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The Lower Kimmeridgian Section at Gallipuén. Ammonite Biochronostratigraphy and Ecostratigraphic Remarks

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Abstract

The precise analysis of ammonite ranges in the Kimmeridgian section at Gallipu_n permits the recognition of the Platynota, Hypselocyclum and Divisum Zones of the Lower Kimmeridgian, but the presence of the lowermost Upper Kimmeridgian in the area is doubtful. From bottom to top, the Platynota Zone is subdivided in the „Orthosphinctes interval", the middle Desmoides Subzone (with the *enayi* and *desmoides* biohorizons), and the upper Guilherandense Subzone (with the Guilherandense (G-1) interval and the *guilherandense* biohorizon). The first appearance of crussoliceratids is the easier way to recognise the Hypselocyclum/Divisum Zone boundary. In general, the correlation with standard biochronostratigraphic units proposed for Submediterranean Europe is acceptable, but the identification of minor differences deserves future research.

The composition of fossil assemblages of macroinvertebrates, including megabenthos, fits well with the assumption of changes in ecospace forced by sea-level fluctuations in low-energy environments. The analysis of changes in the composition of ammonite assemblages complements that of the benthic : pelagic ratio, hence improving ecostratigraphic interpretations at the zone level. The epitome of ammonites correlates with a significant decrease in Ataxioceratinae (the highest specialised group), increasing haploceratids and especially aspidoceratids (less specialised), and the epibole of benthic fauna. The most balanced ammonite assemblages occur in the Divisum Zone, in accordance with the maximum flooding that affected the area.

1 INTRODUCTION

The knowledge on the Kimmeridgian from the eastern Iberian Chain improved significantly during seventies with contributions such as those made by Bulard et al. (1971), Felgueroso Coppel & Ramirez del Pozo (1971), Canerot (1974), El Khoudary (1974) and Gómez (1979). Concerning precise Kimmeridgian ammonite biostratigraphy and the composition of macroinvertebrate fossil assemblages (megabenthos included) in the eastern Iberian Chain, the valuable contribution by Geyer & Pelleduhn (1979) was pioneer. Later, data on the Kimmeridgian in the region increased and diversified from eighties (Moliner, 1983; Atrops & Meléndez, 1984; Moliner & Olóriz, 1984; Olóriz et al., 1988; Aurell, 1990; Aurell & Meléndez, 1990; Meléndez et al., 1990; Finkel, 1992; Bádenas et al., 1993; Salas & Casas, 1993; Atrops et al., 1997; Aurell et al., 1997; Bádenas, 1997; Bádenas & Aurell, 1977; and Gómez & Goy, 1997; among others). Hence, a wide spectrum exists of updated information about Kimmeridgian palaeontology, sedimentology, stratigraphy, tectonics and regional geology. However, the analysis of fossil assemblages in their stratigraphic context, i.e. the basis for ecostratigraphic interpretations, is poorly developed on Kimmeridgian materials. Preliminary data from the Platynota Zone were reported by Olóriz et al. (1988) on the basis of precise ammonite biostratigraphy. Finkel (1992) showed the composition of ammonite assemblages recovered from Kimmeridgian outcrops northeastern from Gallipuén. The aim of the present paper is to show some general traits of the ecostratigraphic analysis applied to the Lower Kimmeridgian in the Gallipuén area, supported by precise ammonite biostratigraphy.

2 LOCATION AND GEOLOGICAL SETTING

Upper Jurassic outcrops in Las Umbrías are located close to the village of Alcorisa, province of Teruel, between coordinates 0°25'6" – 0°24'56"

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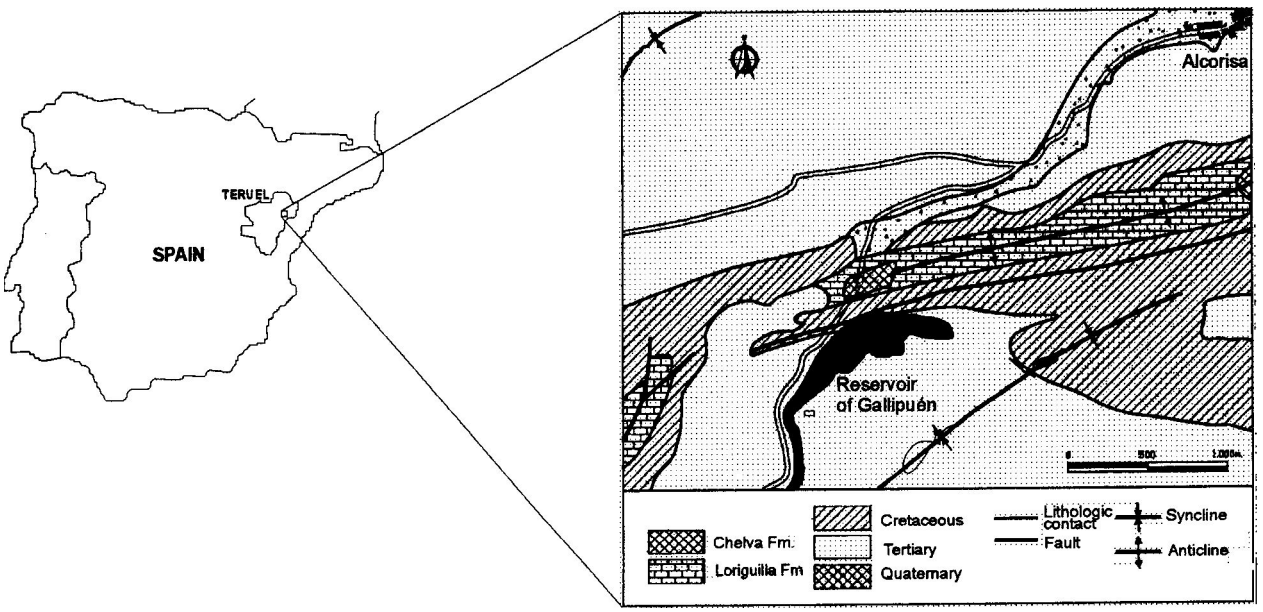


Fig. 1: Location and geologic sketch of the Gallipuén area.

and 40°52'39''- 40°52'46'' in the sheet of Calanda, no 494 (scale 1:50.000) in the National Topographic Map (Fig. 1). The Upper Jurassic shows a W-E trend about 3 Km in the northern limb of the Cerro de las Umbr'as, from the Gallipuén reservoir to the neighbouring of Alcorisa. The Gallipuén sections are located north from the dam and were favoured by quarry works in Kimmeridgian limestones during reservoir construction.

