

The Barremian Stage

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Abstract

Inter-regional correlation in the Barremian is impossible because of strong biotic differentiation between realms coupled with a lack of obvious non-biostratigraphic markers to provide good boundaries. Thus we have chosen the best of the limited options available to define boundaries within the Tethyan Realm.

We recommend that the base of the Barremian be placed at the base of the *Spitidiscus hugii* ammonite Zone in the Río Argos section, SE Spain. Supplementary information will be compiled to fully document this choice before formal submission via the Cretaceous Subcommittee to the Commission on Stratigraphy.

The base of the Upper Barremian should be defined by the first appearance of the ammonite *Ancyloceras vandenheckei* in one of the Subbetic sections in SE Spain, probably section X.KV (Barrano de Cavila, Caravaca). Other sections in the region require further documentation before the final recommendation can be made.

Key-words:

Barremian, Lower Cretaceous, biostratigraphy, magnetostratigraphy, stratotypes.

Résumé:

Pour le Barrémien, toute corrélation interrégionale est impossible à cause d'une forte différenciation biotique entre les différents domaines combinée à un manque évident de marqueurs non biostratigraphiques pour indiquer de bonnes limites. C'est pourquoi nous avons choisi les meilleures parmi les options limitées existantes pour définir les limites dans le domaine téthysien.

Nous recommandons de placer la base du Barrémien à la base de la Zone de l'ammonite *Spitidiscus hugii*, dans la section du Río Argos, Espagne du S.-E. Des informations supplémentaires seront rassemblées pour documenter ce choix avant de le soumettre formellement par l'intermédiaire de la Sous-commission du Crétacé à la Commission de Stratigraphie.

La base du Barrémien supérieur devrait être définie par la première apparition de l'ammonite *Ancyloceras vandenheckei* dans une des sections subbétiques (S.-E. de l'Espagne), probablement la section X.KV (Barrano de Cavila, Caravaca). D'autres sections dans la région doivent être étudiées de façon plus approfondie avant que l'on puisse faire de recommandation définitive.

Mots-clefs:

Barrémien, Crétacé inférieur, biostratigraphie, magnétostratigraphie, stratotypes.

Барремский ярус.

Резюме.

Для Барремского яруса межрегиональная корреляция не

представляется возможной в связи с сильной биотической дифференциацией, существующей между разными областями, а также в связи с очевидным недостатком биостратиграфических знаков, необходимых для правильного обозначения границ. По этой причине мы выбрали наилучшую из существующих ограниченных возможностей для определения границ области Тетис.

Мы рекомендуем определять основание Баррема по основанию аммонитовой зоны *Spitidiscus hugii*, в разрезе Río Argos на юго-востоке Испании. Дополнительная информация будет предоставлена для документации данного выбора до его формального представления Стратиграфической Комиссии, при посредничестве Меловой Подкомиссии.

Основание верхнего Баррема должно быть определено при первом появлении аммонита *Ancyloceras vandenheckei* в одной из предбетских секций на юго-востоке Испании, вероятно в разрезе X.KV (Barrano de Cavila, Caravaca). Другие разрезы данного района требуют дополнительного изучения для формулировки конечных рекомендаций.

Ключевые слова: Барремский ярус, нижний мел, биостратиграфия, магнитостратиграфия, стратотипы.

Introduction

The Barremian Working Group has continued the work initiated by its predecessor, the pre-Albian Stages Working Group, whose conclusions were presented at Munich in 1982 (RAWSON, 1983) and Copenhagen in 1983 (BIRKELUND *et al.*, 1984). The preliminary proposals made at the Subcommittee's 1983 Copenhagen conference are a necessary starting point for defining the base of the Barremian. The Lower/Upper Barremian boundary was not considered at Copenhagen, but had been discussed briefly at Munich. At both meetings debate centred mainly on the ammonite sequence and little information was offered on possible microfossil or other boundary markers (BIRKELUND *et al.*, 1984, pp. 7-8). The main obstacles to making firm recommendations for stage and substage boundaries were recognised as:

- a lack of detailed lithological, palaeontological, magnetostratigraphic and chronostratigraphic logs for many key sections around the world (RAWSON, 1983, p. 499).
- provincialism in many fossil groups, rendering long-distance correlation very difficult (BIRKELUND *et al.*, 1984).

