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Biostratigraphic Review and Ecostratigraphic Analysis of the Fuente Alamo Profile (External Prebetic, Betic Cordillera, Spain)

FEDERICO **OLÓRIZ** & FRANCISCO JAVIER **RODRÍGUEZ-TOVAR**, GRANADA*

Abstract

A detailed palaeontological study of the profile of Fuente Alamo in the eastern External Prebetic (province of Albacete, southern Spain) has enabled the identification of the stratigraphic ranges of biostratigraphically significant ammonite species as well as the subdivision of the Platynota Zone (Lower Kimmeridgian) into standard subzones for submediterranean Europe (Orthosphinctes, Desmoides and Guilherandense). A complementary analysis of the fossil assemblages permited to interpret the relationship between the evolution of these species and the changes in accommodation and ecospace that occurred throughout the progression of the High Stand System Tract during the Platynota Chron.

1 INTRODUCTION

As noted by Professor Otto F. Geyer in his "Sinopsis bibliográfica de las investigaciones geocientíficas en el Mesozoico de la Península Ibérica realizadas por el Instituto de Geología y Paleontología de la Universidad de Stuttgart (1955-1995)", many studies have been completed, and many are under way, by the Stuttgart Institute on the Mesozoic of the Betic Cordilleras (Geyer, 1996). In addition, many abstracts, papers, theses and dissertations have been published on the subject, partially owing to Professor Geyer, both for his personal work as well as his direction of others researches.

In his dissertation on the Jurassic of the eastern sector of the Prebetic Zone, directed by Professor Geyer, Behmel (1970) provided a detailed biostratigraphic scheme at the zone level of ammonites, an especially significant achievement given the comparative rarity of these fossil remains in the Prebetic Zone, as compared to the Subbetic swells, which show a generalized ammonitico rosso facies during the Upper Jurassic.

The present work provides an update on the latest biostratigraphic advances and ecostratigraphic interpretations from the study of Upper Jurassic (Kimmeridgian) deposits in the eastern sector of the Prebetic Zone. For this, we have selected the profile of Fuente Alamo, complementing previous research by French and German colleagues.

2 GEOGRAPHIC AND GEOLOGIC LOCATION

In geological terms, the Prebetic Zone constitutes the external and northern part of the Betic Cordillera (Fig. 1). In accord with previous works, the sector studied is included within the eastern External Prebetic (Jerez-Mir, 1973; García-Hernández, 1978; Rodríguez-Estrella, 1978; Azèma et al., 1979; Rodríguez-Tovar, 1993).

Palaeogeographically, the term External Prebetic applies to the epicontinental marine platforms, relatively proximal to the southern part of the Hesperian Massif. The Iberian platforms represent the continuation of epicontinental environments towards the NE. In the transition areas, the similarities between the Prebetic and Iberian domains is such that they are differentiated on structural criteria (Fourcade, 1970; Jerez-Mir, 1973), so that the eastern External Prebetic includes Betic and combined Iberian-Betic trends (Jerez-Mir, 1973; Rodríguez-Estrella, 1978). Southwards, the most external platforms, or distal sectors of the epicontinental environment, pertain to the area called the Internal Prebetic, which connected with the most proximal oceanic environment, or epioceanic fringe, the bottoms of which were structured in troughs and swells (Subbetic Zone).

The sedimentation of the Upper Jurassic in the External Prebetic is represented primarily by

* Addresses of the authors: Prof. Dr. Federico Olóriz Sáez, Francisco Javier Rodríguez-Tovar, Depto. Estratigrafía y Paleontología, Fac. Ciencias, Univ. Granada. 18002, Granada, Spain. e-mail: foloriz@goliat.ugr.es -- fjrtovar@goliat.ugr.es

