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Upper Bathonian ammonites of the Catalan Basin (Tivissa and Cap Salou, Spain)

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(With 7 figures and 2 plate)

The two ammonite successions described in the present paper represent an unusually complete sequence of Upper Bathonian deposits. Ammonites of the Upper Bathonian from Tivissa and Cap Salou (province of Tarragona), two localities of the Catalan Basin, allow to recognize several bio– and chronostratigraphic units commonly missing in the Iberian Basin. The Retrocostatum and Angulicostatum zones (Upper Bathonian) and the lowermost Bullatus Zone (Lower Callovian) established for Submediterranean areas of Europe can be identified in the Catalan Basin. *Epistrenoceras* and *Parapatoceras* are common in certain levels. Phylloceratina and Lytoceratina are virtually absent. Two specimens of Upper Bathonian Clydoniceratinae have been identified. However, the Discus Zone established for NW European areas of the Subboreal Province has not been recognized. The ammonite fossil assemblages of the Catalan Basin are composed by Submediterranean taxa during the Late Bathonian – Early Callovian interval.

Introduction

Upper Bathonian ammonites are very scarce in the Iberian Peninsula, as a result of non–preservation in shallow water facies or gaps in the geological record. Several authors have mentioned the scarcity of ammonites in the Iberian Basin during this chronostratigraphical interval (FALLOT & BLANCHET 1927, MENSINK 1966, BULARD 1972, MARIN & TOULOUSE 1972, HINKELBEIN 1975, FERNÁNDEZ–LÓPEZ et al. 1978, 1996, 1997, 1999, MANGOLD 1981, WILDE 1988, THIERRY & WILDE 1990, PAGE 1996, 2000, FERNÁNDEZ–LÓPEZ 1997a, b, PAGE & MELÉNDEZ 1997, 2000). Upper Bathonian ammonites of the Iberian Basin, however, have never been figured. The ammonite succession discovered at Tivissa and Cap Salou outcrops (province of Tarragona, Fig. 1), two localities of the Catalan Basin, allows to recognise several of these bio– and chronostratigraphic units commonly missing in the Iberian Peninsula. This area form part of the faulted eastern margin of the Iberian epicontinental platform system developed during the Middle Jurassic (FERNÁNDEZ–LÓPEZ et al. 1994, 1996, 1997, 1999).

The purpose of this paper is to present a description and comparison of the ammonite recorded associations through the Upper Bathonian from two sections (Tivissa and Cap Salou), which until now were unknown from the Catalan and Iberian basins. The biostratigraphy is based on collections made bed by bed since 1977, mainly during the research project PB92–0011 (DGICYT–CSIC). The biochronological data obtained in these sections are compared with those of the other European basins.

Ammonite taphonomy

Upper Bajocian–Callovian limestones of the La Tossa Formation overlie Upper Bajocian marls of the Cardó Formation, at the Catalan Basin (FERNÁNDEZ–LÓPEZ et al. 1996, 1997, 1999, FERNÁNDEZ–LÓPEZ 2000b). Upper Bathonian beds constitute the middle part of the La Tossa Formation in the outcrops of Tivissa and Cap Salou.

At the type section of the La Tossa Formation, located in the Serra de la Creu outcrop (Tivissa), the middle part of this lithostratigraphic unit is composed by light yellow–brown, muddy limestones, regularly bedded, ranging in thickness from 10 to 90 cm, and alternating with marly intervals from 0 to 40 cm (Fig. 2). These carbonate deposits are organized in shallowing–upwards sequences, of metric thickness, thickening upwards, which correspond to stratigraphic cycles of 5^{th} order, resulting from changes in water turbulence and rate of sedimentation (FERNÁNDEZ–LÓPEZ 1997a, b, 2000a). Textures and structures of bioturbation are common (*Zoophycos* in particular). Fossils, especially ammonites, are scarce. Bivalves (*Bositra*, in particular), terebratulid brachiopods, crinoid ossicles and belemnite guards occur. Those taxa which preferred firm or hard sedimentary grounds are absent.

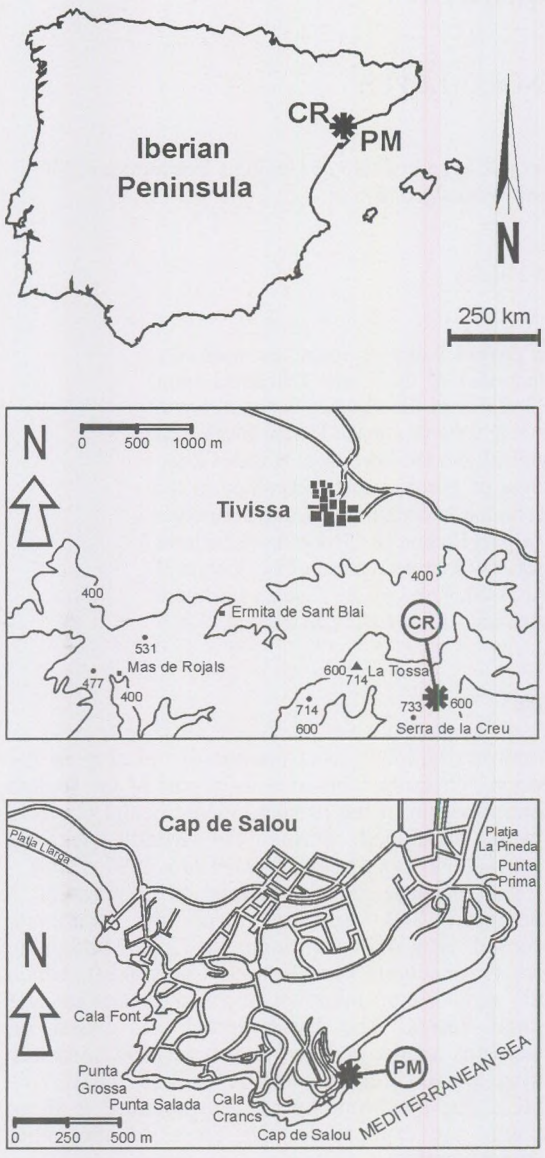

Fig. 1. Location map of the Tivissa (CR) and Cap Salou (PM) outcrops in the Iberian Peninsula (province of Tarragona, Catalan Basin).

