Candidate sections for the GSSP of the base of the Bathonian Stage (Middle Jurassic)*

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ABSTRACT: In accordance with the recommendations of the International Commission on Stratigraphy (ICS), the leading candidate for the Global Boundary Stratotype Section and Point (GSSP) of the base of the Bathonian Stage is located in the Ravin du Bès (Bas Auran area, SE France). This section was formally proposed as candidate nineteen years ago. A second potential candidate section is located in the Cabo Mondego area (Portugal). This Portuguese section, however, has not been formally proposed as a candidate for the Bathonian basal boundary stratotype. The formal selection and proposal of a GSSP for the Bathonian Stage is the responsibility of the Bathonian Working Group (BtWG) and is expected by September 2007. In accordance with the procedures to ratify GSSPs, a formal ballot on the selection and proposal of a GSSP for the Bathonian Stage, by post or email, by all members of the BtWG is the responsibility of the convenor and the International Subcommission on Jurassic Stratigraphy Executive, and will be carried out within this time scale.

INTRODUCTION

In order to establish the Bathonian Global Boundary Stratotype Section and Point there are two particularly relevant areas (Fig. 1): Bas Auran (Chaudon-Norante Commune, Alpes de Haute Provence, South-East France) and Cabo Mondego (Portugal). Of these areas, Bas Auran stands out as the most suitable for defining the Bathonian GSSP.

The leading candidate section is on the west side of the Ravin du Bès, in Bas Auran area, 4 km south of Chaudon-Norante, on the 1:25000 scale topographic map of Barrême (Sheet IGN 3615), in the Geological Reserve of Haute-Provence, around 4 km west of Barrême and 25 km southeast of Digne-les-Bains (Fig. 1B). Its geographic coordinates are: 43º57'38"N, 6º18'55"E, and the altitude is 730 m. Another important section is located on the west side of the Ravin d'Auran, 43º57'21"N, 6º18'56"E, at an altitude of 790 m, around 800 m south of the Ravin du Bès Section and 300 m southwest of the Bas Auran farm, in which this chronostratigraphic boundary can be studied through several hundred metres of outcrops (Fig. 1B). Some other outcrops, delimited by small vertical faults, lie upstream from the Ravin des Robines, on the west side, through four hundred metres towards Le Bès farm, between 800 and 900 m of altitude (Fig. 1B): 43º57'09"N, 6º18'50"E. These sections, which are free from significant

* The GSSP for the base of the Bathonian Stage in the Ravin du Bès section has been approved by International Comission of Stratigraphy and accepted by International Union of Geological Sciences in 2008. As auxiliary section has been accepted the section at Cabo Mondego.