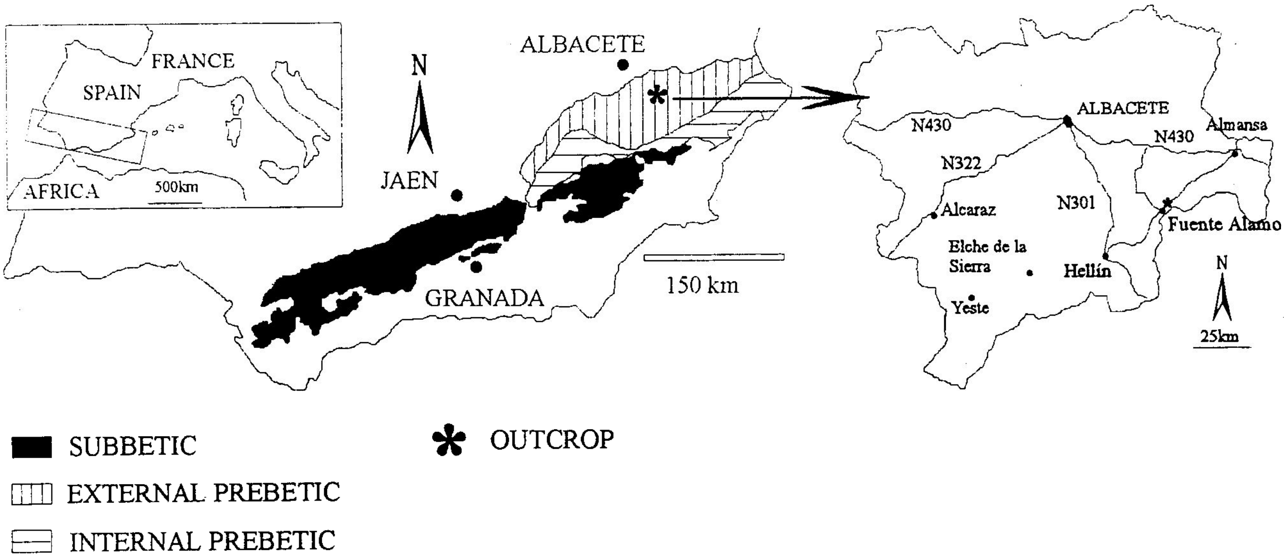

Fig. 1. Geographical and geological location of the Fuente Alamo section (External Prebetic).

marly-calcareous rhythmites from the Upper Oxfordian to part of the Middle Kimmeridgian. Where recognized, the youngest deposits of the carbonate platform overly the marly-calcareous rhythmites throughout the rest of the Upper Jurassic. The meagre record of deposits from the end of the Jurassic is related to erosive phases (Azèma et al., 1979).

3 THE SECTION OF FUENTE ALAMO

This profile has commonly been considered the type profile for the Upper Jurassic in the eastern sector of the Prebetic domain. Data from this profile have been included in numerous biostratigraphic works, as well as in facies analyses and synthetic interpretations made in the late 1960s and early 1970s (Fourcade, 1966a,b, 1970, 1971; Behmel, 1970). Afterwards, at the beginning of the 1990s, the advances in Upper Jurassic research in the area are reflected in works on the sponge megafacies (Pisera, 1991), mineralogical aspects (López-Galindo et al., 1992) and synthetic considerations that treat the overall southern Iberian margin (Rodríguez-Tovar, 1993).

The profile studied is located roughly 1 km east of Fuente Alamo (province of Albacete, with coordinates 1°25'20"-38°41'45" on the topographic sheet of Montealegre del Castillo (nº 26-32, 818) at a scale of 1:50,000 (Fig. 1).

The succession, belonging to the Lorente Formation (Fig. 2 in Pendas, 1971), reaches some 100 m in thickness and is composed of alternating marls, marly limestones and limestones. The bottom of the succession is recognized at a condensation level of the Late Oxfordian (in the traditional sense), of some 10 cm in thickness and which is notable for its irregular and ferruginized upper surface. In this horizon a high concentration of fossil remains has been identified, these containing abundant belemnites and ammonites as well as many brachiopods, bivalves and sponges. Directly above, an essentially marly stretch, greenish blue in color, is distinguishable, with an total thickness of roughly 25 m, containing marly levels of up to 8 m thick and intercalated levels of marly limestones at some 18 m from the bottom. Over this stretch, approximately 12m of marly limestones outcrop with strata varying between 10 and 40 cm thick; the marly intercalations are generally about 15 cm thick, though occasionally reaching 40 cm. In the upper part of this stretch the carbonate character increases and the first limestone strata appear. Over this stretch, lie 50 m of limestone strata with an average thickness of 18 cm and with thin marly intercalations occasionally reaching 1 m in thickness. The upper 14 m of the succession are differentiated by an increase in marls having two notable marl and marly-limestone intercalations, each about 5 m thick and separated by a stretch of limestone of similar thickness. The upper limit of the succession has been established at the top of this stretch.

