The Transversarium-Bifurcatus Zone boundary at Rocha (Peral area, East-Central Algarve, Portugal)

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RESUMO

Palavras-chave: Amonites — Macroinvertebrados bentónicos — Biostratigrafia — Ecostratigrafia — Descontinuidades — Jurássico superior — Oxfordiano — Algarve — Sul de Portugal.

Este trabalho representa o primeiro estudo pormenorizado do limite das Zonas de Transversarium-Bifurcatus no Algarve. Este limite está associado, na área do Peral, a uma descontinuidade estratigráfica cujo hiato afecta, parcialmente, as Zonas de Transversarium e de Bifurcatus. Uma outra descontinuidade foi reconhecida no limite das Zonas de Bifurcatus-Bimammatum que, nesta área, coincide com a descontinuidade do Tipo II que separa os ciclos 4.3-4.4 de HAQ *et al.* (1987); esta descontinuidade tinha já sido individualizada na paleomargem do sul da Ibéria.

Uma análise da evolução ecostratigráfica feita no intervalo entre a parte superior da Zona de Transversarium e a parte inferior da Zona de Bimammatum com base nos espectros de fauna obtidos revela que as amonites são os cefalópodes mais tolerantes ao *stress* ecológico causado pelo aumento dos acarreios de material e pela diminuição do ecoespaço da plataforma. A fauna bentónica diminuiu consideravelmente nestas condições. É de notar uma fauna relativamente abundante e diversificada de *Dichotomoceras* entre as amonites recolhidas, já que este género era, anteriormente, raro no Algarve.

RÉSUMÉ

Mots-clés: Ammonites — Organismes benthiques — Biostratigraphie — Ecostratigraphie — Discontinuités — Jurassique supérieur — Oxfordien — Algarve — Sud du Portugal.

Cette note présente les premières données détaillées sur la limite des zones Transversarium/Bifurcatus en Algarve. Dans la région de Peral, cette limite est associée à une discontinuité sédimentaire qui affecte partiellement les zones à Transversarium et à Bifurcatus. À la limite des zones Bifurcatus/Bimammatum a été reconnue une autre discontinuité, correspondant à celle du type II qui sépare les cycles 4.3-4.4 de HAQ *et al.* (1987); cette discontinuité avait déjà été individualisée sur la marge sud de l'Ibérie.

Dans l'intervalle entre la partie supérieure de la zone à Transversarium et la partie inférieure de la zone à Bimammatum, l'analyse de l'évolution ecostratigraphique, faite à partir des spectres de la faune, a montré que dans l'ensemble des céphalopodes, les ammonites sont les organismes les plus tolérants au *stress* écologique, provoqué, soit par la diminution de l'ecospace, soit par des arrivées de matériel terrigène; dans ces conditions, la faune benthique diminue considérablement. Dans l'ensemble de la faune récoltée on signale la présence, relativement abondante et diversifiée, des *Dichotomoceras*, auparavant pas communs.

ABSTRACT

Key-words: Ammonites — Benthic macroinvertebrates — Biostratigraphy — Ecostratigraphy, Discontinuities — Upper Jurassic — Oxfordian — Algarve — South Portugal.

This paper represents the first detailed study of the Transversarium-Bifurcatus Zone boundary in the Algarve. The boundary studied in the Peral area is associated with a stratigraphic discontinuity, whose hiatus partially affects the Transversarium-Bifurcatus Zones. A discontinuity was also recognized in the Bifurcatus-Bimammatum Zone boundary, which can be correlated with the traces of a Type II unconformity, which separates cycles 4.3 - 4.4 in HAQ *et al.* (1987), present on the South Iberian palaeomargin.

An analysis was made of the ecostratigraphic evolution in the interval between the uppermost Transversarium Zone and the lower part of the Bimammatum Zone on the basis of the faunal spectra obtained. We conclude that ammonites are the most tolerant cephalopods to the ecological stress caused by the increase of inflows and the decrease of the shelf's ecospace. Benthic fauna decreased considerably in these conditions. A relatively abundant and diversified fauna of *Dichotomoceras* is noteworthy among the ammonites collected, as this genus was previously little known in the Algarve.