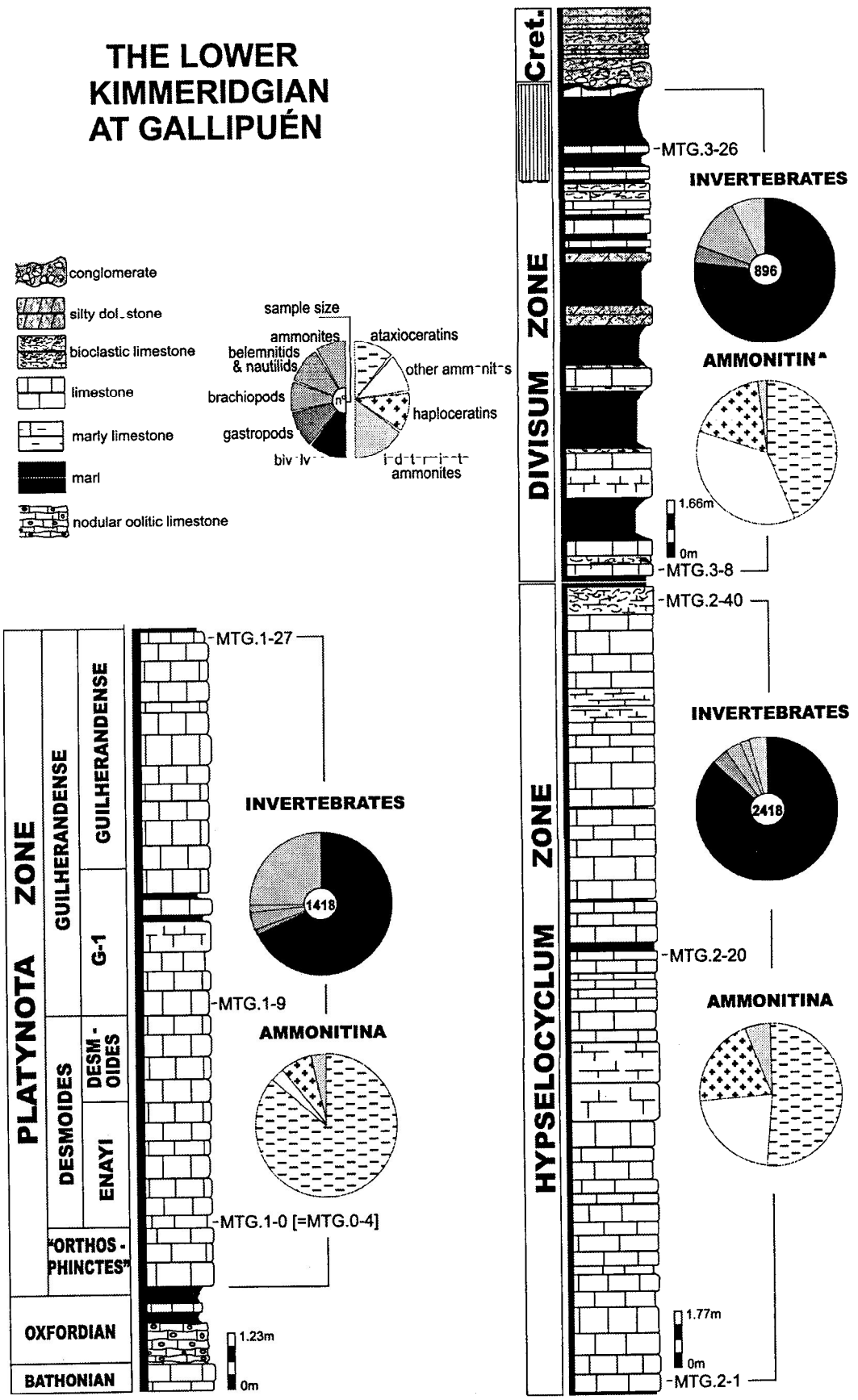
The outcropping of Mesozoic materials in Las Umbr'as shows an anticline with the Upper Jurassic underlying the uncomformable Lower Cretaceous. Favourable sections of Upper Jurassic deposits exist towards the western extreme of this structure. In the Gallipuén sector, the Upper Jurassic is composed of a small section belonging to the Oxfordian, and a better-developed Kimmeridgian section including a thin stratigraphic interval at the top with possibility to shows lowermost Upper Kimmeridgian deposits. An erosive unconformity separates Kimmeridgian deposits from the overlying upper Lower Cretaceous sandstones. Therefore, there is low possibility, if anyone, to recognise Upper Jurassic deposits younger than the uppermost Lower or the lowermost Upper Kimmeridgian in the Gallipuén area. Within the Kimmeridgian, we investigated sections showing the Platynota, Hypselocyclum and Divisum Zones.

3 THE LOWER KIMMERIDGIAN SECTION AT GALLIPUÉN

In the Gallipuén area, the bottom of the Upper Jurassic sections studied (Fig. 2) shows ca. 70cm thick Oxfordian deposits composed of nodular peloid-oolitic-algal limestones indicating low rates of deposition and probably hiatuses during late Oxfordian times. However, these bioclastic wackestones, and locally packstones, with frequent sponge spicules and irregular bedding (horizons 5 to 20cm thick), show energy conditions sporadically higher that background conditions assumed for the typical sponge limestones of the Yátova Mb. of the Chelva Fm. Identifiable ammonites are rare, but *Trimarginites* sp., as well as *Epipeltoceras treptense* from neighbouring areas, were reported by Moliner (1983), thus indicating the possibility for the local recognition of the upper Bimammatum Zone. As recognised by Moliner (1983), the *Trimarginites* sp. mentioned could indicates even the lower Planula Zone according to data in Karve-Corvinus (1966), Wierzbowski (1978), García-Hernández et al. (1979) and Sequeiros & Olóriz (1979).