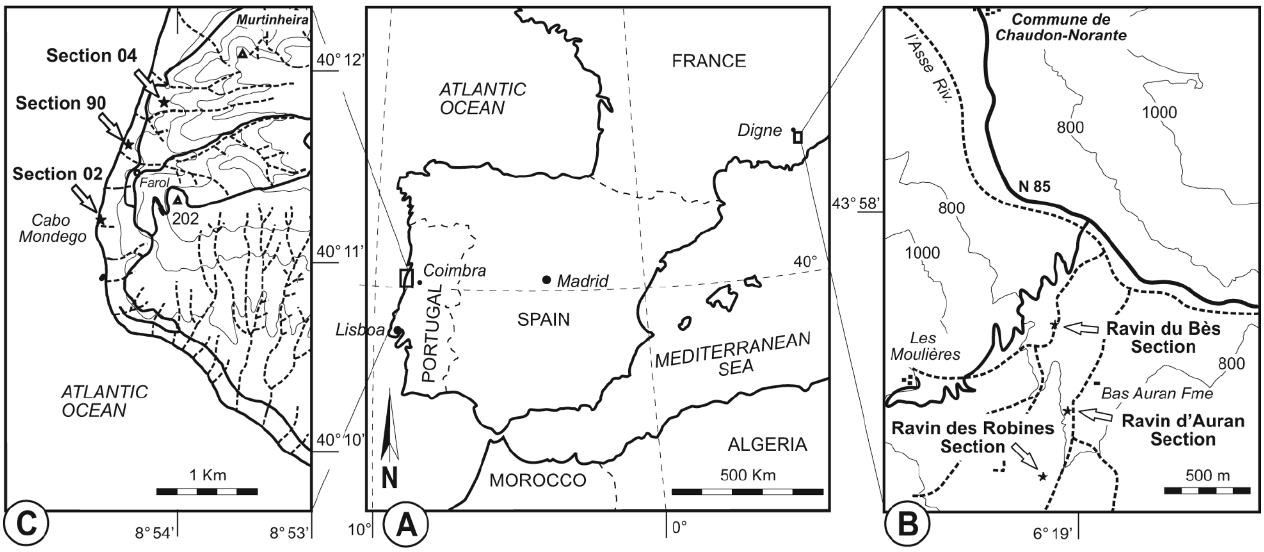

Fig. 1. A – Location maps of the candidate sections in France and Portugal; B-C – detail of Bas Auran (B) and Cabo Mondego (C) areas.

disconformities, range from the Bomfordi Subzone (Parkinsoni Zone, Upper Bajocian) to the Tenuiplicatus Subzone (Aurigerus Zone, Lower Bathonian) and are over 13 m thick. Structural complexity, synsedimentary and tectonic disturbance, or important alterations by metamorphism, are not relevant constraints in the Bas Auran area.

A second potential candidate area for the GSSP of the Bathonian Stage is located on the Portuguese Atlantic coast, 40 km west of Coimbra, 7 km north of Figueira da Foz. The major outcrop is at the foot of Cabo Mondego cliff, 3.4 km southwest of the village Murtinheira, on the 1:25000 scale topographic map of Vais (Sheet 238A). This area has not been formally proposed, however, as a candidate for the Bathonian basal boundary stratotype. Several papers have described Lower Bathonian ammonites from the classical section of Cabo Mondego, 200 m WNW of the lighthouse (Section-90) (Ruget-Perrot 1961; Elmi *et al.* 1971; Mangold 1971, 1990a; Rocha *et al.* 1981, 1987; Mangold and Rioult 1997). This classical section, however, has been modified and became hardly accessible in 1990 due to the mining operations of several stone quarries. At the present time, there are two other outcrops which allow the study in detail of the Bajocian/Bathonian boundary of this region. The first, "Section-02", is 500 m southwest of the lighthouse, on the coast (Fernández-López and Henriques 2002; Fernández-López *et al.* 2006a, b). The second, "Section-04", 700 m north of the lighthouse, is located in a quarry actively worked since 2004. From south to north, geographic coordinates are: Section-02 (40º11'19"N, 8º54'30"W), Section-90 (40º11'34"N, 8º54'21"W) and Section-04 (40º11'52"N, 8º54'04"W). These sections are free from significant disconformities and range from Parkinsoni Zone (Upper Bajocian) to Aurigerus Zone (Lower Bathonian). They are over 30 m thick, and occur in the same region as the Murtinheira section where the Global Stratotype Section and Point for the base of the Bajocian Stage is located. The basal Bathonian subzone (Parvum Subzone) in Cabo Mondego represents an expanded stratigraphic section that provides one of the most complete biostratigraphic records so far recognized on the Iberian Plate. Deposits of the highest Bajocian zone (Parkinsoni Zone), however, include several normally graded event layers (calciturbidites) and contain scarce ammonoids. Structural complexity or important alterations by metamorphism are not constraints in the Cabo Mondego area.

