

The Hauterivian Stage

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Abstract

The base of the Hauterivian is recommended to be drawn at the first appearance of the ammonite genus *Acanthodiscus*. This is known from shallow-water facies in both Tethyan and Boreal areas of Europe. The section at La Charce, Drôme, SE France, is recommended as the boundary stratotype. The same section is also appropriate as boundary stratotype for the base of the Upper Hauterivian, which is here defined by the last occurrence of the nannofossil *Cruciellipsis cuvillieri*.

Key-words:

Hauterivian, Lower Cretaceous, biostratigraphy, magnetostratigraphy, isotope stratigraphy, stratotypes.

Résumé

Il est recommandé de placer la base de l'Hauterivien à la première apparition du genre d'ammonite *Acanthodiscus*. Ce genre est présent dans les faciès peu profonds des dépôts téthysiens et boréaux d'Europe. La coupe à La Charce, Drôme, S.E. France, est recommandée comme stratotype de la limite. La même coupe peut être utilisée comme stratotype pour la base de l'Hauterivien supérieur, qui coïncide avec la disparition du nannofossile *Cruciellipsis cuvillieri*.

Mots-clefs

Hauterivien, Crétacé inférieur, biostratigraphie, magnétostratigraphie, stratigraphie isotopique, stratotypes.

Готеривский ярус.

Резюме.

Рекомендуется определять основание Готерива по первому появлению аммонита рода *Acanthodiscus*. Последний присутствует в неглубоких фациях тетиских и boreальных отложений Европы. В качестве стратотипа границы рекомендуется использовать разрез в поселке La Charce, департамент Drôme на юго-востоке Франции. Тот же разрез может быть использован как стратотип для основания верхнего Готерива, совпадающего с исчезновением нанофоссилия *Cruciellipsis cuvillieri*.

Ключевые слова: Готеривский ярус, нижний мел, биостратиграфия, магнитостратиграфия, изотопическая стратиграфия, стратотипы.

Introduction

In 1874 RENEVIER defined the Hauterivian stage, based on the type area of Hauterive (Neuchâtel, Switzerland). The

“marnes à *Astieria*”, the “marnes bleues d'Hauterive” and the “Pierre Jaune de Neuchâtel” were included in the Hauterivian. More recent studies, however, follow BAUMBERGER (1901), who transferred the “marnes à *Astieria*” to the Valanginian stage (for detailed discussion see RAWSON, 1983).

As for other Cretaceous stages, a distinctive provincialism is recognizable for the Hauterivian, resulting in two different zonation schemes: a Boreal and a Tethyan standard zonation. The Hauterivian stage is, however, marked by a pronounced exchange of marine floras and faunas between Tethyan and Boreal Realms, while the Berriasian, Valanginian and Barremian stages are characterised by more endemic taxa. Thus, within Europe, some markers are present both in the Tethys and in the Boreal realm, allowing an inter-regional correlation.

The base of the Hauterivian

Traditionally the base of the Hauterivian is defined by the first appearance of the ammonite *Acanthodiscus radiatus* and allied species, and that was the boundary recommended at Copenhagen (BIRKELUND *et al.*, 1984, p. 7). The value of *Acanthodiscus* lies in its presence in shallow water facies both in the Tethys and the Boreal Realm, though it is rare in the deeper-water facies.

The Hauterivian Working Group has considered other possible boundary criteria too, and these are discussed below.

DINOFLAGELLATES

Recently, LEEREVELD (1995) compiled the first and last occurrences of dinoflagellates for the European Hauterivian in both the Tethys and the Boreal realms. The FO (first occurrence) of *Muderongia staurota*, an earliest Hauterivian event, is a possible candidate for defining the Valanginian/Hauterivian boundary. In the Mediterranean area *M. staurota* occurs in the upper part of the *Acanthodiscus radiatus* ammonite Zone, in NW Germany

at the top of the *Endemoceras amblygonium* ammonite Zone. Thus the FO of *M. staurota* is an important event, allowing direct inter-regional correlation.