Fig. 2: Lithological columns showing the Kimmeridgian section at Gallipuén. Pie-diagrams give the composition of fossil assemblages of macroinvertebrates (megabenthos included) at the ammonite-zone level, based on the material recovered from particular sections. Note different magnification for the particular sections analysed. Vertical ruling for indeterminate Divisum or Acanthicum Zones.

THE LOWER KIMMERIDGIAN AT GALLIPUÉN



Overlying the condensed deposits are 70cm thick greyish, fine siliciclastics, which include ferruginous ooids at the base (lowermost 20cm) and some intercalations of centimetres-thick marly limestones, but no sandy horizons (Fig. 2). These deposits belong to comparatively basinward records of the Margas de Sot de Chera Fm., the deposition of which was related to pulses of basin instability (Aurell et al., 1997; Gómez & Goy, 1997; Bádenas & Aurell, 1997). These pulses were related to a tectonic phase widely identifiable in the easternmost Iberia (Salas & Casas, 1993), as well as in southern and western Iberia (Marques et al., 1991; Rodr'guez-Tovar, 1993; Olóriz & Rodriguez-Tovar, 1998), and northern Africa (Atrops & Benest, 1986; Benzaggagh, 1988; arques et al., 1991, among others). Ammonites are scarce and not well preserved in the sections studied at Gallipuén, but Atrops & Meléndez (1984) identified the lowermost Platynota Zone (Orthosphinctes Subzone) with *Orthosphinctes (Orthosphinctes) polygyratus* (REINECKE), *Orthosph. (Orthosphinctes) polygyratus* (REINECKE) morph. *pseudopolyplocoides* GEYER, and *Nebrodites hospes* (NEUMAYR) at the top of slightly thicker sections of the Margas de Sot de Chera Fm. in the area. North-westwards, in the Moyuela section, Aurell et al. (1997) recovered *Sutneria galar* (OPEL) and *Orthosphinctes castroi* (CHOFFAT) revealing deposits belonging to the upper Planula Zone. However, Aurell (1990) reported *Orthosph. (Orthosphinctes) polygyratus* (REINECKE) morph. *pseudopolyplocoides* GEYER from the lower part of the Margas de Sot de Chera Fm. In general, these data confirm the time-transgressive character of this formation on shelves of irregular bottoms, and/or its hiatal record. In addition, they reinforce previous hypotheses interpreting the Oxfordian/Kimmeridgian boundary (as traditionally considered in Submediterranean Europe) to be placed within the Margas de Sot de Chera Fm. in the Gallipuén area (Moliner, 1983; Atrops & Meléndez, 1984; Moliner & Olóriz, 1984; Olóriz et al., 1988; Meléndez et al., 1990).

A rather monotonous section of wackestones and mudstones with variable content in pellets and bioclasts, and secondary intercalations of marls, characterises the major part of the Lower Kimmeridgian in the Gallipuén area. Bedding is typically well expressed with decimetres-thick beds showing ferruginized top-surfaces locally. Marly intercalations in the Gallipuén area are only significant and typical in the upper Lower Kimmeridgian, where bioclastic packstones and silty dolostones are found episodically (Fig. 2), probably showing the increasing influence of the Montalbán-Ejulve High at the time. In this upper part of the Kimmeridgian section, condensed horizons show ferruginization in densely packed fossil-remains and bioturbation.

The Lower Kimmeridgian section at Gallipuén is 51,40m thick and belongs to the lower part of the Ritmita Calcárea de Loriguilla Fm. (Calanda Mb.; Meléndez et al., 1990). These deposits have been interpreted to represent deposition in an extensional lagoon (Aurell & Meléndez, 1990), under high rate of carbonate production within photic depths in outer ramp settings (Aurell, 1990). Bádenas (1997) typified the Kimmeridgian ramp as a flat-topped ramp, and calculated a maximum depth higher than 40-60m but lower than 100m.

4 PALEONTOLOGICAL STUDY

Previous researches in the Gallipuén sections were reported by Bulard (1972) and Marin et al. (1977), who identified the Lower Kimmeridgian and indicated the Gallipuén section as a fossiliferous site in the geological map of Calanda (geological-sheet 494, 1:50.000, IGME), respectively. Moliner (1983) made the first detailed analysis on Upper Jurassic ammonites in the Alcorisa-Berge sector (Gallipuén sections included) providing the major traits of the composition of fossil assemblages. Atrops & Meléndez (1984) included data from the Gallipuén area in their revision of Upper Jurassic ammonites from the Calanda-Berge sector. Olóriz & Moliner (1984) reported the precise ranges of ammonite species in the Platynota Zone at Gallipuén. Olóriz et al. (1988) interpreted the composition of fossil assemblages from the Platynota Zone at Gallipuén, and made comparisons with those obtained by the authors in the southern Iberian paleomargin to identify evidences of the *Platform Effect* (Olóriz, 1985) in epicontinental shelves of the Iberian Peninsula during the Early Kimmeridgian. In 1998, the Gallipuén sector has been included in the "Archivo del Patrimonio Aragonés de la Diputación General de Aragón". Recent research on fossil assemblages recovered from the Gallipuén area allows the improvement of published ammonite biostratigraphy (see above), and gives valuable data about general trends in the evolution of fossil assemblages of macroinvertebrates, including megabenthos.

