocket-like bodies

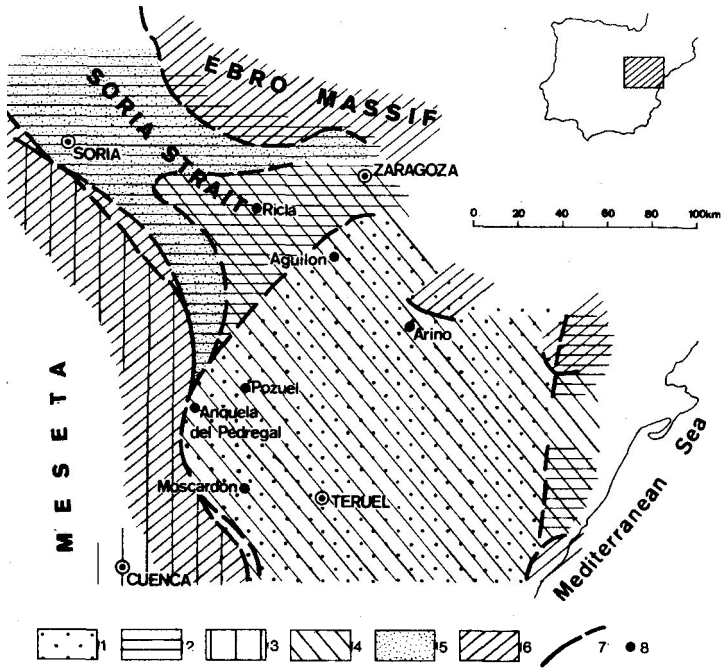


Fig. 1. Distribution of the ferruginous oolite and spongy limestone facies in the studied area (after [18], somewhat modified)

1—facies of ferruginous oolites, 2—coeval strata missing or developed in other facies, 3—coeval strata generally missing, 4—facies of spongy limestones, 5—coeval strata missing or developed in other facies, 6—coeval strata generally missing, 7—extent of the facies (after [18], somewhat modified), 8—localities discussed in the text

some regularity may be found. Ammonites referable to top parts of the Gracilis Zone and the Middle Callovian (except for those of the upper subzone of the Coronatum Zone) seem to be present in the lower part of this layer only. The fossils are usually badly preserved, corroded and sometimes with rusty coatings. The analysis of infilling material [25] suggests reworking and redeposition of the fossils. The lower part of this layer locally yields markedly different ammonite assemblage: peltoceratids, a number of representatives of *Prososphinctes*, including *P. claromontanus* (Buk.), *P.* cf. *mairei* (de Loriol) and *P.* cf. *consociatus* (Buk.), *Passendorferia (Enayites)* ex. gr. *czenstochovensis* (Siem.), *Passendorferia* sp. indet., and *Neocampylites* cf. *delmontanus* (Oppel). The assemblage appears strikingly similar to the classic Bukowski's [6] assemblage from the Lower Oxfordian in the Częstochowa area in Poland. It is referable to the Claromontanus Zone, an equivalent of the Cordatum Zone in the *Perisphinctes* zonation proposed for the Lower Oxfordian [5]. The assemblage seems to be confined to some kind of cavities or pockets here. In a similar position a third ammonite assemblage was also found comprising more or less complete representatives of the *Perisphinctes (Otosphinctes) paturattensis* group, *Kranaosphinctes kranaus* (Buck.), *Perisphinctes*

(Arisphinctes) sp., as well as some *Passendorferia*-like fragments, *Euaspidoceras* most probably of the *E. catena-paucituberculatum* group, *Proscaphites* sp., *Pachyceras (Tornquistes)* sp. and some *Perisphinctes (Dichotomosphinctes)*. Such composition makes possible the allocation of the assemblage in the Antecedens Subzone of the Plicatilis Zone. Pocket- or cavity-like bodies yielding the latter assemblage are usually less clearly marked than those with the assemblage dated at the Claromontanus Zone.

The middle part of the layer No. 109 (A2 in Fig. 2) yields *P. Arisphinctes* sp., *P. (Dichotomosphinctes)* ex gr. *wartae* (Buk.), *P. (D.)* spp. *P. (Perisphinctes)*? gr. *parandieri* de Loriol and other fossils indicative of the Transversarium Zone, and the upper part (109 B in Fig. 2): *Trimarginites* ex gr. *stenorhynchus* (Oppel) and unidentifiable fragments of perisphinctids. The layer is overlain by white-gray massive spongy limestones in which ammonites are rather rare. About 1 m above the top of the oolite layer No. 109 several representatives of the *Larcheria schilli-subschilli* group were found (see [26] for details).

