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Mediterranean Neocomian belemnites, part 3: Valanginian-Hauterivian belemnites

Nico M.M. JANSSEN ¹

Abstract: The classical papers of RASPAIL (1829, 1830) and DUVAL-JOUVE (1841) described a wide range of belemnite species, mainly from the Lower Cretaceous of the Castellane-Peyroules area (Alpes de Haute-Provence, France). The present work focuses mainly on the biostratigraphy of these previously described belemnite taxa for their stratigraphic relationships had not been determined precisely. Here, biostratigraphy is related to the lithologic successions and faunal associations (ammonites) of various outcrops in the area studied. Complementary data were obtained from the La Lagne, Les Allaves and Pas d'Escafe sections (Alpes de Haute-Provence, France). And, in order to attain a better understanding of the stratigraphic distribution of Late Valanginian belemnites in condensed glauconitic deposits, these assemblages are compared with belemnites from deeper water successions in the Angles, Source de l'Asse de Moriez, Cheiron areas and those in the vicinity of La Charce and Vergol that are even deeper.

Key Words: Belemnites; Valanginian; Hauterivian; France; Peyroules.

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Résumé : *Bélemnites néocomienne des régions méditerranéennes, 3ème partie : Bélemnites de l'intervalle Valanginien-Hauterivien.*- Les travaux classiques mais anciens de RASPAIL (1829, 1830) et DUVAL-JOUVE (1841) décrivent une grande variété d'espèces de bélemnites, provenant essentiellement du Crétacé inférieur de la région de Castellane-Peyroules (Alpes de Haute-Provence, France). Cette nouvelle contribution s'articule autour de la distribution biostratigraphique des bélemnites décrites précédemment car jusqu'à présent cet aspect avait été négligé. Le canevas biostratigraphique est calibré avec les successions lithologiques et les associations fauniques (ammonitofaune) de plusieurs affleurements dans cette région. Des données supplémentaires ont été obtenues à partir de coupes levées dans d'autres secteurs des Alpes de Haute-Provence: La Lagne, Les Allaves et Pas d'Escafe. De plus, afin de mieux comprendre la distribution stratigraphique des bélemnites du Valanginien supérieur au sein de niveaux condensés glauconitiques ces associations sont comparées avec les bélemnites de milieux de dépôt plus profonds à Angles, à la Source de l'Asse de Moriez et à Cheiron, et avec celles des environs de La Charce et Vergol qui correspondent à des milieux plus profonds encore.

Mots-Clefs : Bélemnites ; Valanginien ; Hauterivien ; France ; Peyroules.

Introduction

The classical works of RASPAIL (1829, 1830) and DUVAL-JOUVE (1841) were based in part on belemnites from the Castellane-Peyroules area (Fig. 1). KILIAN & REBOUL (1915) and TOMITCH (1922) listed several species of belemnites from this area, and DELATTRE (1952) described a new species of belemnite "*Hibolites rogeri* n. sp.", now *Adiakritobelus rogeri* (DELATTRE). Unfortunately, the collections of RASPAIL and DUVAL-JOUVE are thought to be lost (see COMBÉMOREL, 1973, p. 134), so I figure some topotypes and record their locations.

Here, the belemnite taxa are examined bed-by-bed making use of previous biostratigraphic studies and sequence stratigraphic interpretations of the successions. Their integration will lead to a better understanding of the distribu-

tion of the belemnites. Already, a provisional framework has been established in which several associations of belemnites are recognized. Future research in pelagic sediments should refine the degree of stratigraphic resolution using belemnites. Currently, in the Vocontian basin detailed stratigraphic subdivision using belemnites is available only for the Upper Valanginian. To date no detailed stratigraphic data on belemnites have been available from most of the strata of Hauterivian age there.

Stratigraphic overview

For this paper, several sections, mainly in the Peyroules area, were studied in detail. In this region the sediments of latest Valanginian and earliest Hauterivian age are glauconitic and their lithology varies considerably. Figs. 2-10

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show details of these successions and their relationships to ammonite zones (AUTRAN, 1993; VERMEULEN *et alii*, 1999; VERMEULEN, 2002) and the distribution of belemnites. The sections encompassing the Valanginian-Hauterivian boundary are particularly rich in belemnites. Some of them show traces of reworking, rolling

or physical damage. The majority of the macrofossils are cephalopods.

The following is an enumeration of the sites discussed in this study: see Figure 1 for their geographic location.

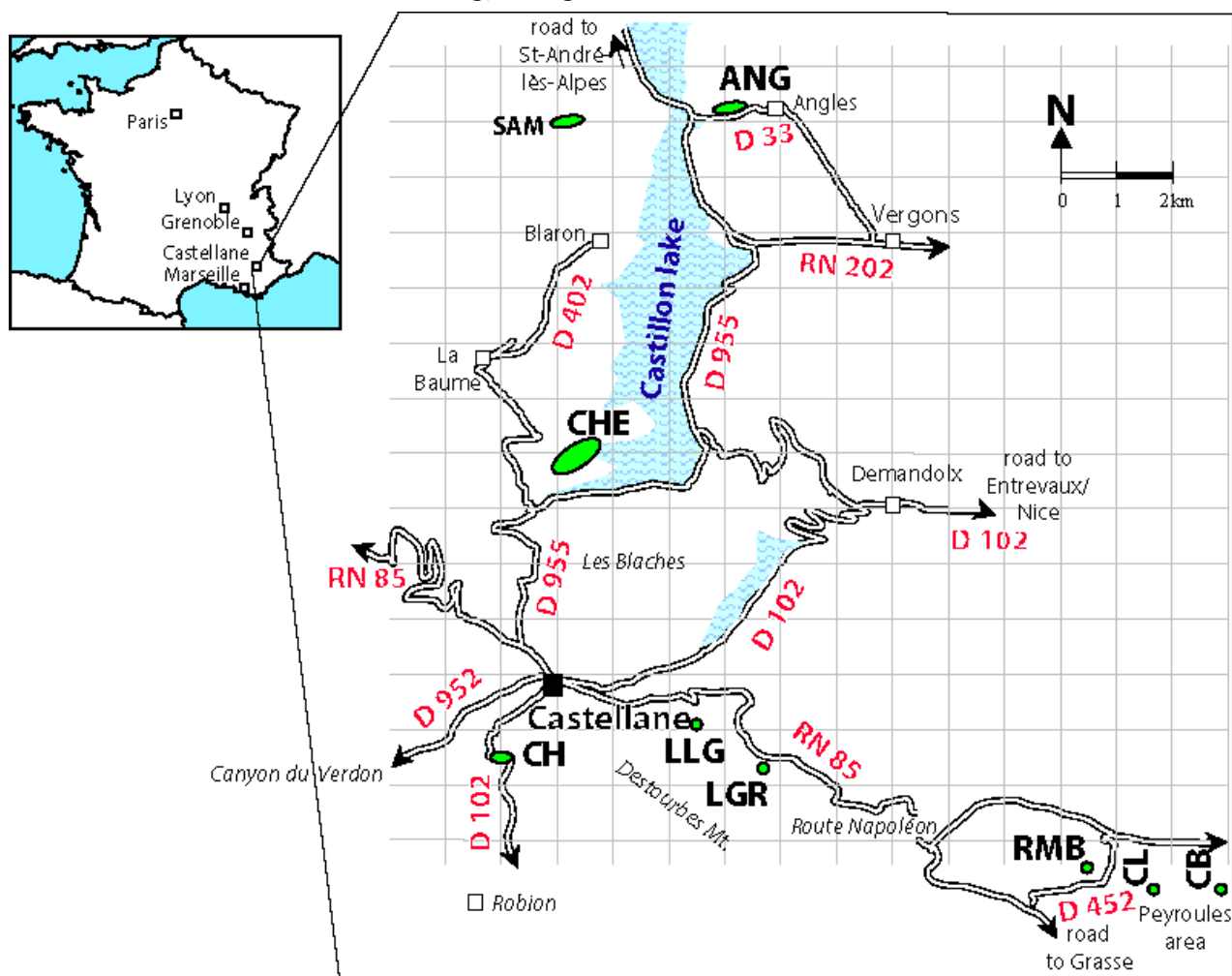


Figure 1: Geographical situation of localities mentioned in the Castellane area (Alpes de Haute-Provence, southeast France). The positions of the main areas of investigation and of some areas with a historical significance are shown.

Key: ANG = Angles (see THIEULOY, 1979, p. 18-20); CB = Collet des Boules; CH = Chamateuil; CHE = Cheiron; CL = Clausson; LGR = La Garde; LLG = La Lagne; RMB = Ravin de Mal Bouisset; SAM = Source de l'Asse de Moriez (see also THIEULOY, 1979, p. 19). The following localities (mentioned by RASPAIL, 1829) are not on the map: Lates (department of Var; 5-6 km east of Peyroules), plateau of Gréolières (east of Castellane, between Castellane and Roquestron, department of Var). Other areas not indicated on the map: PE = Pas d'Escale is near Majastres, approximately 8-10 km northwest of Blieux and ALL = Les Allaves, is approximately 25 km west of Castellane.

Clausson (CL), Peyroules area (Figs. 2-3): In this succession the strata that include the Valanginian-Hauterivian boundary are in a calcareous glauconitic facies. Underlying these beds disconformably are Lower Valanginian strata (the so-called *Karakaschiceras*-beds), that are succeeded by alternations of limestones and marls with abundant *Olcostephanus guebhardi* and pelecypods. These rocks are a partial lateral equivalent of the "Petite-Lumachelle" and represent the upper part of the *Eristavites platycostatus* Subzone. Most of the Valanginian stage is not represented in the remainder of the rock sequence, so it is possible that some of the

fossils in the glauconitic strata above it are reworked (reworked ammonites are found among the phosphatic nodules). The base of this glauconitic succession is a conglomerate consisting mainly of belemnites and phosphatic ammonites. Occasionally, the basal bed of this conglomerate is a nearly monospecific layer of the belemnite *Duvalia binervia* (RASPAIL, 1829).

Ravin du Mal Bouisset (RMB), Peyroules area (Fig. 4): The lithologic succession of this section is comparable to the sequence at Clausson and Collet des Boules, from which it differs by the absence of a basal conglomerate. The section was figured by AUTRAN (1993).

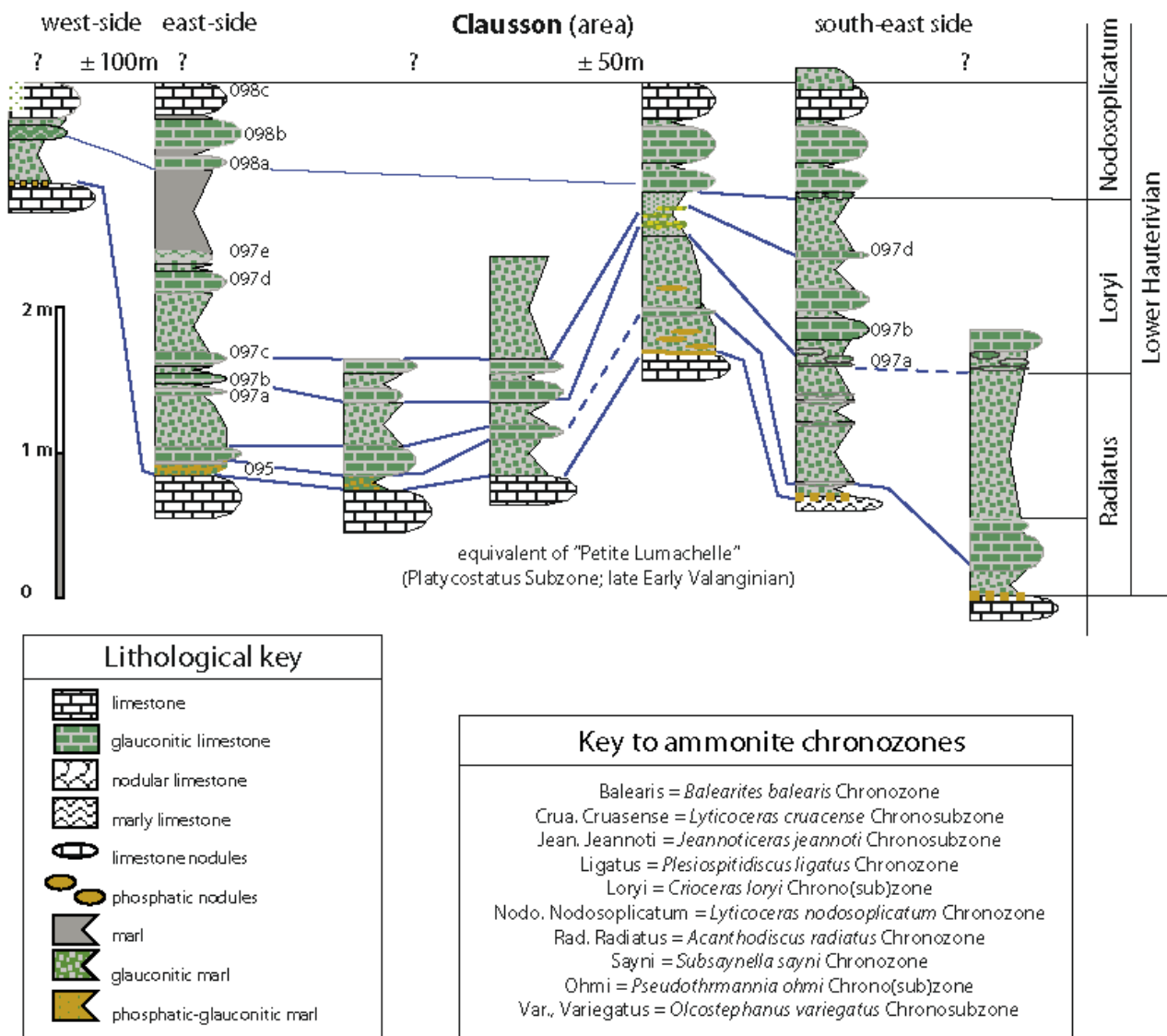


Figure 2: Correlation of sections in the Clausson region (CL; Peyroules area), showing the variations in lithology and thickness of the glauconitic sediments of Early Hauterivian age. Note the absence of a phosphatic basal conglomerate in some sections, and especially the variation in beds CL096 to 097d. The sections figured are sited in approximate accordance with their geographic position, from west to south-east. Note the extreme condensation in the western section which is but 100 m from the first east-side column. The changes in the eastern columns occur over a distance of about 50 m. Vertical scale graduations = 1 m.