INTRODUCTION

During the Jurassic the South West margin of the Iberian subplate was subjected to the Mediterranean Tethys. This region was occupied by an epicontinental sea during the Upper Jurassic. At present the outcrops on land allow us to recognize two platform systems (Fig. 1): a carbonate platform system in the western part of the Algarve (area West of Lagoa belonging to the Southern Sector of the Algarve, cf. MARQUES & OLÓRIZ, 1989a) and a carbonate-terrigenous platform system towards the eastern part (area between Lagoa and Tavira belonging to the Northern sector of the Algarve, cf. MARQUES & OLÓRIZ, 1989a). The block structuring of the Algarve during the Upper Jurassic can also be recognized, the main features of which were caused by the activity of deep, generally inherited fractures. The carbonate-terrigenous platform system coincided with a large depressed region of Tethyan orientation. The northern limits of the carbonate-terrigenous platform can be recognized on land in relation to the general outcropping of hercynian materials of the Iberian Meseta, whereas high carbonate bottoms limited the platform to West and South (off-shore data summarized in MARQUES & OLÓRIZ, 1989a). In the deeper areas the sediments were marls and more or less clayey limestones, in which cephalopods were frequent (studied by MARQUES, 1983) as too were benthic organisms (especially brachiopods, bivalves and gastropods). On the high bottoms buildups were frequent, set on raised blocks linked to fractures and folds probably related to halokinetic activity (MANUPPELLA & *al.*, 1988). During the Upper Jurassic these reefal and parareefal facies developed more or less discontinuously from the Oxfordian on (MARQUES, 1983). The carbonate-terrigenous platform system was replaced by more or less clastic, basically carbonate sedimentation during the Upper Kimmeridgian (s. gallico) and was in part close to emersion during the Upper Tithonian and Berriassian.

Fig. 1— Location and geological sketch for exposed outcrops in the Algarve. Paleozoic in vertical broken lines; black for the Triassic "Grés de Silves"; horizontal ruling for carbonate platform system; Eastern Algarve Basin in crossed framework; stippled for Cretaceous; Cenozoic in white.

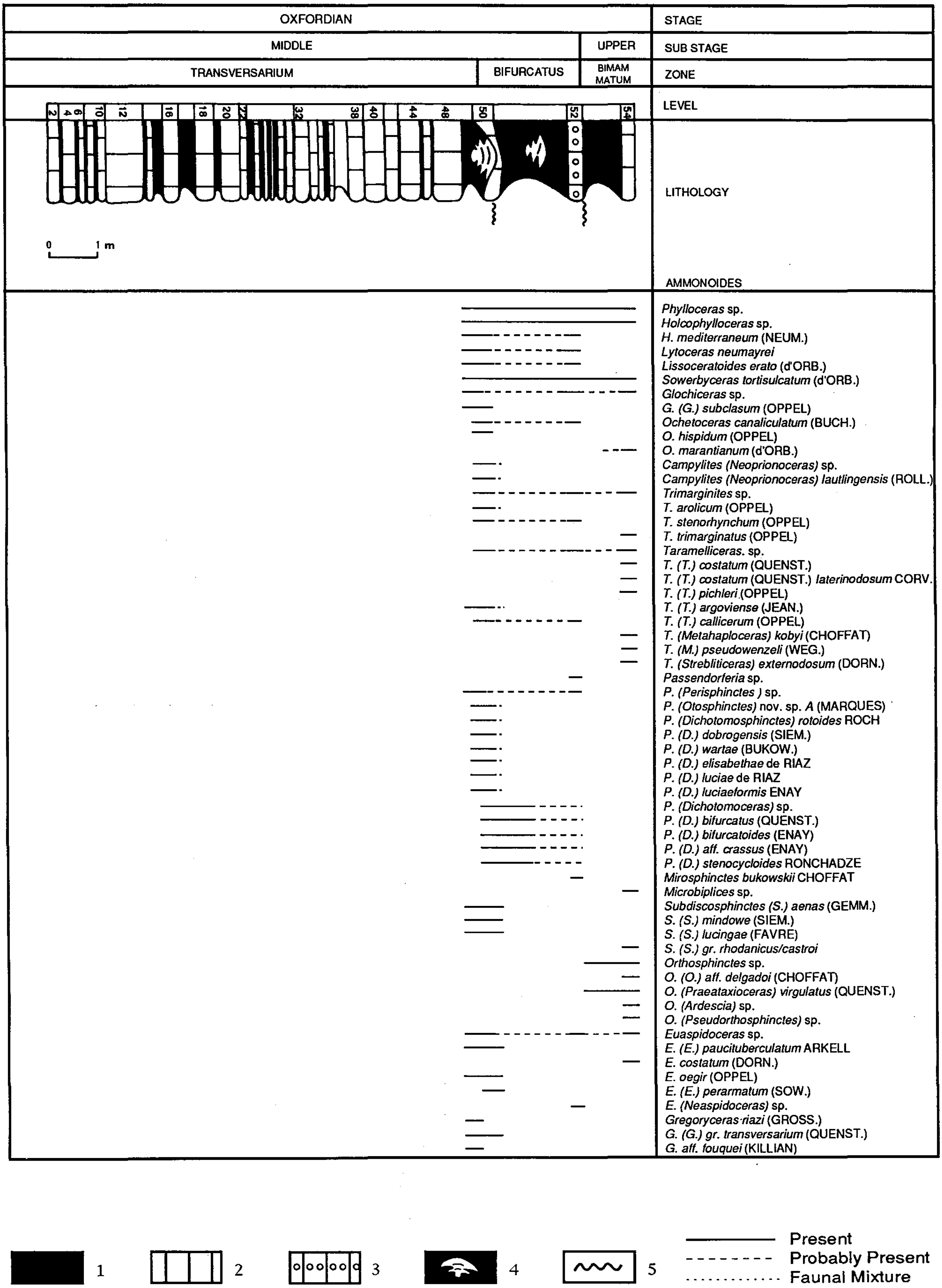

Fig. 2 —The studied section with vertical distribution of ammonite species. 1 - Marls; 2 - Limestones; 3 - Bioclastic limestones; 4 - Sponge buildups; 5 - Discontinuities.