Lower Bathonian deposits have been studied in both the Bas Auran and Cabo Mondego areas during the last forty years. The Bas Auran locality was mentioned by Haug (1891) and visited by an extraordinary meeting of the French Geological Society (Zurcher 1895). In 1967, Sturani published an important monograph on the ammonites and biostratigraphy of the Bathonian in the Digne-Barrême area. After this publication, the base of bed 23 of the Ravin du Bès Section was designated as the base for the Convergens Subzone of the Zigzag Zone and the base of the Bathonian Stage. This section was first informally proposed in a presentation to the Luxembourg II (1967) Colloquium by Torrens, but not published until 1974 (Morton 1974; Torrens 1974, 1987, 2002; Harland *et al*. 1982). The Bathonian Working Group was established in 1984, during the 1st International Symposium on Jurassic Stratigraphy in Erlangen (Mangold 1984), and the Ravin du Bès Section was formally proposed as a candidate for the basal boundary stratotype of the Bathonian Stage by Innocenti *et al*. (1990; Mangold 1990b) during the 2nd International Symposium on Jurassic Stratigraphy in Lisbon (1987). Over the following 19 years, several Bathonian Working Group meetings were held in Digne (1995; Mangold 1994a, b), La Palud (1998; Mangold 1996, 1997a, b, 1999a, b), Budapest (2000; Galácz 2001), Lyon and Torino (2005; Morton 2006a). Recently, in the Bas-Auran area (2006, Fernández-López 2006), the sections of Ravin du Bès, Ravin d'Auran and Ravin des Robines have been remeasured and recollected for taphonomic and palaeoichnological analysis. The formal selection and proposal of a GSSP for the Bathonian Stage, the responsibility of the Bathonian Working Group, is expected by September 2007. In this way, according to the procedure to ratify GSSPs, a formal ballot by post or email of the proposal by all members of the BtWG, the responsibility of the convenor and ISJS Executive, will be carried out.

The main purpose of the present work is to provide an update on developments relevant to these two key areas for the delimitation of the Bajocian/Bathonian boundary.

BAS AURAN AREA

In the Bas Auran area, Lower Bathonian deposits comprise black or grey limestone beds alternating with marls usually known as "*Marno-calcaires à Cancellophycus*" (Graciansky *et al*. 1982; Olivero and Atrops 1996). Petrographically and in terms of biofacies these deposits are relatively uniform mudstones to wackestones, with common ammonoids, scarce sponges and very scarce nautiloids, brachiopods, bivalves, belemnites, echinoids, crinoids and gastropods. Micropalaeontologically, the overall sedimentary facies shows a calcisphere-mudstone texture. The marls contain foraminifers (*Lenticulina*, *Dentalina*), ostracods and molluscs (cephalopods, bivalves, gastropods) along with detrital minerals, quartz, muscovite and biotite (Corbin *et al*. 2000). The Bathonian deposits of this lithostratigraphic unit are interpreted as having been developed in a hemipelagic environment of the French Subalpine Basin, below storm wave base. The base of the Bathonian has been established at the base of limestone bed 071 of the Ravin du Bès Section and at the base of limestone bed 085 of the Ravin d'Auran Section (one or both of these beds correspond to the bed 23 in Sturani 1967), 7.8 and 8.5 m respectively below the "*Terres Noires*" Formation (Fig. 2). The strong similarities in thickness, number and proportion of beds within subzones between the Ravin du Bès and Ravin d'Auran sections suggest that the bed-distribution patterns are of regional extent. However, the total thickness and number of elementary cycles of the Lower Bathonian in the Ravin d'Auran Section is greater than in the Ravin du Bès Section and, consequently, accommodation space and water depth must have been greater in the Ravin d'Auran area (Fernández-López 2007).

Palaeoichnological studies have been carried out by Olivero (1994, 2003 and *in press*). Bioturbation textures are common and bioturbation structures are scarce, indicating dominant softgrounds. *Zoophycos*, *Chondrites* and *Planolites* occur from bed RB093 to bed RB001. Local concentrations of trace fossils of these ichnotaxa in bed RB039 suggest the development of a soft- to firmground at this stratigraphic level. Bioturbation structures indicative of firmground (*Thalassinoides* and *Diplocraterion*) occur in bed RB003. Biogenic borings indicative of hardground (*Zapfella*) are common, associated with very scarce encrusting serpulids, at the top of bed RB001, indicating the exceptional development of a stratigraphic discontinuity at the top of the "*Marno-calcaires à Cancellophycus*" in the Bas Auran area. Sedimentation appears irregular and condensed within bed RB093, compared with previous intervals where a more constant and expanded sedimentation is suggested. At the Bajocian-Bathonian transition, however, no stratigraphic gaps or hiatuses have been recorded.