Aguilón. The section (Figs 1, 3, see [29] for location) begins with grey Callovian limestones, 22 m thick. Ammonite record [29] shows that we are dealing here with fairly complete Lower and Middle Callovian succession. The succession ends with grey to dark grey limestone layer (No. 143 in Fig. 3 [29]) with highly uneven, corroded top surface, occasionally with ferruginous crust. The layer is covered with limestone with ferruginous ooids (0.5 to 2.0 mm in size). In the layer with corrosional top surface there were found several *Hecticoceras (Sublunuloceras), Peltoceras* ex gr. *athleta, Euaspidoceras* ex. gr. *hirsutum* Bayle and *Pseudoganites calloviense* (d'Orb.), suggesting the Upper Callovian (Athleta and possibly early Lamberti zone) age. The overlaying limestone with ferruginous ooids was found to yield: *Hecticoceras (Putealiceras)* sp., *Choffatia (Choffatia) waageni* (Teiss.), *Peltoceras* ex gr. *athleta* (Phill.), referable to the Upper Callovian, and *Prososphinctes claromontanus* (Buk.), *P.* close to *P. mazuricus* (Buk.), *Neocampylites* cf. *delmontanus* (Oppel), *Perisphinctes* (?) *bernensis* Arkell non de Loriol, *Peltomorphites*? gr. *aplophorum*, and *Passendorferia (Enayites)* cf. *czenstochovensis* (Siem.), indicative of the Lower Oxfordian, Claromontanus Zone. In that limestone were also found some specimens referable to the *Perisphinctes (Otosphinctes) paturattensis* group and *Kranaosphinctes* as well as nuclei and a fragment of body chamber of giant *Perisphinctes (? Arisphinctes)* which may be treated as indicative of upper parts of the Tenuicostatum Subzone and the lower part of Antecedens Subzone of the Plicatilis Zone. The latter forms were mainly found in the upper part of the oolite layer. Further studies should show whether or not we are dealing here with mixing of ammonite fauna or its occurrence in a system of separate pockets, similarly as in the above-discussed locality. However, differences in frequency of ooids and the mode of development of crusts seem to favour the latter explanation.

The layer with ferruginous ooids is overlain by a grey marly limestone

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The layer with ferruginous ooids is overlain by a grey marly limestone

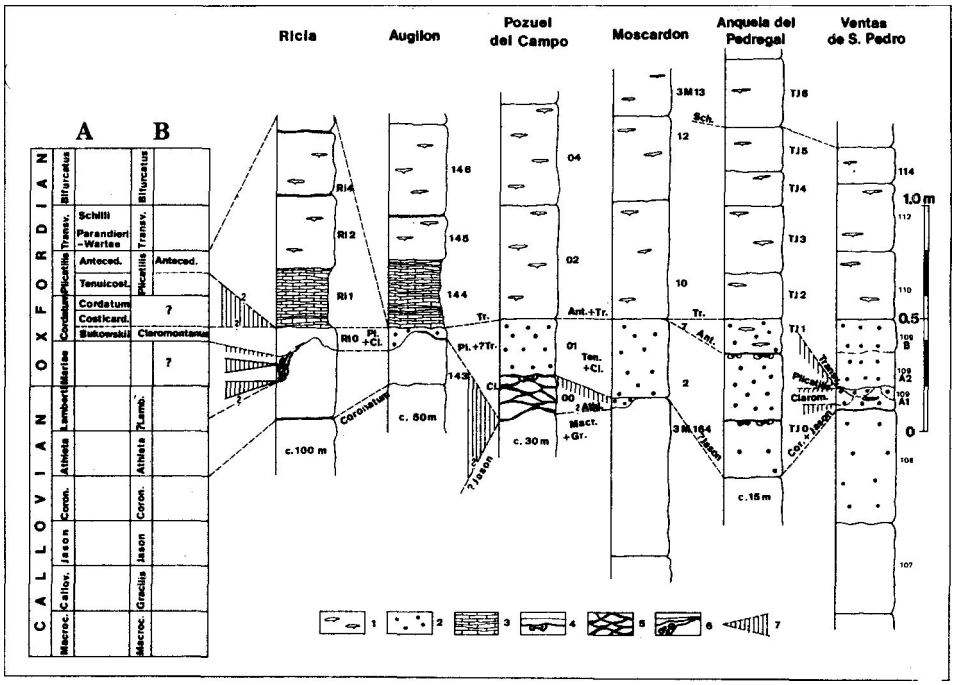

Fig. 2. Correlation of the Callovian–Oxfordian sections in the central and northern parts of the Iberian Chain

1—spongy limestones, 2—limestones with ferruginous ooids, 3—marls, 4—ferruginous crusts and coatings, 5—nodular limestones, 6—corrosional pockets, 7—gaps; A—standard Submediterranean subdivision (after Enay [12]) B—subdivision used here

layer, 0.3 m thick. The layer, rich in sponges, yields ammonites characteristic of the lower part of the Transversarium Zone (Parandieri Subzone): *Trimarginites* cf. *arolicum* (Oppel), *Ochetoceras* cf. *canaliculatum* (v. Buch) and *Perisphinctes (Dichotomosphinctes) wartae* (Buk.). The latter species is also frequent in overlaying spongy limestones in that locality.