During the Middle and Upper Oxfordian, successions of marls and clayey limestones with occasional small developments of buildups (Peral Fm., MARQUEs, 1983) were predominantly in the deeper areas of the carbonate-terrigenous platform system (traditionally known as the Eastern Algarve Basin). The only important buildup was that of Nossa Senhora da Rocha, which developed in the upper part of the Upper Oxfordian (the base is assigned to the Bimammatum or Planula Zones, cf. MARQUES, 1983). Apart from the limestone-marl rhythmite of the Peral Fm., there are other carbonate facies whose development is more local: the poorly known "Calcaires Hydrauliques de Loulé" (CHOFFAT, 1887), which MARQUES (1985) tentatively assigned to the Middle Oxfordian, and the "Calcaires de São Romão" which, according to RAMALHO (1985), represent a thick internal shelf succession begun in the Upper Oxfordian.

A study of the most significant discontinuities recorded in the Oxfordian of the Eastern Algarve forms part of the paper by MARQUES & OLÓRIZ (1989b). On the basis of the biostratigraphic characterization by MARQUES (1983), these authors interpreted the scarce ammonite record in the upper part of the Transversarium Zone and the lower part of the Bifurcatus Zone as being connected with a discontinuity (D4 in MARQUES & OLÓRIZ, 1989b), whose stratigraphic gap should be related with "phénomènes erosives en phase d'haut niveau eustatique". According to these authors this discontinuity is a case of tectonics-eustasy interaction.

The recent opening of quarries in the bioconstructed facies with Spongiaria in the areas of Barracha and Rocha has created favourable conditions for the analysis of the materials belonging to the transition between the Transversarium Zone and the Bifurcatus Zone. This study contributes to our knowledge of both the lithostratigraphic and biostratigraphic characteristics of the boundary between these two chronozones.

THE SECTION AT PERAL

The section studied by us (Fig. 2) belongs to the lower part of the outcropping succesion of the Peral Fm. whose top seems to be restricted to the Lower Kimmeridgian (MARQUES & OLÓRIZ, 1992). The limestone beds in this section are more or less clayey mudstones or wackestones. Some levels show traces of bioturbation *(Thalassinoides* of 2-4 cm in diameter) and, since their development is very localized (levels 20, 42 and 48), they may represent sporadic reduction in the sedimentation rate. Other benthic

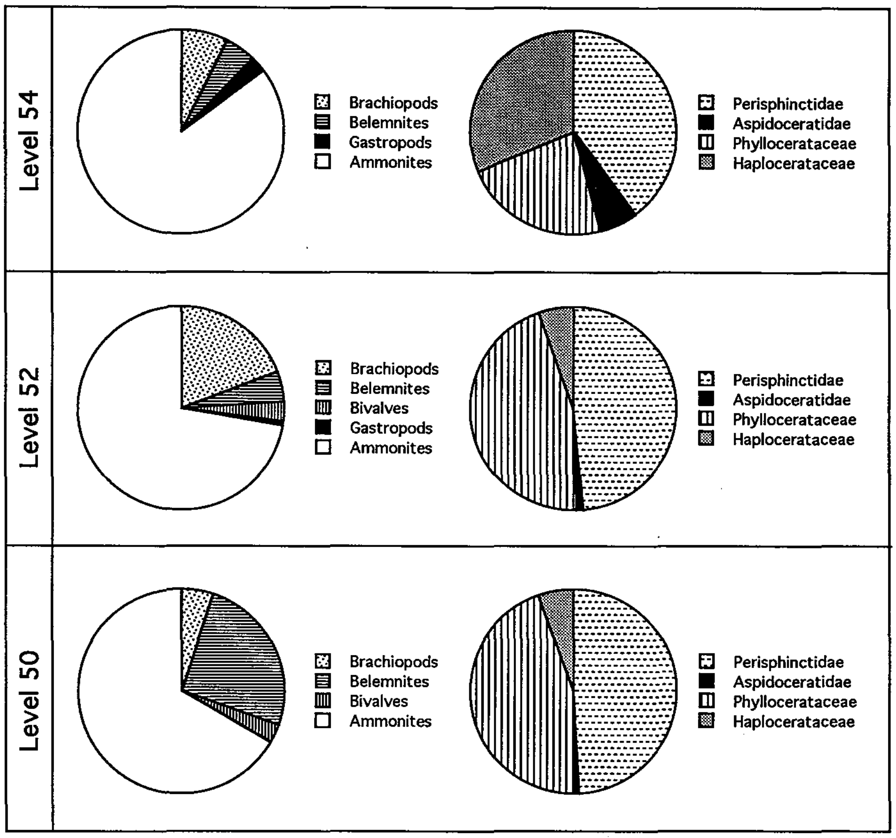

Fig. 3 — Faunal spectra of levels 50, 52 and 54.

macroinvertebrates also have a discontinuous record (brachiopods, crinoids, echinoids, gastropods and bivalves), which could be interpreted as the result of intermittent colonizations of the bottoms during favorable phases (lesser depositional rate ?). Ammonites were also found in bed 48.