Since the Copenhagen meeting much new information has been published, especially on various European sequences. Some important palaeomagnetic data are now available and sequence stratigraphy has given new insights. However, this new information has highlighted the difficulty of correlating the better-known West Tethyan (Spain to the Caucasus) sequences with Barremian successions elsewhere. Even within Europe, the increasing endemicity of many fossil taxa by the beginning of the Barremian makes it difficult to correlate the West Tethyan faunas/floras with those of the NW European "Boreal" area. Conversely, the stratigraphy of some of the rich ammonite faunas of the Americas is poorly known.

We are therefore taking the pragmatic view that as a truly global correlation of Barremian rocks is still an unachieved ideal which may never be fully satisfied, it is better not to delay making our recommendations on the boundary levels. Although there are differences of opinion and emphasis within our working group, which will be elaborated upon below, the consensus is that the boundaries should be defined in the Western Tethys and based primarily on the ammonite sequence there. It proved impossible to find good, reliable microfossil markers of any wide applicability, but we have indicated those useful biological (and non-biological) events that coincide closely with the ammonite boundaries.

Definition of the Barremian Stage

BUSNARDO (1965) noted that although COQUAND's (1861) original definition of the Barremian was not very precise, it embraced both the Upper Hauterivian and Barremian of current usage. The pre-Albian Stages Working Group agreed with BUSNARDO that "despite historical priority it is best in the interests of stability" to follow KILIAN's (1888) more limited interpretation of the Barremian (RAWSON, 1983, p. 497). KILIAN had included the zone of *Pseudothurmannia angulicostata* in the Hauterivian, and that is the view taken by the majority of, though not all, workers since (see discussion below).

The base of the Barremian

During the preliminary exchange of ideas among Working Group members, it became apparent that there were no obvious microfossil or non-biostratigraphic markers that could convincingly supplant the ammonites as a primary tool for defining the base of the Barremian. Thus debate has centred primarily on which ammonite level would provide the best boundary.

At Copenhagen it was noted that while some workers placed the base of the Barremian at the base of the *Pseudothurmannia angulicostata* Zone (i.e. base of the *Pseudothurmannia* beds) others put it above that zone while BUSNARDO (*in* RAWSON, 1983, p. 498) drew it high

within the *angulicostata* Zone based on the first appearance of the desmoceratid ammonites *Raspailiceras* and *Barremites*. The Copenhagen meeting recommended that the Hauterivian/Barremian boundary should be placed