Taphonomically (Fernández-López 2007), the occurrence of resedimented and reelaborated ammonoids implies that some form of current flow or winnowing affected the burial of concretionary internal moulds. Ammonoids show the following taphonomic characters at the Bajocian-Bathonian transition: 1) high values of stratigraphic persistence of ammonoid shells, 2) dominance of homogeneous concretionary internal moulds of phragmocones, completely filled with sediment, and 3)

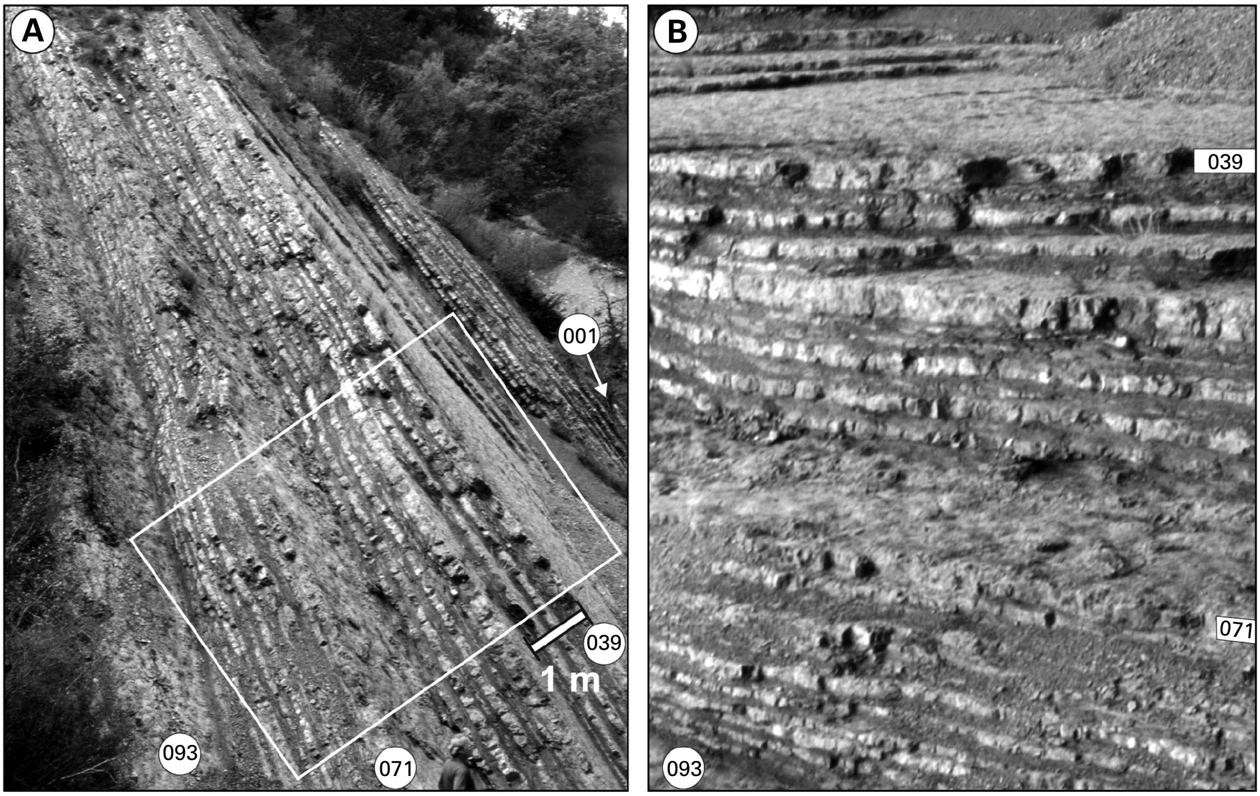

Fig. 2. A – Photograph of Ravin du Bès Section; B – beds around the Bajocian/Bathonian boundary. Limestone bed 071 indicates the base of the Bathonian. Scale bar 1 m.

dominance of sedimentary moulds bearing no signs of rounding, bioerosion or dense encrusting by organisms (such as serpulids, bryozoans or oysters). These taphonomic features are indicative of a low rate of sedimentation and a low rate of accumulation of sediment, associated with sediment starving in deep environments.

The bed-scale limestone-marl alternation is primary in origin, although accentuated by diagenetic redistribution of carbonate. Lithological differentiation between marly and limestone intervals resulted from alternating episodes of carbonate input and starvation. Both lithologies may contain evidence of sedimentary and taphonomic reworking, associated with scours, that reflects a low rate of sedimentation and stratigraphic condensation. There is no evidence, however, of taphonomic condensation (*i.e.* mixture of fossils of different age or different chronostratigraphic units) in the ammonoid fossil assemblages, except in level 002.