In general, the upper and lower surfaces of the beds are not irregular, except in those cases in which bioturbation had developed. The marly levels are better developed in the upper part of the section in connection with, or close to, discontinuities on the Transversarium-Bifurcatus and Bifurcatus-Bimammatum boundaries. Inside the lower-middle part of the marly levels carbonate concretions and sponge remains were observed.

The sponge buildups, which are ephemeral and small (Fig. 2), are irregularly distributed in the section. Their development clearly indicates ecological alterations which discontinuously affected the shelf bottoms, permitting their colonization during short intervals of time. Decreases in detrital inflows may have played an important role in the colonization events. This interpretation is coherent with the fact that the disappearance of the sponge buildups coincides with the increase of marly sedimentation during the Upper Oxfordian (Bimammatum Zone, cf. MARQUES, 1983).

In the section studied here, two discontinuities have been recognized (Fig. 2). The first of these is associated with a level containing Spongiaria. This is a condensed level with a ferruginized upper surface and glauconite remains. The bioclasts are partially mineralized. The fossils are mainly found in the upper surface of the bed, placed in horizons which are parallel and subparallel to bedding. In general, the ammonites are fragmented, except the smaller ones which are irregularly distributed. Implantation of serpulids and ostreids is frequent in the upper surface of the bioclasts. Traces of *Thalassinoides* are frequent in the lower part of the bed. This discontinuity is attributed to the Transversarium - Bifurcatus Zone boundary and we interpret it as the result of a decrease in sedimentation rate which favoured stratigraphic condensation. Ammonites predominate among the fauna found here, and belemnites, brachiopods, bivalves, gastropods, echinoderms (echinoids, crinoids), and aptychi are also present (Fig. 3).

A second discontinuity was detected in a grain selected bioclastic level with a ferruginized upper surface. This level is related to the end of the Spongiaria record and the interval attributed to the Bifurcatus Zone. In the upper beds the ammonites therefore belong to the Bimammatum Zone. Ooids, intraclasts, quartz grains, sponge fragments, brachiopods, echinoderms, bivalves, sepulids and, of course, ammonite remains were observed in thin section. The interpretation of this horizon as a product of resedimentation is coherent with the mixed and fragmented character of the fossil remains.

AMMONITE BIOSTRATIGRAPHY

The ammonite assemblage found in the section studied is that known from Submediterranean Europe, although there are deviations in comparison with more northern areas (MARQUES, 1983). Fig. 2 shows the ammonite distribution bed-by-bed: *Phylloceras* sp., *Holcophylloceras* sp., *H. mediterraneum* (NEUM.), *Lytoceras neumayrei*, *Lissoceratoides erato* (d'ORB.), *Sowerbyceras tortisulcatum* (d'ORB.), *Glochiceras* sp., *G. (G.) subclasum* (OPPEL), *Ochetoceras canaliculatum* (BUCH.), *O. hispidum* (OPPEL), *O. marantianum* (d'ORB.), *Campylites (Neoprionoceras)* sp., *Campylites (Neoprionoceras) lautlingensis* (ROLL.), *Trimarginites* sp., *T. arolicum* (OPPEL), *T. stenorhynchum* (OPPEL), *T. trimarginatus* (OPPEL), *Taramelliceras* sp., *T. (T.) costatum* (QUENST.), *T. (T.) costatum* (QUENST.) *laterinodosum* CORV., *T. (T.) pichleri* (OPPEL), *T. (T.) argoviense* (JEAN.), *T. (T.) callicerum* (OPPEL), *T. (Metahaploceras) kobyi* (CHOFFAT), *T. (M.) pseudowenzeli* (WEG.), *T. (Strebliticeras) externodosum* (DORN.), *Passendorferia* sp., *P. (Perisphinctes)* sp., *P. (Otosphinctes)* nov. sp. *A* (MARQUES), *P. (Dichotomosphinctes) rotoides* ROCH, *P. (D.) dobrogensis* (SIEM.), *P. (D.) wartae* (BUKOW.), *P. (D.) elisabethae* de RIAZ, *P. (D.) luciae* de RIAZ, *P. (Dichotomoceras)* sp., *P. (D.) bifurcatus* (QUENST.), *P. (D.) bifurcatoides* (ENAY), *P. (D.)* aff. *crassus* (ENAY), *Mirosphinctes bukowskii* CHOFFAT, *Microbiplices* sp., *Subdiscosphinctes (S.) aenas* (GEMM.), *S. (S.) mindowe* (SIEM.), *S. (S.) lucingae* (FAVRE), *S. (S.)* gr. *rhodanicus/castroi*, *Orthosphinctes* sp., *O. (O.)* aff. *delgadoi* (CHOFFAT), *O. (Praeataxioceras) virgulatus*, *O. (Ardescia)* sp., *O. (Pseudorthosphinctes)* sp., *Euaspidoceras* sp., *E. (E.) paucituberculatum* ARKELL, *E. costatum* (DORN.), *E. oegir* (OPPEL), *E. (E.) perarmatum* (SOW.), *E. (Neaspidoceras)* sp., *Gregoryceras riazi* (GROSS.), *G. (G.)* gr. *transversarium* (QUENST.), *G.* aff.*fouquei* (KILLIAN).