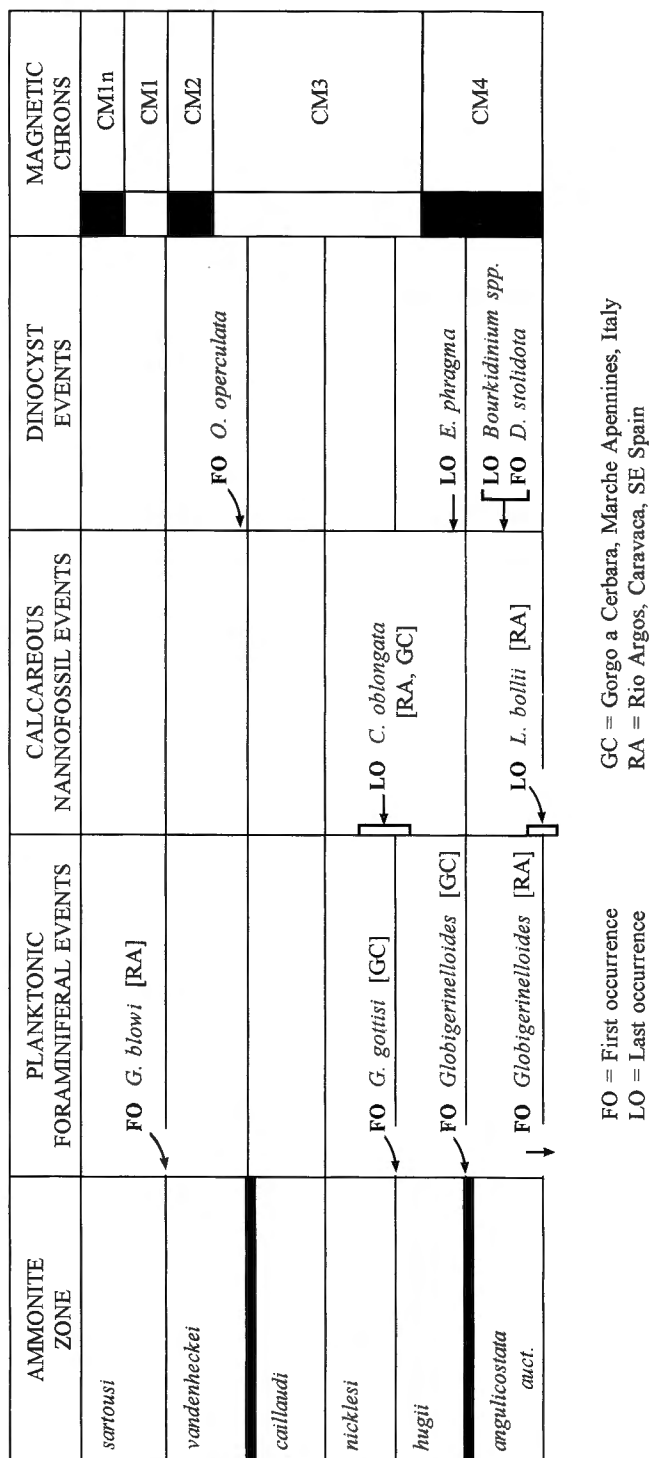


Fig. 1 — Lower Barremian and lower Upper Barremian Tethyan (Mediterranean) ammonite zones, microfossil events and magnetic polarity chrons.

The solid line beneath the *hugii* Zone represents the recommended base of the Barremian and that beneath the *vandenheckei* Zone the recommended base of the Upper Barremian.

either below or above the *Pseudothurmannia* beds and that a boundary **within** them should be avoided (BIRKELUND *et al.*, 1984, p. 8).

Three possible horizons for the base of the Barremian were discussed at Brussels:

- base of the *Spitidiscus hugii* Zone (i.e. above the *Pseudothurmannia* beds)
- middle of the *Pseudothurmannia* beds
- base of the *Pseudothurmannia* beds

BASE OF THE *SPITIDISCUS HUGII* ZONE

The Lower Cretaceous Cephalopod Team of IGCP Project 262 (now transferred to Project 362) suggested that the boundary could be placed at the base of the *Spitidiscus hugii* Zone, immediately **above** the *Pseudothurmannia* beds (HOEDEMAEKER & BULOT, 1990, fig. 1).

The *Spitidiscus hugii* Zone was first named by BUSNARDO (in ROGER, 1980, table). The index species first appears in Bed 73 of the Angles section in SE France (BUSNARDO & VERMEULEN, 1986), about 4 m above the last *Pseudothurmannia*, and it occupies a similar position in sections in SE Spain through France eastwards to the Caucasus.

In the Subbetic Domain (Betic Cordillera, southern Spain) the base of the zone is defined by the first appearance of specimens of the *Spitidiscus hugii* (OOSTER) - *Spitidiscus vandeckii* (d'ORBIGNY) group, but no one ammonite species is restricted to the zone (COMPANY *et al.*, 1995).