4.1 AMMONITES AND BIOCHRONOSTRATIGRAPHY

The analysis of a total of 530 ammonites collected *in situ* supports the recognition of the Platynota, Hypselocyclum and Divisum Zones in the Lower Kimmeridgian. Doubts persist about the possible existence of lowermost Upper Kimmeridgian deposits belonging to the lower part of the Acanthicum Zone, due to the scanty record of ammonites obtained from the uppermost Kimmeridgian horizons

below sandy deposits of the Lower Cretaceous (Bedulian). The following bio-chronostratigraphic interpretations are based on the standard proposed by the Group Fran_ais du Jurassic as shown by Hantzpergue et al. (1991, see column nr. 3) for Submediterranean Europe, which fits the definition of the Hypselocyclum/Divisum Zone boundary according to Geyer (1961) and Olóriz (1978). To note that in the schema of Hantzpergue et al. (1991), the base of the Divisum Zone in column number 1 was placed higher than considered by Olóriz (1978). The interpretation and correlation of the Hypselocyclum/Divisum Zone boundary in the northeastern Iberian Chain made by Finkel (1992) did not take into account the different interpretation of this zone boundary by previous authors.

4.1.1 PLATYNOTA ZONE

The Platynota Zone is based on the range of the index species in the Gallipuén area where frequent Ataxioceratinae accompanied it. On the basis of the latter, the Platynota Zone is subdivided in subzones and biohorizons. In the Gallipuen area the Platynota section is 14,40m thick. Ataxioceratinae overwhelmingly dominate. Among the remainder ammonites, Glochiceratidae are more abundant than Aspidoceratidae, Passendorferiinae-"Idoceratids", and Taramelliceratinae.

The lowermost "Orthosphinctes" interval

This is the lowermost stratigraphic interval recognisable within ammonitiferous deposits of the Platynota Zone. The lowermost "Orthosphinctes" interval is 1,20m thick, yielding incomplete specimen of *Orthosphinctes polygyratus* (REINECKE) and *Orthosphinctes* sp., together with *Presimoceras hossingense* (FISCHER), *Taramelliceras (Metahaploceras) litocerum* (OPPEL), *Glochiceras* sp. Among indeterminate Ammonitina one specimen could belong to Passendorferiinae (see discussion about the record of Passendorferiinae within the Platynota Zone in Caracuel et al.; this volume). Moliner (1983) proposed the "Orthosphinctes Subzone" for the lowermost Platynota Zone in the Gallipuén area. Moliner & Olóriz (1984) labelled this stratigraphic interval as "Orthosphinctes" interval. The stratigraphic interval analysed is correlatable with the Orthosphinctes Subzone defined by Atrops (1982) and proposed by Atrops & Meléndez (1984) for the lowermost Platynota Zone at the surroundings of Gallipuén

The Desmoides Subzone

This subzone is registered in the overlying 4,50m and corresponds to the stratigraphic interval between the first appearance datum (FAD) of *Ardescia* spp. and *Schneidia guilherandense* ATROPS and relatives. Ataxioceratinae are dominant and permit the subdivision of the Desmoides Subzone in a lower *enayi* horizon and an upper *desmoides* horizon, which are correlated with those defined by Atrops (1982) in SE France. Thus, the Desmoides Subzone recognised in the Gallipuén area by Moliner (1983), Moliner & Olóriz (1984), and Atrops & Meléndez (1984) are correlated with the same subzone proposed by Atrops (1982).

- The *enayi* horizon. The *enay* biohorizon identified is 2,50m thick, embraces the range of *Ardescia enayi* ATROPS accompanied by large forms of the group of *desmoides* WEGELE, and yielded *Orthosphinctes polygyratus* (REINECKE), *Orthosph.* sp., *Ardescia* sp. aff. *Ardescia enayi* ATROPS, *Ardesc. desmoides quenstedti* ATROPS, *Ardesc. desmoides desmoides* (WEGELE), *Ardesc.* sp. gr. *Ardesc. desmoides* (WEGELE), *Ardesc.* sp., *Lithacosphinctes* sp.1, *Lithacosph.* sp. gr. *Lithacosph. evolutus* (QUENSTEDT), *Lithacosph.* sp., Ataxioceratinae (celtiberic form A), *Presimoceras hossingense* (FISCHER), *Sutneria platynota* (REINECKE), *Pseudowaagenia micropla* (OPPEL), *Glochiceras nimbatum* (OPPEL), and *Lingulaticeras* sp. gr. *Ling. lingulatum* (QUENSTEDT). Within the Desmoides Subzone recognised at Gallipuén, this *enayi* biohorizon was labelled as "*Ardescia* sp. 1" horizon by Moliner (1983), and named intrasubzone interval, D-1 horizon by Moliner & Olóriz (1984). The *enayi* biohorizon is equivalent to the *enayi* horizon in Atrops (1982).
- The *desmoides* horizon. This biohorizon expands from the upper boundary of the *enayi* horizon to the FAD of *Schneidia guilherandense* ATROPS. This biohorizon, is 2m thick and yielded *Ardescia desmoides desmoides* (WEGELE), *Ardesc.*sp. gr. *Ardesc. desmoides* (WEGELE), *Ardesc.* sp., *Lithacosphinctes* sp. 2., *Lithacosph.* sp., Ataxioceratinae (celtiberic form A), *Sutneria platynota* (REINECKE), *Pseudowaagenia* sp., *Physodoceras* sp., and *Glochiceras* sp. From the top of the *desmoides* biohorizon was recovered *Ardesc.* sp. gr. *Ardesc. desmoides debelmasi* ATROPS and *Ardescia* sp. gr. *Ardesc. thieuloyi* ATROPS. In the Gallipuen area, the *desmoides* biohorizon was proposed by Moliner (1983) and confirmed by Moliner & Olóriz (1984). This biohorizon is correlatable with the homonymous defined by Atrops (1982).

The Guilherandense Subzone

This stratigraphic interval is 8,70m thick embracing the range of *Schneidia guilherandense* ATROPS in the Gallipuén area. This subzone shows the range of *Schneidia* with no records of *Schneidia lussasense* ATROPS, although Atrops and Meléndez (1984) reported relative forms from the

Platynota/Hypselocyclum Zone boundary in the northeastern Val de la Piedra section. The major component in ammonite assemblages from the Guilherandense Subzone recognised in Gallipuén are Ataxioceratinae, the record of others ammonites being occasional. Based on Ataxioceratinae, two biohorizons were identified in the Guilherandense Subzone.