Pozuel del Campo. The section displayed by the road cutting at the 228th km of the road from Molina de Aragón to Monreal del Campo was described by Goy *et al.* [19]. The Callovian, about 30 m thick, is represented by a monotonous sequence of grey limestónes with yellow to rusty spots and marly intercalations, rather poor in ammonites. In top parts of the sequence several representatives of *Reineckeia, Grossouvria* and *Hectoceratinae* were found making possible their assignation to the Middle Callovian (? Jason Zone) by the above authors. The limestones are overlain by a layer of yellow limestone, somewhat nodular in appearance, with irregular ferruginous crust or crusts at the top. Ammonites are fairly numerous but usually fragmentary here (rounded, phosphatized, with Fe-coatings, especially close to the top of this layer): *Perisphinctes (?) bernensis* Arkell non de Loriol, *Prososphinctes claromontanus* (Buk.), *Passendorferia (Enayites)* ex gr.

czenstochovensis (Siem.), *Peltoceratoides* sp., *Parawedekindia* sp. and *Neocampylites delmontanus* (Oppel), indicative of the Lower Oxfordian, Claromontanus Zone, and the *Perisphinctes (Otosphinctes) paturattensis* group, several incomplete specimens or nuclei of *Perisphinctes* s.l., and *Kranaosphinctes ?* gr.

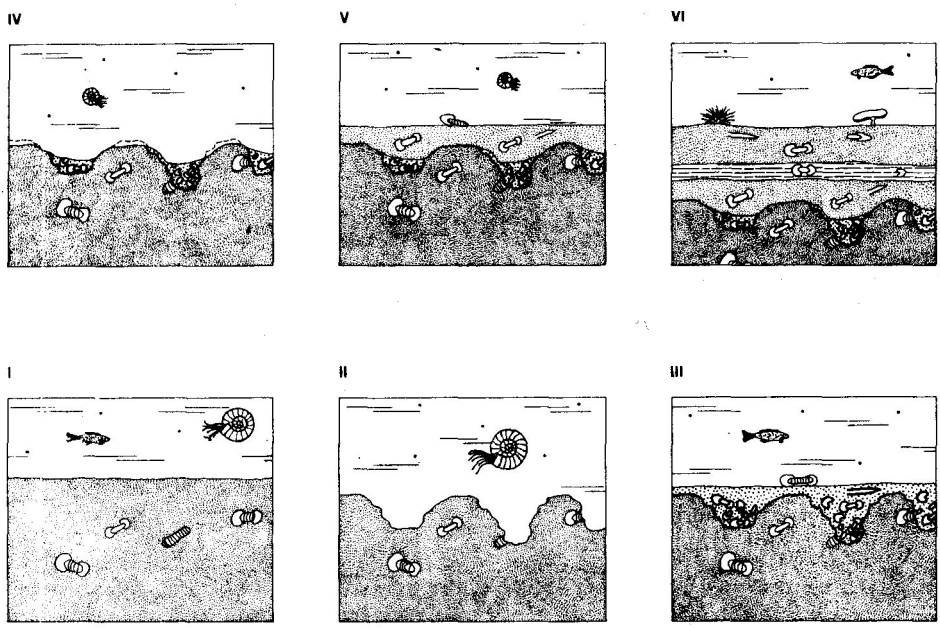

Fig. 3. Reconstruction of major events in the formation of a boundary sequence of the Callovian and Oxfordian at Ricla

I—deposition of filamentous limestones (Athleta or Lamberti Zone, Upper Callovian), II—submarine corrosion, III—infilling of corrosional pockets with limestones rich in generally corroded skeletal fragments, mainly fragments of ammonite whorls and belemnite rostra; thick lines—ferruginous coatings (latest Callovian and/or lowermost Oxfordian), IV—next phase of submarine corrosion, V—deposition of limestone layer with ammonites of the *Prososphinctes claromontanus* assemblage (lower Cordatum Zone) (Note: for clarity, the events leading to the origin of the second generation of pockets and their infilling are omitted here), VI—deposition of marls and the first layer of spongy limestones (Plicatilis Zone)

promiscuus (Buk.), indicative of upper parts of the Tenuicostatum Subzone and lower Antecedens Subzone of the Plicatilis Zone.

The "nodular" layer (No. 00 in Fig. 4) is overlain by 20 cm layer of light-gray limestone with homeometric, small (below 2 mm in size) ferruginous ooids (No. 01). Numerous fragments of crinoids and sponges were found here, and also scarce ammonites, mainly unidentifiable perisphinctids.

The oolite layer is overlain by a sequence of massive grey sponge limestones. Although ammonites are rather scarce here, there were found: *Perisphinctes (Dichotomosphinctes)* ex gr. *wartae* (Buk.), *P. D.* gr. *elisabethae* de Riaz, *P. (? D.)* gr. *trichoplocus* Gemmellaro, *P. (Arisphinctes)* gr. *tenuis* Enay, *P. (Otosphinctes)* cf. *vermicularis* Lee, *Passendorferia (Enayites) birmensdorfensis* (Moesch), *Passendorferia* sp. indet., which form an assemblage typical of the Transversarium Zone.