Collet des Boules (CB), Peyroules area (Figs. 5-7): Outcrops of this sedimentary sequence are comparable to those of the above-mentioned exposures, for the beds dated Early Valanginian are succeeded by glauconitic sediments. However, a basal glauconitic-phosphatic conglomerate is for the most part absent. In the easternmost exposure of the Collet des Boules area, the glauconitic succession is quite different (Fig. 5; middle and right lithological columns), for here the section is comparable to the succession exposed near La Lagne. In addition, glauconitic levels occur near the top of the Lower Hauterivian succession (Fig. 5), and in some beds of Late Hauterivian age (Figs. 6-7). Rocks representing the uppermost Hauterivian at Collet des Boules (Fig. 7) are characterized by an increase in the thickness and induration of the limestones, which form a small crest in the topography (the *Pseudothurmannia*-beds with possibly a few

beds dated earliest Barremian). These resistant limestones are followed by sandy to marly Albian strata in an erosional relationship.

La Lagne (LLG) (Fig. 8): This profile is exposed south of Castellane. With the exception of some thick, glauconite-rich beds with abundant cephalopods, the limestones are often irregular, nodular, and are well exposed only in weathered profiles. Strata of latest Hauterivian to earliest Barremian age are followed by Albian sandstones and marls.

Les Allaves (ALL) (Fig. 9): Exposures in the area between Les Allaves and the Ravin du Carrine are typical condensed outer-platform deposits with many variations in lithology. In contrast to the Peyroules area, strata of latest Early Valanginian to Late Valanginian age in the Les Allaves area are rich in marls with abundant echinoids and belemnites. Generally, the ammonite zones that characterize the Late

Valanginian are expressed in only a few thin limestones, separated by relatively thick marls (see DAVID, 1979; THIEULOUY *et alii*, 1991; BULOT, 1995; REBOULET, 1996). These marls contain typical Upper Valanginian belemnite species: *Duvalia* gr. *binervia* (*D. binervia*, *D. sp. 1*), *Adiakritobelus* spp., and *Hibolithes* gr. *subfusiformis* RASPAIL, but *Pseudobelus* sp. appears to be rare. The beds of earliest Hauterivian age are characteristically developed in a glauconitic facies. However, glauconite is

clearly less abundant than it is in the Peyroules area, while on the other hand there are many marly limestones with well-developed levels of nodules. With the exception of the base of the *Crioceratites loryi* Zone (*C. loryi* Subzone; glauconitic facies) the strata representing the upper Lower Hauterivian and Upper Hauterivian are marl-rich ("hemipelagic facies"). A striking feature is the abundant occurrence of nautilids throughout the succession.

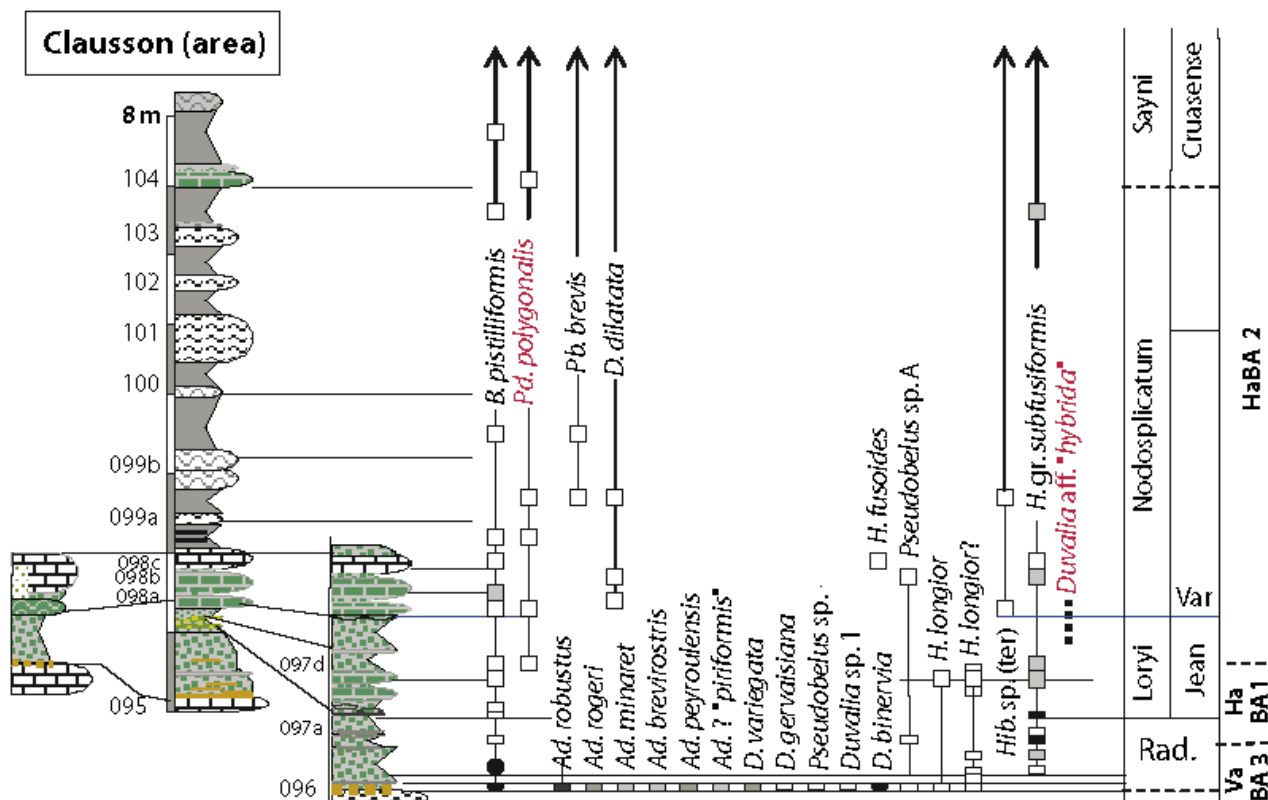


Figure 3: Belemnite distribution in the Clausson area (Peyroules), beds CL095 - CL104a. Three columns are figured, approximately 300 metres apart (see Fig. 2 for comparison of distances) showing bed-numbers, their correlation, and their lithology. The distribution of the belemnites in these columns (with data from the columns depicted in Fig. 2 added) is given on the right, along with ammonite- (sub)zones, and belemnite associations. Key in Figs. 2 and 4. Scale bar graduations = 1 m. The following species were collected as free material below the base of the glauconitic succession: *Duvalia* gr. *dilatata* (BLAINVILLE), *Duvalia* cf. *maioriana* (STOYANOVA-VERGILOVA) or *Duvalia* sp. 2 (= *D. clapiti* GAYTE [-unpublished-: *nom. nud.*]), *Duvalia* aff. "hybrida" (DUVAL-JOUVE), and *Duvalia* sp. 4.

In the sections we measured there are many small faults. So we could not compare our profiles directly with the succession depicted by BULOT (1995, fig. 32; in particular as regards the thickness of the *C. loryi* Subzone) and also because bed 112d (base of *Acanthodiscus radiatus* Biozone in THIEULOUY *et alii*, 1991, fig. 6) could not be recognized. With these two exceptions, their bed numbers could be correlated with a fair degree of reliability. A basal conglomerate appears to be present only rarely in the Allaves area.

Pas d'Escaie (PE) (Fig. 10): Here the lowermost Hauterivian (*A. radiatus* Zone) sequence is marl and limestone with abundant glauconite, phosphatic nodules and belemnites. Cephalopods are often concentrated, and occur in alternate layers of belemnites and ammonites (sorting?). The strata below these glauconitic beds are not well exposed due to

recent erosion and plant growth. Apparently, specifically determinable ammonites are rare in these beds (ROBERT, 1994; BULOT, 1995). The bed numbers used by these authors were transferred to the extent possible. The strata at the base of the Hauterivian are more or less comparable, both in thickness and lithology, to the beds in the Les Allaves area. Notable is the occurrence of *Crioceratites loryi* in PE211e-f (summit of highstand). These levels correlate with the glauconitic marl above bed ALL116 (Les Allaves; Fig. 9). We collected the ammonite *Jeannoticeras jeannoti* from the glauconitic marl above bed PE213a.

The Angles Barremian Stratotype Section (ABSS): The ABSS sequence is exposed along the road to the hamlet of Angles (THIEULOUY, 1979), where rocks of latest Hauterivian age yielded but few belemnites. According to VERMEULEN (2002, p. 27-31) the

lowest beds of this section represent the *Balearites balearis* Zone. Note that the first two beds (bed 1 and 1a) of this outcrop are not figured: they may represent either the *B. balearis* or the *Plesiospitidiscus ligatus* Zone. Some 80-90 limestone-marl interbeds comprise the succession up to the Hauterivian-Barremian boundary at bed 72. Most of the belemnites are

Hibolithes gr. *subfusiformis* RASPAIL. In the marl above bed 73 the first typical earliest Barremian belemnite *Duvalia binervia* RASPAIL (= *Duvalia silesiaca* UHLIG, 1902) occurs. *Hibolithes*-like belemnites are still rather common in the exposures of lowermost Barremian strata but disappear in late Early Barremian times (CLÉMENT, 2000; JANSSEN & FÖZY, 2005, p. 66).

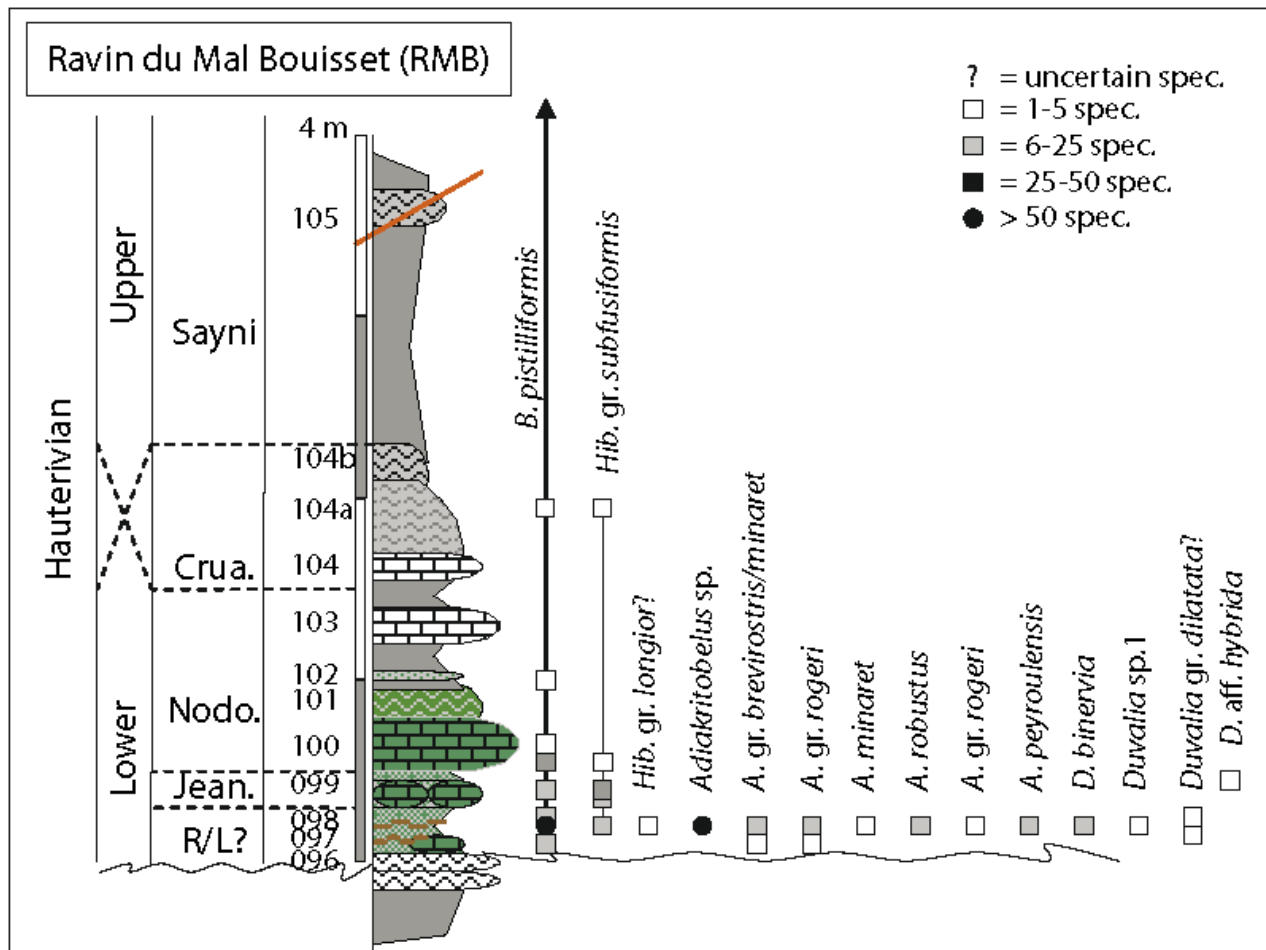


Figure 4: Valanginian-Hauterivian in the Ravin du Mal Bouisset (RMB) near Clausson area (see Fig. 1). Indicated are (sub-)stages, ammonite zones, bed-numbers, lithology and belemnite distribution. Scale bar indicated (1 m interval). Key: R/L? = *Acanthodiscus radiatus* or *Crioceratites loryi* Zone, for explanation of other ammonite zone abbreviations (see Fig. 2 for key). Scale bar graduations = 1 m.

In the Angles section data concerning the Early Hauterivian are sporadic, for the beds of this age are poorly exposed owing to an extensive cover of vegetation and scree. There is no uninterrupted succession of exposures, with the exception of the lowermost Hauterivian portion, which includes the *Acanthodiscus radiatus* Zone and the latest *A. radiatus* to earliest *Crioceratites loryi* zones. These upper beds are slumped; they are the top of the Angles Valanginian Hypostratotype Section (AVHS) as it crops out in the Angles section. In one of the slumped beds a very elongated, long grooved *Hibolithes*-like species occurs. It resembles very closely an immature *Hibolithes longior* (SHVETSOV, 1913, Pl. III, figs. 2.d, 2.g). Similar specimens occur earlier in the *A. radiatus* Zone (bed 386; Pl. 2, figs. 15-16). Few belemnites were collected from the succession above the slumped beds immediately after the

A. radiatus Zone. This interval consists of densely packed thick beds of limestones (apparently in the *C. loryi* Zone) with: *H. gr. subfusiformis* RASPAIL, *Duvalia* cf. *dilatata binervioides*? (STOYANOVA-VERGILOVA, 1965), and *D. gr. dilatata* (BLAINVILLE, 1827).