- The Guilherandense-1 (G-1) horizon. This stratigraphic interval is 3,25m thick ranging from the FAD of *Schneidia* to the last appearance datum (LAD) of *Ardescia* sp. gr. *Ardescia schaireri* ATROPS. Other ammonites recovered are *Ardesc.* sp. gr. *Ardesc. desmoides* (WEGELE) from the base, and from higher levels *Ardescia* sp. gr. *Ardesc. schaireri* ATROPS, *Ardescia* sp., *Schneidia guilherandense* ATROPS, *Schn.* sp. cf. *Schn. guilherandense* ATROPS, *Schn.* sp., *Lithacosphinctes pseudoachilles* (WEGELE), *Lithacosph.* sp. aff. *Lithacosph. subachilles* (WEGELE), *Lithacosph.* sp. 2, *Lithacosph.*sp., *Ataxioceras striatellum* ? SCHNEID, *Ataxioceratinae* (celtiberic forms A and B), *Presimoceras* or *Trenerites* sp., *Sutneria platynota* (REIN.), and *Glochiceras* sp. The stratigraphic interval Guilherandense-1 (G-1 horizon) recognised corresponds to the *thieuloyi* horizon proposed by Moliner (1983) and to the intra-subzone interval G-1 horizon identified by Moliner & Olóriz (1984) in the lower part of the Guilherandense Subzone. The precise correlation with the *thieuloyi* horizon in Atrops (1982) is not conclusive.
- The *guilherandense* horizon. This biohorizon corresponds to the upper 5,45m of the Guilherandense Subzone at Gallipuén and ranges from the LAD of *Ardescia schaireri* ATROPS to the LAD of *Schneidia guilherandense* ATROPS. The latter coincides with the LAD of *Sutneria platynota* (REINECKE) that determines the upper boundary of the Platynota Zone in the Gallipuén area. Within the *guilherandense* biohorizon have been recovered *Lithacosphinctes pseudoachilles* (WEGELE) from the base, and from higher levels *Ardescia* sp., *Schneidia guilherandense* ATROPS, *Schn.* sp., *Lithacosphinctes* sp., *Sutneria platynota* (REINECKE), *Physodoceras altenense* morph. *altenense* (D'ORBIGNY), *Physodoceras altenense* (D'ORBIGNY) morph. *circumspinosum* (OPPEL), and *Glochiceras* sp. The *guilherandense* horizon described is slightly thicker than the homonymous biohorizon in Moliner (1983) and Moliner and Olóriz (1984). More research is necessary to evaluate its precise correlation with the *guilherandense* horizon proposed by Atrops (1982).

4.1.2 HYPSELOCYCLUM ZONE

Just above the LAD of *Schneidia guilherandense* ATROPS and *Sutneria platynota* (REINECKE) there is a significant impoverishment in ammonites in the Gallipuén area, a fact previously reported by Moliner (1983) and Atrops & Meléndez (1984). Hence, the precise identification of the Platynota/Hypselocyclum Zone boundary is difficult, this being reinforced by the scanty record of the youngest *Sutneria platynota* (REINECKE). Since no *Schneidia lussasense* ATROPS has been recorded, the Platynota/Hypselocyclum Zone boundary interpreted coincides with the LAD of *Schneidia*. The upper boundary of the Hypselocyclum Zone is marked by the FAD of *Crussoliceras*, *Garnierisphinctes*, and *Huguenisphinctes*, which is considered as a valuable biostratigraphic datum in such a context of scarce ammonite record. Hence, the Hypselocyclum Zone at Gallipuén is 23,55m thick. The Ataxioceratinae are dominant, but the record of other Ammonitina increases, especially in aspidoceratids and haploceratids. From the Hypselocyclum Zone have been recovered *Ardescia inconditus* (FONTANNES), *Ardesc.* sp., *Ataxioceras* sp., *Nebrodites* sp. cf. *Nebrodites hospes minor* (QUENSTEDT), *Nebrod.* sp., *Pseudowaagenia micropla* (OPPEL), *Physodoceras* sp. cf. *Physod. wolfi* (NEUMAYR), *Taramelliceras (Metahaploceras)* sp. aff. *subnereus* (WEGELE), *Taram. (Metahaploceras)* sp., *Glochiceras* sp. gr. *Gloch. nimbatum* (OPPEL), and *Gloch.* sp. From the upper levels of this zone was registered *Ataxioceras* sp. gr. *Atax. hypselocyclum* (FONTANNES).

The scanty ammonite record at Gallipuén impedes to identify the Hypselocyclum Zone as the stratigraphic interval that shows the epibole (acme) of *Ataxioceras s.l.*, as proposed by Geyer (1961) for southern Germany. Without doubt, environmental factors forced variation of acme zones in different areas. In addition, the impoverishment in ammonites during the Hypselocyclum Chron has been identified as a common feature in the Hypselocyclum Zone recognisable in epicontinental shelves southwards from Germany (Atrops, 1982; Rodríguez-Tovar, 1993; Olóriz & Rodríguez-Tovar, 1993; Olóriz et al., 1993; Benzzaghag & Atrops, 1997).

Moliner (1983) interpreted the subdivision of the Hypselocyclum Zone at Gallipuén in a lower "Hypselocyclum-I" and an upper "Hypselocyclum-II" section. Ammonites reported from the lower Hypselocyclum-I" section were *Schneidia* sp. aff. *collignoni* ATROPS, *Schn.* sp., and rare *Glochiceras* sp. Later findings of *Sutneria platynota* (REINECKE) in these levels determined their reinterpretation as belonging to the uppermost Platynota Zone. The stratigraphic interval labelled as "Hypselocyclum-II" by Moliner (1983) is here retained as repre-

senting the Hypselocyclum Zone without subzone divisions, at least preliminary, and could be correlated with part of the Hippolytense and Lothari Subzones defined by Atrops (1982).