Anquela del Pedregal (Gudalajara Province). In that locality (Figs. 1, 2 see Goy *et al.* [19], the Callovian is represented by 15 m sequence of well--bedded light-gray limestones with thin marly intercalations. The ammonites recorded here indicate Lower Callovian (Macrocephalus and Gracilis zones s.l.) age of the limestones [19]. The limestones are overlain by a 0.55 m layer of reddish limestone (No. TJ/00 in Fig. 5) with numerous small- to medium-sized 0.5 to 2.0 mm), fairly homeometric ferruginous ooids and several irregular ferruginous crusts. The upper boundary of this layer is developed in the form of irregular hard limonitic crust, displaying numerous fossils, often truncated and with ferruginous coatings. It should be noted that basal parts of reddish limestone, relatively poor in oolites, yield numerous fragments of *Macrocephalites*. In the lower part of the layer, there were several representatives of Reineckeiidae *(Rehmania)* and Hecticoceratidae, presumably of the Middle Callovian age, and in the upper part—fragmentary *Peltoceratoides* cf. *constanti* (d'Orb.) and other representatives of that genus, small-sized specimen presumably belonging to *Parawedekindia choffati* (de Loriol), nucleus referable to *Paraspidoceras* and very large (c. 290 mm in size) aspidoceratid with subquadrate outer whorl with prominent spinuous tubercles, *Prososphinctes* cf. *claromontanus* (Buk.), *P.* sp., *Perisphinctes (?)* cf. *bernensis* Arkell non de Loriol, several fragments of outer whorls of *? Kranaosphinctes* and a half of the outer whorl of *Passendorferia (Passendorferia)* sp., which evidence the presence of the Lower Oxfordian, most probably the Claromontanus Zone, and, possibly, the upper parts of the Tenuicostatum Subzone and lower parts of the Antecedens Subzone of the Plicatilis Zone, Middle Oxfordian.

The next layer (TJ/1) is formed of grey-yellow limestone, 0.15 m thick. Here ooids are still present but in small amounts. The limestone yields sponges which makes it similar to the overlaying spongy limestones. Ammonites recorded here include a representative of *? Pseudopeltoceras* sp., about 225 mm in size but too poorly preserved for specific identification, and an incomplete somewhat deformed *Perisphinctes (Dichotomosphinctes)* which seem to represent an involute variety of *P. (D.) antecedens* Salfeld, so it may only be supposed that we are dealing here with the upper part of the Plicatilis Zone, Antecedens Subzone.

Somewhat higher in the section, in layer No. TJ5, there were found *Glochiceras* sp., *Perisphinctes (Perisphinctes)* sp., *P. (Dichotomosphinctes)* sp. and *Passendorferia (Enayites) birmensdorfensis* (Moesch), and in layer No. TJ/6—representatives of the same taxa as well as *Trimarginites* sp. and *Larcheria* ex. gr. *schilli* (Lee), typical of the top part of the Transversarium Zone. The record of the latter taxon indicates that this layer belongs to the Schilli Subzone, and, therefore, that the underlaying ones belong either to the Parandieri/Wartae Subzone of that zone or top parts of the Plicatilis Zone.

Moscardon. The Moscardon locality, situated about 45 km SSW of the Anquela del Pedregal, was studied by Tintant and Villard [31] and

Fernandez-López *et al.* [14]. According to the latter authors the Lower Callovian (Macrocephalus and Gracilis Zones) is here represented by the 0.7 m thick grey-yellowish nodular limestone, overlain by Fe-oolite layer—"brown-reddish limestone layer rich in medium-sized (2–3 mm in size) ferruginous ooids, 0.20–0.45 m thick, with abundant, usually fragmentary macrofauna" ([14], p. VI–16). Forms referable to the Lower Callovian were found to predominate in its lower part, whereas those indicative of the Middle and Upper Callovian as well as innumerous Lower Oxfordian ones (*Peltoceratoides* and some representatives of the subgenus *Otosphinctes* of the genus *Perisphinctes)*. This made it possible for Fernandez-López *et al.* [14] to interpret the oolitic limestone as an important condensation level, comprising Upper Callovian–Middle Oxfordian interval and characterized by "slow and discontinuous sedimentation, with heterochronous nature of fauna indicating the existence of an intraoolite maximum discontinuity corresponding to the Dogger–Malm boundary" (l.c., p. VI–18).

Further studies on this succession revealed relics of another oolitic limestone layer beneath the above-mentioned one. The relics are preserved in isolated pockets corroded in the underlaying Lower Callovian limestone and often truncating fossils within the latter layer (here we are indebted to H. Tintant for his comments and discussions on this phenomenon). The light-grey limestone with small-sized, innumerous Fe-ooids, infilling the pockets, appears strikingly similar to the lowermost layer with ooids from the Ventas de San Pedro section (No. 108), thus suggesting wide distribution of presumably Lower Callovian ferruginous oolite limestone layer. The layer was subsequently almost completely eroded and some fragments were redeposited, so they may be found nowadays in subsequent oolite layer or layers.