Sedimentological data and sequence-stratigraphy interpretations of these sections have been published by Ferry and Mangold (1995) and Olivero *et al.* (1997). In the Jurassic deposits of the French Subalpine Basin, sixth to second order cycles may be recognized (Ferry *et al.* 1989, 1991; Ferry and Mouterde 1989; Mouterde *et al.* 1989; Zany *et al.* 1990; Ferry and Dromart 1991; Graciansky *et al.* 1993, 1998; Olivero and Atrops 1996; Hardenbol *et al.* 1998; Jacquin *et al.* 1998).

Geochemically, in the French Subalpine Basin during the Jurassic Period, several authors have emphasized that the manganese content of pelagic carbonates is related to second-order sea-level changes and episodes of hydrothermal activity that affected the chemistry of global sea water. The main transgressive phases are marked by an increase in manganese content, whereas regressive phases are characterized by decreasing trends (Corbin 1994; Corbin *et al.* 2000). In the Chaudon-Norante section, 4 km north of Bas Auran area, the Early Bathonian maximum transgression is marked by sedimentary condensations, associated with a high manganese content (from 300 to 1370 mg kg^{-1}). In contrast, the Middle Bathonian and Late Bathonian regressive phases coincide with low manganese content periods. These stratigraphical patterns in divalent manganese can be of either local or regional significance, being concentrated, most probably, as a very early diagenetic phase only in oxygen-depleted waters that typically underlie zones of elevated organic productivity (Jenkyns *et al.* 2002). For strontium isotope ($^{87}Sr/^{86}Sr$ ratio), oxygen isotope ($\delta^{18}O$) or carbon isotope ($\delta^{13}C$) chemostratigraphy, no data are currently available.

Palaeoichnological, taphonomic, sedimentological and geochemical results confirm, therefore, the development of a deepening phase associated with sediment starvation, within 3rd and 2nd order cycles, in the Bas Auran area, during the Early Bathonian. The maximum deepening of a 2nd-order transgressive/regressive facies cycle (T/R 7, Upper Aalenian – Upper Bathonian, in Graciansky *et al.* 1993, 1998) is at the end of the Early Bathonian, corresponding to an extensional and deepening phase of the basin. The outcrop successions at Bas Auran show no obvious signs of non-sequence or discontinuity across the Bajocian/Bathonian boundary interval.

From a biochronostratigraphic point of view, over a thickness of up to 5 metres, over 52 successive ammonoid fossil assemblages from successive stratigraphic intervals pertaining to two biohorizons of the Parvum Subzone have been recognized. In the two studied sections, Ravin du Bès and Ravin d'Auran sections, the Bomfordi Subzone attains a minimum thickness of 5.0 m and encompasses 42 successive ammonoid fossil assemblages. Consequently, this ammonoid succession shows a maximum value of biostratigraphic completeness and is one of the most complete in the world (Fernández-López *et al.* 2006a).

In the French Subalpine Basin, Upper Bajocian and Lower Bathonian Phylloceratina and Lytoceratina, characteristic elements of the Mediterranean Province, are common. The successive ammonoid fossil assemblages are composed of Submediterranean taxa, although they contain elements allowing chronocorrelation at (sub)zonal scale with the Mediterranean and NW European provinces. Biochronostratigraphic data and interpretations of the Bas Auran sections have been published by Sturani (1967), Pavia (1973, 1983, 1984, 2007), Torrens (1987), Innocenti *et al.* (1990), Olivero *et al.* (1997) and Joly (2000). Over 500 ammonoid specimens from 80 stratigraphic levels, through 9 m in thickness, of the Bomfordi and Parvum subzones have been studied. New studies involving biochronostratigraphic and taphonomic analysis of ammonoid fossil-assemblages at the Bajocian/Bathonian boundary in the Bas Auran area are in progress. The base of the Bathonian (base of the Zigzag Zone) corresponds to the renewal of parkinsoniids and the first occurrence level of *Gonolkites convergens* Buckman at the base of limestone bed 071 (bed 23 in Sturani 1967) in the Ravin du Bès Section. The base of the Bathonian in the Bas Auran sections also coincides with the lowest occurrence of the dimorphic pair *Morphoceras* [M] – *Ebrayiceras* [m] and the lowest occurrence of *Morphoceras parvum* Wetzel. New palaeontological data concerning the youngest members of the Bigotitinae and the oldest members of the Zigzagiceratinae, of biochronostratigraphic importance for the subdivision and correlation of the basal Bathonian Zigzag Zone, have been recently published (Fernández-López *et al.* 2007).