Due to scarcity in ammonites in the extended middle Lower Kimmeridgian section studied at Gallipuén, it was difficult to identify the Hypselocyclum Zone as proposed by Atrops (1982), who paid special attention to the relative record of *Ataxioceras* and *Crussoliceras*. In contrast, the base of the Divisum Zone placed at the FAD of crussoliceratids seems easier to apply in the Gallipuén area, such as usually has been made in condensed epioceanic deposits of the Mediterranean Tethys (Sapunov, 1977; Olóriz, 1978; Sarti, 1985, 1988a-b, 1990, 1994). However, an equivalent to the Hypselocyclum/Divisum Zone Boundary proposed by Atrops (1982) could be recognised in the interpretations made by Pavia et al. (1987) and Sarti (1993) on ammonitico rosso sections in the Venetian Alps, NE Italy. Notwithstanding, these authors worked on condensed deposits, and their records reported from horizons below the Divisum Zone, or equivalent stratigraphic intervals assumedly deposited during the Divisum Chron, alluded to specimens of rare and/or less typical crussoliceratids. Caracuel et al. (1998) showed the significance of the Divisum Zone based on the range of *Crussoliceras* for correlation in The Mediterranean Tethys.

4.1.3 DIVISUM ZONE

A relative increase in ammonites occurs in the Galllipuén area just from the FAD of crussoliceratids upward in the Lower Kimmeridgian section. This trend is interpreted to be not an artefact since this was registered despite of the fact that limestone-beds, the ammonite bearing deposits at Gallipuén, decreased in number and thickness (Fig. 2). In contrast, siliciclastic deposition increased notably within the range of crussoliceratids, and carbonates registered episodic deviations recognised as sandy dolostone-horizons. Thus, marly and shaly deposits poor in ammonites overwhelming dominated during the late Early Kimmeridgian, and probably also during the earliest Late Kimmeridgian, providing the typical appearance of the upper 13,45m of the Kimmeridgian section at Gallipuén.

Among ammonites, the record of Ataxioceratinae was nearly counterbalanced by other Ammonitina (aspidoceratids) by the first time. The ammonites recovered were *Crussoliceras divisum* (QUENSTEDT), *Crussol.* sp. cf. *Crussol. crussoliense* (FONTANNES), *Crussol.* sp. gr. *Crussol. almolaense* (GEYER & OLÓRIZ), *Garnierisphinctes championneti* (FONTANNES), *Garnierisph.* sp., *Progeronia (Huguenisphinctes)* sp., *Nebrodites* sp., *Mesosimoceras* sp., *Sutneria* sp. gr. *Sutn. cyclodorsata* (MOESCH) - *batalleri* GEYER, *Aspidoceras* sp. gr. *binodum.* (OPPEL) - *longispinum* (SOWERBY), *Glochiceras* sp., and *Glochiceras (Lingulaticeras)* sp. gr. *Gloch. (Lingulaticeras) crenosum* (QUENSTEDT). Overlapping the uppermost records obtained for crussoliceratids and in the overlying three limestone-beds was found *Progeronia (Huguenisphinctes)* sp. gr. *Proger. (Huguenisphinctes) breviceps* (QUENSTEDT). *Taramelliceras* sp was recovered from the limestone-bed just above the youngest crussoliceratids registered, and *Streblites levipictus* (FONTANNES) from a limestone-bed one meter above.

The biochronostratigraphic interpretation applied to the upper 13,45m in the Kimmeridgian section at Gallipuén cannot be conclusive due to limitations induced by the ammonite record obtained. In fact, the lower 10,80m belong to the Divisum Zone, but the upper 2,66m, which are above the youngest *Crussoliceras* and *Garnierisphinctes* registered, yielded rare ammonites among which the most significant for biochronostratigraphy were *Progeronia (Huguenisphinctes)* group of *breviceps* QUENSTEDT and *Orthaspidoceras* group of *lallierianum* OPPEL. The holotypes of these two species have been assigned to the Upper Kimmeridgian, but these species and/or their relatives could exist in the uppermost Lower Kimmeridgian Divisum Zone as envisaged by Atrops (1982) for *Huguenisphinctes.* In addition, Finkel (1992) reported *Progeronia* sp. ex. gr. *breviceps* (QUENSTEDT), as well as *Proger. lictor* (FONTANNES) and relatives from the Lower Kimmeridgian slightly north-eastern from Gallipuén. Other records of interest from North Italy are those of *Progeronia (Huguenisphinctes) breviceps* (QUENSTEDT), *Prog. (Huguenisphinctes)* sp. aff. *breviceps* (QUENSTEDT), *Prog. (Huguenisphinctes)* sp. cf. *ernesti* (LORIOL), *Proger. (Huguenisphinctes)* spp. (sp1 and sp2 in Pavia et al., 1987), *Proger. (Progeronia) pseudolictor* (CHOFFAT), and *Orthaspidoceras* sp. cf. *lallierianum* (OPPEL) from the Divisum Zone at northern Monti Lessini (Pavia et al., 1987). Moreover, *Progeronia* sp. gr. *pseudolictor* (CHOFFAT) was collected from the Divisum Zone in the Venetian Alps and *Progeronia* sp. cf. *eggeri* (AMMON) and *Prog.* sp. aff. *ernesti* (LORIOL) from the Acanthicum Zone in the same area (Sarti, 1993). In addition, the significant absence of *Orthaspidoceras uhlandi* (OPPEL), a common species in the upper Divisum Zone from both epicontinental and epioceanic deposits (Olóriz, 1978; Pavia et al., 1987; Marques & Olóriz, 1992; Olóriz & Rodr'guez-Tovar 1993; Sarti, 1993; and Caracuel at al., 1998; among others) is significant. This absence could be interpreted as related to sampling hazards or to erosions in the area before

the preserved Lower Cretaceous (Bedulian). Both two hypotheses could be admitted since the record of this species is known from close areas of the Iberian Chain (Atrops & Meléndez, 1984; Finkel, 1992) and could be used to identify the Uhlandi Subzone in the area, as envisaged by Olóriz & Rodríguez-Tovar (1993).