In the upper part of the oolite layer from Moscardon, there were found innumerous ammonites of the Middle and Upper Callovian age (macrocephalitids, *Reineckeia* s.l., *Grossouvria, Chanasia, Choffatia, Jeanneticeras, Proplanulites, Peltoceras* and *Hecticoceras)* as well as several forms forming Lower Oxfordian assemblage known from several other localities: *? Neocampylites* sp., *Peltoceratoides, ? Parawedekindia, Euaspidoceras, Prososphinctes* ex gr. *claromontanus* (Buk.), *Perisphinctes (?)* gr. *bernesis* Arkell non de Loriol, *P. (Arisphinctes)* sp., *P. (Otosphinctes) paturattensis* de Loriol, *Kranaosphinctes, Passendorferia (Enayites) czenstochovensis* (Siem.), with possible admixture of early Middle Oxfordian ones.

The layer with Fe-ooids is overlain by greyish massive sponge limestones, in the first layer of which there was found *Perisphinctes (Dichotomosphinctes)* cf. *elisabethae* de Riaz, and in the next ones—*P. (Otosphinctes)* of the *P. (O.) vermicularis-sorlinensis* group, *P. (Dichotomosphinctes)* ex. gr. *wartae* (Buk.), *Passendorferia (Enayites) birmensdorfensis* (Moesch), *Trimarginites* and *Glochiceras*, indicative of lower parts of the Transversarium Zone and, which is not excluded, top parts of the Plicatilis Zone.

Ricla. This locality is of special importance for the interpretation of

events from the Dogger–Malm boundary as it was studied by both Bulard [9] and Benke [1] as well as Mensink [27] and Geyer *et al.* [15]. The Callovian is thickest here (about 70 m thick) and it ends with black biomicrites with filaments. Ammonites recorded in its top bed *(Peltoceras, Lunuloceras* and *Grossouvria)* seem to be characteristic of the Athleta Zone (here we are idebted to H. Tintant for his comments) whereas Bulard [9] reported from that bed *Distichoceras* and *Concavites,* dating it at the Lamberti Zone.

Benke [1] found the uppermost Callovian and Lower Oxfordian to be confined here to pockets in the top part of the Callovian sequence. The infilling of the pockets was defined as developed in *Glaukonit-(Phosphorit-fazies)* with phosphatized ammonites and intraclasts, glauconite, filaments, echinoderm fragments, foraminifers, peloids and detrital quartz as major components of rocks classified as "biomicrite, biointramicrite *bzw.* wackestone, floatstone" and Stromatolithfazies ([1], pp. 106–107, Pl. 6, fig. 5, pl. 7, figs 3–4, pl. 8, fig. 8).

Our studies have shown that the picture is somewhat more complex. First of all we are dealing here not with one but with at least two if not three generations of pockets. The analysis of the mode of development of the Middle–Upper Jurassic boundary in this locality (excellently exposed at the distance of almost 0.5 km) showed that the top layer of the Callovian, with the pockets, is highly uneven and it locally directly contacts dark marls yielding *Kranaosphinctes* ex. gr. *methodii* Neumann, *Perisphinctes (Otosphinctes)* sp. and *P. (Dichotomosphinctes)?* cf. *antecedens* (Salf.), i.e. forms indicative of the Antecedens Subzone, Plicatilis Zone of the Middle Oxfordian. This dating is further supported by the record of *Gregoryceras* cf. *toucasianum* at the base of the first spongy limestone layer (No. Ri2–4). Direct contact of the Upper Callovian black biomicrites and Middle Oxfordian dark grey marls shows that in some places we may speak about fairly large hiatus, comprising the uppermost Callovian to lower Middle Oxfordian. In other places, as we mentioned above, rocks representing some parts of that time interval may be traced in the pockets. Pockets of the first generation, the easiest to identify, are usually deep (30–40 cm deep), often developed around vertical to subvertical borings which may be explained as progress of corrosion mainly along borings. Pocket walls are sometimes accentuated by ferruginous crusts and the pockets are usually full of phosphatized fragments of ammonites and belemnites. Pockets of the second generation often developed independently of the former and they truncate them. Fossils are here also phosphatized or limonitized but much scarcer. The pockets are separated from those of the first generation by limonitic crusts and, sometimes, stromatolitic structures. It is worth noting that one of the figures given by Benke ([1] Fig. 8, pl. 8) seems to show such a case: a first generation pocket full of phosphatized ammonite moulds and with stromatolite at the top is overlain by a pocket of the second generation, infilled with lighter-coloured material. We were