In the Carpathians exposure is poor and consequently there is a lack of suitable sections and faunas. This is especially true for the Silesian Unit of the Outer West Carpathians, well known for ammonite occurrences in the last century (UHLIG, 1883). However, the base of the *S. hugii* Zone is clearly marked, especially by a strong reduction to sudden disappearance of crioceratids and *Pseudothurmannia*, while the spitidiscids appear anew but sporadically. *Hamulinites parvulus* (UHLIG) appears as a new element but extends through the whole Lower Barremian (VASICEK *et al.*, 1994; VASICEK, *in press*). However, in Italy CECCA (*unpublished*) has found the latter species lower down, in the Faraoni Level (*catulloi* Subzone).

In the Khidikari section of western Georgia the highest Hauterivian beds with *Pseudothurmannia* are overlain by Lower Barremian limestones with *Spitidiscus* spp. According to new, preliminary data, very rare *S. hugii* occur at the base of these limestones (KVANTALIANI & SAKHELASHVILI, *in preparation*).

DELANOY (*personal communication*) notes that it does not seem possible to use any other truly characteristic form between the last *Pseudothurmannia* and the first *S. hugii*. In the Barrême region of SE France these species

are separated by some levels very rich in Desmoceratidae (*Barremites*, *Raspailiceras*). These desmoceratids do not appear to be of a very refined stratigraphic usage, and their local abundance is perhaps due to particular ecological conditions. VASICEK (*personal communication*) also points out that as desmoceratids are rather difficult to determine and are mostly not very well preserved, it is unrealistic to use them for defining the boundary.

CECCA *et al.* (1994) suggest that the base of the *hugii* Zone lies somewhat above the last occurrence of the nannofossil *Lithraphidites bollii*. However, von SALIS (*personal communication*) notes that in general the nannofossils show little change in the vicinity of the Hauterivian/Barremian boundary. CECCA *et al.* (1994) also indicate that planktonic foraminifera are of little help in broad regional correlation as the first and last occurrences appear to fluctuate considerably from one area to another (see Table 1).

The base of the *hugii* zone falls high in magnetochron M4 (BARTOLOCCI *et al.*, 1992).

MIDDLE OF THE *PSEUDOTHURMANNIA* BEDS

HOEDEMAEKER (in HOEDEMAEKER, COMPANY *et al.*, 1993, and *personal communication*) proposes that in the Río Argos (SE Spain) section the old *Pseudothurmannia angulicostata* Zone at the top of the Hauterivian can be split into two, a lower subzone of *P. ohmi* and an upper subzone of *P. catulloi*. He prefers to lower the base of the Barremian stage to the base of the *P. catulloi* Subzone. In terms of sequence stratigraphy, HOEDEMAEKER notes that the *catulloi* Subzone corresponds to a lowstand systems tract which "is commonly missing, especially in rather shallow seas. It is fortunately well represented along the Río Argos where the sea was rather deep."

LEEREVELD (*personal communication*) has examined the dinoflagellate data. He points out that the base of the *S. hugii* Zone is difficult to characterise but that the middle of the *P. angulicostata* auct. Zone can be identified quite easily in SE France and SE Spain. This level approximates to that suggested as a boundary by HOEDEMAEKER. It is characterised by:

- the last consistent and frequent presence of *Cymosphaeridium validum*
- the last occurrence of *Bourkidinium* spp.
- the first occurrence of *Diphasio-sphaera stolidota*.

BASE OF THE *PSEUDOTHURMANNIA* BEDS

AVRAM (*personal communication*) recommends this level, following, for example, BRESKOWSKI (1975), AVRAM (1983), VASICEK *et al.* (1983) and, indirectly, COQUAND (1861) in his original definition of the Barremian. His

argument is based on ammonite ranges at the Svinita section in Romania. Here the Cheloniceratinae (*Paraspiticeras*) first appear just beneath the *Pseudothurmannia* beds, followed by the first Hemihoplitidae (*Pseudothurmannia*) and then the Pulchelliidae (*Psilotissotia*). AVRAM regards the assemblage as much more related to the Barremian than to the Hauterivian.