Additional macrofossil groups occur in the section (*e.g.* sponges, bivalves, brachiopods and belemnites), although they are scarce and have not yet been studied in detail.

The Bajocian/Bathonian boundary may be characterized by secondary (auxiliary) biostratigraphic markers, such as nannofossils. According to the results of Erba (1990a, b; Cobianchi *et al.* 1992; Mattioli and Erba 1999), calcareous nannofossils are present in all beds and facilitate the characterization of the Bajocian-Bathonian transition. Fossil assemblages are dominated by the genus *Wautznaueria*. The Bajocian *Hexalithus magharensis* occurs up to one metre below the Bathonian basal level (bed 25-26 in Sturani 1967). The first occurrence of *Stephanolithion octum* and *Truncatoscaphus hexaporus* are recorded in the lowermost Bathonian (beds 18-20 in Sturani 1967).

The Ravin du Bès Section appears to be suitable for the biostratigraphical study of microfossils, such as foraminifers or ostracods, but there are no published studies. According to preliminary results (Bodergat *in* Mangold 1999a) ostracods are present in all marly samplings, but are badly preserved between bed 23 and bed 13. The marine taxa are different from those known in the Paris Basin and England. The Subalpine taxa, specially the genera *Pontocyprella*, *Isobythocypris* and *Cordobairdia,* indicate deeper environments (more than 200 m). Palynomorphs are poorly preserved and are not yet stratigraphically useful across the boundary (Poulsen 1997; Mangold 1999a).

Several magnetostratigraphical research teams have studied these Bathonian deposits (Andreello 1986; Lanza *in* Mangold 1999a; Aubourg and Chabert-Pelline 1999; Cairanne *et al.* 2002).

All magnetizations are characterized by lack of reverse polarity. Bajocian and Bathonian deposits thus have been remagnetized with a steady normal polarity. The ICS requirement of suitability for magneto-stratigraphy and geochronometry can be indirectly satisfied, however, by reference to the Bathonian magnetostratigraphic scale of Steiner *et al.* (1987; O'Dogherty *et al.* 2006) as defined in the Subbetic Cordillera.

Volcanogenic deposits suitable for direct radio-isotope dating are not known in the section. The age of the Bajocian/Bathonian boundary has been dated 167.7±3.5 Ma by Gradstein and Ogg (2004) and Gradstein *et al*. (2005).

The criteria of accessibility, conservation and protection are also guaranteed by the "*Réserve Naturelle Géologique de Haute Provence*", a European Geopark as recognised by UNESCO, and managed by the "*Centre de Géologie de Digne*".

CABO MONDEGO AREA

At Cabo Mondego, Lower Bathonian deposits comprise limestone-marl alternations corresponding to the Cabo Mondego Formation. Petrographically, the limestones are bioclastic mudstones to wackestones, with ammonoids, bivalves (*Bositra*), rhynchonellid brachiopods, crinoids and belemnites. Bioturbation structures are common (*Zoophycos*, *Thalassinoides*, *Chondrites*). These fossiliferous deposits were developed in an open sea, in a hemipelagic environment of distal and outer carbonate ramp, below wave base (Watkinson 1989; Soares *et al*. 1993; Azerêdo *et al*. 2003).