unable to find identifiable fossils in pockets of the first generation whereas those of the second generation gave: *Neocamphylites* cf. *delmontanus* (Oppel), *Prososphinctes* sp. and *? Properisphinctes* sp., indicative of the Lower Oxfordian. From the pockets Benke [1], (Abb. 28) reported *Hecticoceras* sp., *Kosmoceras (K.) spoliatum, ? Grossouvria* sp., and *? Concavites* sp., indicative of the uppermost Callovian, and forms such as *Campylites (? Neoprionoceras)* sp., *Perisphinctes (Properisphinctes) bernensis, P. (Prop.) ? bernensis, Clambites (Euaspidoceras) perarmatum, C. (E.) ? perarmatum, C. (E.)* cf. *ferrugineum*, and *C. (E.)* sp. which made it possible for him to date the deposit at the Upper Callovian–Middle Oxfordian. Unfortunately, he neither described nor figured the fossils, which impedes appropriate evaluation of his findings. If Benke actually found *Kosmoceras*, it would follow that we are also dealing with uppermost Callovian fossils in the pockets (most probably those of the first generation). The representative of this genus would give the ultimate answer here especially as identification of Upper Callovian and Oxfordian perisphinctids on the basis of strongly reworked and phosphatized or limonitized material is rather hazardous. The presence of Middle Oxfordian fossils in the pockets is improbable in the light of the record of imprints of complete individuals of *Neocampylites* cf. *delmontanus* (Oppel) in the top part of infilling of a third generation pocket. The specimens, similarly as others present there, appear neither phosphatized nor limonitized, and their redeposition seems doubtful. So the third-generation pockets, not very clearly separated from the older ones, seem to be of the Lower Oxfordian and possibly uppermost Callovian in age. This shows that we are dealing here with several breaks in sedimentation and erosion.

Stratigraphic comments. As it follows from the above descriptions, the Callovian sequences are here fairly well dated, except for their top part (the question of the presence of the Lamberti Zone at Ricla and Aguilon) Similarly, there is no trouble in dating Oxfordian sequences upwards of the layers developed in either ferruginous oolite or stromatolite limestone facies. Difficulties in establishing the age of the latter are in part connected with limited fossil material and also with insufficient knowledge of stratigraphic value of perisphinctids, peltoceratids and oppeliids as cardioceratids are lacking here. However, some data from stratigraphic sequences yielding cardioceratids and the former [3, 12, 23, 24, 5] suggest the possibility to reconstruct succession of non-cardioceratid ammonite assemblages and, eventually, to establish biostratigraphy based on the latter fauna (see [28, 5]). Taking the data into account it appears possible to establish time brackets for the relevant parts of the studied sequences.

The available biostratigraphic data make it possible to differentiate the *Prososphinctes claromontanus* assemblage, to which are assigned the recorded representatives of the genus *Prososphinctes, Perisphinctes* sp. ex gr. *bernensis*

Arkell, *Passendorferia (Enayites) czenstochovensis* (Siem.), some individuals of the genera *Peltoceratoides, Peltomorphites* and *Parawedekindia,* and early *Neocampylites.* The assemblage appears strikingly similar to the classic Bukowski [6] one (taking aside the lack of cardioceratids) suggesting that we are most probably dealing with an assemblage coeval with that known from the strata of the Bukowskii Zone or subzone of the Cordatum Zone in the Częstochowa area (southern Poland) (see [23, 24, 5]). There is growing evidence for a marked stratigraphic value of the representatives of the genus *Prososphinctes.* Of these, *P. claromontanus* (Buk.), *P. mazuricus* (Buk.) and similar larger-sized ones seem to be confined to lower parts of the Cordatum Zone [5] whereas miniature ones of the *P. mairei-mathyei* group are known from the above strata and underlaying Mariae Zone. That is why we tentatively differentiated the Claromontanus Zone here (see also [5]).

Another distinct assemblage is that comprising the *Perisphinctes (Otosphinctes) paturattensis-montfalconensis* group, early *Kranaosphinctes* and some other forms which may be dated at the upper part of the Tenuicostatum Subzone of the Plicatilis Zone [3] or the Episcopalis/Paturattensis Zone [5], (see also [28]).

Up to the present, no forms have been recorded which would evidence the presence of upper parts of the Cordatum Zone and lower horizon of the Tenuicostatum Subzone of the Plicatilis Zone and, therefore, sedimentary continuity in this part of the sections.

The question of the nature of gaps. The studies of the sections showed a general trend of the rate of sedimentation to decrease at the turn of the Callovian and Oxfordian. As we stated above, in the most complete, Ricla section, black biomicrite referable to the Athleta (or Lamberti–I) Zone is usually separated from Middle Oxfordian gray marls by a layer which may be best interpreted as more or less continuous system of pockets. The pockets are known to yield Lower Oxfordian fossils and, if Benke [1] is right, uppermost Callovian ones, so the gaps would be very small here. However, the pockets locally wedge out and the Middle Oxfordian is found to contact directly the layer dated at the Athleta (? Lamberti) Zone. The character of pockets makes it necessary to explain their origin and their infilling as a net result of several breaks in deposition and submarine corrosion and deposition. Similar is the case of the Aguilon section where a layer with corrosional top surface, dated at the Upper Callovian (Athleta and possibly lower Lamberti Zone) appears separated from that assignable to the Middle Oxfordian (Transversarium Zone) by limestone with ferruginous ooids and a mixed assemblage of the uppermost Callovian, and Lower and possibly lower Middle Oxfordian fossils. However, the separating layer may be locally missing as it appears to represent an infill of irregular corrosional depressions in the top surface of the Callovian. The analysis of the remaining sections shows that we should also be aware of the presence of other gaps in both the Callovian

and Middle Oxfordian. Delineation of time intervals of such gaps is usually rather troublesome but here it is additionally impeded by a limited amount of identifiable material in individual pockets (which makes failures in collecting almost certain) and high probability that we are dealing with a net result of unknown number of events leading to breaks in sedimentation and corrosion.