The ammonites are commonly preserved as calcareous moulds of resedimented shells (*i.e.*, displaced on the sea–bottom, before their burial). Accumulated shells, showing no evidence of removal after laying on the sea–bottom, are very scarce. Moulds of fragmentary shells are common, but bearing no signs of rounding during resedimentation processes on the sea–bottom, due to the low turbulence near the water/sediment surface. Reelaborated, calcareous or phosphatic, concretionary internal moulds (*i. e.*, exhumed and displaced before their final burial) are absent. Ammonite mixed assemblages composed of specimens representing several biozones or biohorizons in a single bed have not been identified and the biostratigraphical completeness can reach 100%. Taphonic populations of type 3 (*i.e.* composed of polyspecific shells showing uni– or polymodal and asymmetric distribution of size frequencies, with negative skew) are dominant, those of type 1 being scarcely represented (FERNÁNDEZ–LÓPEZ 1991, 1997a, 2000a). Shells of juvenile individuals are very scarce, but they are predominant among the specimens of certain taxonomic groups, such as *Epistrenoceras* and *Parapatoceras,* in the upper part of the Retrocostatum Zone (Fig. 3; Plate 2, fig. 9). Biostratinomic processes of biodegradation–decomposition were intense. Before burial, ammonite shells commonly lose the soft–parts, the aptychi, the periostracum and the connecting rings. However, skeletal remains of encrusting organisms (such as serpulids, bryozoans or oysters) and biogenic borings are very scarce or absent. Shells are normally filled by homogeneous sediment, similar to the sedimentary matrix. Hollow phragmocones (*i.e.*, shells without septa) are scarce, and shells were usually compressed by increasing sedimentary loading during diagenesis (Plate 1, figs. 4 and 10). The older septa can disappear by early dissolution, whilst the wall of the shell may still stand, giving rise to compressed elements showing discontinuous deformation by gravitational diagenetic compaction (Plate 2, fig. 4). Complete concretionary internal moulds of the body chamber and phragmocone, indicative of low rates of sedimentation and accumulation, are very scarce. In contrast, compressed, partial internal moulds of body chambers (*i.e.*, hollow ammonites *sensu* FERNÁNDEZ–LÓPEZ 1997a, b, 2000a), indicative of very rapid sedimentary infill and high rate of sedimentation, are abundant. Ammonites with their long axes parallel to bedding surface are dominant, and normally appear dispersed in the sediment, showing no pattern of imbricated or encased clustering.

At the cliff section of Cap Salou, Upper Bathonian deposits comprise comparable muddy limestones, although they are less fossiliferous (Fig. 4). Textures and structures of bioturbation are common (*Zoophycos* and *Thalassinoides*, in particular). The ammonites are commonly preserved as calcareous moulds of resedimented shells. Taphonic populations are of type 3. Accumulated shells are absent. Reelaborated, calcareous, concretionary internal moulds, bearing signs of rounding during removal processes on the sea–bottom, are present in several marly levels (such as: PM23, PM25, PM27, PM29, PM73, in Fig. 4). However, ammonite mixed assemblages composed of specimens representing several biozones or biohorizons in a single bed have not been identified and the biostratigraphical completeness can reach 100%.

Most of these Upper Bathonian ammonite shells of the Catalan Basin represent ademic organisms and are interpreted as allochthonous elements having arrived at their present location by necroplanktic drift. However, the occurrence of taphonic populations of type 1 (FERNÁNDEZ–LÓPEZ 1991, 1997a, b), showing no signs of sorting by necroplanktic drift or transport, is indicative of autochthonous biogenic production of shells by *Epistrenoceras* and *Parapatoceras*.