Cheiron section (CHE) (Fig. 11): The Cheiron area is of historical importance for cephalopod research because many species have been described from this area, which is now partly covered by an artificial lake (Lac de Castillon). However, when water-levels are low, the succession of Valanginian strata is more or less continuously exposed and easily accessible. Strata of Late Valanginian and Early Hauterivian ages remain exposed along the shore of the lake and in the hills to the west of the lake. Compared to the Angles section, the Cheiron section has more complex limestones. Some minor slumped levels exist in the Late

Valanginian *Olcostephanus nicklesi* and *Criosarasinella furcillata* zones and also in the Early Hauterivian *Crioceratites loryi* Zone. A small number of belemnites was also collected

(Fig. 11). Interestingly, the alveolar of these belemnites is often missing, suggesting physical damage by predation, by transportation, or a combination of both.

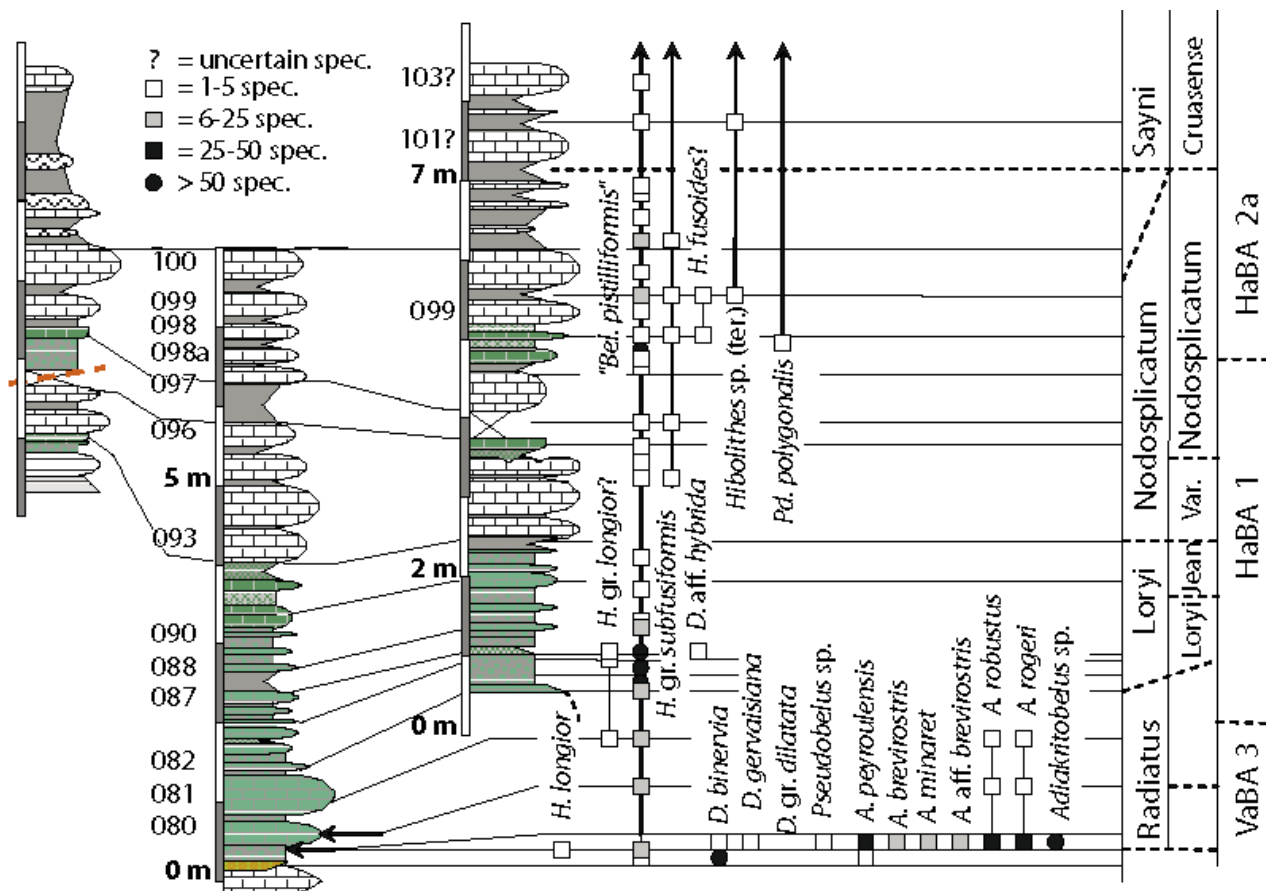


Figure 5: Correlation of three field-sections in the Collet des Boules: beds CB078 to CB100/103?. Lithology (see Figs. 2 and 4 for key), bed-numbers, belemnite distribution, ammonite (sub-)zones, and belemnite associations are shown. Scale bar graduations = 1 m. Key: A. = *Adiakritobelus*, Bel. = *Belemnites*, D. = *Duvalia*, H. = *Hibolites*, Pd. = *Pseudoduvalia*.

Late Valanginian to Early Hauterivian ammonite stratigraphy

Recently the "KILIAN Group" proposed an emended standard zonation for the ammonites of the Lower Cretaceous based on intensive research over the past years (REBOULET & HOEDEMAEKER *et alii*, 2006). Many details have been published concerning the ranges of ammonites in the Lower Hauterivian glauconitic facies (ARNAUD & BULOT, 1992; AUTRAN, 1993; BULOT, 1995; BULOT *et alii*, 1996; REBOULET, 1996) but there are also several regarding deeper-water deposits (Angles, La Charce: THIEULOUY, 1977b; BULOT *et alii*, 1993, 1996; THIEULOUY & BULOT, 1993; REBOULET, 1996; REBOULET & ATROPS, 1999). Figures 12-14 summarize the data from these sources and compare deep and shallow water environments with respect to the lithology and distribution of ammonites. Only some of the "important" ammonite species and genera are shown, their positioning based on a correlation of the various outcrops discussed in the above references. The combination of the stratigraphic distribution of

ammonites and the associated lithology is used to make sequence stratigraphic interpretations in the several palaeogeographic domains.

Some apparent discrepancies in stratigraphic relationships seem to be present in the successions that span the transition between the Lower and Upper Hauterivian. Most probably they are caused by a misinterpretation of some ammonite index species (see Fig. 13). This failing seems most common in the lack of understanding of ontogenetic variation, genetic relationships and development of speciation in the genus *Lyticoceras* and in the species *Cruasicerus cruasense* TORCAPEL *s.s.* Moreover, data are sparse and inconsistent in their interpretation of index species (*e.g.* *Balearites balearis* (NOLAN) *s.s.*) so the zonal scheme for parts of the Hauterivian is to some extent provisional.

Belemnite distribution

To create a widely applicable biozonation based on belemnites, the author chose first to determine the characteristics of the associations of the faunas as they relate to the discrete

lithologic successions laid down in the several marine environments. Eventually a combination of these associations along with more detailed knowledge concerning the vertical and

horizontal distribution of belemnites should lead to a well-founded biozonation. These associations will be numbered successively according to their stratigraphic position within a stage.

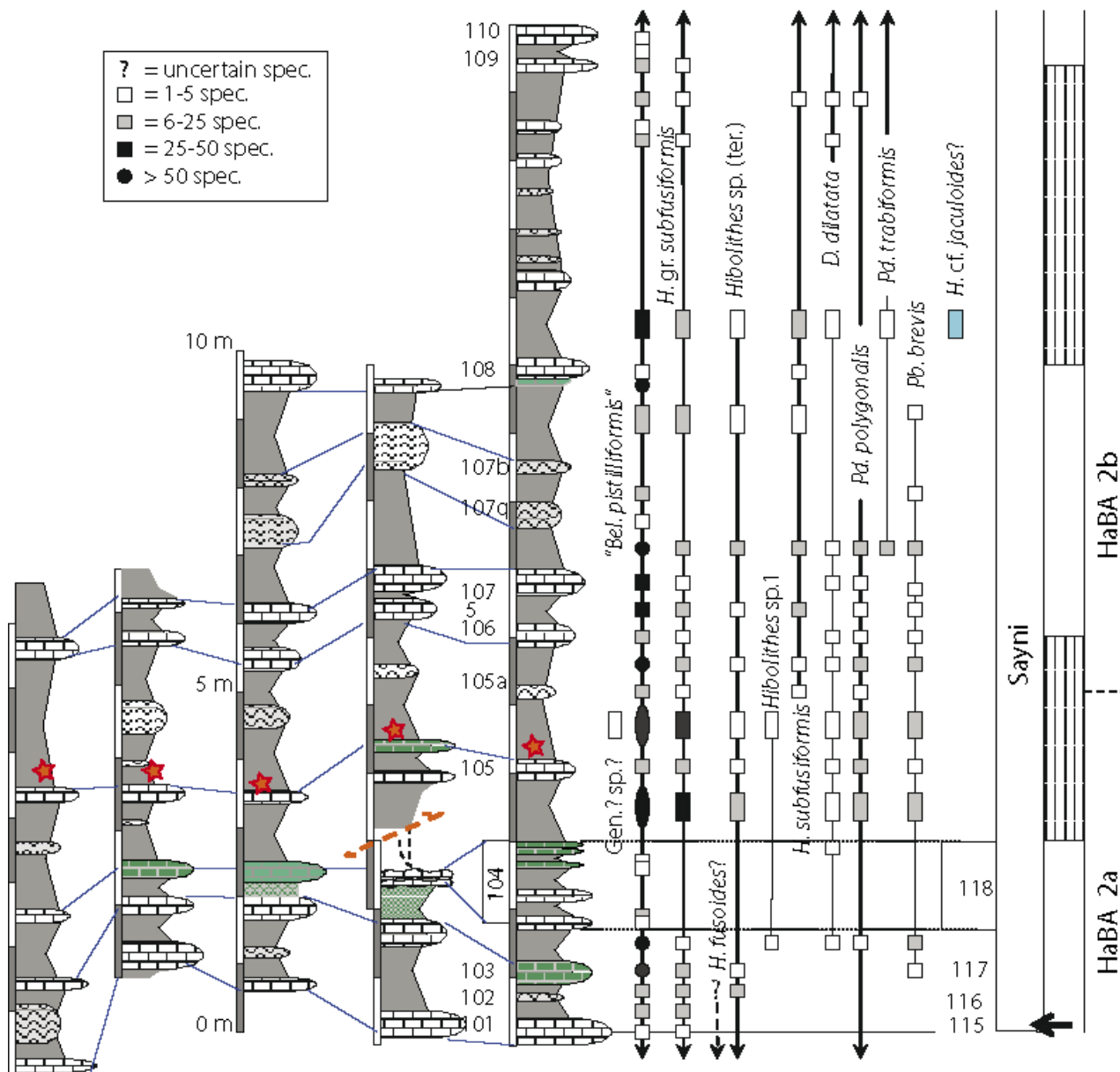


Figure 6: Correlation of five field-sections in the Collet des Boules area: beds CB101 to CB109/110, all within approximately 100 meters of each other. Indicated are lithology (key in Fig. 2), bed-numbers, belemnite distribution, bed-numbers *sensu* VERMEULEN, 2002 (beds 115-118 on right), ammonite zones, sequences, and belemnite associations. Black arrow indicates position of (first?) occurrence of *Subsaynella sayni* (after VERMEULEN, 2002). Key: Bel. = *Belemnites*, D. = *Duvalia*, Gen. = Genus, H. = *Hibolithes*, Pb. = *Pseudobelus*, Pd. = *Pseudoduvalia*. Red star indicates occurrence of *Isocrinus peyroulensis* (LORJOL). Scale bar graduations = 1 m.

Valanginian Belemnite Association 3 (VaBA3; see JANSSEN & CLÉMENT, 2002): In the Vocontian basin the sedimentary record of the Late Valanginian (above the *Saynoceras verrucosum* Horizon) is characterized by a significant change in the composition of the belemnite faunas (JANSSEN & CLÉMENT, 2002). This interval, that includes the *Vartheideites peregrinus* to *Criosarasinella furcillata* zones, is comprised of sets of beds with associations dominated by *Duvalia binervia* (RASPAIL, 1829), that alternate with sets of beds without a dominant belemnite species. In the Peyroules

area the *binervia*-bearing strata appear to be correlative with the uppermost of these intervals. There, above the *binervia*-bed and still in the environment that causes the deposition of condensed phosphatic and glauconitic sediments are several species of belemnites, among them: *Duvalia gervaisiana* (DUMAS, 1876), *D. variegata* (RASPAIL, 1829; = *D. hybrida* (DUVAL-JOUVE, 1841)), *D. aff. variegata* (RASPAIL, 1829), *Duvalia* sp. 1 (= *D. vaunagensis* GAYTE, 1984 [-unpublished-, *nom. nud.*]), *Pseudobelus* sp. indet., *Pseudobelus* sp. A (in JANSSEN & FÖZY, 2004), *Hibolithes* gr.

subfusiformis RASPAIL, *H. longior* SHVETSOV, 1913, *Hibolithes* sp., *Vaunagites* sp., and *Adiakritobelus* JANSSEN & FÖZY, 2004. This genus is particularly abundant with the species: *Adiakritobelus brevisrostris* (RASPAIL, 1829), *A. minaret* (RASPAIL, 1829), *A. robustus* (DUVAL-JOUVE, 1841), *A. rogeri* (DELATTRE, 1952), *A. brevisrostris* (RASPAIL, 1829), *A. gr. rogeri*

(DELATTRE, 1952), *Adiakritobelus peyroulesensis* sp. nov., and *Adiakritobelus (?) gayteae* sp. nov. Other forms, in part juvenile and immature Mesohibolitidae, like *Belemnites pistilliformis* BLAINVILLE, predominate in certain levels. All these species are a part of the VaBA3 association and may occur up to the lowest levels of the *A. radiatus* Zone.