4 PALAEONTOLOGICAL STUDY

This study presents recent advances in ammonite bio-chronostratigraphy and in the reconstruction of the most general features of the composition of the macroinvertebrate assemblages, including megabenthos. Thus, we hereby update the information collected in the latest field surveys performed in the Fuente Alamo sector, both those oriented to synthetic works on the southern Iberian margin (Rodríguez-Tovar, 1993) as well as those concerned only on its eastern sector (Olóriz et al., 1995a).

With respect to the composition of fossil assemblages, we recognized the ammonite domain in comparison with other macroinvertebrates, except towards the top of the profile. Other non-ammonite macroinvertebrates, including megabenthos, are generally dominated by bivalves, except for the belemnite-rich horizons. Despite the frequency of ammonoid remains, there is a notable scarcity of aptychi.

Preservation takes the form mainly of internal moulds, and only on occasions are epigenized shells found. Some remains of delicate structures have been recorded, such as thoracic exoskeletal fragments of arthropods, pedunculate peristomes of ammonites and spiny ornamentation of gastropods.

The breacking, generally negligible, affecting larger discoidal forms (ammonites) and being practically absent among the benthos. However, disarticulation often affects bivalves. Plastic deformation by compaction is most common, causing a variable appearance of the remains, according to their orientation during burial.

With exceptions (e.g. horizons with belemnites), the distribution of remains in the strata do not present differential concentrations of bioclasts. In general, there are no preferential orientations, except for the predictable horizontal trend among the discoidal forms of ammonites larger than 20 to 30 mm. No case of size selection was recognized in the fossil remains. Normally contact between the remains of different specimens is uncommon. Examples of vertical burial are known, as well as some cases of impact of shells on the bottom, indicating soft substrates.

Taphonomic observations confirm the predominance of low-energy conditions in which the weak currents did not significantly rake the bottom, except on rare occasions in which horizons formed with high concentrations of heavy skeletal fragments (belemnites). This interpretation is compatible with hydrodynamic conditions which favoured a certain amount of *post-mortem* transport of the organic remains (cephalopod shells) in the water column.

4.1 AMMONITES: SYSTEMATIC ASPECTS

In the present study, we recognized 2 superfamilies, 5 families, 6 subfamilies, 9 genera, 10 subgenera and 17 species of ammonoids, as well as 7 cases of doubtful species identification. The biochronostratigraphic interpretation will be presented in the next section:

Phylloceras sp.
Sowerbyceras sp.
Haplocerataceae (indet.)
Taramelliceras (Metahaploceras) litocerum (OPPEL)
T. (M.) falcula (QUENSTEDT)
T. (M.) kobyi wegelei SCHAIRER
T. (M.) sp.
Glochiceras sp.
G. (Glochiceras) nimbatum (OPPEL)
G. (Lingulaticeras) nudatum (OPPEL)
G. (Coryceras) modestiforme (OPPEL)
Ochetoceras sp.
Physodoceras altenense (D'ORBIGNY)
Physodoceras sp.
Aspidoceratidae (indet.)
Nebrodites (Nebrodites) hospes hospes (NEUMAYR)
N. ("Mesosimoceras") hossingense (FISCHER)
Sutneria platynota (REINECKE)
Orthosphinctes (Orthosphinctes) polygyratus (REINECKE)
O. (Ardescia) proinconditus (WEGELE)
O. (A.) thieuloyi ATROPS
O. (A.) sp. aff. *thieuloyi* ATROPS
O. (Lithacosphinctes) pseudoachilles (WEGELE)
O. (L.) nov.sp. A
Orthosphinctes sp.
A. (Ataxioceras or Schneidia) sp.
Ataxioceratinae (indet.)