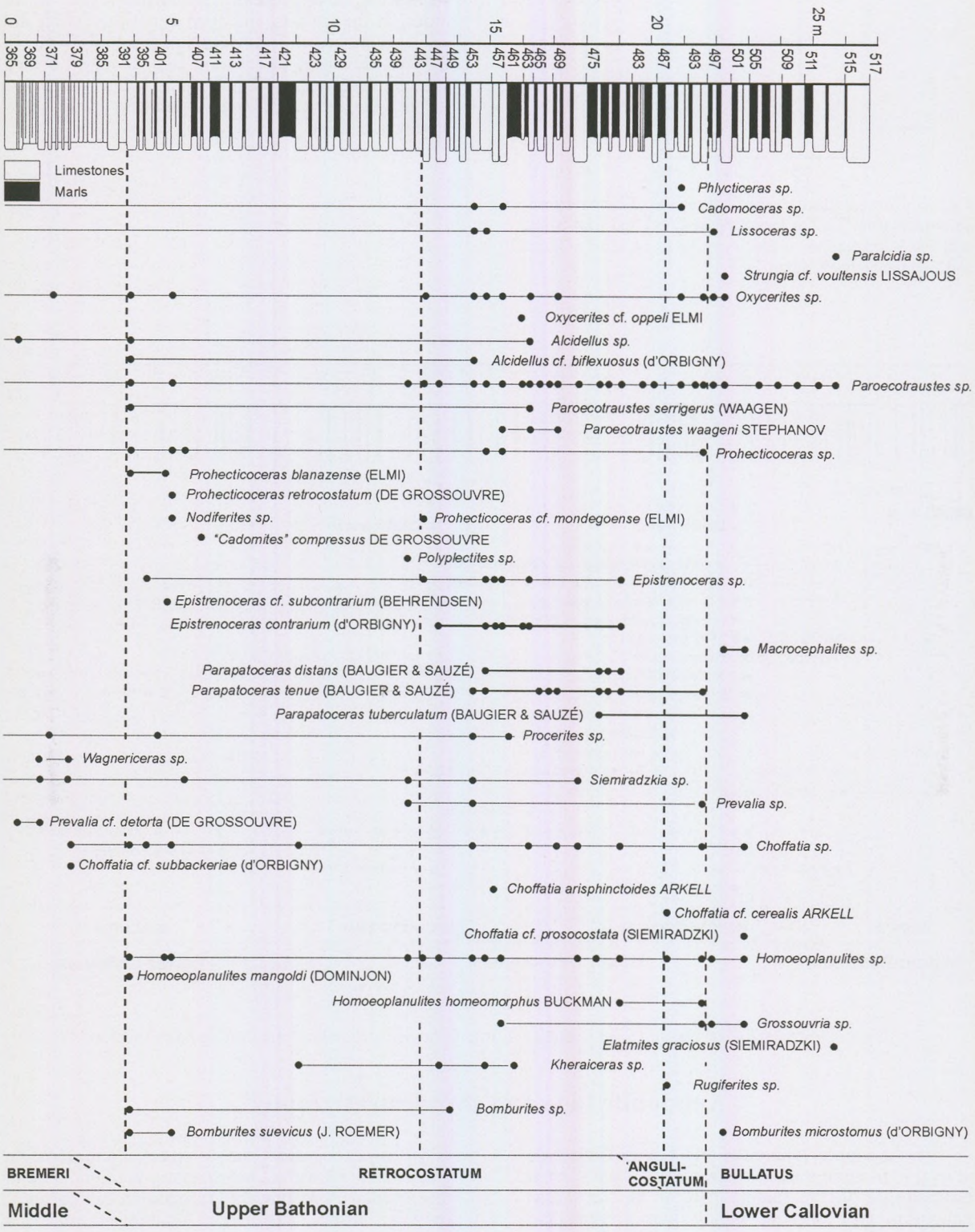

Fig. 2. Biostratigraphical data of Upper Bathonian/Lower Callovian ammonites from the Tivissa (Serra de la Creu) outcrop, type section of the La Tossa Formation.

These Upper Bathonian deposits are interpreted as having been deposited in an open sea, below wave base, in distal areas of a carbonate platform. The fine–grained nature of the mudstones suggests deposition in a low–turbulence setting. Currents were slight, but ammonite shells were reoriented on soft– to firmgrounds through resedimentation (*i.e.*, displacement on the sea–bottom, before their burial).

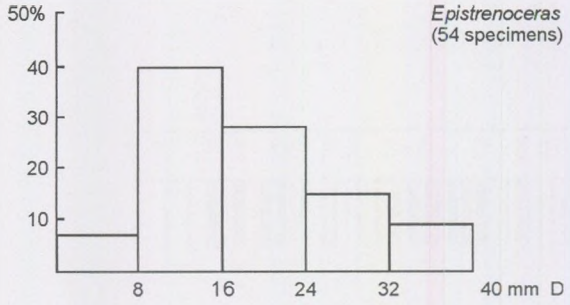

Fig. 3. Size–frequency distribution of *Epistrenoceras* specimens from Tivissa (Serra de la Creu) and Cap Salou sections. Total number of specimens up to 54, most of them showing the body chamber.

These regional results allow to corroborate the development of a last phase of advanced shallowing of a deepening/shallowing cycle of 3rd order, in the Catalan and Iberian basins, during the Late Bathonian (FERNÁNDEZ–LÓPEZ 1997a, b, 2000a). However, there is no sign of major hiatus, stratigraphical gap or lithological change associated to the Bathonian/Callovian boundary in the two studied localities.