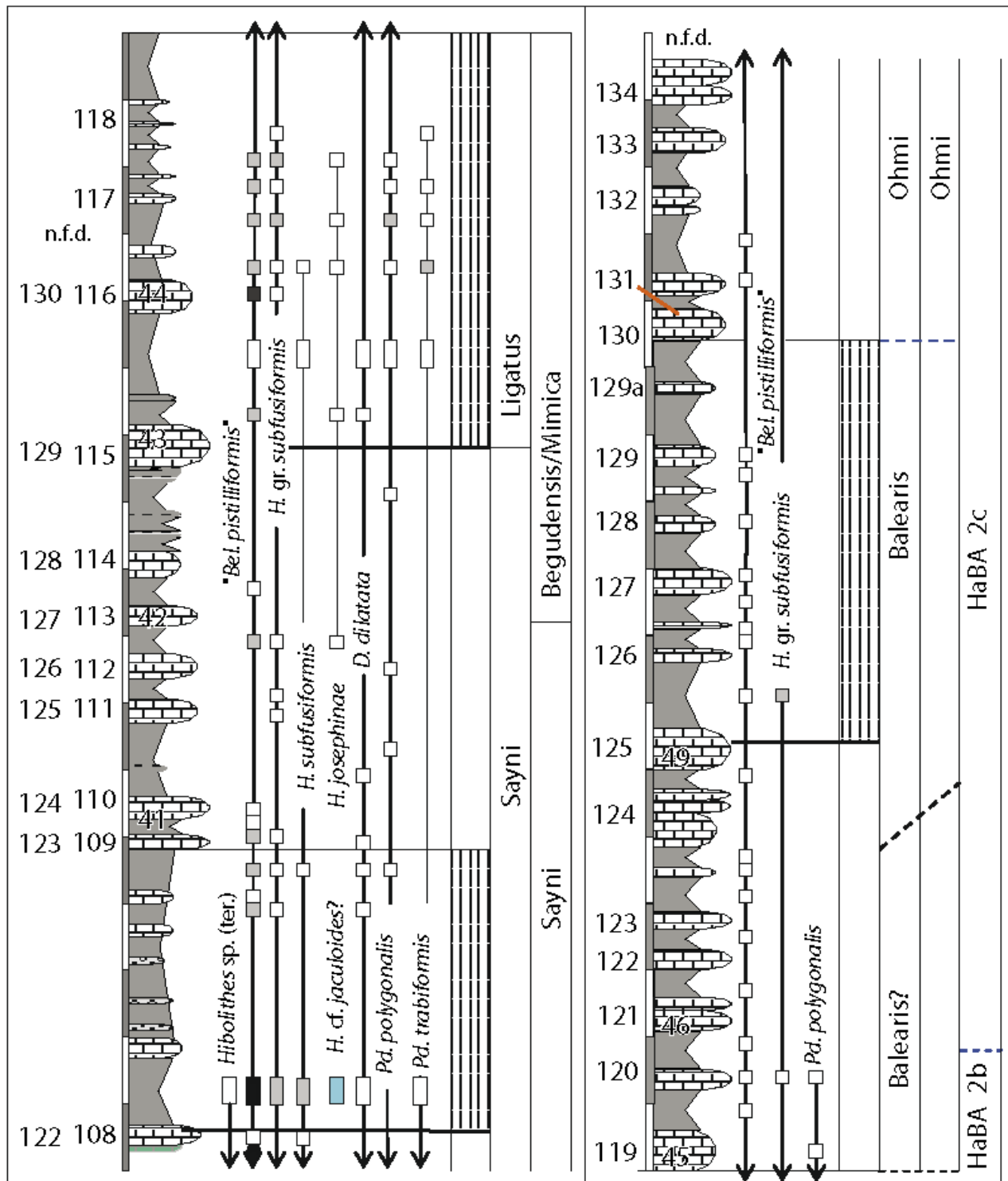


Figure 7: Late Hauterivian sequences in the Collet des Boules (beds CB108-134) with bed-numbers, lithology (key in Fig. 2), belemnite ranges, sequences, and ammonite (sub)zones. Abbreviations used: Bel. = *Belemnites*; D. = *Duvalia*; H. = *Hibolithes*; Pd. = *Pseudoduvalia*. Bed numbers after BULOT (1995, beds: 40 to 49), VERMEULEN *et alii*, 1999, VERMEULEN, 2002 (beds 122 to 130), pers. obs. (beds: CB108 to CB134). Note that BULOT (1995) indicated *Balearites* sp. to occur in bed 45 (= 119). Scale bar graduations = 1 m.

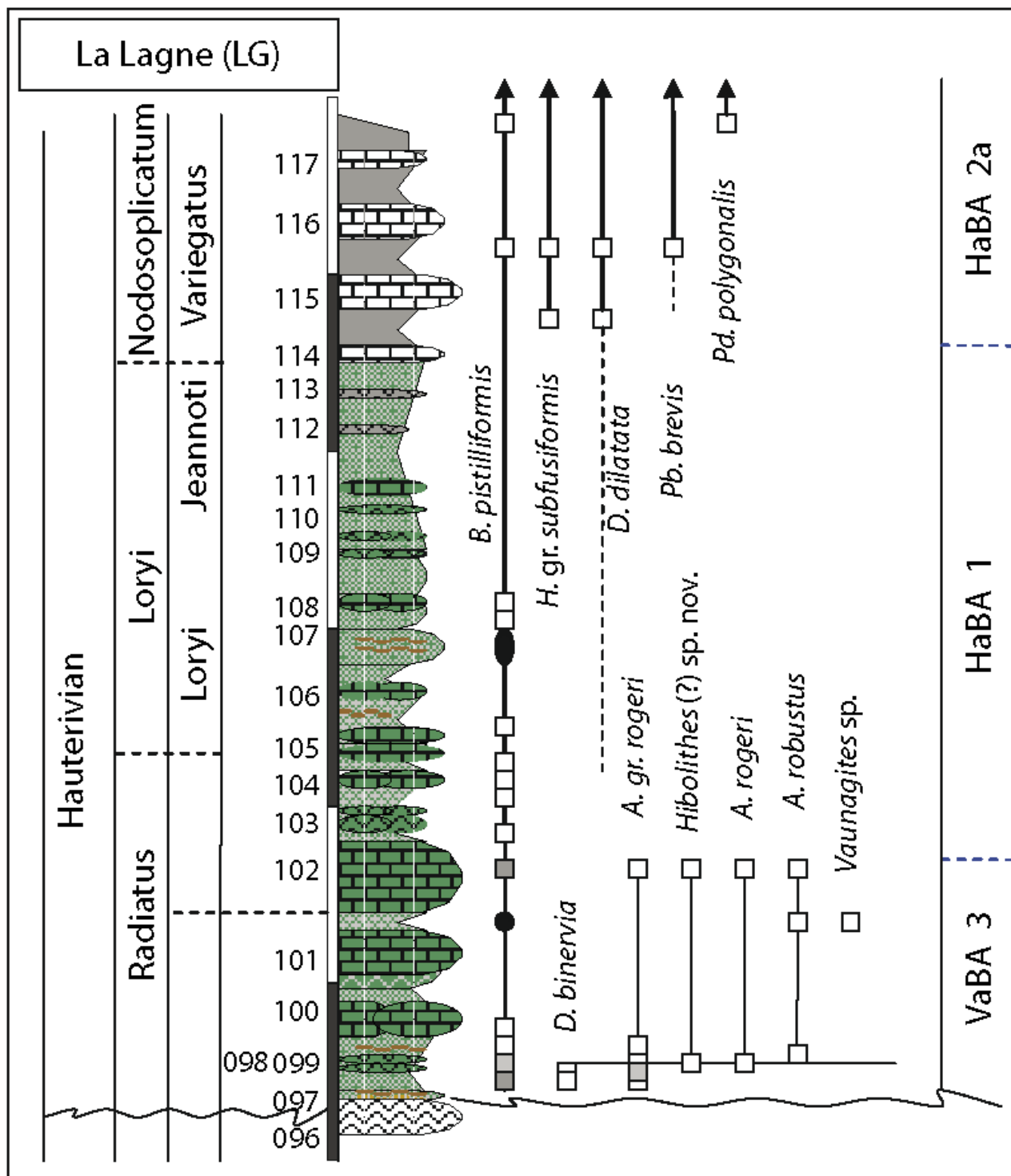


Figure 8: Valanginian-Hauterivian section in the La Lagne area. Indicated are stage, ammonite (sub)zones, bed-numbers, lithology and belemnite distribution. Key to lithology and abbreviations in Figs. 2 and 4. Scale bar graduations = 1 m.

Hauterivian Belemnite Association 1 (new association) (**HaBA1**): Although still present in the glauconite-generating succession, Duvaliidae become rare, both in and above the *A. radiatus* beds. What may be a new species appears at this level and it is named provisionally *Duvalia* aff. "hybrida" (DUVAL-JOUE). It is most probably the ancestor of the *Pseudoduvalia*. Here too appear sporadically the first strongly compressed species, possibly assignable to *Duvalia* gr. *dilatata* (BLAINVILLE).

Mesohibolitidae, especially *Hibolithes* gr. *subfusiformis* RASPAIL and some very elongate forms are the major constituents of this belemnite faunal association. Some of these very elongated forms are representatives of *Belemnites pistilliformis* BLAINVILLE resembling or equivalent to *Vaunagites* COMBÉMOREL & GAYTE, 1981, while others are various ontogenetic stages of *Hibolithes longior* SHVETSOV, 1913. This association is transitional, between association VaBA3 and the association above it,

HaBA2. In the standard ammonite zonation its range encompasses the upper part of the

Acanthodiscus radiatus Zone and the base of the *Crioceratites loryi* Zone (Fig. 15).

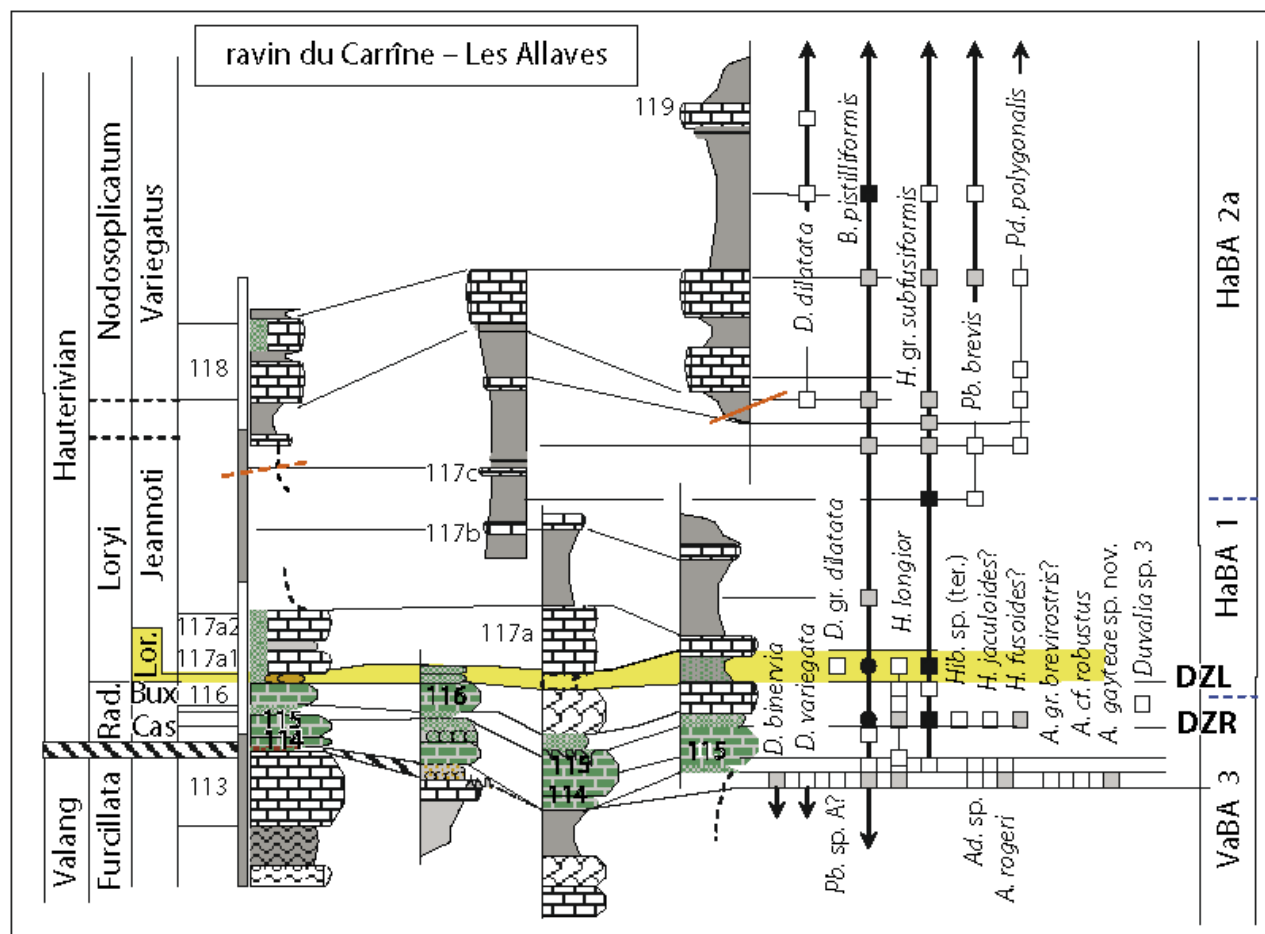


Figure 9: Comparison of lithology and belemnite distribution in strata of Valanginian–Hauterivian age in the Les Allaves area (between Les Allaves profile and the Ravin du Carrîne (southwest of Les Allaves)). In columns to the left of the seven profiles are stages, ammonite zones (modified after: THIEULOUY *et alii*, 1991; BULOT, 1995; pers. obs.) and bed-numbers (modified after BULOT, 1995). Abbreviations used: Ad. = *Adiakritobelus*; B. = *Belemnites*; Bux. = *Leopoldia buxtorfi* Subzone *sensu* ARNAUD & BULOT, 1992; Cas = *Breistrofferella castellanensis* Subzone; D. = *Duvalia*; H. = *Hibolithes*; Pb. = *Pseudobelus*; Pd. = *Pseudoduvalia*; Valang. = Valanginian. See Figs. 2 and 4 for key to lithology and abbreviations. Scale bar graduations = 1 m.

Hauterivian Belemnite Association 2 (new association) (**HaBA2**): The first valid representatives of *Pseudobelus brevis* PAQUIER and the genus *Pseudoduvalia* occur in the *Jeannoticeratites jeannoti* Subzone. They are characteristic faunal elements of the new association (HaBA2), and occur together with typical *Duvalia dilatata* (BLAINVILLE). This species is common, especially in strata bridging the Lower - Upper Hauterivian boundary. Belemnites in the pelagic sediments of the Col de Rousset section, north of Die (Drôme, France; unpublished data) have comparable associations and stratigraphic relationships. The stratigraphic range of HaBA2 spans the *J. jeannoti* Subzone, the *Lyticoceras nodosoplicatum* Zone, and attains the Hauterivian-Barremian boundary. However, in the Peyroules region the belemnite data from the upper part of the localities studied are too few to define precisely the upper boundary. Nevertheless, a threefold division of this association appears feasible, based on the first occurrence (= FO) of

Pseudoduvalia polygonalis (BLAINVILLE) and/or *Pseudobelus brevis* PAQUIER (HaBA2a; Fig. 15), the FO of true *Hibolithes subfusiformis* (RASPAIL, 1829) (HaBA2b; Fig. 15), and the presence or absence of *P. brevis* PAQUIER along with *D. dilatata* (BLAINVILLE) and *Pseudoduvalia* spp. (HaBA2c; Fig. 15). Apparently, *Pseudobelus* becomes extinct near the middle of the *Subsavnella sayni* Zone and the youngest specimens of *Pseudoduvalia* are found near the boundary between the *P. ligatus* Zone and the *B. balearis* Zone (Peyroules area and unpublished data from Vallon de Valbonette near Barrême, southeastern France, pers. obs.), while the range of *D. dilatata* (BLAINVILLE) ends at the Hauterivian - Barremian boundary. Although the upper portion of these Hauterivian strata in a hemipelagic facies is exposed poorly, it is one of the most nearly continuous exposed sections of the outer slope to pelagic deposits of the Angles Barremian Stratotype (ABSS). The main constituent of the belemnite fauna appears to be the family Mesohibolitidae.