5 BIO-CHRONOSTRATIGRAPHY

5.1 PREVIOUS DATA

In the eastern sector of the Prebetic Zone, the Fuente Alamo section is the best biostratigraphically characterized profile and thus discussed in many publications.

Fourcade (1966a,b, 1970 and 1971) was the first to study this succession. Fourcade (1966a) recognized the presence of ammonites, which he used to differentiate the Middle Oxfordian in the basal limestones containing sponges. In subsequent works (1966b, 1970 and 1971) Fourcade presented the stratigraphic column of the profile, differentiating, from bottom to top: a) basal limestones with ammonites assigned to the Upper Oxfordian (Argovian and Rauracian); b) marls with pyritic ammonites from the bottom of the Kimmeridgian (Fourcade, 1966b), dated to the Lower Kimmeridgian for the presence of *Sutneria platynota* (REINECKE) and *Ataxioceras* (Fourcade, 1970, 1971); c) alternation of limestones and marls with fragments of *Ataxioceras* at the bottom, over which limestones containing oncolites with *Pseudocyclammina (Alveosepta) jaccardi* were recognized clearly above the Oxfordian/Kimmeridgian boundary (Fourcade, 1966a) and which were attributed to the Lower Kimmeridgian in Fourcade (1970, 1971), and d) upper dolostones and limestones with microfacies of "cachet kimméridgien" (Fourcade, 1966b), dated as Middle or Upper Kimmeridgian with microorganisms (Fourcade, 1970) or as Middle Kimmeridgian (Fourcade, 1971).

Nevertheless, by the study of ammonites, Behmel (1970, profile 15) established a quite detailed biostratigraphy of the succession of the Fuente Alamo section. This author recognized the Middle Oxfordian (Plicatilis Zone) and Upper Oxfordian (Bifurcatus, Bimammatum and Planula Zones) in the basal limestones with sponges, except for the Planula Zone, differentiated almost completely in the lower third of the marls, where the marly-calcareous rhythmite begins. In the Lower Kimmeridgian, the Platynota, Hypselocyclum and Divisum Zones are recognized. The Platynota Zone, with a thickness of roughly 40 m, would correspond fundamentally to the rest of the basal marls and to a small part of the alternation of marls and marly limestones, in which the Hypselocyclum and Divisum Zones are also recorded. In a markedly calcareous stretch, the boundary between the Lower and Upper Kimmeridgian is not clearly established. The upper part of the succession is assigned to the Tithonian. From the data and biostratigraphic interpretations of Behmel (1970), the following facts are notable for the Lower Kimmeridgian:

- The coincidence at the same level of *Sutneria galar* (OPPEL) and *Sutneria platynota* (REINECKE).
- The distribution of *Sutneria platynota* (REINECKE) throughout the interval assigned to the Platynota Zone.
- The presence of *Ataxioceras (Parataxioceras) pseudoeffrenatum* WEGELE practically throughout the Hypselocyclum Zone.
- The presence of *Lithacoceras (Lith.)* sp. ex gr. *lictor* (FONTANNES), *Lithacoceras (Lith.) albulum* (QUENSTEDT), *Perisphinctes (Orthosphinctes)* cf. *praenuntians* FONTANNES and *Virgatosphinctes (Virgataxioceras)* cf. *setatum* (SCHNEID), in which the successive records characterize the Divisum Zone and the Setatum Subzone (Lower and Upper Kimmeridgian, respectively).