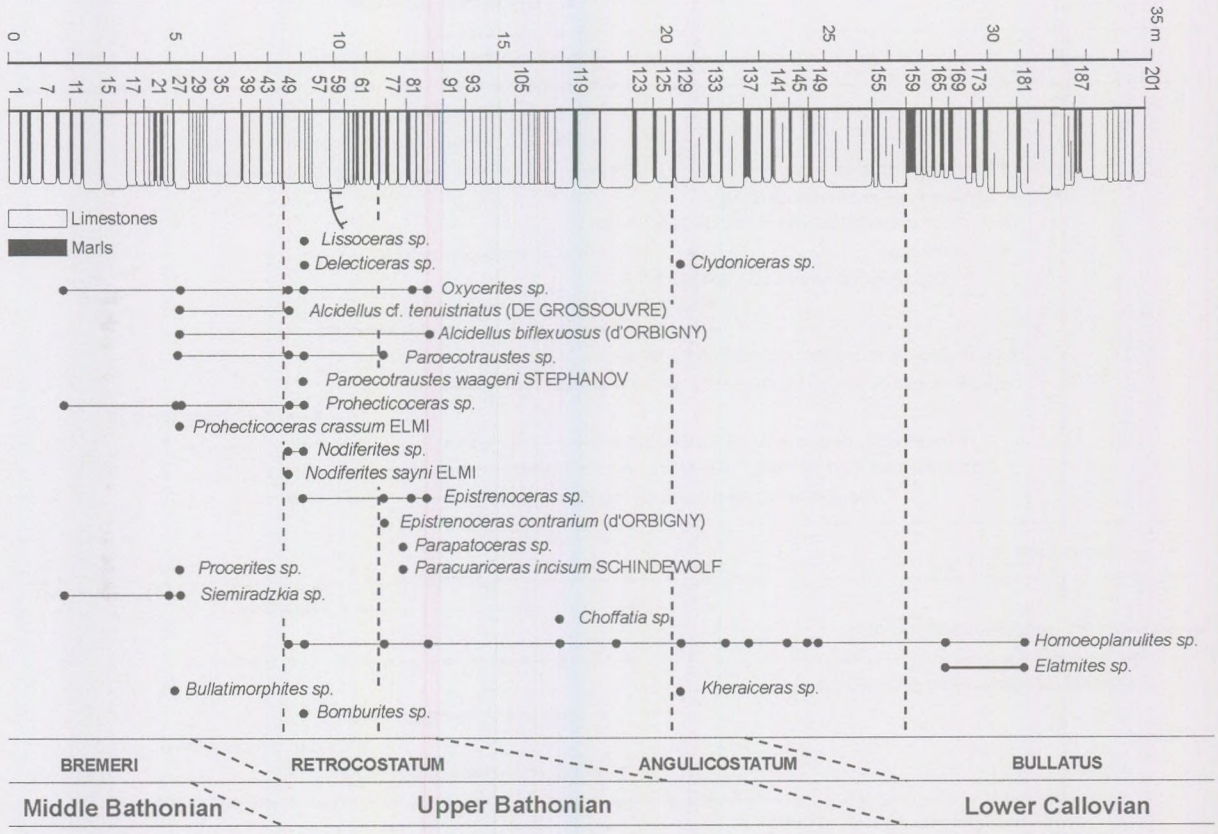

Fig. 4. Biostratigraphical data of Upper Bathonian/Lower Callovian ammonites from the Cap Salou outcrop.

Ammonite bio– and chronostratigraphy

For the Upper Bathonian and Lower Callovian, several biostratigraphic intervals have been distinguished in the middle part of the La Tossa Formation type section, taking into account the taxonomic data about the ammonites. The dimorphic status and abundance of specimens will be indicated by [M] and [m] macroconch and microconch forms; R, C, VC, scarce, common, very common respectively.

In the Tivissa section, *Wagnericeras* spp. [M] have been identified in the middle part of the La Tossa Fm., associated with specimens of *Prevalia* cf. *detorta* (DE GROSSOUVRE) (Plate 1, fig. 12) and *Choffatia* cf. *subbackeriae* (D'ORBIGNY). These taxa allow to recognized the Bremeri Zone (Middle Bathonian). However, the scarcity of ammonites in the Bremeri Zone prevents recognition of subzones. In this locality, the Upper Bathonian attains a maximum thickness of 18 m and is overlain by the Bullatus Zone, which attains a thickness of up to 10 m. The stratigraphical interval CR393 – CR496 belongs to the Upper Bathonian, mainly the Retrocostatum Zone defined in the Submediterranean Province (CARIOU et al. 1985, MANGOLD & RIOULT, 1997). Ammonites allow recognition of three biostratigraphic intervals. The lower interval of the Retrocostatum Zone (levels CR393 – CR444) yields fairly common perisphinctids: *Procerites* [M] –

Siemiradzkia [m] and *Choffatia* [M] – *Homoeoplanulites* [m]. The following taxa have been identified:

Oxycerites sp. [M] (R)
Alcidellus sp. [M] (R)
A. cf. *biflexuosus* (D'ORBIGNY) [M] (R) (Plate 1, fig. 8)
Paroecotraustes sp. [m] (R)
P serrigerus (WAAGEN) [m] (R)
Prohecticoceras sp. [M] (R)
P blanazense (ELMI) [M] (R) (Plate 1, fig. 11)
P retrocostatum (DE GROSSOUVRE) [M] (R) (Plate 1, fig. 10)
Nodiferites sp. [m] (R)
"*Cadomites*" *compressus* DE GROSSOUVRE [M] (R)
Polyplectites sp. [m] (R)
Epistrenoceras sp. [M] (R)
E. cf. *subcontrarium* (BEHRENDSEN) [M] (R)
Procerites sp. [M] (R)
Siemiradzkia sp. [m] (R)
Prevalia sp. [m] (R)
Choffatia sp. [M] (C)
Homoeoplanulites sp. [m] (R) (Plate 1, fig. 7)
H. mangoldi (DOMINJON) [m] (R) (Plate 1, fig. 6)
Kheraiceras sp. [M] (R)
Bomburites sp. [m] (R)
B. suevicus (J. ROEMER) [m] (R) (Plate 1, fig. 4)

The second biostratigraphic interval of the Retrocostatum Zone (levels CR445 – CR480), characterized by the common occurrence of *Epistrenoceras* [M + m] and *Parapatoceras* [M + m], contains abundant perisphinctids: *Choffatia* [M] – *Homoeoplanulites* [m]. The following taxa have been identified:

Cadomoceras sp. [m] (R)
Lissoceras sp. [M] (R)
Oxycerites sp. [M] (C)
Oxycerites cf. *oppeli* ELMI [M] (R)
Alcidellus sp. [M] (R)
Alcidellus cf. *biflexuosus* (D'ORBIGNY) [M] (R)
Paroecotraustes sp. [m] (C)
Paroecotraustes serrigerus (WAAGEN) [m] (R)
Paroecotraustes waageni (STEPHANOV) [m] (R)
Prohecticoceras sp. [M] (R)
Prohecticoceras cf. *mondegoense* (ELMI) [M] (R)
Epistrenoceras sp. [M] (C)
E. contrarium (D'ORBIGNY) [M] (C) (Plate 1, figs 1–3, 5)
Parapatoceras sp. [M + m] (C)
P. distans (BAUGIER & SAUZÉ) [M] (C) (Plate 2, fig. 13)
P tenue (BAUGIER & SAUZÉ) [M] (C) (Plate 2, fig. 12)
P. tuberculatum (BAUGIER & SAUZÉ) [M] (R) (Plate 2, fig. 11)
Procerites sp. [M] (R)
Siemiradzkia sp. [m] (R)
Prevalia sp. [m] (R)
Choffatia sp. [M] (C)
C. arisphinctoides ARKELL [M] (R)
Homoeoplanulites sp. [m] (C)
H. homeomorphus BUCKMAN [m] (R) (Plate 2, fig. 8)
Grossouvria sp. [m] (R)
Kheraiceras sp. [M] (R)
Bomburites sp. [m] (R)

The third biostratigraphic interval of the Upper Bathonian (levels CR487 – CR496) may represent the Angulicostatum Zone proposed in the Submediterranean Province (ELMI 1967, MANGOLD & RIOULT 1997). It is characterized by the common occurrence of perisphinctids: *Choffatia* [M] – *Homoeoplanulites* [m], but specimens of *Parapatoceras* [M + m] are very scarce and *Epistrenoceras* [M + m] are virtually absent. The following taxa have been identified:

Phlycticeras sp. [M] (R)
Cadomoceras sp. [m] (R)
Oxycerites sp. [M] (C)
Paroecotraustes sp. [m] (C)
Prohecticoceras sp. [M] (R)
P. tenue (BAUGIER & SAUZÉ) [M] (R)
Prevalia sp. [m] (R)
Choffatia sp. [M] (C)
C. cf. *cerealis* ARKELL [M] (R)
Homoeoplanulites sp. [m] (C)
H. homeomorphus BUCKMAN [m] (R)
Grossouvria sp. [m] (R)
Rugiferites sp. [M] (R)

Above CR497, the Bullatus Zone of the Lower Callovian is characterized by the first occurrence of *Macrocephalites* [M + m]. The following taxa have been identified:

Lissoceras sp. [M] (R) (Plate 2, fig. 4)
Paralcidia sp. [M] (R) (Plate 2, fig. 3)
Strungia cf. *voultensis* LISSAJOUS [M] (R) (Plate 2, fig. 2)
Oxycerites sp. [M] (R)
Paroecotraustes sp. [m] (C)
Parapatoceras sp. [M + m] (R)
Macrocephalites sp. [M + m] (R) (Plate 2, fig. 1)
Choffatia sp. [M] (R)
C. cf. *prosocostata* (SIEMIRADZKI) [M] (R)
Homoeoplanulites sp. [m] (R)
Grossouvria sp. [m] (R)
Elatmites graciosus (SIEMIRADZKI)[m] (R) (Plate 2, fig. 5)
Bomburites microstoma (D'ORBIGNY) [m] (R)

In the Cap Salou section, *Prohecticoceras crassum* ELMI [M] have been identified in the middle part of the La Tossa Fm. (level PM28 in Fig. 4; Plate 1, fig. 13), associated with specimens of *Oxycerites* sp., *Alcidellus* cf. *tenuistriatus* (DE GROSSOUVRE) (Plate 1, fig. 14), *Alcidellus biflexuosus* (D'ORBIGNY), *Paroecotraustes* sp, *Procerites* sp., *Siemiradzkia* sp. and *Bullatimorphites* sp. These taxa allow to recognized the Bremeri Zone (Middle Bathonian). The Upper Bathonian attains a maximum thickness of 18 m (stratigraphic interval PM49–PM158) and is overlain by the Bullatus Zone. Ammonites allow recognition of three biostratigraphic intervals. The lower interval of the Retrocostatum Zone (levels PM49–PM74) contains:

Lissoceras sp. [M] (R)
Delecticeras sp.[m] (R) (Plate 2, fig. 6)
Oxycerites sp. [M] (R)
Alcidellus cf. *tenuistriatus* (DE GROSSOUVRE) [M] (R)
Paroecotraustes sp. [m] (R)
P. waageni STEPHANOV [m] (R)
Prohecticoceras sp. [M] (R)
Nodiferites sp. [m] (R)
N. sayni ELMI [m] (R) (Plate 1, fig. 9)
Epistrenoceras sp. [M] (R)
Siemiradzkia sp. [m] (R)
Homoeoplanulites sp. [m] (R)
Bomburites sp. [m] (R)

The second biostratigraphic interval of the Retrocostatum Zone (levels PM76–PM86) is characterized by the common occurrence of

Epistrenoceras [M + m]. The following taxa have been identified:

Oxycerites sp. [M] (R)
Alcidellus biflexuosus (D'ORBIGNY) [M] (R)
Paroecotraustes sp. [m] (R)
Epistrenoceras contrarium (D'ORBIGNY) [M] (C)
Parapatoceras sp. [M + m] (R)
Paracuariceras incisum SCHINDEWOLF (R) (Plate 2, fig. 10)
Homoeoplanulites sp. [m] (C)

Above this second interval of the Retrocostatum Zone, and below beds containing *Elatmites* spp. [m] characterizing the Bullatus Zone, a specimen of *Clydoniceras* [M] (Plate 2, fig. 7) has been identified in the level PM130, associated with *Kheraiceras* sp. The occurrence of these taxa can be indicative of the Angulicostatum Zone.