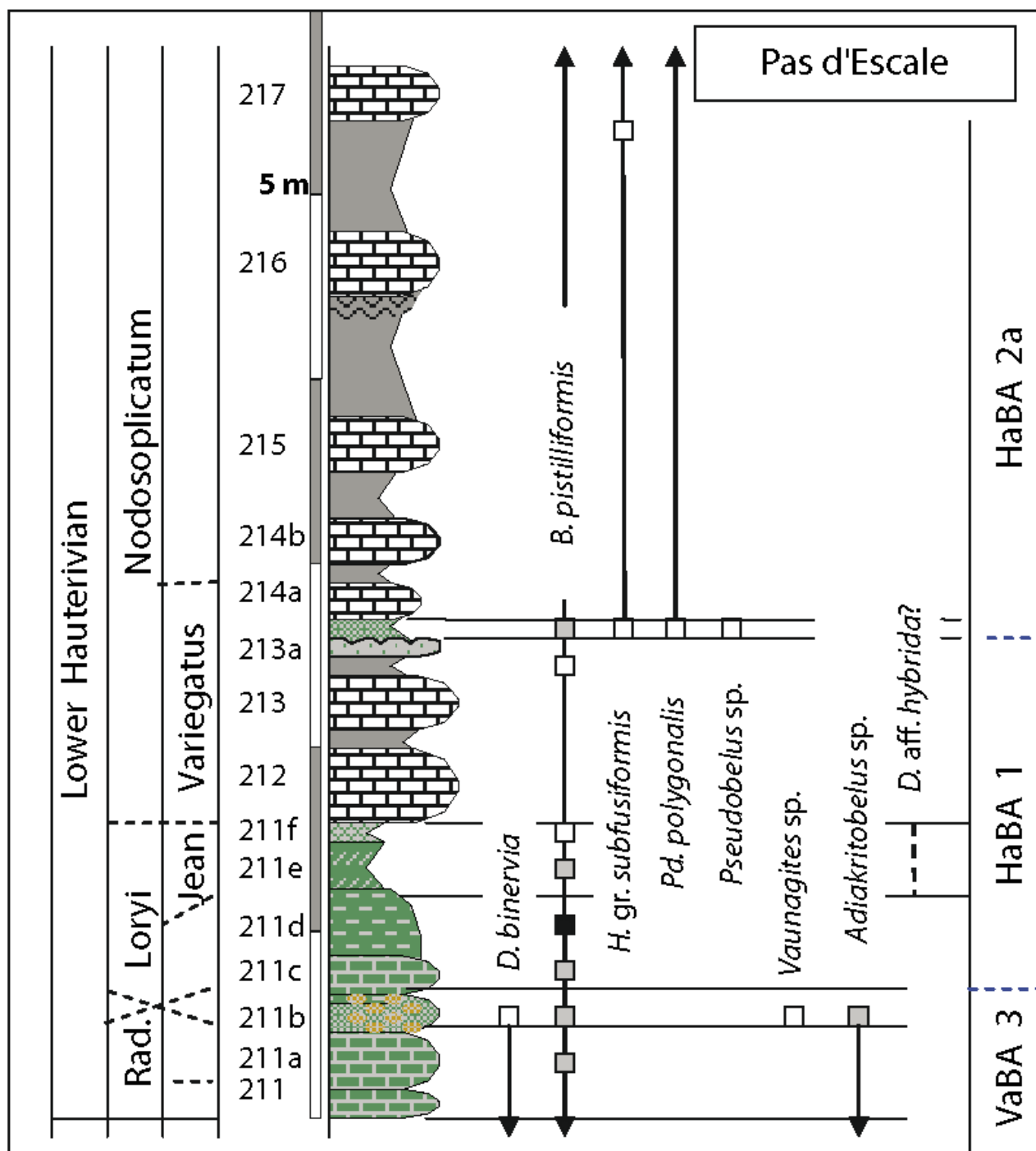


Figure 10: Lower Hauterivian sequence in the Pas d'Escale area. Indicated on the left are stages, ammonite (sub)zones, bed-numbers (modified after ROBERT, 1994; BULOT, 1995), and lithology, belemnite distribution and zonation on right. For abbreviations see Figs. 2 and 4. Free specimens from glauconitic beds include: *Duvalia* sp. 1 (?) and *Adiakritobelus rogeri* (DELATTRE, 1952). Scale bar graduations = 1 m.

In the ABSS the belemnite fauna in strata of Late Hauterivian age is mainly *Hibolites* gr. *subfusiformis* RASPAIL and subordinate *Hibolites* gr. *jaculiformis* (SHVETSOV, 1913). The former is almost circular in cross-section while the latter is clearly elliptical. A small morph of *D. dilatata binervioides* (STOYANOVA-VERGILOVA, 1965) was collected in the lower part of the *B. balearis* Zone (bed 9-10). This specimen shows some

binervia-like characteristics that may indicate an ancestral affinity to the smaller, earliest Barremian *Duvalia silesiaca* UHLIG, 1902. This rather impoverished association of belemnites is characteristic of the latest Hauterivian when genera such as *Pseudobelus* and *Pseudoduvalia* became extinct. The Duvaliidae and also the Mesohibolitidae show more diversity in the earliest Barremian.

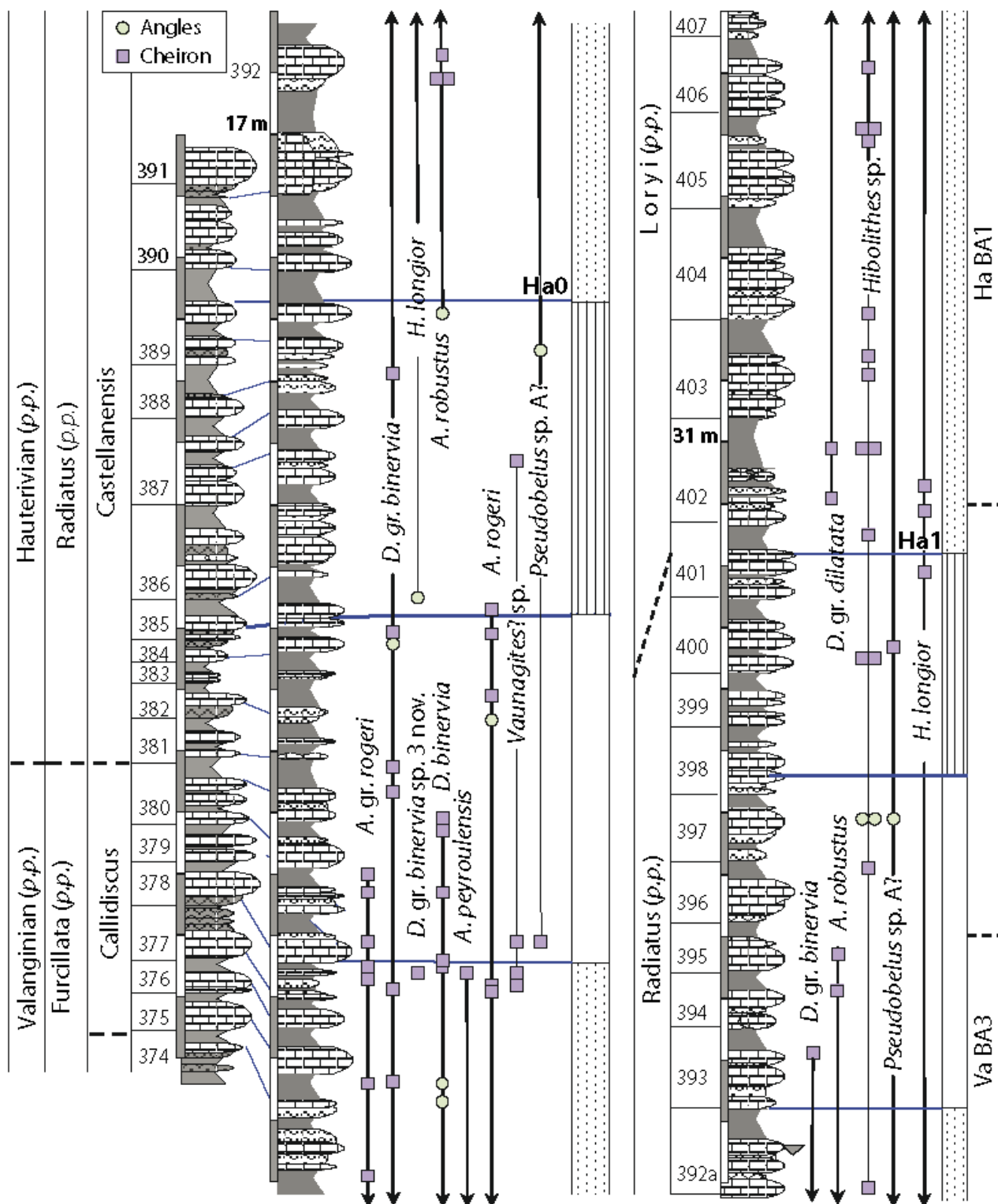


Figure 11: Valanginian-Hauterivian boundary and lowermost Hauterivian beds in the Cheiron section. Bed-numbers according to their equivalents in the Angles Valanginian Hypostratotype. Indicated are: stages, ammonite zonation (zones and subzones), bed-numbers, lithology (key in Fig. 2), sequences (Va6 (p.p.), Ha0 (new sequence), and Ha1), and belemnite distribution (from Cheiron and Angles both). Key: A. = *Adiakritobelus*, D. = *Duvalia*, H. = *Hibolithes*. Small triangle indicates occurrence of *Pygope*. Scale bar graduations = 1 m.

Basin facies

In the VaBA3 association the stratigraphic distribution of belemnites is based primarily on their occurrences in the Angles, Source de l'Asse de Moriez, La Charce, and Vergol areas (see JANSSEN & CLÉMENT, 2002). More recent

data allow a more precise correlation, and suggest that the base of VaBA3 can be fixed at bed 308 (Angles) or at bed 107 (Vergol), both of which are at the upper limit of the *S. verrucosum* Subzone (in the "*Neocomites neocomiensis* Subzone" *sensu* ATROPS & REBOULET, 1993). The interval thus bounded is

characterized by abundant *Hibolites* cf. *jaculoides* SWINNERTON (see JANSSEN & CLÉMENT, 2002), a form that contrary to previous findings, occurs first in the uppermost levels of the *S. verrucosum* Horizon, but is most abundant in the "*N. neocomiensis* Subzone" and at the base of the *Karakaschiceras*

pronecostatum Subzone (Fig. 15). It continues to occur in fluctuating abundances throughout the *K. pronecostatum* Subzone, the *V. peregrinus* Subzone up to the base of the *Olcostephanus nicklesi* Subzone (Fig. 16). And scattered occurrences have been recorded in younger strata.

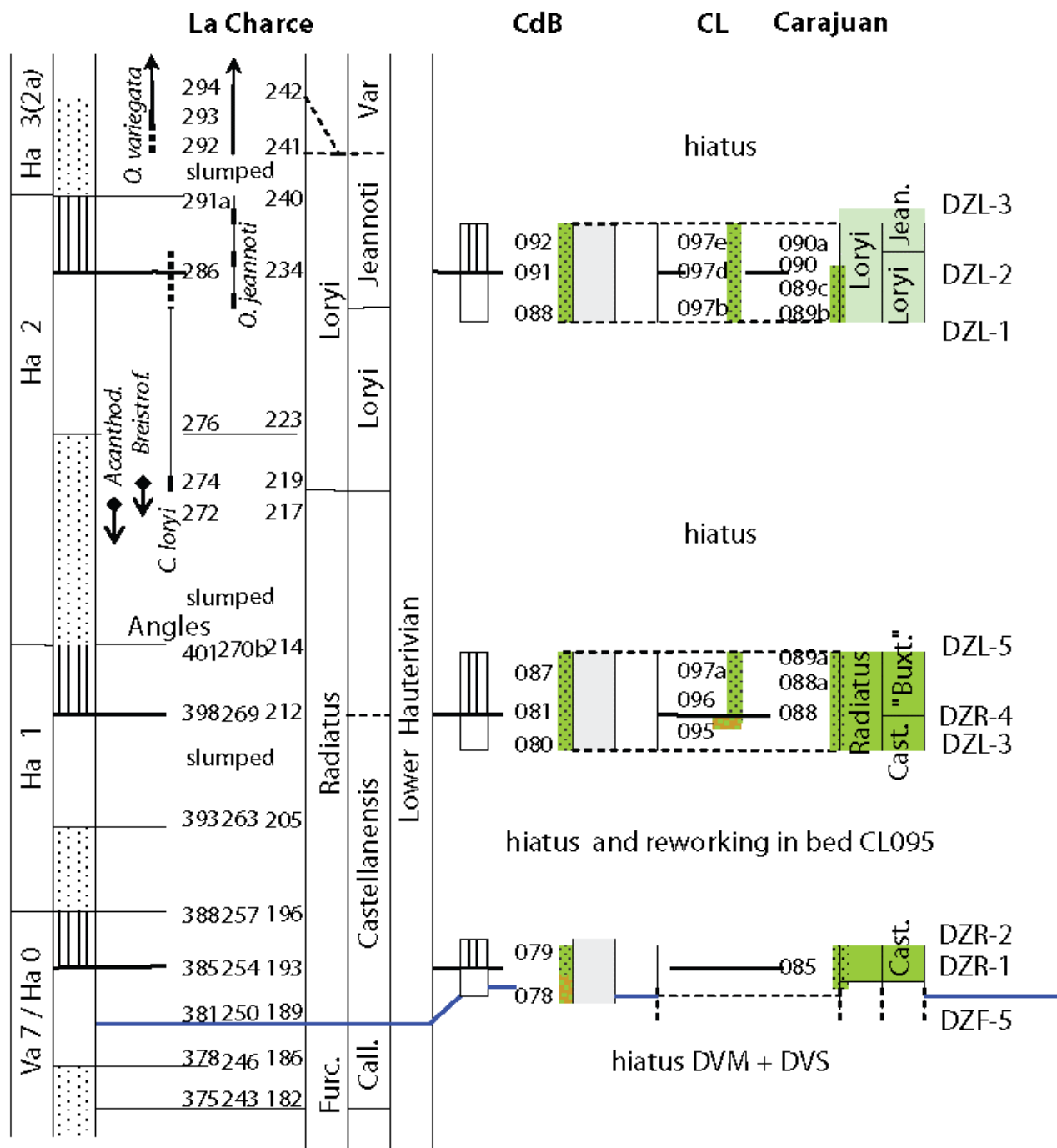


Figure 12: Correlation of ammonite distribution in Lower Hauterivian deep-water deposits (Vocontian Basin: La Charce, bed-numbers after BULOT (243-294) and REBOULET (182-242); Angles (375-401)) and shallow depositional areas (glauconitic platform deposits of Peyroules and platform "type section" of Carajuan, see ARNAUD & BULOT, 1992). Some stratigraphically important ammonite species and genera are indicated (after BULOT, 1995; BULOT *et alii*, 1996; REBOULET, 1996; VERMEULEN, 2002). Bed-numbers refer to calcareous beds only. Abbreviations used: Acanthod. = *Acanthodiscus*; Breistrof. = *Breistrofferella*; Call. = *Teschenites callidiscus* Subzone; C. = *Crioceratites*; Furc. = *Criosarasinella furcillata* Zone; L. = *Lyticoceras*; O. = *Olcostephanus*; S. = *Subsarynella*. Key in Figs. 2 and 4.