5.2 BIO-CHRONOSTRATIGRAPHIC INTERPRETATION

The most complete biostratigraphic review of the basal and middle part of the Lower Kimmeridgian in epicontinental Submediterranean areas of Europe was made by Atrops (1982) in southeastern France. The scheme proposed by this author has been since considered a standard reference for the biostratigraphic subdivision based on Ataxioceratinae *s.* Zeiss (1968) and for the correlations in areas with Submediterranean ammonite assemblages. In fact, the basic arguments for the subdivision appear to be recognizable in different regions, both in the Iberian Peninsula and in North Africa, Switzerland and southern Germany. Nevertheless, some differences, which might at first appear minor, are receiving more attention as knowledge advances in the southernmost epicontinental areas.

In the Iberian Peninsula, shelf deposits of the Lower Kimmeridgian with ammonites have been studied from a biostratigraphic standpoint in the Iberian Cordillera (Moliner, 1983; Atrops & Meléndez, 1984; Moliner & Olóriz, 1984; Moliner & Olóriz, this volume) and in the Algarve (Marques, 1983, 1984; Marques & Olóriz, 1992; Rodríguez-Tovar, 1993). These works provide basic information practically without subsequent changes. In the Prebetic, the studies are less frequent and detailed, given the comparative rarity of fossil remains (Geister & Geyer, 1968; Behmel, 1970; Fourcade, 1970; Azèma et al., 1971; Foucault, 1971; López-Garrido, 1971; García-Hernández et al., 1979); only recently have the first detailed analyses been made, focusing on ammonites of the Lower Kimmeridgian (Rodríguez-Tovar, 1990, 1993; Olóriz & Rodríguez-Tovar, 1993a; Olóriz et al., 1995a).

With respect to the profile studied, the stratigraphic distribution recognized for the components of the ammonite assemblage cited above (Chapter 4.1, Fig. 2) enabled the recognition of the Platynota Zone with a thickness of about 100 m, including the record of the index fossil *Sutneria platynota* (REINECKE). In addition, the distribution of Ataxioceratinae has enabled the identification at the subzonal level, with the recognition of the standard subzones Orthosphinctes, Desmoides and Guilherandense. The presence of *Orthosphinctes (Orthosphinctes) polygyratus* (REINECKE) enabled the characterization of the Orthosphinctes Subzone in the basal marls. *Orthosphinctes (Ardescia) proinconditus* (WEGELE) was recorded approximately 45 m from the Oxfordian/Kimmeridgian boundary, clearly in the interior of the marly calcareous rhythmite, enabling the identification of the Desmoides Subzone; the presence of *O. (A.) thieuloyi* ATROPS and *O. (A.)* aff. *thieuloyi* ATROPS in the upper part of the succession enabled the characterization of the top of the Platynota Zone (Guilherandense Subzone). However, even while recognizing the three standard subzones, it has not been possible to specify the precise subzonal boundaries, as evidenced by the difficulty in characterizing known biohorizons in the northernmost areas, such as the Iberian Cordillera (Moliner & Olóriz, 1984; Moliner & Olóriz, this volume) and southeastern France (Atrops, 1982). Thus, the resulting biostratigraphic scheme proves closer to that recognized in other areas of the Prebetic (Olóriz & Rodríguez-Tovar, 1993a; Rodríguez-Tovar, 1993), the most characteristic features of the lower Kimmeridgian being: a) the reduced thickness of the lowermost Platynota Zone (Subzone of Orthosphinctes), b) the difficulty in recognition and correlation at the level of the biostratigraphic horizon, c) the absence of the significant *Amoeboceras* biohorizon at the bottom of the Platynota Zone, and d) the apparent differences in the intervals of maximum frequency and diversification in taxa of the subfamily Ataxioceratinae (Olóriz & Rodríguez-Tovar, 1993a; Rodríguez-Tovar, 1993).

6 ECOSTRATIGRAPHY

The ecostratigraphic analysis applied facilitated the long-term palaeoecological interpretation of the composition of the macroinvertebrate assemblages recorded (including megabenthos) in the interval studied, assuming the existence of organism-environment interactions. The grouping of organisms into communities and the variations of these is usually related to changes in the parameters which characterize the physical medium occupied (temperature, oxygenation, salinity, nutrients, etc.).