Palaeobiogeographical remarks

Separate zonal schemes have been established in Europe, for the Upper Bathonian and Lower Callovian, due to faunal differences (Fig. 5).

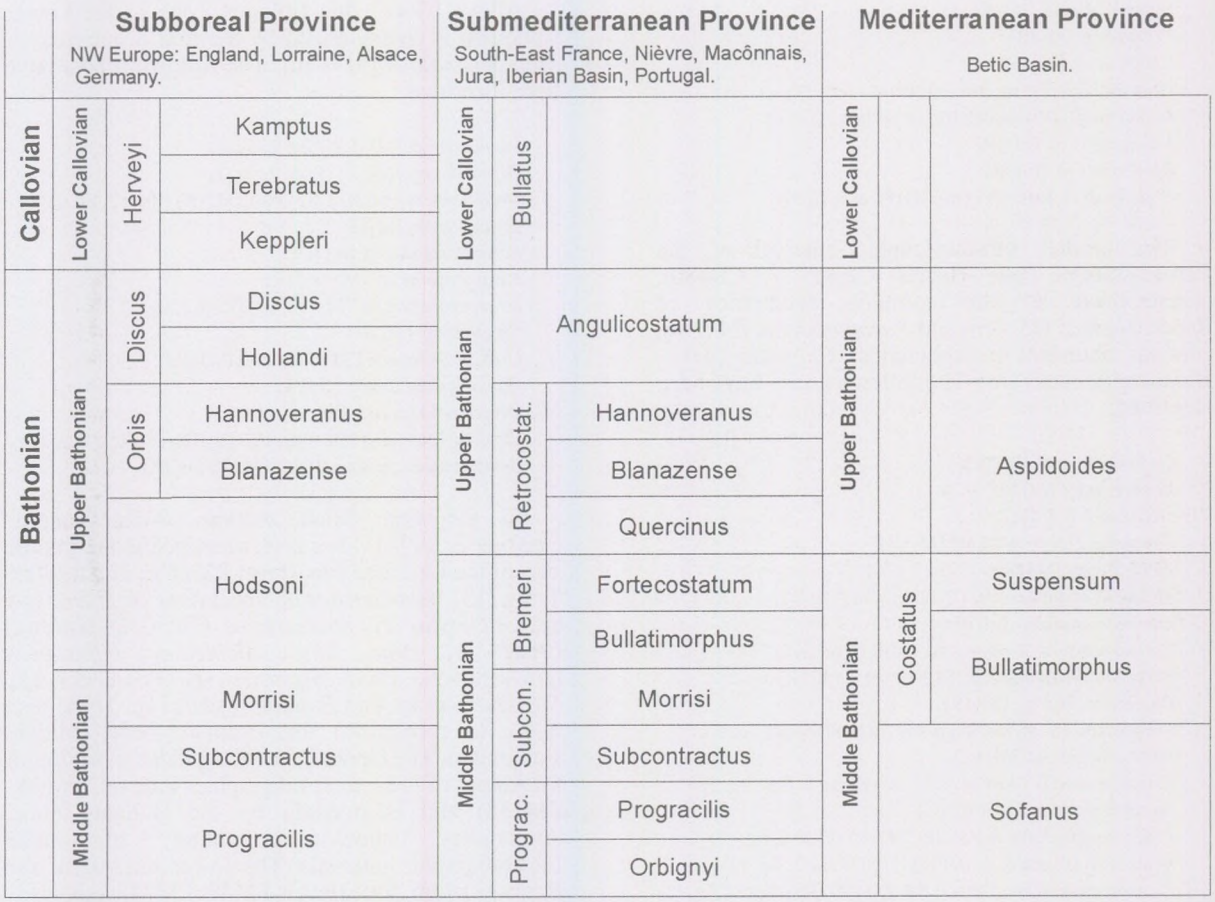

Fig. 5. Ammonite zones and subzones of the Upper Bathonian and the lowermost Callovian in the so–called Subboreal (WESTERMANN & CALLOMON 1988, DIETL 1994, CALLOMON & COPE 1995), Sub–Mediterranean (CARIOU et al. 1985, MANGOLD 1990, RIOULT et al. 1997, MANGOLD & RIOULT 1997, THIERRY et al. 1997) and Mediterranean (GALACZ 1980, SANDOVAL 1983, SEQUEIROS et al. 1988, ZANY et al. 1990, OLIVERO et al. 1997, GÉCZY & GALÁCZ 1998) provinces of Europe.