POSSIBLE BOUNDARY STRATOTYPE SECTIONS

At Copenhagen it was recommended that sections in southeast France, southeast Spain, the Carpathians, the Crimea and the Caucasus should be considered as candidates for the Hauterivian/Barremian boundary stratotype. The WG meeting at Brussels considered several possible candidates. At Angles (the Barremian "stratotype section"), the boundary seems to occur at the base of bed 72, where *S. hugii* first appears (data of BUSNARDO & VERMEULEN, 1986). Ammonites are scarce around this level, and there are problems of exposure. Conversely, COMPANY, HOEDEMAEKER, SANDOVAL and TAVERA considered that the Río Argos section in SE Spain would make a very good boundary stratotype as it is well exposed and ammonites are abundant.

AVRAM (*personal communication*) suggested that there are two possible candidate localities in Romania. At Svinita (western end of the Southern Carpathians) the *Pseudothurmannia* beds are well represented, while several metres above the *Spitidiscus hugii* group appears, well below the *caillaudianus* Zone assemblage. Unfortunately there is not yet a good and completely studied section.

In Dambovicioara (eastern end of the Southern Carpathians) the beds with *Pseudothurmannia* are rich in individuals but poorly exposed (because of their structural setting). They are obviously followed by beds with *Spitidiscus vandeckii*, *Pulchellia changarnieri* and, 1 m above, the first *Holcodiscus ex. gr. caillaudianus-perezianus*.

The Crimean sections are too condensed to be considered for a boundary stratotype (BARABOSHKIN, *personal communication*) but the base of the *angulicostata* Zone is well marked. Sections in the Northern Caucasus, Mangyshlak and Turkmenia contain only very rare ammonites across the boundary interval, and most are boreal forms.

RECOMMENDATIONS

By a majority view the Brussels meeting of our Working Group recommended drawing the base of the Barremian at the base of the *Spitidiscus hugii* Zone. In a subsequent postal vote, 13 members replied; 11 supported this proposal while the other two alternatives received one vote each. The alternative of lowering the boundary to the base of the *catulloi* Zone was rejected because this zone is of limited applicability — it is apparently missing in many

of the shallower water areas as it represents an interval of low sea level. This at least partially explains why some other contributors could not recognise a twofold division of the widespread *Pseudothurmannia*-rich beds at the top of the Hauterivian. Conversely the deposits of the overlying *hugii* Zone are much more widespread and are now recognised from SE Spain eastwards to the Western Caucasus, the index species occurring at least sparsely over most of that area.

Such a distribution goes some way towards meeting the need to establish a correlation of relevant strata and define a boundary "that will be recognisable over as wide an area as possible". But we have no evidence whether the *hugii* Zone can be traced further to the west, to Mexico or Columbia. And it is probably impossible to correlate the horizon very closely with boreal sequences, at least by using ammonites alone. However, dinoflagellates may provide a useful guideline.

The meeting also recommended that the Río Argos section would make an appropriate boundary stratotype section. In the subsequent postal vote, 12 members supported this proposal and one abstained. Information on the ranges of other fossil groups in this section is now documented (HOEDEMAEKER & LEEREVELD, 1995).

The Lower/Upper Barremian boundary

DEFINITION OF THE BOUNDARY

For the Pre-Albian Stages Working Group, BUSNARDO (*in RAWSON, 1983, p. 498*) defined the base of the Upper Barremian "by the appearance of *Heinzia* and of "*Emericiceras*" of the *barremense* Group. Table 1 in RAWSON (1983) showed an "*Emericiceras*" *barremense* Zone at the base of the Upper Barremian, following BUSNARDO (*in ROGER, 1980*).

The Cephalopod Working Group of IGCP Project 262 rejected the "*Emericiceras*" *barremense* Zone because of the ambiguous interpretation of "*E.*" *barremense*. They replaced it with the *Ancyloceras vandenheckei* and overlying *S. sartousiana* Zones, taking the base of the *vandenheckei* Zone to mark the base of the Upper Barremian. This position has been followed in several subsequent publications (e.g. BARTOLOCCI *et al.*, 1992; CECCA *et al.*, 1994; COMPANY *et al.*, 1995; VASICEK *et al.*, 1994).