Concerning the biostratigraphic data obtained by MARQUES (1983), attention should be drawn to the following: a) the more abundant and diversified record of *Gregoryceras*; b) the absence or scarcity of *Larcheria* is confirmed, as too is the scarcity of *Passendorferia*; c) *Dichotomoceras* is relatively frequent and diversified; d) Haploceratids are rare in the Bifurcatus Zone; and e) *Epipeltoceras* seems to be rare in the lower part ot the Bimammatum Zone according to its absence of the ammonite record.

At the level of ammonite assemblages, Perisphinctids and Phylloceratids are recognized to be clearly predominant in the Transversarium and Bifurcatus Zones, other ammonites being minorities. In the lower part of the Bimammatum Zone Haplocerataceae share predominance with the previously mentioned groups.

Comparison with the biostratigraphic distributions in other epicontinental areas of Iberia (Iberian Range, cf. MELÉNDEZ, 1989) is particularly interesting as the absence of *Larcheria* in the Algarve would seem to indicate that the upper part of the Transversarium Zone is missing (Schilli Subzone of MELÉNDEZ, 1989). Another possibility is that *Larcheria* may not have developed in the Algarve and was substituted by *Subdiscosphinctes*. Since the higher preserved levels of the Transversarium Zone in the Algarve seem to be always linked to a discontinuity, the first of these hypotheses seems more likely, although the second cannot as yet be discounted.

As regards the discontinuity of the Transversarium-Bifurcatus boundary in the Algarve and the record of a condensation level in the section studied in the Peral area, the appearance of *Dichotomoceras bifurcatoides* and *Dichotomoceras crassus* in the same stratigraphic level is significant. According to MELÉNDEZ (1989), these two species belong to different subzones in the Iberian Range.

In comparison to the Iberian Range, the scarcity of Passendorferiinae and related forms in the Middle and Upper Oxfordian in the Algarve seems to be confirmed according to the data obtained from the studied section at Peral. Finally, it can not be established whether any biostratigraphic differences exist as regards the first appearance of *Praetaxioceras* in the Algarve and the Iberian Range.

REMARKS ON THE FAUNAL ASSEMBLAGES

The abundance of faunal assemblages related to the record of buildups, irrespective of what the origin of these was, is a well known fact (ENAY, 1966; BARTHEL & *al.*, 1971; GAILLARD, 1983; ROLIN & *al.*, 1990; GYGI, 1990). In the case studied here the predominant macrofauna is made up of molluscs and brachiopods; echinoderms were also found. Ammonoids are predominant, amongst which the major groups are either that composed exclusively of Perisphinctids and Phylloceratids, or that made up of Perisphinctids, Haploceratids and Phylloceratids. "Aspidoceratoides" are always minorities. Aptychi are rare *(Laevaptychus)*. Bivalves (ostreids) and gastropods *(Pleurotomaria)* are rare among macroinvertebrates. Echinoderms are represented by remains of crinoids (fragments of slightly disarticulated peduncles in the condensed horizons) and some echinids. Serpulids are frequent and only two fish teeth were found.

Fig. 3 shows the stratigraphic evolution of the macroinvertebrate assemblages and the composition of the ammonite assemblages. Towards the upper part of the Transversarium and Bifurcatus Zones, Perisphinctidae and Phylloceratacea together predominate the ammonite spectrum, while Haploceratacea, Euaspidoceratinae and Peltoceratinae are practically accidental components. In the lowermost part of the Bimammatum zone the previously predominant groups (Perisphinctids and Phylloceratids) decrease in number and share predominance with Haploceratacea, which show a marked increase. Euaspidoceratinae also increase during this interval, despite the scarcity of Peltoceratinae.

Interpretation of the alterations observed in the faunal spectra is not easy and must be undertaken paying attention to the eco-sedimentary context. Following the proposal of a sequential organization by MARQUES & *al.* (1991), the sucession studied here at least partly corresponds to the 4.3 cycle and the lower part of the 4.4 cycle in supercycle LZA-4 in the chart by HAQ & *al.* (1987). In other words, the significant increase in marls towards the upper part of the section must be related to the tectonic pulse affecting the Algarve during part of the Transversarium and Bifurcatus Zones (MARQUES & OLÓRIZ, 1989b), and also to the progradation caused by the development of the Shelf Margin Wedge System Tract (SMWST) during part of the Bimammatum Zone.