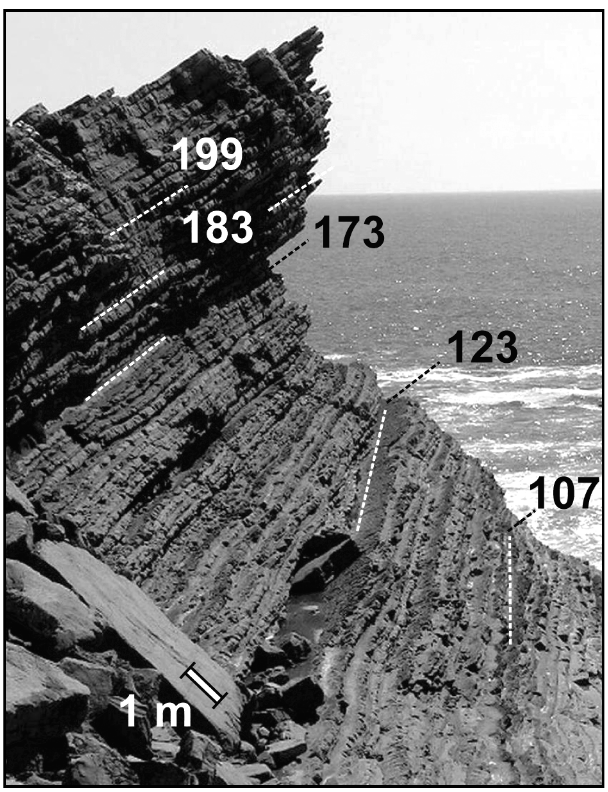

Fig. 3. Photograph of Cabo Mondego Section-02. Marly interval 123 indicates the base of the Bathonian (from Fernández-López *et al.* 2006a). Scale bar 1 m.

The presence of resedimented and reelaborated fossils implies that some form of current flow, bypassing or winnowing, affected the burial of concretionary internal moulds (Fernández-López *et al*. 2006a). The abundance of "hollow ammonites" (*i.e*. shells showing no sedimentary infill in the phragmocone) is indicative, however, of high rate of accumulation of sediment during biostratinomic processes. There is no evidence of taphonomic condensation (*i.e*. mixture of fossils of different age or different chronostratigraphic units) and ammonoid assemblages composed of specimens representing several biohorizons in a single bed or marly interval have not been identified. The base of the Bathonian has been established at the base of marly interval 123 of Section-02 (Fig. 3) and at the base of the marly interval FC1 of Section-90. Similarities in thickness, number and proportion of beds within subzones between sections 02 and 90 suggest that the bed-distribution patterns are of regional extent.

Ammonoid biochronostratigraphic data from Section-90 have been published by Mangold (1990a). New results on the ammonite succession at the Bajocian/Bathonian boundary in the Cabo Mondego region, incorporating data from the three observable sections, have been recently published (Fernández-López *et al*. 2006a, b). Over 500 ammonoid specimens from 112 stratigraphic levels, through 13.5 m in thickness, of the Bomfordi and Parvum subzones have been studied. The base of the Bathonian has been established by the lowest occurrence of representatives of the *Morphoceras* [M] – *Ebrayiceras* [m] group in the marly interval 02CM123. The Lower Bathonian index ammonite *Morphoceras parvum* Wetzel occurs in the marly interval 02CM139. The Lower Bathonian index ammonite *Gonolkites convergens* Buckman occurs in the marly interval 02CM181. The occurrence of *Bigotites* gr. *diniensis* Sturani [M+m] in Cabo Mondego in the lower horizon of the Parvum Subzone represents a new criterion for chronostratigraphical subdivision and chronocorrelation with the Digne-Castellane area, useful in understanding the evolution of the West Tethyan Perisphinctidae during the earliest Bathonian (Fernández-López *et al*. 2006a, b, 2007).

From a biochronostratigraphic point of view, 10 metres of strata with 62 successive ammonoid fossil assemblages from 77 successive fossiliferous stratigraphic intervals have been recognized in the Parvum Subzone. Consequently, this ammonoid succession shows a maximum value of biostratigraphic completeness and is one of the most complete in the world. Subzones of the Parkinsoni Zone, however, have not been so far identified in Cabo Mondego.