In his attempt to explain the events taking place at the Middle–Upper Jurassic boundary in this region, Benke [1] was right trying to look for a solution in some processes active not only in this region but also throughout Europe.*) Actually, there is growing evidence for the commonness of similar phenomena of a marked decrease in the rate of sedimentation and even non-deposition reflected by hardgrounds and/or stratigraphic gaps, not to say about advanced condensation. It should be noted that these phenomena are not limited to that boundary as they appear also fairly common at the boundary of the Lower and Middle Oxfordian [24, 5] and in the Callovian. It appears justified to speak about a general trend to the development of such phenomena at the turn of the Middle and Upper Jurassic. Further studies are needed for unequivocal statement whether or not the peak in their development coincides with the Callovian–Oxfordian boundary.

We fully agree with Benke *et al.* [1, 2] that the above phenomena cannot be explained by marine regression and related erosion. First of all, trends to regression usually coincide with the increase in provincialism of marine faunas whereas the turn of the Middle and Upper Jurassic (Lamberti and Mariae zones) is the time when the Boreal Spread reached its acme and there was an unusually extensive northward migration of some Tethyan elements (J. H. Callomon in: [21], p. 134). Sedimentological analyses also fail to confirm any trend to regression, being rather in favour of some deepening of the sea. Our data support Benke [1], according to whom we are dealing here with replacement of subtidal nearshore and shallow-water microfacies by the deeper subtidal ones. Ferruginous oolites in Switzerland, assumed to be of terrestial origin by some authors, have recently been shown to be deposited in an environment not only marine but also distant from the shore [20]. Recent studies on the Callovian and Callovian–Oxfordian boundary in southern Poland [16, 32] have also shown a trend to deepening of the sea in areas where the relevant sequences are strongly reduced and with well-evidenced hardgrounds and gaps.

Another traceable regularity which may cast some light on the reasons of the above phenomena is the fact that condensation phenomena and gaps seem omnipresent in sequences developed in carbonate facies (i.e. such as in the

*) The phenomena, surprisingly similar to those from Ricla section, have been previously reported from the Nord du Col de Guerre section in the Alpes-Maritimes by Dardeau and Thierry ([33], p. 1634, Fig. 3).

Iberian Chain), being much less clear in clastic facies areas where individual sections tend to be much more continuous. The latter is the case of classic English sections as well as several sections in NW Poland.

Recently Marchand and Brochwicz-Lewiński [24] have attempted to explain gaps from the Lower–Middle Oxfordian boundary by block movements. Although there is growing evidence for such movements, the hypothesis fails to get support in record of thick compensating sequences which should originate due to erosion connected with movements and related erosion in uplifted areas. Uplifting block movements when responsible for condensation and erosion in some places should be accompanied by subsiding movements and development of sequences of increased thickness elsewhere. This also speaks against explanation of the condensed sequences and hardgrounds as a consequence of bottom-current activities as swept-out sediments should accumulate in some other place. It is not excluded that the omnipresence of corrosion may give the clue to this question. Infill of corrosional pockets at Ricla, Moscardon and other localities indicates subaqueous nature of the corrosion. Such corrosion appears best explainable by a rise of the CCD calcite compensation depth which, in turn, might be caused by an increase of dissolved CO_2 in seawater [22]. Putting forward the hypothesis of the CCD rise the following model may be outlined. The Middle and Late Callovian and Early Oxfordian were the times when the marine transgression reached its peak in Europe (see [13] for evidence of a trend of regression in the Late Oxfordian) so land areas become smaller and less effective as a source for clastic material than in Early Callovian. This may be regarded as a factor impeding the development of relevant sequences in clastic facies throughout major parts of Europe. On the other hand, paleogeographic setting of Europe from that time is interpreted as at low latitudes and within coral reef belt, i.e. favourable for the development of Middle Callovian–Middle Oxfordian sequences in carbonate facies, especially in southern and central Europe. Actually, they are developed in such facies except for some areas situated close to still active sources of clastic material, i.e. in the neighbourhood of the Baltic Shield or, in the case of the Iberian Range and adjoining areas, those situated between the Meseta and Ebro Massifs, in the so-called Soria Strait [1, 2, 17]. When this is the case, a rise of the CCD might be expected to lead to a decrease in the rate of net sedimentation of calcium carbonate and, finally, predominance of solution on precipitation, resulting in submarine corrosion of previously deposited material. The succession of corrosional surfaces and infillings of resulting depressions, traceable at Ricla (Fig. 3) and other localities, suggests that there were at least three marked rises of the CCD; after deposition of the layer with ammonite fauna of the Athleta (? Lamberti) Zone, that with fauna of the *Prososphinctes claromontanus* assemblage (lower Cordatum Zone) and at least one rise before deposition of rocks of the Antecedens Subzone. The analysis of other sequences suggests that such events may also be inferred before and after the above-mentioned

ones: before deposition of rocks of the Athleta Zone (pockets with fauna of that zone at Moscardon) and before deposition of those of the Transversarium Zone.