Given the context described above, we may expect a deterioration in life conditions for the benthos and a reduction of the ecospace during the Bimammatum Zone. The record of benthic macroinvertebrates is coherent with this hypothesis, as the Spongiaria do not persist significantly into the Bimammatum Zone, and the other bentic fauna undergo a significant decrease. The slight difference between the corresponding spectra in the sampled levels of the Transversarium and Bifurcatus Zones coincides with a relatively small change in the volume of the ecospace in this sector of the platform during the evolution of the transgressive interval (TST) and the development of the High Stand System Tract (HSST), both of which were subjected to a large rate of inflows. The slight increase in benthic fauna towards the Bifurcatus-Bimammatum Zone boundary may perhaps be due to taphonomic noise (resedimented bioclasts in bed 52). The ammonites do not seem to have suffered from the slight change in environmental volume and the composition of the spectra is practically identical towards the upper part of the TST (Transversarium Zone p.p.) and the HSST (Bifurcatus Zone p.p.). Phylogenetic evolutionary events did not alter the balance between the groups of ammonites represented in the faunal spectra.

The development of the SMWST also increased ecological stress for cephalopods during the interval of the Bimammatum Zone analyzed here. Ammonites were the least affected cephalopods (see the decrease of belemnites in the spectra of Fig. 3). The new ecological conditions were favourable for apparently "more balanced" spectra, but all the ammonite groups show a decrease in taxonomic diversity (Perisphinctids, Euaspidoceratinae); either one of the components is clearly predominant in its group (*Sowerbyceras* in Phylloceratidae), or both trends are combined (*Euaspidoceras* in "Aspidoceratoids"). The only group showing a clear increase is Haplocerataceae, particularly after the increase of one of its taxa (*Metahaploceras*).

The increase of Haplocerataceae during an eco-sedimentary situation of reduction of the ecospace and progradation (SMWST) is particularly interesting, since these ammonites have traditionally been interpreted as being related to sufficiently deep areas (ZIEGLER, 1967; GYGI, 1986). However, the data obtained allow us to consider that the sector studied here evolved towards comparatively more proximal and presumably shallower positions during the development of the SMWST in the Bimammatum Zone. The reinterpretation of the Haplocerataceae record has already been suggested by OLÓRIZ (1987).

CONCLUSIONS

— It has been possible to analyze the transition between the Transversarium-Bifurcatus Zones in the Algarve for the first time. Both Zones seem to be incomplete, especially the Transversarium Zone and very probably the lowermost part of the Bifurcatus Zone.

— A relatively abundant and diversified *Dichotomoceras* fauna has been found for the first time in the Algarve.

— The absence or extreme scarcity of *Larcheria* in the Algarve cannot as yet be interpreted unequivocally. Although it seems clear that there is a generalized stratigraphic gap in the upper part of the Transversarium Zone, which would explain the almost complete absence of *Larcheria*, we cannot discount the possibility that this taxon had a less specialized substitute among the *Subdiscosphinctes*.

— As regards the previous biostratigraphic data (MARQUES, 1983), a more representative record of *Gregoryceras* has been obtained, and the relative scarcity of *Passendorferia* has been confirmed; *Epipeltoceras* seem to be rare in the lower part of the Bimammatum Zone; *Haplocerataceae* are not predominant in the Bifurcatus Zone as was previously thought.

— The materials of the Bifurcatus Zone reach a thickness of approximately 1m in the area studied. This small thickness is the greatest presently known for this chronozone in the Algarve, which contrasts with the much greater thicknesses of the other Oxfordian chronozones identified in this region. A possible biostratigraphic condensation has been detected in the lower and middle parts of the Bifurcatus Zone.

— On the boundary between the Bifurcatus and Bimammatum Zones, a discontinuity linked to a bioclastic level was detected for the first time. This discontinuity coincides with a Type II sequence boundary and can be correlated with the traces recognized in the rest of the South-Iberian margin (MARQUES& *al.*, 1991).

— In the context of the sequential organization proposed for the South-Iberian margin (MARQUES& *al.*, 1991), the changes detected in the macroinvertebrate assemblages are coherent with the eco-sedimentary evolution recognizable in the eastern Algarve, and they permit the interpretation of significant features of the ecostratigraphic evolution.

— Evidence of correlation was recognized between the increase in clayey inflows, the decrease of the ecospace on the shelf, and the deterioration of life conditions for macroinvertebrates (particularly brachiopods and molluscs).

— The reactions of cephalopods to ecological stress are varied. As a group, belemnites are less tolerant than ammonites and their representation decreases with the increase in the recognized environmental deterioration. According to the recorded spectra, the ammonites adapted to the new conditions by changes in the global composition of the assemblages, reduction of their taxonomic diversity and/or changes in the predominant component(s) of the different groups.

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REFERENCES

BARTHEL, K. W., JANICKE, V. & SCHRAIRER, G. (1971) — Untersuchungen am Korallen-Riffkomplex vom Laisacker bei Neuburg a. D. (unteres Untertithon, Bayern). *N. Jb. Geol. Paläont.*, München, H 1, pp. 4-23.