In this type of analysis, the stratigraphic aspects are of prime importance. That is, not only the control of the composition of the fossil assemblages, but also the consideration of taphonomic and sedimentary features in their stratigraphic contexts enable interpretations of factors that determined the known fossil record and make it possible to infer ecological factors that characterized the environment. This type of study has been used in the treatment of chronological aspects in high-resolution stratigraphy (High Resolution Event Stratigraphy, HIRES, Kauffmann, 1986; Kauffman et al., 1991), and recently its use has been proposed with a decidedly palaeoecological orientation in basin analysis (Olóriz et al., 1991, 1992, 1993a,b, 1994a,b, 1995b; Marques et al., 1992, 1993; Rodríguez-Tovar, 1993; Caracuel et al., 1994; Olóriz, 1997). With this focus, the ecostratigraphic analysis has proved especially useful in the analysis of monotonous lithological successions with changes of comparatively minor facies as in the case of the succession under study.

The Fuente Alamo section was studied bed-by-bed, providing more than 1000 *in situ* specimens. This analysis included taphonomical and ichnological observations in addition to palaeontological sampling with a standard sample size of 50 specimens per level. The average composition of the fossil assemblages recorded is represented in circular diagrams (Fig. 2), interpreted within the general context of the information obtained. These data can be represented in various ways, progressively increasing detail of the information according to the consideration of taxonomic units of lesser range. In specific, two types of representations were considered:

a) A preliminary approach included diagrams showing the total fossil assemblage recorded (left pie diagram, Fig. 2). In these diagrams, the ratio between ammonites and the rest of the fossil macroinvertebrates (including megabenthos, fundamentally bivalves) was established, to indicate the relative proportions of pelagic and benthic forms.
b) In a more detailed representation, the composition of the ammonite assemblage is illustrated, differentiating between Ataxioceratinae, Phylloceratina+Lytoceratina, Haploceratаceae and the rest of Ammonitina (right pie diagram, Fig. 2). The usefulness of this type of grouping of ammonites for ecostratigraphic analysis in epicontinental areas has previously been demonstrated in Upper Jurassic materials (Olóriz et al., 1996, among others).

For an adequate evaluation of the data collected, we diagrammed the average spectra characterizing the lower, middle and upper parts of the Fuente Alamo section. In broad terms, when we analysed the ratio of ammonites to benthos from the bottom to the top of the Platynota Zone, we found a clear rise in the percentage of benthos, fundamentally bivalves, and consequently a fall in the number of nectonics (ammonites). In addition, there was sudden notable increase in benthos (>95%) around the boundary between the Platynota and Hypselocyclum Zones.

The analysis of the evolution of the ammonite assemblages throughout the Playnota Zone shows a generalized increase in the percentage of Ataxioceratinae in the lower to medium part of the Zone, accompanied by a decline in Phylloceratina+Lytoceratina and Haploceratacea. The reduced number of ammonites collected in the lowest part of the Platynota Zone hinders a reliable evaluation of their relative record.

6.1 ECOSTRATIGRAPHIC INTERPRETATION

The general composition of the fossil assemblages was typical Submediterranean ("proximal association" in Olóriz, 1985), characteristic of epicontinental platform environments connected with the open sea (Olóriz et al., 1991, 1993a).