CALCAREOUS NANNOFOSSILS

Various species of calcareous nannofossils have their first and last occurrences (FO, LO) in the early Hauterivian: FO of *Nannoconus bucheri* (Tethys only), LO of *Eiffelithus windii*, FO and LO of *Eprolithus antiquus* (Boreal Realm only).

The LO of *Eiffelithus windii* has been observed within the early Hauterivian *Acanthodiscus radiatus* Zone in France (BERGEN, 1994; GARDIN, *in prep.*). *E. windii* is, however, rare or absent in the Boreal Realm. Furthermore it is a taxonomically problematic form.

The LO of *Tubodiscus verenae* has often been recorded as a latest Valanginian event in the Mediterranean sections (BRALOWER, 1987; BERGEN, 1994; CHANNELL *et al.*, 1995; ERBA *et al.*, 1995).

However, although it is usually very rare and discontinuous in range, it appears to extend through the Hauterivian too (BULOT *et al.*, this volume). *T. verenae* has not been observed in expanded sections in the Boreal Realm covering the Valanginian/Hauterivian boundary interval.

FORAMINIFERA AND OSTRACODS

Benthic foraminifera and ostracods have been used quite successfully in the Boreal Realm for a zonation and regional correlation (e.g. BARTENSTEIN & BETTENSTAEDT, 1962; BARTENSTEIN, 1978; MEYN & VESPERMANN, 1994). However, the fairly detailed zonal scheme based on benthic foraminifera cannot be used for inter-regional correlation.

The FO of the ostracod *Protocythere triplicata* has been observed by many authors in the Boreal Realm (BARTENSTEIN & BETTENSTAEDT, 1962); this event occurs in the *Astieria* beds (*Eleniceras paucinodum* ammonite Zone of QUENSEL, 1988) in the latest Valanginian of NW Germany (NIEDZIOLKA, 1988). In France (Alpes-de-Haute-Provence) the FO of *P. triplicata* seems to equate to the base of the *furcillata* Subzone (DONZE, 1976). Consequently the FO of *P. triplicata* is time transgressive, having its FO in NW Europe later than in France. Planktonic foraminifera are of no help as although they first appear in the late Valanginian in the Mediterranean area [*Globigerinelloides gottisi* (COCCIONI & PREMOLI SILVA, 1994)], they not occur before the earliest Aptian in the Boreal Realm.