CHOFFAT, P. (1887) — Recherches sur les terrains secondaires au sud du Sado. *Com. Com. Trab. Geol. Portugal*, Lisboa, t.1, pp. 222-312.

ENAY, R. (1966) — L'Oxfordien dans la moitié sud du Jura français. Étude stratigraphique. II - Contribution à la connaissance des Perisphinctidés. *Nouv. Arch. Mus. Hist. Nat.*, Lyon, pp. 331-624.

GAILLARD, C. (1983) — Les biohermes à spongiaires et leur environnement dans l'Oxfordien du Jura meridional. *Doc. Lab. Geol.*, Lyon, 90, 515 pp.

GYGI, R. (1986) — Eustatic sea level changes of the Oxfordian (Late Jurassic) and their effect documented in sediments and fossil assemblages of an epicontinental sea. *Eclogae Geol. Helvetiae*, Basel, vol. 79, nº 2, pp. 455-491.

GYGI, R. (1990) — Die paläogeographie im Oxfordium und frühesten Kimmeridgium in der Nordschweiz. *Jh. geol. Landesamt*, Baden-Württemberg, 32, pp. 207-222.

HAQ, B. U., HARDENBOL, J. & VAIL, P. R. (1987) — Chronology of fluctuating Sea Levels since the Triassic. *Science*, 235, pp. 1156-1167.

MANUPPELLA, G., MARQUES, B. & ROCHA, R. B. (1988) — Evolution tectono-sédimentaire du bassin de l'Algarve pendant le Jurassique. *2nd Int. Symp. Jurassic Stratigr.*, Lisboa, pp. 1031-1046.

MARQUES, B. (1983) — O Oxfordiano-Kimeridgiano do Algarve Oriental: estratigrafia, paleobiologia (*Ammonoidea*) e paleobiogeografia. *Tese Doutoramento, Univ. Nova Lisboa*, Lisboa, 547 p., 77 fig., 28 est.

MARQUES, B. (1985) — Litostratigrafia do Oxfordiano-Kimeridgiano do Algarve. *Com. Serv. Geol. Portugal*, Lisboa, t. 71, pp. 33-40.

MARQUES, B. & OLÓRIZ, F. (1989a) — La marge sud-ouest d'Ibérie pendant le Jurassique supérieur (Oxfordien-Kimméridgien): essai de reconstruction géo-biologique. *Cuad. Geol. Ibérica*, Madrid, 13, pp. 251-263.

MARQUES, B. & OLÓRIZ, F. (1989b) — La plate-forme de l'Algarve au Jurassique supérieur: les grandes discontinuités stratigraphiques. *Cuad. Geol. Ibérica.*, Madrid, 13, pp. 237-249.

MARQUES, B. & OLÓRIZ, F. (1992) — The *Orthaspidoceras uhlandi* (OPPEL) record and the maximum flooding in the eastern Algarve during the Lower Kimmeridgian. *Revista Española de Paleontología*, Madrid.

MARQUES, B., OLÓRIZ, F. & RODRIGUEZ-TOVAR, F. J. (1991) — Interactions between tectonics and eustasy during the Upper Jurassic and lowermost Cretaceous. Examples from the south of Iberia. *Bull. Soc. Geol. France*, Paris, t. 162, nº 6, pp. 1109-1124.

MELÉNDEZ, G. (1989) — El Oxfordiense en el Sector Central de la Cordillera Ibérica (Provincias de Zaragoza y Teruel). *Tésis Doctoral, Inst. Fernando el Católico & Inst. de Estudios Turolenses*, Zaragoza-Teruel, 418 p.

OLÓRIZ, F. (1987) — El significado de las plataformas mexicanas en el Jurássico superior. Consideraciones sobre un modelo eco-evolutivo. *Revista de la Sociedad Mexicana de Paleontología*, v.1, 1, pp. 219-247.

RAMALHO, M. (1985) — Considérations sur la biostratigraphie du Jurassique supérieur de l'Algarve oriental (Portugal). *Com. Serv. Geol. Portugal*, Lisboa, t. 71, pp. 41-50.

ROLIN, Y., GAILLARD, Ch. & ROUX, M. (1990) — Ecologie des pseudobiohermes des Terres Noires jurassiques liés à des paléo-sources sous-marines. Le site Oxfordien de Beauvoisin (Drôme, Bassin du Sud-Est, France). *Palaeogeography, Palaeoclimatology and Palaeoecology*, Amsterdam, 80, pp. 79-105.

ZIEGLER (1967) — Ammoniten-Okologie am Beispiel des Oberjura. *Geol. Rundsch.*, Stuttgart, 60, pp. 439-464.

DOCUMENTAÇÃO FOTOGRÁFICA

PLATE 1

Fig. 1 — *Perisphinctes (Dichotomoceras) wartae* (BUKOW). Slow growth specimen. Thin and dense ribbing, regularly bifurcated near the ventral margin, single ribs and intercalated ribs. Presence of constrictions.

Fig. 2 — *Gregoryceras (Gregoryceras) transversarium* (QUENST.).