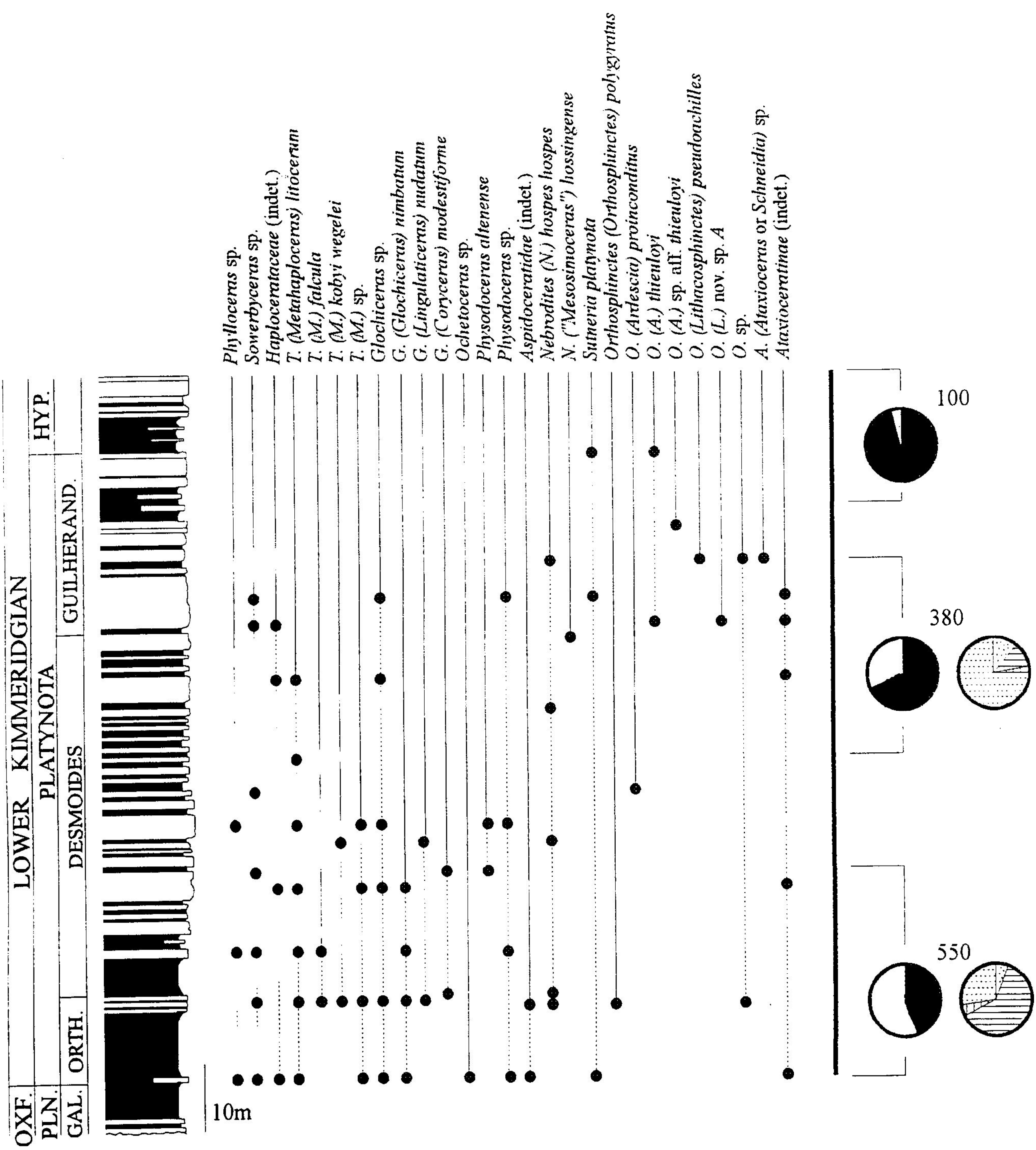

Fig. 2. Fuente Alamo section. Biochronostratigraphy according to traditional proposal (OXF = Oxfordian, PLN = Planula, HYP = Hypselocyclum, GAL = Galar, ORTH = Orthosphinctes, GUILHERAND = Guilherandense), lithological column, stratigraphic distribution of chosen ammonite species, and evolution of the fossil assemblages (white=ammonites, black=other macroinvertebrates, broken lines = ataxioceratinae, vertical hatching = phylloceratids+lytoceratids, horizontal hatching = haploceratacaeae, dotted = other ammonitina, numbers = recorded specimens).