In the Lusitanian Basin, Upper Bajocian and Lower Bathonian Phylloceratina and Lytoceratina represent less than 1% of the total ammonoid assemblage, and parkinsoniids are very scarce (less than 5.0%). Successive ammonoid fossil assemblages are composed of Submediterranean taxa, but they allow correlation with the zonal scales of the diverse basins of the Mediterranean and NW European provinces. Ammonoid chronocorrelation with other faunal provinces is possible using as a criterion the first appearance of the dimorphic pair *Morphoceras* [M] – *Ebrayiceras* [m]. The most difficult problem in biochronocorrelation of the boundary, however, is not the low diversity of the fossil record across the boundary interval in Bas Auran area or Cabo Mondego area, but strong provincialism. Ammonoid biochronostratigraphic correlations between different bioprovinces and realms have been recently published by Mangold and Rioult (1997), Beznosov and Mitta (2000), Galácz (1999, 2001), Riccardi and Westermann (1999), Fernández-López (2000), Matyja and Wierzbowski (2000), Westermann (2000), Sandoval *et al*. (2001), Dietze *et al*. (2002), Mitta and Seltzer (2002), Callomon (2003), Mitta (2004), Moyne *et al*. (2004), Schlögl and Rakús (2004), Schlögl *et al*. (2005), Dietze and Dietl (2006), Zatoń and Marynowski (2006).

New provisions for the conservation and protection of these Portuguese outcrops have now been implemented under national laws (Henriques and Ramalho 2005; Page *et al*. 2006).

SUMMARY

The leading candidate Global Boundary Stratotype Section and Point for the base of the Bathonian Stage at the Ravin du Bès Section, France, satisfies most of the requirements recommended by the ICS (*e.g.* in Remane *et al.* 1996; Gradstein *et al*. 2003; Morton 2006b):

- The exposure extends over 13 m in thickness, comprising several metres of fossiliferous levels below and above the boundary. The stratigraphic succession can be recognized laterally over several hundred metres distance.
- At the Bajocian-Bathonian transition, no vertical (bio-, ichno- or tapho-) facies changes, stratigraphic gaps or hiatuses have been recorded. There is no evidence of taphonomic condensation (*i.e.* mixture of fossils of different age or different chronostratigraphic units). In relation to the rate of sedimentation, the Bomfordi and Parvum subzones are over 10 m thick.
- Structural complexity, synsedimentary and tectonic disturbances, or important alterations by metamorphism are not relevant constraints in the Bas Auran area.
- The hemipelagic, bed-scale limestone-marl alternations show a maximum value of biostratigraphic completeness for the Bajocian/Bathonian transition. In the Ravin du Bès Section, 5 metres thickness with 52 successive ammonoid fossil assemblages from successive stratigraphic intervals pertaining to the Parvum Subzone have been recognized. The Bomfordi Subzone attains a minimum thickness of 5.0 m and includes 42 successive ammonoid fossil assemblages. The ammonoid succession of this transition shows a maximum value of biostratigraphic completeness and is one of the most complete in the world.
- There is a well-preserved, abundant and diverse fossil record across the boundary interval, with key markers (ammonites and nannofossils) for worldwide correlation of the uppermost Bajocian and Lower Bathonian. The boundary can be characterized by both primary and secondary (auxiliary) biostratigraphic markers. The section appears to be suitable for biostratigraphic study of microfossils, such as foraminifera, but as yet there are no published studies.
- Regional analysis of sequence stratigraphy and manganese chemostratigraphy are available. A transgressive systems tract associated with a deepening phase and sediment starvation, within 3rd and 2nd order deepening/shallowing cycles, was developed in the Bas Auran area of

the French Alpine Basin, during the Early Bathonian. No data are currently available for strontium isotope ($^{87}Sr/^{86}Sr$ ratio), oxygen isotope ($\delta^{18}O$) or carbon isotope ($\delta^{13}C$) chemostratigraphy.

- Bajocian and Bathonian deposits have been remagnetized with a steady normal polarity. The requirement of suitability for magnetostratigraphy and geochronometry, however, can be indirectly satisfied by reference to the Bathonian magnetostratigraphic scale of Steiner *et al*. (1987) as defined in the Subbetic Cordillera.
- Volcanogenic deposits suitable for direct radioisotope dating are not known in the section. According to the data published by Gradstein and Ogg (2004) and Ogg (2004), the age of the Bajocian/Bathonian boundary is 167.7 ± 3.5 Ma in other basins.
- The criteria of accessibility, conservation and protection are assured by the "*Réserve Naturelle Géologique de Haute Provence*", protected under national low and a European Geopark as recognised by UNESCO. The park is managed by the "*Centre de Géologie de Digne*".

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