The above-outlined model suggests some resemblance between the Middle–Upper Jurassic passage beds and those from the Cretaceous–Tertiary boundary. The mode of development of the Ricla of Moscardon sequences actually bears a marked similarity to those of the Cretaceous–Tertiary boundary from the Vistula River george near Kazimierz Dolny and other areas in central and northern Poland and Zealand–Scania area, especially in the development of corrosional pockets and channels (mainly by widening the previously formed borings and burrowings) but it should be stated that in the latter case we are not dealing with prolonged oscillations but rather with a strong but single event.

The assumed rise of the CCD may be explained as due to increased igneous activity connected with intense seafloor spreading in the Atlantic. Recent DSS data show that the oldest marine sedimentary rocks between the North America and Africa are Callovian in age [30] so the phenomena seem to be more or less coeval. However, such crises connected with a rise of the CCD should be traceable in much greater scale than that of Europe. That is why we would accept any record of undoubtedly continuous sequence of Callovian–Oxfordian passage beds developed in carbonate facies and without correlable breaks as a negative test for the above hypothesis.

The studies were greatly facilitated owing to generous financial support of the Rector of Zaragoza University and the Institute of Studies of Teruel (Instituto de Estudios Turolensis).

Thanks are due to R. Enay, A. Goy, L. Malinowska, D. Marchand, T. M. Peryt, I. Sapunov and H. Tintant, and several other colleagues for fruitful discussions. Any errors in the above interpretations are entirely the authors'.

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G. Melendez, L. Sequeiros, W. Brochwicz-Lewiński, **El Oxfordiense inferior de la Cordillera Iberica (España). Parte I. Bioestratigrafia y facies**

Los estudios llevados a cabo en diversos cortes en esta región muestran una tendencia general a la disminución de la velocidad de sedimentación en el límite entre el Calloviense y Oxfordiense en la Cordillera Iberica, habiéndose detectado la existencia de varios "gaps" o interrupciones en la sedimentación de dichos niveles. Se ha registrado la existencia de Oxfordiense inferior, bien en el interior de un nivel de caliza con oolitos ferruginosos que presenta claras muestras de condensación, o bien en el relleno de una serie de "cavidades de corrosión" localizadas en dichos niveles de transición. Estos fenómenos se pueden seguir asimismo a lo largo de extensas áreas en Europa y no puedenser explicados por un proceso de regresión marina y eu erosión correspondiente puesto que los datos existentes parecen indicar claramente el

fenómeno opuesto. El estudio de los materiales del tránsito Calloviense-Oxfordiense en Ricla (provincia de Zaragoza) y otras localidades, en donde pueden observarse huellas de avanzados procesos de corrosión submarina, hacen posible el intentar explicar estos fenómenos en términos de sucesivas elevaciones del nivel de compensación de la calcita (CCD), durante el tránsito Calloviense-Oxfordiense.

Г. Мелендез, Л. Сегуэйрос, В. Брохвич-Левиньски, **Нижний оксфорд в Иберийском кряже (Испания). Часть I. Биостратиграфия и фации**

Анализ избранных (главным образом классических) разрезов келловея и оксфорда в центральной и западной частях Иберийского кряжа позволяет проследить генеральную тенденцию понижения темпа седиментации на пограничьи этих ярусов. Это явление подтверждают многочисленные седиментационные и стратиграфические перерывы. Границы стратиграфических перерывов удалось в последнее время благодаря обнаружению аммонитов нижнего оксфорда. Эти аммониты были найдены в известняках, содержащих железистые оолиты, в которых явно усматриваются следы стратиграфической конденсации, а также в породах, заполняющих корозионные карманы, встречающиеся на границе этих ярусов в разрезе Рикля. Наблюдаемые явления развительно напоминают те, которые описаны в иных районах Ввропы и их трудно объяснить морской регрессией и связанной с ней эрозией, т.к. скапливается все больше и больше данных, свидетельствующих скорее с расширении трансгрессии в позднем келловее и раннем оксфорде. Изучение пород на пограничьи келловея и оксфорда в Рикля (провинция Зарагоза) и в других районах Иберийского кряжа, позволяет отметить широкое развитие процессов подводной коррозии в рассматриваемый период времени. Показана попытка объяснения этих явлений как результата повторявшегося несколько раз повышения уровня компенсации карбоната кальция в позднем келловее и раннем оксфорде.