If the palaeogeographic framework is known, variations in the fossil assemblages over time can be related, firstly, with fluctuations of the ecospace, brought about by changes in the relative level of the sea at different scales (Olóriz et al., 1991, 1995b). In this context, it becomes highly useful to analyse the relationship between the variations of the fossil assemblages and the pattern of changes of the relative sea level during the Platynota Chron in the study area, especially those related to the short-term curve adapted to the specific area in question. We applied the adaptation of the global eustatic curve (Haq et al., 1987, 1988) proposed by Marques et al. (1991) for the Upper Jurassic in the south Iberian margin. In accord with this, we assumed a lowering trend in relative sea level accompanied by the development of a High Stand System Tract (HST) during the Platynota Chron. Consequently, we analysed the stratigraphic evolution of the fossil assemblages and their possible relationship with the model of changes in the ecospace during the development of the HST in the palaegeographic context propose:

a) Lower part of the succession. In agreement with Marques et al. (1991), the boundary between the Planula and Platynota Zones corresponds to the condensed section from the 3rd-order cycle 4.4 belonging to the 2nd-order supercycle LZA-4 proposed by Haq et al. (1987, 1988). According to this, the bottom traditionally accepted for the Kimmeridgian (Platynota Zone) would coincide with the deposits characteristic of HST which followed the condensed section that determined the deposit of the nodular limestones of the upper part of the Oxfordian.

b) The middle part of the succession. Biochronostratigraphically, the middle part of the succession belongs to the interval corresponding to the Desmoides and Guilherandense Subzones p.p. of the Platynota Zone. In the proposed sequential organization taken as reference (Marques et al., 1991), the middle part of the succession studied shows the evolution of the 3rd-order HST mentioned above. In ecostratigraphic terms, the decline in the ratio of ammonites to other macroinvertebrates (including megabenthos) and the rise of Ataxioceratinae and the fall in the percentage of Phylloceratina+Lytoceratina are consistent with the decrease in the ecospace available for the ammonites and the increase for the benthos (improved living conditions for benthos). These data are compatible with a progressive reduction in the ecological volume on the platform caused by the regressive effect of the developing HST.

c) The upper part of the succession. The upper part of the succession corresponds biochronostratigraphically to most of the Guilherandense Subzone (uppermost Platynota Zone) and to the lowermost Hypselocyclum Zone. In accord with the sequence organization assumed, this upper part of the succession correlates with advanced phases of the HST and/or with the tail of the Shelf Margin Wedge (SMW). That is, it is possible that in the interior of the thick marly stretches that characterize the upper part of the succession studied, the record is relatively distal from the sequence boundary between the 3rd-order cycles 4.4 and 4.5 of the 2nd-order supercycle LZA-4 proposed by Haq (1987, 1988) and reinterpreted by Marques et al. (1991). In this context, the predominance of benthic fauna is consistent with the progradation of facies predicted by the model of the sequence stratigraphy and the trend associated with the reduction of accommodation and ecospace (Olóriz et al., 1995b).

In general, the ecostratigraphic analysis evidences a progressive and significant deterioration for the living conditions of ammonites, as well as a steady improvement for benthic fauna. Consequently, we deduce a notable reduction in ecological volume associated with the decline in accommodation over the southern Iberian platform in the sector studied.

7 CONCLUSIONS

The bed-by-bed analysis of the Fuente Alamo section, the type-section of the Upper Jurassic for the eastern sector of the Prebetic Zone, has enabled a biostratigraphic review of the Platynota Zone (Lower Kimmeridgian), as well as the refinement of preliminary ecostratigraphic considerations concerning this section.

The record of the index fossil *Sutneria platynota* (REINECKE) enables the characterization of the Platynota Zone with a thickness of approximately 100 m. The analysis of the subfamily Ataxioceratinae facilitated the subdivision of the Zone into standard subzones Orthosphinctes, Desmoides and Guilherandense.

The analysis of the fossil associations indicated the Submediterranean character of the ammonites in relation to the colonization of the epicontinental platform environments at intertropical latitudes. The evolution of the composition of the assemblages (ratio of ammonites to other macroinvertebrates and ratio between the different types of ammonites) is consistent with predictions based on the reduction of accommodation and ecospace during the development of a HST in a ramp that received the mixed carbonate-siliciclastic sedimentation during the Platynota Chron.

8 ACKNOWLEDGEMENTS

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