AMMONITES

The Hauterivian ammonites show a distinctive provin-

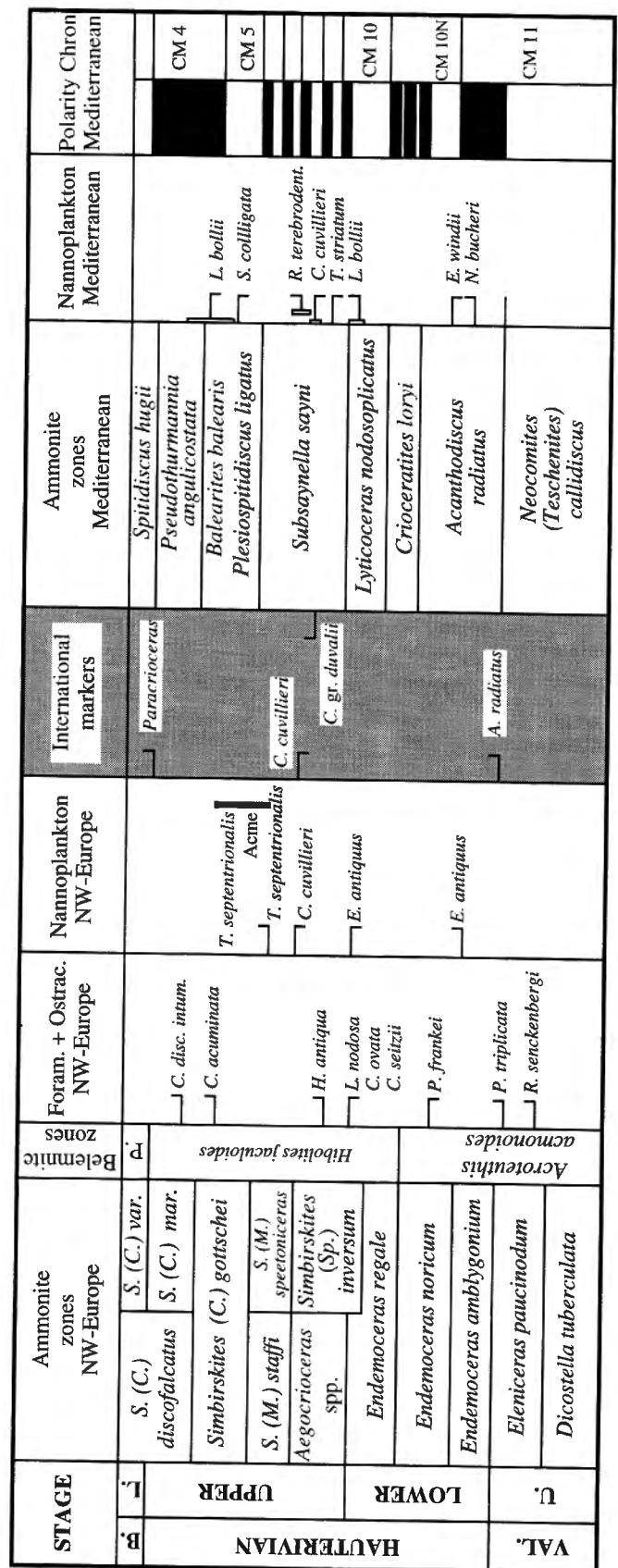


Fig. 1 — Integrated stratigraphy of the Hauterivian for the Boreal and Tethyan areas. Compiled from numerous sources (see text).

cialism, allowing two different biostratigraphic zonation schemes to be used for the Tethys and the Boreal Realm. In the Tethys the base of the Hauterivian is traditionally defined by the first appearance of the ammonite genus *Acanthodiscus*, in the Boreal Realm by the FO of the ammonite *Endemoceras amblygonium*. In the Boreal Realm the first *Acanthodiscus* (*A. bivirgatus*) has been observed in the upper part of the *E. amblygonium* Zone. This might give the basal *E. amblygonium* Zone of the Boreal Realm a latest Valanginian age. Since, however, the first Boreal *Acanthodiscus* is a phylogenetically advanced form it is believed here that the base of the Tethyan *A. radiatus* Zone and the base of the Boreal *E. amblygonium* Zone correlate.

In NW Germany, QUENSEL (1988) placed the *Astieria* beds (beds with *Olcostephanus*), which underlie the *E. amblygonium* Zone, into the *Eleniceras paucinodum* Zone and defined the Valanginian/Hauterivian boundary at the base of this unit. This suggestion has not been followed subsequently, since the FO of the overlying *E. amblygonium* is quite distinctive throughout NW Europe. HOEDEMAEKER (1984) and HOEDEMAEKER & LEEREVELD (1995) have proposed that the base of the Hauterivian be drawn much lower, at the base of the *Karakaschiceras pronocostatum* horizon, i.e. the second horizon within the *Saynoceras verrucosum* Zone. This level is marked by a faunal turnover of the ammonites and a change in the dinoflagellate assemblages. It correlates approximately with the level in which true *Dichotomites* and *Juddiceras* appear in NW Germany. This would alter the Hauterivian/Valanginian boundary radically and most of what presently is part of the Upper Valanginian would be included in the Hauterivian. Another problem is the correlation with the Boreal succession. However, both *Saynoceras verrucosum* and rare *Karakaschiceras* are known from the lowermost Upper Valanginian of NW Germany, where they co-occur.