Another characteristic of VaBA3 appears to be the fluctuations in the occurrences of *Duvalia* gr. *binervia* (RASPAIL). The early Late

Valanginian (base of VaBA3) is characterized by *D. binervia* (RASPAIL) and *D. aff. gervaisiana* (DUMAS, 1876; = DUVAL-JOUE, 1841, Pl. III, fig.

6). Near the boundary between the *V. peregrinus* and *O. nicklesi* Subzones these species are replaced by *D. binervia* (RASPAIL) and *D. variegata* (RASPAIL, 1829). Another species of the *binervia*-group (*Duvalia* sp. 1) appears first in the *Criosarasinella furcillata*

Zone, and *D. variegata* may become extinct in the middle of the *C. furcillata* Zone (Fig. 16). *Duvalia* sp. 2 occurs only in the lowest beds of Hauterivian age (middle of the *Acanthodiscus radiatus* Zone).

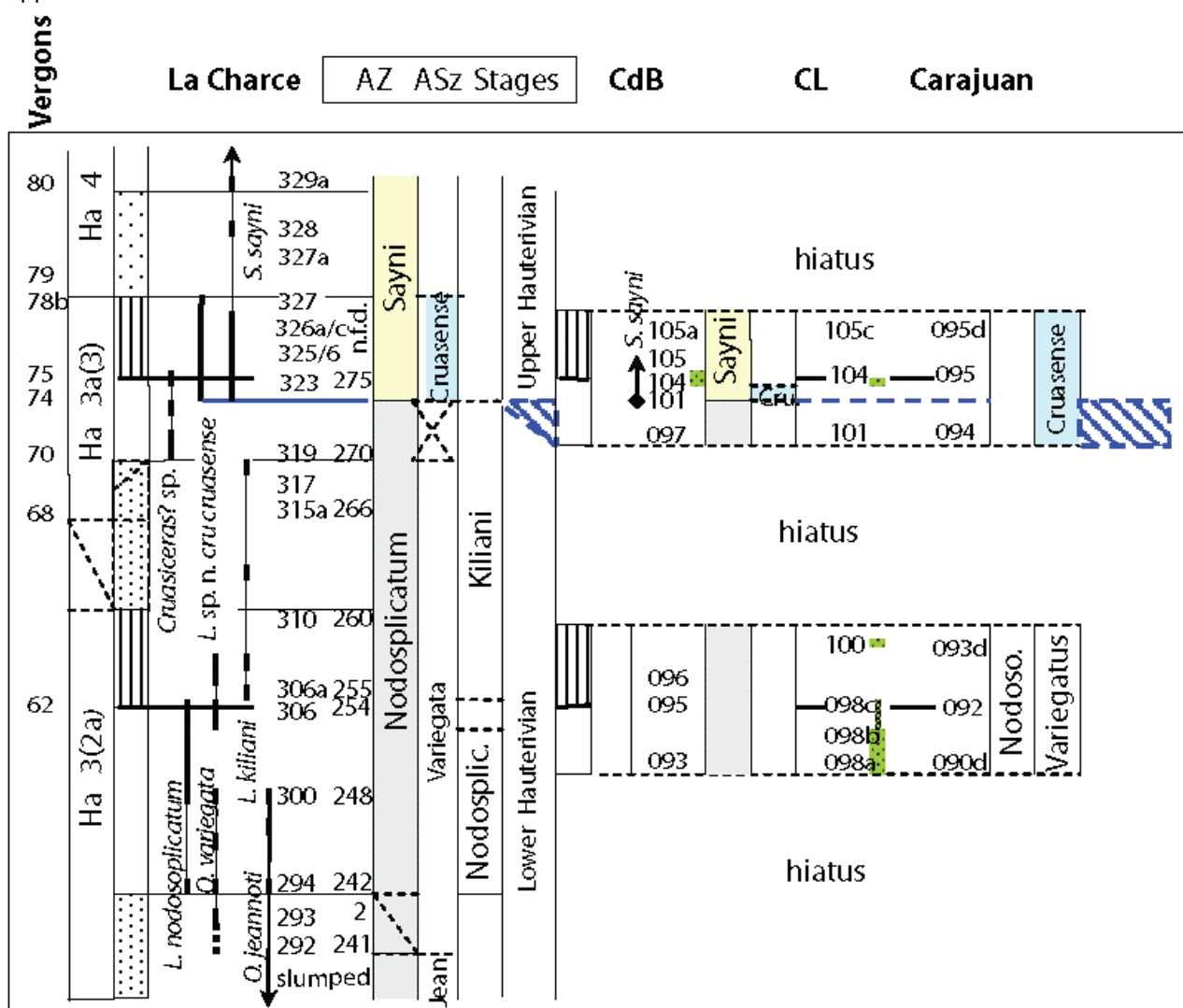


Figure 13: Correlation of ammonite distribution in Lower Hauterivian deep-water deposits (Vocontian Basin; La Charce section, bed-numbers after BULOT (292-329a) and REBOULET (241-275); Vergons section after BULOT, 1995) and shallow depositional areas. Ammonite data after BULOT, 1995, BULOT *et alii*, 1996, REBOULET, 1996, REBOULET & ATROPS, 1999, and VERMEULEN, 2002. A correlation is indicated to the platform "type section" of Carajuan (ARNAUD & BULOT, 1992). Bed-numbers refer to calcareous beds only. Sequences (Ha 3, etc. modified after ARNAUD & BULOT, 1992). *Cruasicerat?* sp. and/or *Lyticoceras* sp. nov. (in BULOT *et alii*, 1996) could be conspecific with *Lyticoceras killiani* REBOULET & ATROPS, 1999. Abbreviations used: Cru. = *Cruasicerat?*; Cru. = *Lyticoceras cruasense* Subzone; L. = *Lyticoceras*; n.f.d. = no further data; O. = *Olcostephanus*; S. = *Subsaynella*. Key in Figs. 2 and 4.

Comparison of coeval stratigraphic intervals shows no significant differences between the associations of belemnites that lived in shallow and those for which the habitat was deeper water. Figure 16 shows the first and last occurrences of taxa in the several stratigraphic columns. A comparison of the occurrences of several belemnite species in the Late Valanginian deep-water sequences with those

that lived in shallow water indicates that most of the genera and species of belemnites in the shallow-water basal phosphatic and glauconitic levels can be found also in the *O. nicklesi* and *C. furcillata* zones. As indicated above, in the Vocontian basin most of the data concerning belemnites from deeper water is lacking for the greater part of Hauterivian times.

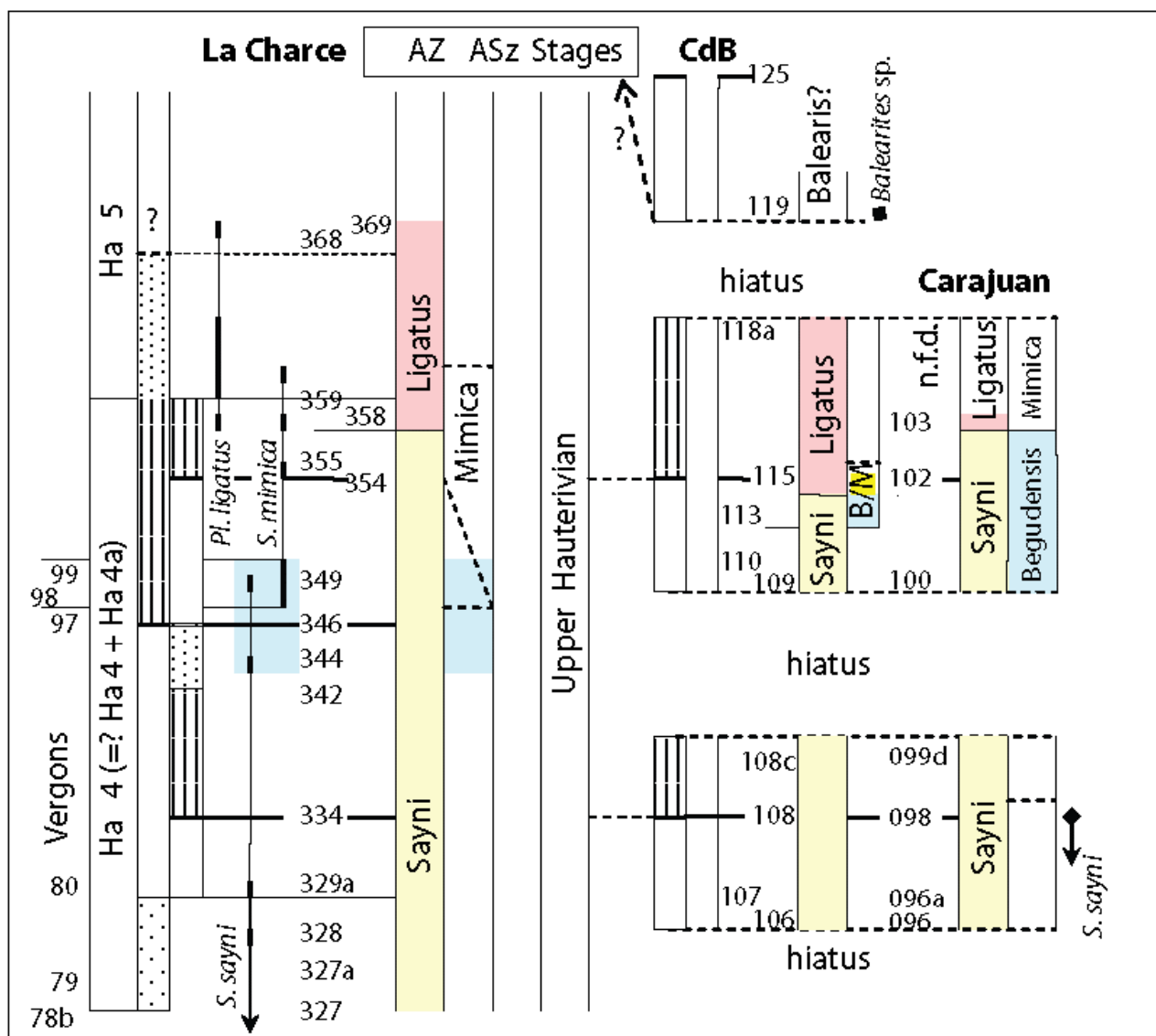


Figure 14: Correlation of ammonite distribution in Late Hauterivian deep-water deposits (Vocontian Basin). La Charce (bed-numbers after BULOT *et alii*, 1993: 327-368; note that bed-numbers between sections depicted on p. 49 and 51 are not comparable, e.g. bed 342-364 on p. 49 = bed 340-359 on p. 51), Vergons (after BULOT *et alii*, 1993, BULOT, 1995), and shallow water deposits (glaucoplastic platform deposits of Peyroules and "type section" of Carajuan, ARNAUD & BULOT, 1992). Bed-numbers refer to calcareous beds only. Sequences modified after ARNAUD & BULOT, 1992. Some stratigraphically important ammonite species and genera are indicated after: BULOT *et alii*, 1993, 1996; BULOT, 1995; VERMEULEN, 2002. Light bluish area indicates possible occurrence of *Subsaynella begudensis* (indicated as *Subsaynella sayni* in BULOT *et alii*, 1993). The interval between beds 329a and 359 appears to correlate with two sequences in the platform deposits. Abbreviations used: B. = *S. begudensis*; M. = *S. mimica*; Pl. = *Plesiospitidiscus*; S. = *Subsaynella*. Key in Figs. 2 and 4.

Recognition of discontinuities, systems tracts and correlation of sections

Several key-horizons can be recognized in the Valanginian to Hauterivian successions. These horizons are generally erosional surfaces or discontinuities (see COTILLON, 1971, 1975; MASSE & LESBROS, 1987; AUTRAN, 1993; BULOT, 1995; LOREAU & DURET, 2000; PASQUINI *et alii*, 2004). Also, there are sets of characteristic marker beds, such as the *A. radiatus*-beds, the *L. nodosoplicatum*-beds, and characteristic bundles of couplets (*S. sayni* beds; beds 106 and 107 in Fig. 6) or multipliets (*S. mimica*/*P. ligatus* beds, Fig. 7). These bundles can be

correlated virtually throughout the hemipelagic-area.