4.2 FOSSIL ASSEMBLAGES AND ECOSTRATIGRAPHIC REMARKS

Based on precise ammonite biostratigraphy and then the biochronostratigraphic interpretation, the approach to ecostratigraphic interpretations is available to envisage long-term paleoecologic trends according to the fossil record of macroinvertebrate assemblages (megabenthos included). The following comments will be necessarily restricted to the data obtained at Gallipuén and, therefore, their ecostratigraphic interpretation should be complemented with data recovered from other areas in the Iberian Chain before to be conclusive.

An early approach to the interpretation of the composition of fossil assemblages of macroinvertebrates in the Gallipuén area was given by Olóriz et al. (1988). Finkel (1992) provided pie-diagrams with the composition of ammonite assemblages at the genus level according to data recovered northeastern from Gallipuén. In the Lower Kimmeridgian, this author gave a combined spectrum for Platynota+Hypselocylum Zones separately from the ammonite spectrum belonging to the Divisum Zone.

The Kimmeridgian section analysed at Gallipuén yielded a total of 4732 specimens and fragments recovered *in situ*, bed-by-bed, following sampling methods and observations widely applied to Upper Jurassic deposits by Olóriz and collaborators during more than a decade (see references in Olóriz & Rodríguez-Tovar, this volume). Main traits of preservation include dominant concave-up position of valves in epibenthic bivalves, some of them showing open and articulated valves or complete auricles; although separate valves including those of endobenthic bivalves were found in horizons with dense packing of fossils. Moreover, ammonites with preserved lappets and/or peristomal and preperistomal structures are frequent, and the majority of those that show epibionts are usually of great size. Body-chamber preservation is common, and isolates phragmocones are secondary, as they are fragments of body chambers that belong to great-size specimens that usually show epibionts (serpulids and briozoa, among others). Aptychi are scarce, but some were found within the body chamber in aspidoceratids. On the whole, these data point to dominant settling in low energy conditions, with episodic exceptions, to the existence of variable *post-mortem* transportation of cephalopod carcasses, affecting especially to great-size specimen, and finally to that ammonite assemblages might be considered a mixture of *in-situ* and slightly drifted shells. Since no cases of reworking with biostratigraphic incidence were identified to affect to ammonites, the studied ammonite assemblages offer a very common picture of the ammonite record in low energy deposits.

The averaged composition of fossil assemblages per ammonite zone is shown in Fig. 2. Pie-diagrams in Fig. 2 include, separately, the representation of the composition of ammonite assemblages, but the total amount of ammonites and other cephalopods (belemnitids, nautiloids) are included as distinct components in pie-diagrams showing invertebrates other than ammonites. Thus, can be analysed the main traits of the evolution of the record obtained of pelagic vs. benthic macroinvertebrates (including megabenthos), as well as fluctuations in the composition of ammonite groups. The latter were selected according to the total amount of ammonites registered per stratigraphic interval of reference (here, the zone level) and the relative significance assumed for different groupings, which was deduced from previous research (for an extended treatment see references in Olóriz & Rodríguez-Tovar; this volume).

Two major features shown in Fig. 2 are the absence of Phylloceratina and Lytoceratina in ammonite assemblages, and the accentuated increase of invertebrates other than ammonites in the Hypselocyclum Zone. The exclusive record of Ammonitina points to ammonite assemblages representatives of inhabitants of relatively proximal ammonite ecospaces, certainly unconnected from (and sporadically connected with) open sea environments and their communities. Given the assumed potential for *post-mortem* transport in Phylloceratina, among which existed ubiquitous taxa (i.e. *Sowerbyceras*), the non-record of these ammonites reinforces our interpretation of a inland, epeiric, sea colonised by the Ammonitina registered, even assuming some degree of *post-mortem* transportation of cephalopod shells. This hypotheses fits well paleoecologic and paleobiogeographic data and interpretations in Olóriz et al.(1988) and does not contradict the environmental reconstruction as proposed by Aurell (1990), Aurell & Meléndez (1990), Bádenas (1997), and Bádenas & Aurell (1997).

The accentuated increase of invertebrates other than ammonites in the Hypselocyclum Zone separates the lower (Platynota Zone) and the upper (Divisum Zone) parts of the Kimmeridgian section at Gallipuén. The averaged record registered in the Hypselocyclum Zone might be related with ecospace deterioration for ammonites. This agrees with the long-time assumed picture of proximal environ-

ments enriched in benthics, and impoverished to devoid in ammonites, while increasing distance from shore would reverse the assumed ratios landwards. In general, this hypothesis is acceptable and supported by empirical data elsewhere. On the other hand, since vagrant organisms track favourable environments as far as possible, following shifting ecological conditions, ammonites should have a similar behaviour despite of their low capability for swimming. Therefore, pattern of currents and movements of water masses essentially drove ammonites. In accordance, major fluctuations in the record of ammonites might be interpreted, finally, in terms of shifting ecospaces. In accordance, the significant decrease in ammonites registered in the Hypselocyclum Zone at Gallipuén might correspond to unfavourable life-conditions for ammonites. Olóriz et al. (1993) identified this feature as general one registered in Lower Kimmeridgian deposits from southern epicontinental shelves in Europe and North Africa, in relation with ecospace reduction during low sea levels and deposition under shelf-margin-wedge conditions. This interpretation agrees with proposals of sequence stratigraphy worked on the southern paleomargin of Iberia (Marques et al., 1991; Rodríguez-Tovar, 1993; Olóriz et al., 1994; among others), but contrasts with those applied in the Iberian Chain (Aurell, 1990; Bádenas, 1997; among others). We interpret this disagreement to results from different orders of observations and analyses, resulting in the recognition of sequences of different order, that does not contradict the hierarchical model of sequence stratigraphy.