MAGNETOSTRATIGRAPHY

No direct correlation between ammonites and polarity chrons has been established so far. BESSE *et al.* (1986) described a magnetostratigraphy for the Angles section (Alpes-de-Provence, France), which cannot be correlated to the standard magnetic polarity chrons. The traditional Valanginian/Hauterivian boundary is probably correlatable with the base of magnetic polarity chron CM 11n (CHANNELL *et al.*, 1995; ERBA *et al.*, 1995). Indirect correlation is indicated by correlations via calcareous nannofossils and dinoflagellates. No magnetic zonation exists for the Boreal Realm. This is partly due to a different lithology, not allowing palaeomagnetic data to be collected.

ISOTOPE STRATIGRAPHY

LINI *et al.* (1992) published a $\delta^{13}\text{C}$ isotope curve for the

Valanginian to Aptian of northern Italy. This curve shows a distinctive latest Valanginian isotope shift correlated to magnetostratigraphy and a nannofossil zone, but not to ammonite zones. This isotopic excursion has been calibrated with bio-magnetostratigraphy in several sections (CHANNELL *et al.*, 1993) and has been observed from various ODP sites. The peak value correlates with magnetic chron M11 and may well be a good proxy for the Valanginian/Hauterivian boundary. The mudstone facies of the Boreal realm does not allow any isotope analyses due to its low calcium carbonate content.

RECOMMENDATIONS

Following the discussions in Brussels it is suggested that the base of the Hauterivian is defined by the first occurrence of the ammonite genus *Acanthodiscus*. Using *Acanthodiscus* for the definition of the Valanginian/Hauterivian boundary, the base of the Tethyan *A. radiatus* ammonite Zone and the base of the Boreal *Edemoceras amblygonium* ammonite Zone may correlate (see above). The reasons for using *Acanthodiscus* are as follows:

- the genus is present in the shallow-water facies in both the Tethyan and Boreal Realms.
- the boundary is defined by a genus, not a species.
- there are no taxonomic problems with *Acanthodiscus*.
- this definition follows the traditional boundary.

Disadvantages in using *Acanthodiscus* are:

- its rarity in the deep-water facies of both the Tethyan and Boreal Realms.
- in the deep-water facies of the Boreal Realm the first *Acanthodiscus* spp. (including *A. radiatus*) appear at the base of the *Endemoceras noricum* Zone (QUENSEL, 1988).

BOUNDARY STRATOTYPE

Originally the Hauterivian stage was defined at Hauterive (Neuchâtel, Switzerland) (RENEVIER, 1874). Because of the condensed nature of some units, poor exposure and the general rarity of ammonites the type area has long been regarded as unsatisfactory. Thus from the time of KILIAN onward, French workers have preferred to use the expanded sequences in SE France as a standard for reference. Of these, that at La Charce (Drôme) is the best documented exposure across the Valanginian/Hauterivian boundary.

vian boundary (THIEULOUY, 1977; BULOT *et al.*, 1993) and was proposed as the boundary stratotype by THIEULOUY (1977, p. 125). Here, the first *Acanthodiscus* appear in bed 254 of BULOT *et al.* (1993).

As no alternative section in Spain or the Caucasus/Crimea areas has been put forward, the Hauterivian Working Group follow THIEULOUY's (1977) recommendation to use the La Charce section as the boundary stratotype for the Valanginian/Hauterivian boundary.

The base of the Upper Hauterivian

In the Mediterranean the Lower/Upper Hauterivian boundary has traditionally been placed at the base of the *Subsavnella sayni* ammonite Zone. Other possible criteria have been considered by the Working Group.

DINOFLAGELLATES

The basal Upper Hauterivian in the Tethyan Realm is characterised by three successive FOs of dinocyst taxa. Two of these species (*Aprobolocysta eilema*, *Canningia pistica/grandis*) are typical boreal elements. *A. eilema* has its FO in SE France in the *S. sayni* ammonite Zone. A best fit of the FOs of these three species suggests the position of the traditional boundary somewhere in the *Simbirskites inversum* ammonite Zone.

CALCAREOUS NANNOFOSSILS

The FOs and LOs of the following nannofossil species have been observed in the Upper Hauterivian: FO and LO of *Lithraphidites bollii* (Tethys only), LO of *Tegumentum striatum*, LO of *Cruciellipsis cuvillieri*, FO of *Rucinolithus terebrodentarius* (Tethys only), LO and acme of *Tegulalithus septentrionalis* (Boreal Realm mainly) and LO of *Speetonia colligata*.