A hiatus that marks an absence of sedimentation during the period of time that spans the interval between the upper limit of the Early Valanginian and a point in the Late Valanginian is apparent in the Peyroules area. There are two superimposed discontinuities, the so-called "mid Valanginian discontinuity" and the "Upper Valanginian discontinuity" (respectively DVM and DVS *sensu* AUTRAN, 1993). Burrows with glauconitic infill are abundant at the top of the bed immediately below the phosphatic-glaucoplastic sequence. The strata of Hauterivian age include the discontinuity DZL (AUTRAN, 1993; e.g. Fig. 17), the discontinuity

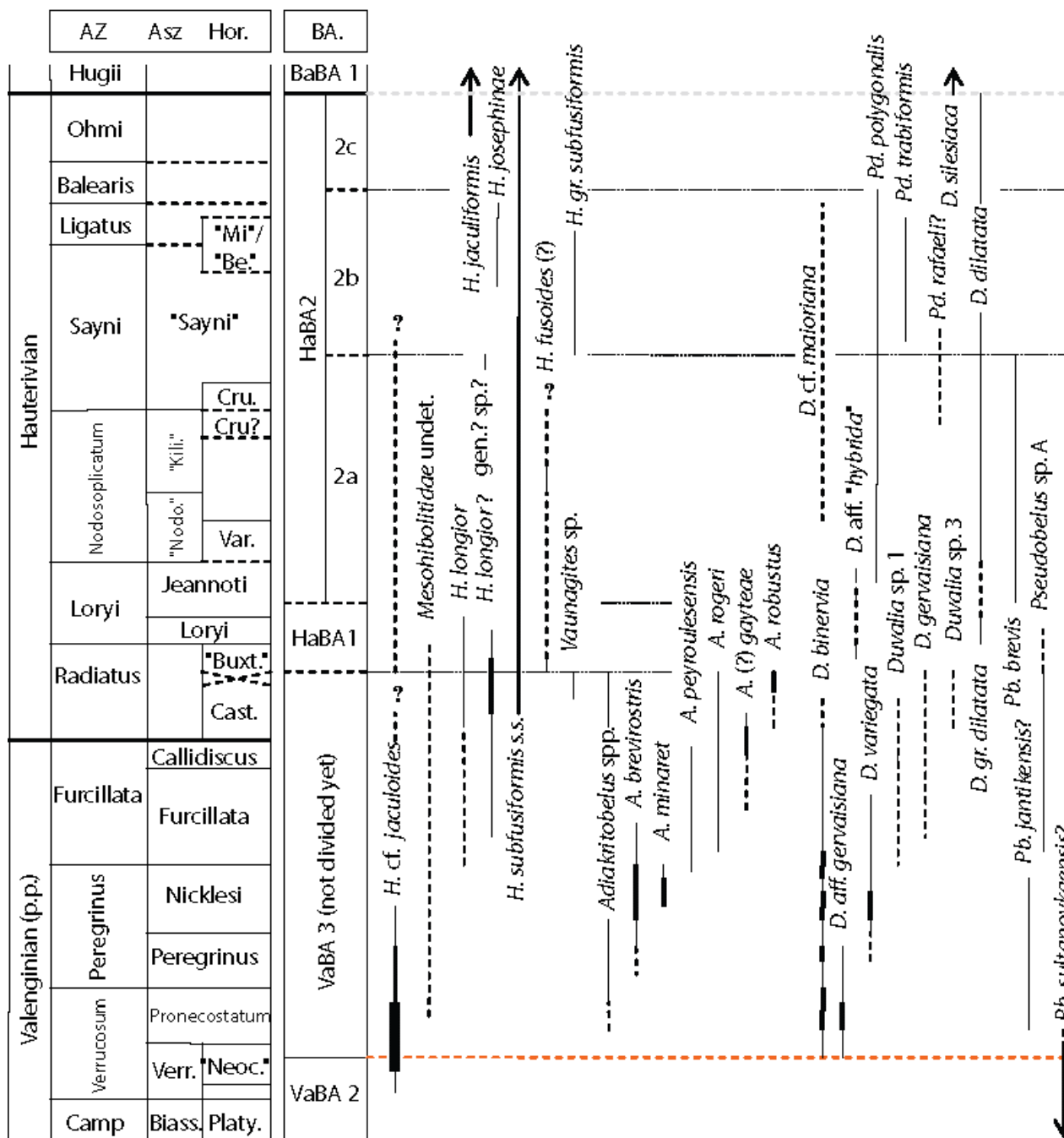


Figure 15: Distribution of belemnites in Late Valanginian to Hauterivian age strata in the investigated areas. Ammonite zonation modified after REBOULET *et alii*, 2006 (ammonite zones between "" are not yet accepted). Belemnite associations after JANSSEN & CLÉMENT, 2002; JANSSEN & FÖZY, 2004, and data presented herein. Possible zonal belemnite species are in red. More abundant occurrences are indicated by thicker lines. Broken lines indicate approximate range of species. Abbreviations used: AZ = Ammonite zones; Biass. = *Karakaschiceras biassalensis*; "Buxt." = *Leopoldia buxtorfi* Horizon *sensu* ARNAUD & BULOT, 1992; Camp. = *Busnardoites campylotoxus*; Cast. = *Breistrofferella castellanensis*; Cru. = beds with *Cruasicerus*? sp. (in BULOT *et alii*, 1993); Cru. = *Lyticoceras cruasense*; "Kili." = *Lyticoceras kiliani sensu* REBOULET & ATROPS, 1999; "Mi/Be." = *Subsainella mimica* resp. *Subsainella begudensis* Horizon *sensu* VERMEULEN *et alii*, 1999; "Neoc." = *Neocomites neocomiensis* Horizon *sensu* ATROPS & REBOULET, 1993; "Nodo." = *Lyticoceras nodosoplicatum* Subzone *sensu* REBOULET & ATROPS, 1999; Platy. = *Eristavites platycostatus*; Var. = *Olcostephanus variegatus*; Verr. = *Saynoceras verrucosum*.

of the *C. loryi* Zone, and the discontinuity DZR (BULOT, 1995; BULOT *et alii*, 1996) of the *A. radiatus* Zone. Based on sequence stratigraphic interpretations, these discontinuities are here proposed to be either related to maximum flooding surfaces (MFS), or denote the boundary between two sequences. Field observations show that many more

discontinuities can be identified (Fig. 12), either owing to the presence of borings (bio-erosion), or of encrusting (non-deposition), or because of an abundance of phosphatic fossils and pebbles. On the other hand they can sometimes be interpreted as having been caused by "bypassing". The discontinuity at the top of the *O. variegatus* Subzone is especially well

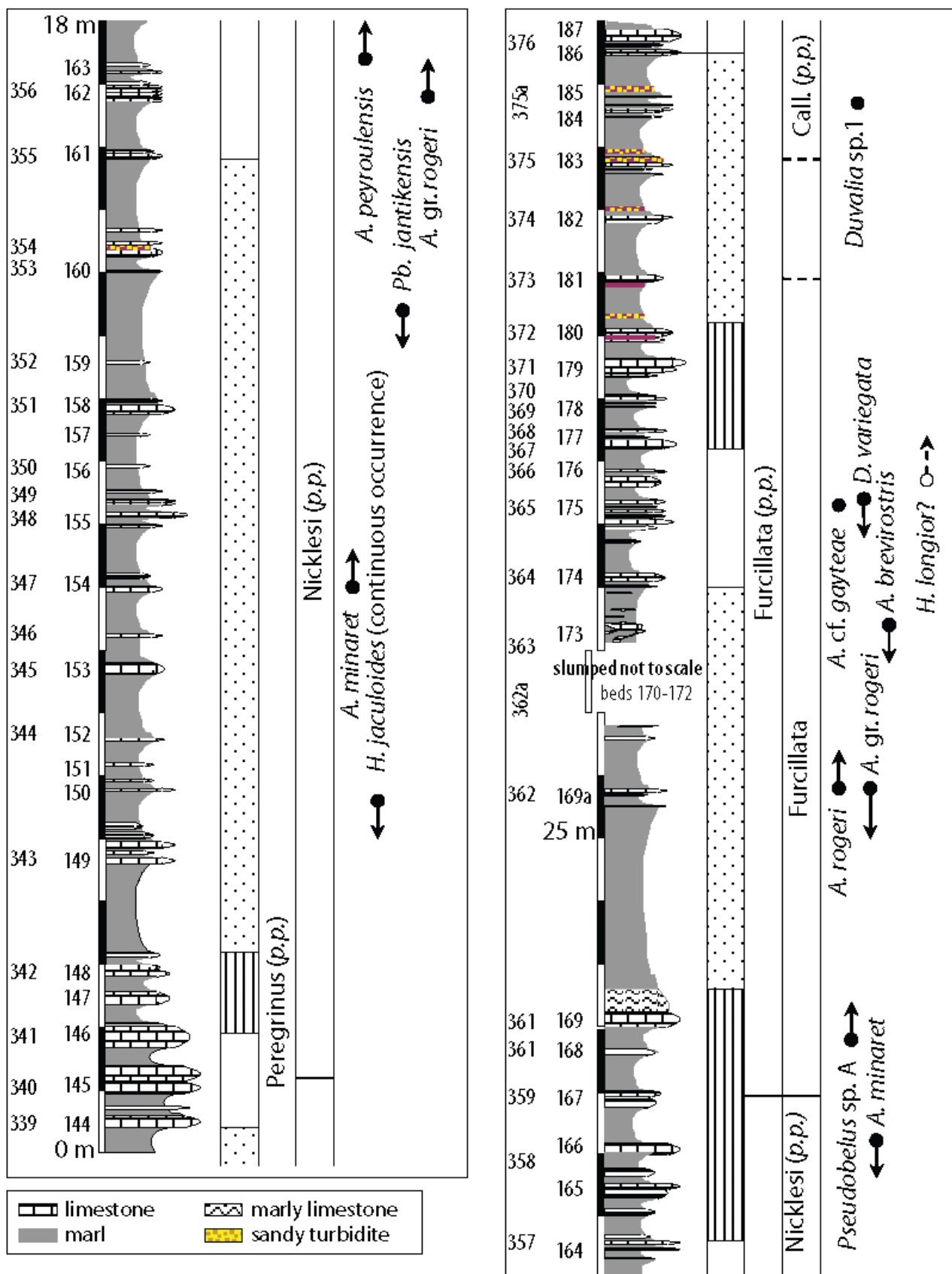


Figure 16: Vergol area: a Late Valanginian succession. Note that the slumps below bed 174 and above 169b are not to scale. Bed numbers correlated with those of beds 339-376 at Angles, are shown, along with lithology, sequences, and ammonite zonations (based on correlations). The FO, LO, or single occurrences of belemnite species are indicated. Key in Figs. 2 and 4. Scale bar graduations = 1 m.

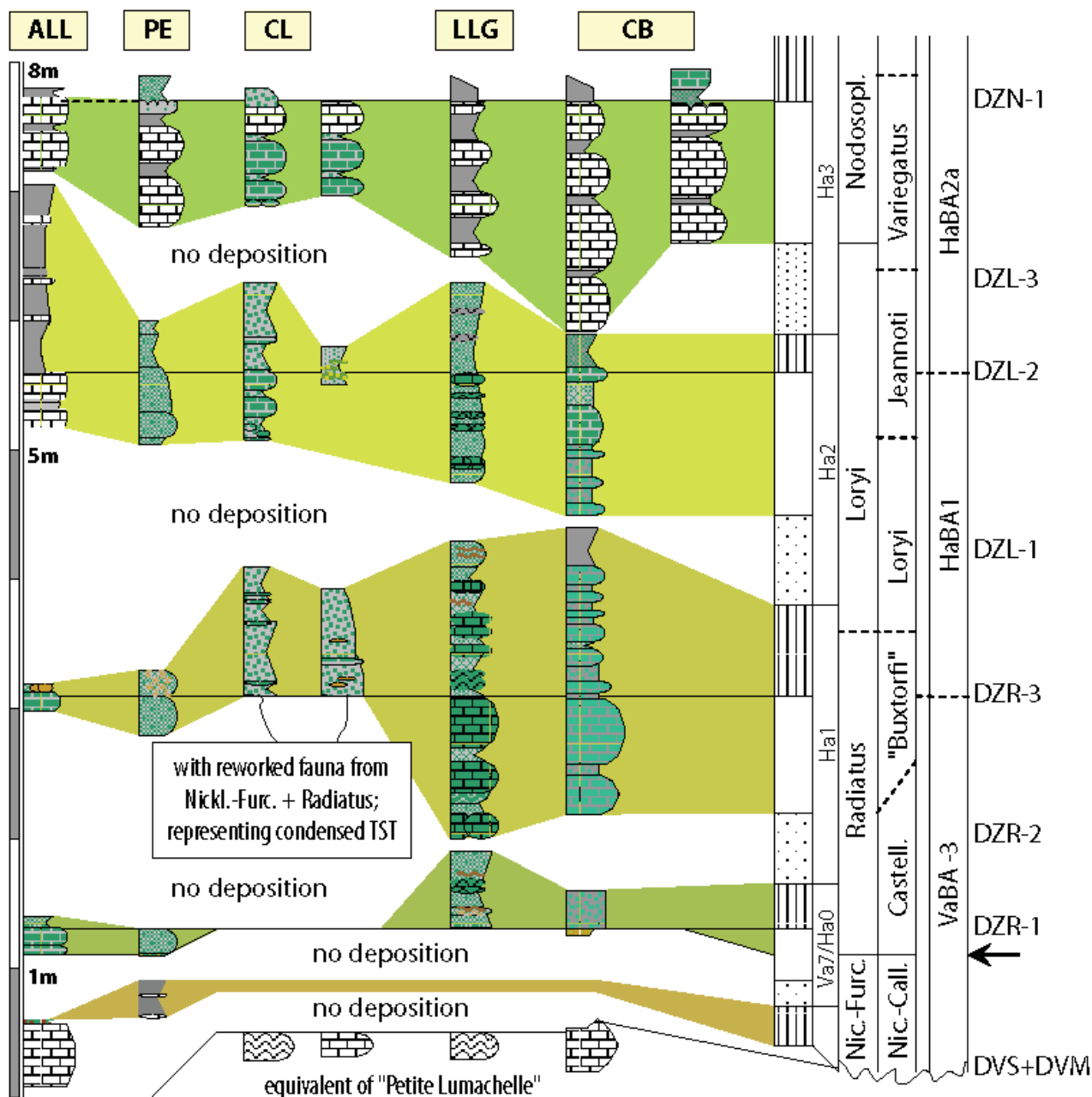


Figure 17: Correlation of Lower Hauterivian sedimentary rocks. Arrow indicates position of Valanginian-Hauterivian boundary. Abbreviations: ALL = Les Allaves; CB = Collet des Boules; CL = Clausson; Nic. = *Olcostephanus nicklesi* Zone; PE = Pas d'Escale. Lithology, sequences, ammonite (sub)zones, belemnite associations (VaBA-3, HaBA1, and HaBA2a), and discontinuities (DVS, DZR, DZL, and DZN) are depicted. See text for explanation. Keys to lithology and abbreviations in Figs. 2 and 4. Scale bar graduations = 1 m.

represented in some profiles (Collet des Boules, Fig. 3; Pas d'Escale, Fig. 10) where it is made evident by strong boring activities. Here, this discontinuity is named DZN-1 (Fig. 17), for it is located near the base of the *L. nodosoplicatum* Zone. Note that these discontinuities are less evident in the Les Allaves area. The succession there consists of stacked "condensed" transgressive system tracts with expanded prolonged highstands (sometimes including latest highstand system tracts), while lowstand system tracts are absent (Fig. 17).