A northern European faunal region or Subboreal Province, from Britain to southern Germany, has been distinguished by several authors (WESTERMANN & CALLOMON 1988, DIETL 1994, CALLOMON & COPE 1995, PAGE 1996) giving careful consideration to the occurrence of Clydoniceratids. In contrast, Phylloceratina and Lytoceratina characterizing the Mediterranean Province (CARIOU et al. 1985, ZANY et al. 1990, CARIOU & ENAY 1999) are very common in the Subbetic Basin (SANDOVAL 1981, 1983, SEQUEIROS et al. 1988). These taxonomic groups (Clydoniceratinae, Phylloceratina and Lytoceratina) are very scarce in the so–called Sub–Mediterranean areas, such as Portugal, Centre–West France, Nièvre, Macônnais South–Est France and Jura (GALÁCZ 1980, 1994, 1995a, b, TORRENS 1987, KRISHNA & CARIOU 1990, MANGOLD 1990, THIERRY 1994, MANGOLD & RIOULT 1997, THIERRY et al. 1997, OLIVERO et al. 1997, GÉCZY & GALÁCZ 1998). However, *Epistrenoceras* and *Parapatoceras* are widespread in very distant areas: Europe, Madagascar, South Mexico and northern Chile (Fig.

6, COLLIGNON 1958, SANDOVAL et al. 1990, FERNÁNDEZ–LÓPEZ et al. 1995).

Fig. 6. Palaeogeographical distribution of Late Bathonian *Epistrenoceras* representatives.

In the Iberian Basin, Middle Jurassic Phylloceratina and Lytoceratina represent less than 1% of the whole of ammonoids (FERNÁNDEZ–LÓPEZ & MELÉNDEZ 1996) and Upper Bathonian clydoniceratids are virtually absent. A Sub–Mediterranean zonation can be recognized in the Iberian Basin and has also been applied to the Catalan Basin (FERNÁNDEZ–LÓPEZ et al. 1978, 1996, 1997, 1999, FERNÁNDEZ–LÓPEZ 1997a, b, 2000b). However, Upper Bathonian ammonoids of the Iberian and Catalan basins have never been figured. In the Tivissa (Serra de la Creu) and Cap Salou sections, the total number of the Upper Bathonian studied ammonites is up 500 (Fig. 7). Specimens of the family Perisphinctidae are common (43,5 %). Pseudoperisphinctinae of the genera *Choffatia* [M] – *Homoeoplanulites* [m] are the most common ammonites in the Retrocostatum and Angulicostatum zones. Zigzagiceratinae of the genera *Procerites* [M] – *Siemiradzkia* [m] are fairly common. Among the Oppeliidae (26,7 %), *Oxycerites* [M] – *Paroecotraustes* [m] are one of the most common ammonites in some levels of the Upper Bathonian *Alcidellus* [M] occurrs. Stephanoceratidae (15,5%) are common in certain levels, in particular *Epistrenoceras* [M + m]. However, *Cadomites* [M] and *Polyplectites* [m] are very scarce. Spiroceratidae of the genre *Parapatoceras* (7,2 %) are common in several levels. A single specimen of *Paracuariceras* has been found. Very scarce are the families Glochiceratidae (3,2%), Tulitidae (2,4 %), Strigoceratidae (1,0 %), and Lissoceratidae (0,5 %). Clydoniceratinae of the group *Clydoniceras* [M] – *Delecticeras* [m] represent lower than 0,4% and correspond to post–juvenile individuals.

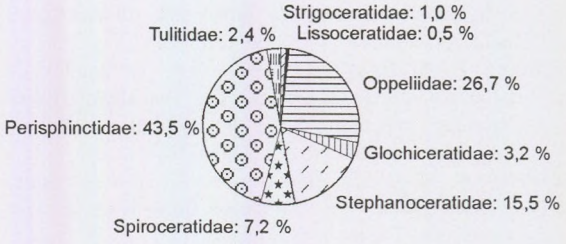

Fig. 7. Distribution of the percentage of the ammonite taxonomic groups (400 specimens) in the Upper Bathonian of the Tivissa (Serra de la Creu) section.

Consequently, the successive recorded associations of ammonites at the Catalan Basin reflect the transition between the influences of the Mediterranean and Subboreal provinces during the Late Bathonian. Some pandemic ammonites, such as *Epistrenoceras* and *Parapatoceras* inhabited this basin. The Retrocostatum and Angulicostatum zones (Upper Bathonian) and the Bullatus Zone (Lower Callovian) established for Submediterranean areas of Europe can be identified in the Catalan Basin. The Discus Zone established for NW European areas of the Subboreal Province has not been recognized, although several specimens of clydoniceratids have been discovered among the Upper Bathonian ammonite fossil assemblages.

Conclusions

The Upper Bathonian at the section of Tivissa (Serra de la Creu) provides the best–known biostratigraphical record of the Catalan and Iberian basins. Several specimens of Upper Bathonian Clydoniceratinae have been found in the outcrop of Cap Salou. However, the Discus Zone established for NW European areas of the Subboreal Province has not been recognized. The ammonite fossil assemblages of the Catalan Basin are composed by Submediterranean taxa during the Late Bathonian–Early Callovian interval.

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Plates

Plate captions

All the ammonites are in natural size, except for 1. Arrow indicates end of phragmocone

Plate 1

Fig. 1 *Epistrenoceras* sp. Incomplete immature shell. Right view. Specimen 4CR456/42. Retrocostatum Zone. Upper Bathonian.

Fig. 2. *Epistrenoceras contrarium* (D'ORBIGNY) [m]. Incomplete shell of immature microconch. Left view. Specimen 4CR456/32. Retrocostatum Zone. Upper Bathonian.

Fig. 3. *Epistrenoceras contrarium* (D'ORBIGNY) [m]. Complete shell of mature microconch without lateral lappets. Right view. Specimen 4CR456/31. Retrocostatum Zone. Upper Bathonian.

Fig. 4. *Bomburites suevicus* (J. ROEMER) [m]. Complete microconch. Left view Specimen 3CR406/3. x1.Retrocostatum Zone. Upper Bathonian.