Tegumentum striatum has its last occurrence in the basal part of the *S. sayni* ammonite Zone in France (GARDIN, *in prep.*). This species is rare to common in the Mediterranean sections and common in the Boreal sections. Its disappearance seems to be time transgressive, since it has its LO in NW Europe in the late Hauterivian *Simbirskites discofalcatus* ammonite Zone.

In SE France *Cruciellipsis cuvillieri* has its LO in the upper part of the *S. sayni* Zone (BERGEN, 1994; GARDIN, *in prep.*). In Italy, the LO of *C. cuvillieri* is correlated to magnetic chrons M7-M8 and therefore is Late Hauterivian in age (CHANNELL *et al.*, 1995; ERBA *et al.*, 1995). In the Boreal Realm *C. cuvillieri* has its LO just above the top of the *Aegocrioceras* beds in NW Germany (KEMPER

et al., 1987), but somewhat lower (top of *E. regale* ammonite Zone) at Speeton (CRUX, 1989). Its absence in the Speeton *Aegocrioceras* beds probably reflects the extremely condensed nature of the beds there, leading to poor preservation and a generally impoverished flora. Since *C. cuvillieri* is a quite distinctive species it may be a good candidate for defining the Lower/Upper Hauterivian boundary.

The LO of rare *Tegulalithus septentrionalis* has been reported from the *Plesiospidiscus ligatus* ammonite Zone in France (GARDIN, *in prep.*), while it is common in the Boreal *Simbirskites staffi* and *S. gottschei* ammonite zones.

Speetonia colligata occurs too high in the Upper Hauterivian to be considered as a marker for the Lower/Upper Hauterivian boundary. Furthermore it is a rare species in both the Boreal Realm and the Tethys.

AMMONITES

In the Mediterranean the Lower/Upper Hauterivian boundary is currently defined by the disappearance of the Neocomitinae and the first appearance of *Subsavnella sayni* (BULOT *et al.*, 1993). It is placed at the base of the *Subsavnella sayni* Zone (*Cruasicerus cruasense* horizon). The Boreal Upper Hauterivian is characterised by the ammonite *Simbirskites* which occurs from California and Arctic Canada to NW-Europe and the former Soviet Union. Ammonites typical of the *Lyticoceras nodosplacatus* and *Subsavnella sayni* zones occurring in the Speeton Clay (eastern England) succession show that there the base of the *sayni* Zone equates with the middle part of the boreal *Simbirskites inversum* Zone. In NW Germany *S. inversum* is very rare; the heteromorph ammonite genus *Aegocrioceras* is extremely common in this interval. Consequently the base of the *Aegocrioceras* beds has been taken to approximate to the Lower/Upper Hauterivian boundary.

RECOMMENDATIONS

For defining the boundary of the Lower/Upper Hauterivian substages the LO of the nannofossil *Cruciellipsis cuvillieri* in the Mediterranean area is suggested. This event lies in the upper part of the *Subsavnella sayni* ammonite Zone (*sensu* HOEDEMAEKER & BULOT, 1990) in the Tethys and just above the top of the *Aegocrioceras* beds in NW Europe. Using *C. cuvillieri* has the following advantages:

- the species is present in the Boreal Realm, in the Tethys and in the Indian Ocean. It thus has a really world-wide distribution.
- the species is easily recognised.

- there are no taxonomic problems with *C. cuvillieri*.
- the current definition compares closely with the traditional boundary.

The disadvantage of using *C. cuvillieri* is that it splits the Tethyan *S. sayni* Zone, placing the lower part in the Lower Hauterivian.

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BOUNDARY STRATOTYPE

As no alternative section in Spain or the Caucasus/Crimea areas has been put forward, the Hauterivian Working Group agreed to recommend the La Charge section as the boundary stratotype for the Lower/Upper Hauterivian boundary.

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