DELANOY (*personal communication*) notes that in France there is a significant but progressive change of the ammonite faunas from this level upward, which ushers in the great faunal renewal of the *sartousiana*, *feraudianus* and *giraudi* Zones. He also points out that *E. barremense* occupies higher levels than *A. vandenheckei*.

The base of the *vandenheckei* Zone was the only boundary suggested by members of the WG prior to the Brussels meeting and no other boundary was put forward at Brussels. LEEREVELD (*personal communica-*

tion) points out that the first occurrence of the dinoflagellate *Odontochitina operculata* approximates to the base of this zone. BARTOLOCCI *et al.* (1992, pp. 63-68) show that the boundary lies high in magnetochron M3.

POSSIBLE BOUNDARY STRATOTYPE SECTIONS

COMPANY, SANDOVAL and TAVERA (*personal communication*) suggest that section X.KV (Barrano de Cavila, Caravaca) of the Subbetic Zone of SE Spain may be a suitable candidate. Studies of the distribution of calcareous nannofossils, planktonic foraminifers, palynomorphs and sequence stratigraphy are being carried out on this and other Subbetic sections.

AVRAM (*personal communication*) notes that in the Carpathian localities mentioned above the boundary beds are not exposed but could be excavated artificially; the lack of exposure does not reflect a structural problem.

RECOMMENDATIONS

We recommend that the base of the upper Barremian is defined by the base of the *vandenheckei* Zone. In the postal vote, 11 members supported this view, one abstained and one disagreed. The zonal species is widely distributed in western Tethys, being recorded from SE Spain eastwards as far as the Tvishi section of western Georgia (KAKABADZE & KOTETISHVILI, 1995).

The meeting also agreed that a boundary stratotype should be chosen from one of the Subbetic sections of SE Spain, and this was supported in the subsequent postal vote by 12 members (with one abstention). Further documentation of the most appropriate sections is awaited.

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Correlation with the Boreal Realm

The recommended boundaries are based on Tethyan taxa belong to the Mediterranean faunal province. The nearest boreal area to this is the West European Province *sensu* RAWSON (1981), embracing the North Sea and North German basins. This region was open to considerable Tethyan influence during the Valanginian and Hauterivian but less so during much of the Barremian (e.g. MUTTERLOSE, 1988; RAWSON, 1994). There are no records of the *Spitidiscus hugii* group or of other distinctively basal Barremian ammonites. However, dinoflagellate "tops" in the lower part of the *variabilis* Zone indicate that this interval correlates with the top of the *balearis* Zone to the base of the *angulicostata* Zone and not, as currently suggested, with the base of the Barremian (LEEREVELD, *personal communication*). This may indicate that the appearance of the belemnite *Praeoxyteuthis pugio* high in the *variabilis* Zone gives a reasonable approximation to the base of the Barremian.

RAWSON (1995) has provisionally drawn the base of the Upper Barremian at the base of the *denckmanni* Zone, while suggesting that the boundary could be a little lower, "in or at the base of the *elegans* Zone. The latter position would be supported by KAKABADZE's (1981) Georgian record of *P. cf. elegans* (which is from the Upper Barremian *Heinzia matura* Zone) and of *P. denckmanni* in the overlying *Hemihoplites feraudianus* Zone. Furthermore, LEEREVELD (*personal communication*) points out that the dinoflagellate *Odontochitina operculata*, whose first occurrence is at about the base of the Upper Barremian in western Tethys, first appears in the lower part of the *P. elegans* Zone in the West European Province (Speeton). The base of this zone also coincides with the LO of the belemnite genus *Aulacoteuthis* and the FO of its successor, *Oxyteuthis*.

- inférieur de la formation crétacée un nouvel étage entre le Néocomien proprement dit (couches à *Toxaster complanatus* et à *Ostrea couloni*) et le Néocomien supérieur (étage Urgonien de d'ORBIGNY). *Mémoires de la Société d'Emulation de Provence*, **1**: 127-139.
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