Fig. 5. *Epistrenoceras contrarium* (D'ORBIGNY) [M]. Incomplete shell of immature macroconch. Left view Specimen 4CR458/4. Retrocostatum Zone. Upper Bathonian.

Fig. 6. *Homoeoplanulites mangoldi* (DOMINJON) [m]. Complete shell of mature microconch with lateral lappets. Right view Specimen 3CR394/13. Retrocostatum Zone. Upper Bathonian.

Fig. 7. *Homoeoplanulites* sp. [m]. Complete microconch with lateral lappets. Left view. Specimen 3CR394/28. Retrocostatum Zone. Upper Bathonian.

Fig. 8. *Alcidellus* cf. *biflexuosus* (D'ORBIGNY). Incomplete shell of immature macroconch. Right view. Specimen 3CR394/47. Retrocostatum Zone. Upper Bathonian.

Fig. 9. *Nodiferites sayni* ELMI. Incomplete microconch. Left view. Specimen 3PM58L50/1. Retrocostatum Zone. Upper Bathonian.

Fig. 10. *Prohecticoceras retrocostatum* (DE GROSSOUVRE). Incomplete shell of immature macroconch. Right view Specimen 3CR406/1. Retrocostatum Zone. Upper Bathonian.

Fig. 11. *Prohecticoceras blanasensis* (ELMI). Incomplete phragmocone of macroconch. Right view. Specimen 3CR396/2. Retrocostatum Zone. Upper Bathonian.

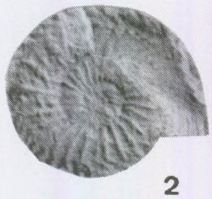
Fig. 12. *Prevalia* cf. *detorta* (DE GROSSOUVRE). Incomplete microconch. Right view. Specimen 3CR370/8. Bremeri Zone. Middle Bathonian.

Fig. 13. *Prohecticoceras crassum* ELMI [M]. Incomplete phragmocone of macroconch. Right view. Specimen 3PM28/1. Bremeri Zone. Middle Bathonian.

Fig. 14. *Alcidellus* cf. *tenuistriatus* (DE GROSSOUVRE) [M]. Incomplete phragmocone of macroconch. Right view Specimen 3PM28/3. Bremeri Zone. Middle Bathonian.

Plate 1


1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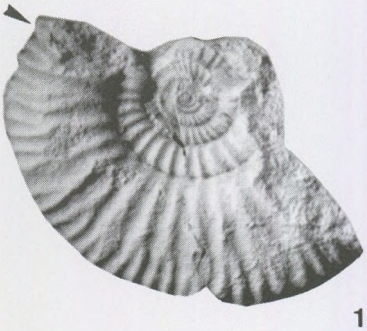
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Plate captions

All ammonites are in natural size, except for 6B, 7B, 9 and 10. Arrow indicates end of phragmocone.

Plate 2

Fig. 1. *Macrocephalites* sp. Incomplete body chamber of immature shell. Left view. Specimen 3CR500/1. Bullatus Zone. Lower Callovian.

Fig. 2. *Strungia* cf. *voultensis* LISSAJOUS [M]. Incomplete shell of immature macroconch. Right view. Specimen 3CR500/7. Bullatus Zone. Lower Callovian.

Fig. 3. *Paralcidia* sp. Incomplete shell. Right view. Specimen CR516/8. Bullatus Zone. Lower Callovian.

Fig. 4. *Lissoceras* sp. [M]. Incomplete macroconch. Right view. Specimen 3CR498/8. Bullatus Zone. Lower Callovian.

Fig. 5. *Elatmites graciosus (*SIEMIRADZKI*)* [m]. Incomplete microconch. Left view. Specimen CR516/1. Bullatus Zone. Lower Callovian.

Fig. 6. *Delecticeras* sp. [m]. Incomplete body chamber of immature microconch. Left view. Specimen 3PM58L30/13. 6A x1. 6B x2. Angulicostatum Zone. Upper Bathonian.

Fig. 7. *Clydoniceras* sp. [M]. Incomplete shell of immature macroconch. Left view. Specimen 3PM130/1. 7A x1. 7B x2. Angulicostatum Zone. Upper Bathonian.

Fig. 8. *Homoeoplanulites homoeomorphus* BUCKMAN. Incomplete body chamber of microconch. Left view. Specimen 3CR480/6. Upper part of Retrocostatum Zone or lower part of Angulicostatum Zone. Upper Bathonian.

Fig. 9. *Epistrenoceras* sp. Incomplete immature shells. Specimens 4CR456/33–35. x2. Retrocostatum Zone. Upper Bathonian.

Fig. 10. *Paracuariceras incisum* SCHINDEWOLF. Incomplete phragmocone. Specimen 3PM76U30/1. Retrocostatum Zone. Upper Bathonian.

Fig. 11. *Parapatoceras tuberculatum* (BAUGIER & SAUZÉ). Incomplete phragmocone. Left view. Specimen 3CR476/3. Retrocostatum Zone. Upper Bathonian.

Fig. 12. *Parapatoceras tenue* (BAUGIER & SAUZÉ). Incomplete body chamber. Right view. Specimen 3CR470/6. Retrocostatum Zone. Upper Bathonian.

Fig. 13. *Parapatoceras distans* (BAUGIER & SAUZÉ). Incomplete phragmocone. Right view. Specimen 4CR456/57. Retrocostatum Zone. Upper Bathonian.

Plate 2

1

2

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4

5

6A

6B

7A

7B

8

9

10

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