Fig. 3 — *Euaspidoceras (E.) oegir* (OPPEL)

Fig. 4 — *Perisphinctes (Dichotomoceras) bifurcatoides* (ENAY). Specimen showing numerous thin ribs on the umbilical area, becoming salient, sharp and less crowded towards the outer whorls. The ribs bifurcate regularly. The fast growth, with little involving whorls, originate a slightly tight and flat umbilical area.

Fig. 5 — *Campylites (Neoprionoceras) lautlingensis* (ROLL.).

Plate 1

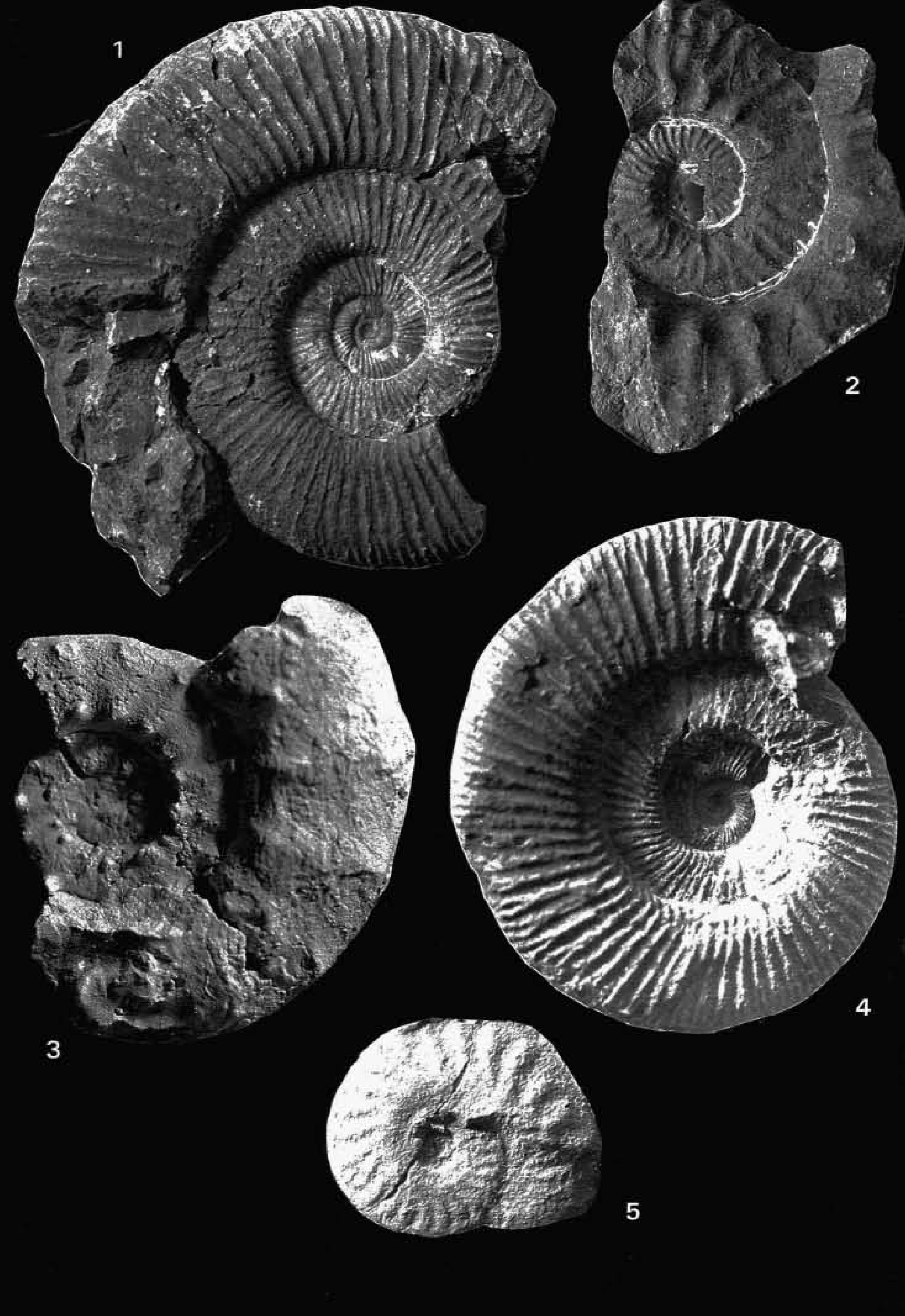

PLATE 2

Fig. 1 — *Perisphinctes (Dichotomoceras) bifurcatoides* (ENAY).

Fig. 2 — *Perisphinctes (Dichotomoceras) bifurcatoides* (ENAY).

Fig. 3 — *Perisphinctes (Dichotomoceras) bifurcatoides* (ENAY).

Fig. 4 — *Perisphinctes (Dichotomosphinctes) elisabethae* de RIAZ. Specimen with highly densed ribbing, high and compressed section and reduced umbilical area. Presence of single ribs.


Plate 2
1
2
3
4