Concerning the composition of ammonite assemblages, pie-diagrams in Fig. 2 show the Ataxioceratinae as the dominant group, and its progressive decrease throughout the Lower Kimmeridgian. The latter determines an increasing balance in the composition of ammonite assemblages. An interesting feature is registered in the Hypselocyclum Zone where the ammonite epitome combines decreased Ataxioceratinae and increased haploceratids and others Ammonitina, especially aspidoceratids. In paleoecologic terms, it is compatible with relatively long-term processes of ecological turnover during maximal reduction of ecospace (i.e. the highly specialised Ataxioceratinae giving place to other more generalists ammonites). Thus, the higher amount of aspidoceratids together with less specialised Ataxioceratinae were registered in the Divisum Zone, the stratigraphic interval that shows the most balanced composition in the averaged ammonite assemblage. These facts are in accordance with enlarging ecospaces related to higher sea levels during the late Early Kimmeridgian, the latter being a widely accepted hypothesis based on the recognition of transgressive deposits, with or without signs of relative condensation, in southern Europe and northern Africa.

The comparison with data on ammonite assemblages in Finkel (1992) is limited since this author did not separate data from the Platynota and Hypselocyclum Zones [its UKK (I/II) ammonite spectrum]. UKK (I/II) ammonite spectrum in Finkel (1992) differs from the averaged spectrum of the Platynota plus Hypselocyclum Zones in Fig. 2. UKK (I/II) ammonite spectrum in Finkel (1992) shows higher number of Ataxioceratinae and *Sutneria* recovered from the area studied by Finkel (1992), the latter genus being fortuitous component throughout the Kimmeridgian section studied at Gallipuén. The UKK (III) ammonite spectrum in Finkel (1992) corresponds to the Divisum Zone and is more similar to that shown in Fig. 2 for the same stratigraphic interval. In fact, Finkel' spectrum shows a comparatively balanced ammonite assemblage respect to the lower UKK (I/II) ammonite spectrum. However, *Sutneria* and "simoceratins" are more abundant while haploceratids are rarer in Finkel' spectrum of the Divisum Zone. Anyway, that does the ammonite record studied by Finkel (1992) to share a feature with that analysed in this paper is the comparatively balanced ammonite assemblage recovered from the Divisum Zone. This is a fact of significance revealing enlarging ecospaces for ammonites in north-eastern Iberian shelves (Iberian Chain) during the late Early Kimmeridgian, the time for major flooding in epicontinental shelves surrounding Iberia (Aurell, 1990; Marques et al., 1991; Marques & Olóriz, 1992; Rodríguez-Tovar, 1993; Bádenas, 1997; among others). Other differences between Finkel' ammonite assemblages and those discussed in this paper could be the evidence of minor ecological (and taphonomic?) differences for epicontinental (neritic) ammonites in different sectors of the flat-topped ramp developed during the Kimmeridgian in eastern Iberia.

Recent paleoenvironmental reconstruction (Aurell & Meléndez, 1990; Bádenas, 1997) agrees with our data and taphonomic and ecostratigraphic interpretations. All of this reinforce previous interpretations by Olóriz et al. (1988) on factors controlling the composition of fossil assemblages, especially ammonites, from the Platynota Zone in the Alcorisa-Berge area, which includes the lower part of the Kimmeridgian section studied at Gallipuén. In fact, the extensional lagoon interpreted by Aurell & Meléndez (1990) and the external ramp of the flat-topped-ramp proposed by Bádenas (1997) as depositional models for the Kimmeridgian Loriguilla Fm. does not contradict the interpretation by Olóriz et al. (1988) of a turbid, shallow-water, and nutrient-rich environment, with depths rather

shallower than deeper in the range of 30-80m, and with restricted connection with open seas during the Platynota Chron. In such a depositional environment, Olóriz et al. (1988) concluded that the ecological scenario determined the catching of ammonite assemblages through adaptation. Hence, their composition was ecologically determined, which was interpreted in terms of the so-called *Platform-Effect* (Olóriz, 1985; Olóriz et al., 1988). The ecological dynamics of the model applied by Olóriz et al. (1988) fit well with ecostratigraphic interpretations in this paper, which are based on the assumption of shifting ecospaces during fluctuations of sea level as modelled by Olóriz et al. (1995) within the conceptual template of Sequence stratigraphy.

5 CONCLUSIONS

The Kimmeridgian section at Gallipuén offers favourable conditions for precise ammonite biostratigraphy and correlation of Lower Kimmeridgian deposits within and outside of the eastern Iberian Chain. The Platynota, Hypselocyclum and Divisum Zones of the Lower Kimmeridgian have been identified. Due to limitations in the ammonite record obtained, the presence of the lowermost Upper Kimmeridgian in the area is doubtful. The Platynota Zone is subdivided in a lower "Orthosphinctes interval", the middle Desmoides Subzone with the *enayi* (lower) and the *desmoides* (upper) biohorizons, and the upper Guilherandense Subzone with the Guilherandense (G-1) interval (lower) and the *guilherandense* biohorizon (upper). The first appearance of crussoliceratids, rather than the last appearance of *Ataxioceras* and *Ardescia*, permits the easier recognition of the Hypselocyclum/Divisum Zone boundary. In general, the correlation with standard biochronostratigraphic units proposed for Submediterranean Europe is acceptable, but minor differences seems to exist and need of future research.

The composition of fossil assemblages of macroinvertebrates, including megabenthos, fits well with the assumption of shifting ecospaces forced by sea-level fluctuations and settling of shells in low energy conditions, mainly. The analysis of changes in the composition of ammonite assemblages complements that of the benthic : pelagic ratio to improve the ecostratigraphic interpretation at the ammonite-zone level. The epitome of ammonites correlates with a significant decrease in Ataxioceratinae (the highest specialised group), increasing haploceratids and especially aspidoceratids (less specialised), and the epibole of benthic fauna. The Divisum Zone yields the most balanced ammonite assemblage, at the zone level, in accordance with the maximum flooding in the area.

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