Generally, it is possible to correlate the various sections set-by-set. The *O. variegatus* beds in the Peyroules area are closely comparable with successions near La Lagne and

the Pas d'Escale area (Fig. 17). Differences in the sedimentary development of the several areas are presumably related to the amount of condensation and to the accessibility of accommodation space. Sometimes, but not necessarily, differences in the degree of condensation are reflected in the colour of the rocks, dependent on the relative percentage of glauconite. In general, all beds are condensed and transgressive systems tracts (TST) are reduced to one or a few beds of limestone that are recognizable as discrete layers. The MFS is at the top of these more calcareous sets, while the subsequent marly set is the high stand systems tract (HST) and probably partially the latest HST). These marl sets are often very rich

in belemnites ("marnes à bélemnites" *sensu* COTILLON, 1971), brachiopods or echinoids (*Toxaster* marls *sensu* DAVID, 1979, 1980). Ammonites appear to be restricted to the TST and MSF. However, these beds may also contain abundant macrofossils of other phyla, while some limestones in the HST include abundant ammonites too. Apparently the diversity of the ammonite genera and species in these hemipelagic deposits is low, but the individuals are abundant.

Research on these sediments, their sequences and their integration with biostratigraphic information, has led to a number of correlations between basin and platform deposits (ARNAUD-VANNEAU *et alii*, 1982; FERRY & MONIER, 1987; FERRY & RUBINO, 1989; FERRY *et alii*, 1989; MAGNIEZ-JANNIN, 1992) based on discontinuities and/or faunas in common. I follow a different approach (see MANCINI & TEW, 1995, p. 290-291; HOEDEMAEKER, 1999; JANSSEN & CLÉMENT, 2002, fig. 4). Parts of the marly sequences in the basin interpreted as lowstand systems tracts (LST) are represented by hiatus in the hemipelagic deposits (Figs. 12-14 & 17). In both, only the MFS's are supposed to be time-equivalents. The broken lines in Fig. 17 representing the transgressive surfaces are respective sequence boundaries that are not necessarily time-equivalent but are correlative. However, the interpreted hiatuses in the deposition of the shallow-water sequences in most cases continue into the lower part of the TST's and upper part of the HST's. Moreover, condensation of the sedimentary successions laid down in shallow water is not always accompanied by the production of glauconite visible to field observation.

Remarks

In the vertical distribution of the belemnites, the most striking phenomenon seems to be the fluctuations in the respective abundances of Mesohibolitidae *versus* Duvaliidae. In general, Upper Berriasian to Lower Valanginian sediments are dominated by Duvaliidae ("warm"). Decrease of the Duvaliidae, in both species diversity and dominance, takes place at the boundary between the Early and Late Valanginian, the Valanginian-Hauterivian boundary and in the uppermost Hauterivian, and could, at least in part, be related to temperature changes in surface waters. In the hemipelagic deposits, Duvaliidae diversify again but do not become more abundant, in connection with the diversification of the genus *Pseudoduvalia* in the *S. sayni* Zone. However, Mesohibolitidae remain by far the most abundant of the belemnite families.

A marked change in facies takes place in the Peyroules area at the boundary between the Early and the Late Hauterivian. Though marls are already present in the latest beds of the Lower Hauterivian, hemipelagic marls in notable

thickness developed mainly in Late Hauterivian times. Especially, the basal unit (*S. sayni* Zone) consists mainly of marly sediments, with huge quantities of belemnites, brachiopods, and at its base remains of *Isocrinus peyroulensis* (LORJOL). Also, the boreal ammonite *Simbirskites*, though not known in the area under investigation, in other parts of southeastern France occurs in sediments attributed to the *S. sayni* beds (THIEULOY, 1977a, p. 424). Generally, these Late Hauterivian rocks include large numbers of *Hibolithes* but to the author's knowledge, no *Hibolithes jaculoides* SWINNERTON, 1937, is known from the areas of this study with the sole exception of the basin deposits of earliest Late Valanginian age (Fig. 16). However, scattered occurrences of *Hibolithes jaculoides*? may exist in the lowermost Hauterivian (Les Allaves; Fig. 9) and in the lower Upper Hauterivian of the Peyroules area (CB108-108a, Fig. 6).

In general the belemnite associations discussed here can be compared with faunas in many discrete sedimentary and palaeogeographic settings in the Mediterranean Tethys: the Carpathian Mts. (VAŠIČEK *et alii*, 1994), northeast Bulgaria (Kolarovgrad area; STOYANOVA-VERGILOVA, 1965), Georgia (Abkhazia; SHVETSOV, 1913; KAKABADZE & KELEPRISHVILI, 1991); Gerecse Mountains (Hungaria; JANSSEN & FÖZY, 2004), Morocco (MUTTERLOSE & WIEDENROTH, 2008), Switzerland (Châtel Saint-Denis area, Fribourg; OOSTER, 1857), and the Subbetic domain of Spain (pers. obs.). Eventually, this broad dissemination will be useful for the establishment of a biostratigraphic zonation based on belemnites.

Palaeontological notes

As some readers may not be familiar with certain of the belemnites mentioned in this work, brief remarks concerning these species are added. In addition, the species introduced by RASPAIL (1829, 1830) and DUVAL-JOUVE (1841) from the Peyroules area, have been revised when necessary and placed in synonymy (Table I). Synonymization here may deviate from previous interpretations (see d'ORBIGNY, 1840, DUVAL-JOUVE, 1841, and COMBÉMOREL, 1973). Some new species are introduced and "unfamiliar" species are treated more extensively.

DUVAL-JOUVE (1841, p. 6-7) reported several localities for the provenance of the material he investigated, among which are: "la plaine de Cheiron entre Castillon et Castellane" (now partially submerged by the artificial lake of Castillon), Angles, Vergons, and the "glauconitic localities": La Lagne, Chamateuil, Peyroulles (now Peyroules), etc. As several of his new species have no precisely located site of origin, it is reasonable to select one of the collecting localities to be the *locus* of a topotype, provided that pertinent material can still be collected.

Among the variants around *Belemnites subfusiformis* introduced by DUVAL-JOUVE, the following species, assigned *Adiakritobelus*, are important for this work: *Belemnites subfusiformis* RASPAIL var. γ , and var. δ (= var. *robustus*). They are restricted to glauconitic deposits (see DUVAL-JOUVE, 1841, p. 71; La Lagne, Peyroules, etc.). And also *Belemnites Platyurus* [nov.] from several localities: the Blaron-Castillon area and La Garde, Chamateuil, Robion, Escragnoles, etc. (glauconitic facies). Probably that author included some specimens of the Valanginian-Hauterivian genus *Adiakri-*

tobelus (species like *Adiakritobelus peyroulesensis* sp. nov.) in the early Late Barremian *Belemnites Platyurus* from La Garde.

Systematic descriptions

Abbreviations used are in according with GRANZOW (2000). In addition, the following abbreviations are used: "+" = invalid: a *nomen dubium*, *nomen nudum*, or *nomen nullum* (= secondary typing error), and "pt" = *partim*.

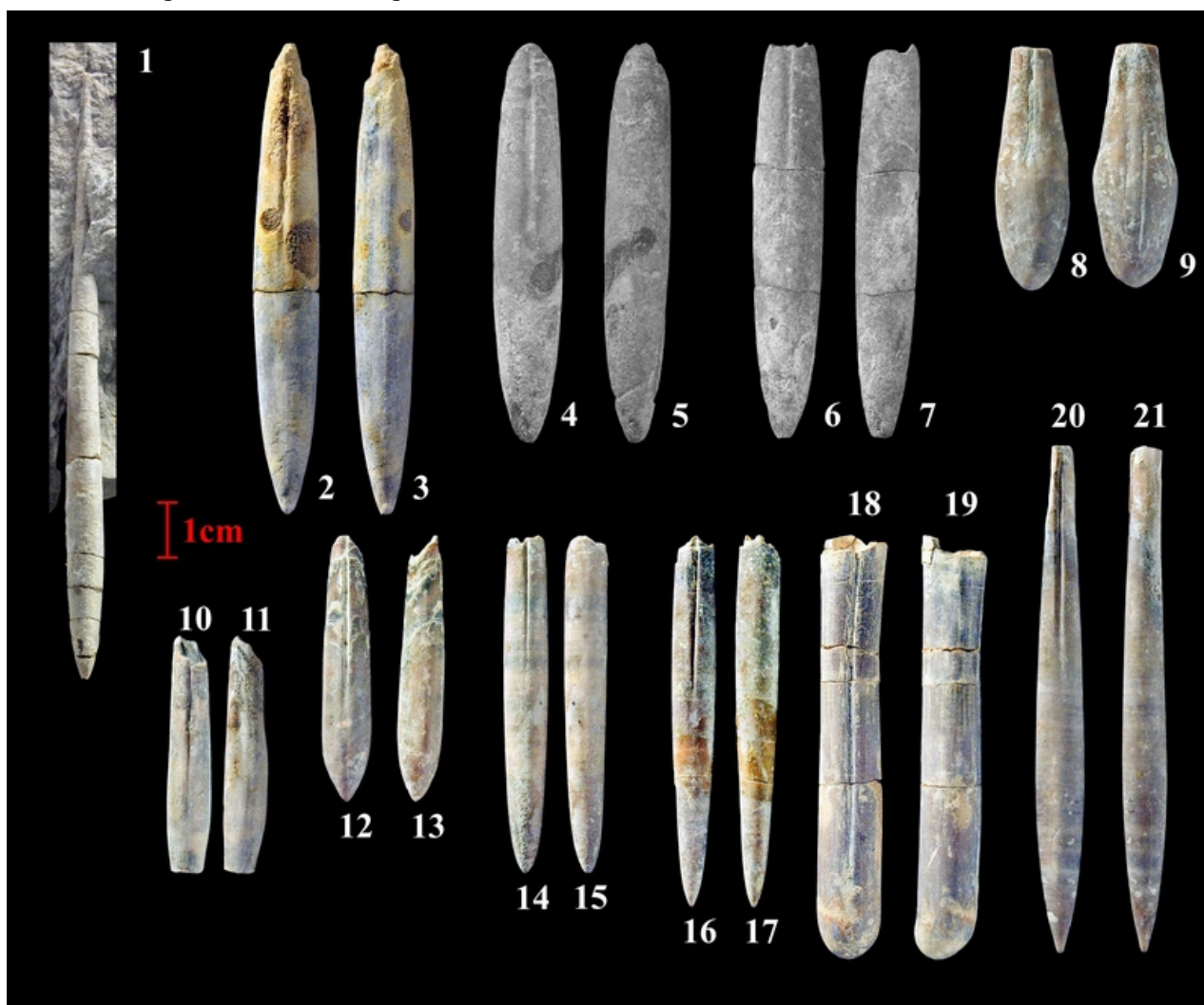


Plate 1: (Valanginian-Hauterivian; *Hibolithes*): Fig. 1.- *Belemnites pistilliformis* BLAINVILLE, RGM 288.898, ALL121, *Lyticoceras nodosplicatum* Zone. Figs. 2-3.- *Hibolithes fusoides* (LAMARCK, 1822), RGM 288.483, CL099top, *Lyticoceras nodosplicatum* Zone. Figs. 4-5.- *Hibolithes fusoides* (LAMARCK, 1822), RGM 214.809, Clausson (west), free specimen. Figs. 6-7.- *Hibolithes fusoides* (LAMARCK, 1822), RGM 214.810, Clausson (west), free specimen. Figs. 8-9.- *Hibolithes* sp. (ter.), RGM 288.296a, CB107-107a, *Subsajnella sayni* Zone. Figs. 10-11.- *Hibolithes* sp. (ter.), RGM 288.296b, CB107-107a, *Subsajnella sayni* Zone. Figs. 12-13.- *Hibolithes* sp. 1, RGM 288.295, CB106-107, *Subsajnella sayni* Zone. Figs. 14-15.- *Hibolithes subfusiformis* (RASPAIL, 1829), RGM 288.764, La Bâtie, LB113-114, "*Subsajnella mimica*" Subzone. Figs. 16-17.- *Hibolithes subfusiformis* (RASPAIL, 1829), RGM 288.307a, CB107a-108, *Subsajnella sayni* Zone. Figs. 17-19.- *Hibolithes* sp. (ter.), RGM 288.481, CL097-098, top *Acanthodiscus radiatus*/base *Crioceratites loryi* Zone. Figs. 20-21.- *Hibolithes* gr. *subfusiformis* RASPAIL, RGM 288.333, CB104a-105, *Lyticoceras cruasense* Zone.

Family Mesohibolitidae
NERODENKO, 1983

Genus "Belemnites"

Belemnites pistilliformis

BLAINVILLE, 1827

(Pl. 1, fig. 1)

- non + 1819 *Belemnites attenuatus* FAURE-BIGUET, p. 47-48 [=? *Pseudobelus* but inadequately described: *nom. dub.*].
- pt? 1827 *Belemnites pistilliformis* BLAINVILLE, p. 98-99, Pl. 5, figs. 14-15, 16-17 [*nom. dub.*?].
- non + 1828 *Belemnites attenuatus* SOWERBY, p. 176, Pl. 589, fig. 2 [to be replaced by *Belemnites minimus* MILLER *fide* RIEGRAF *et alii*, 1998, p. 64].
- pt 1829 *Belemnites pistilliformis* RASPAIL, p. 327, Pl. 8, figs. 95-97 (non figs. 98-102 [= *Hibolites* gr. *subfusiformis* RASPAIL]).
- ? + 1829 *Belemnites attenuatus* RASPAIL, p. 319-320, Pl. 8, fig. 72 [deformed specimen: *nom. dub.*].
- pt 1829 *Belemnites marginatus* RASPAIL, p. 319, Pl. 8, figs. 73-74 [juvenile], non fig. 70 (= *Hibolites* gr. *jaculiformis* SHVETSOV, 1913).
- 1829 *Belemnites pistilloides* RASPAIL, p. 320, Pl. 8, fig. 75 [juvenile].
- + 1829 *Belemnites gemmatus* RASPAIL, p. 321, Pl. 8, fig. 77 [teratological specimen: *nom. dub.*].
- ? + 1829 *Belemnites rostratus* RASPAIL, p. 321, Pl. 8, fig. 78 [teratological specimen: *nom. dub.*].
- + 1829 *Belemnites crassior* RASPAIL, p. 327, Pl. 8, fig. 84 [*nom. dub.*].
- + 1829 *Belemnites crassissimus* RASPAIL, p. 327, Pl. 8, figs. 85-86 [teratological specimen: *nom. dub.*].
- + 1829 *Belemnites aculeus Echini* RASPAIL, p. 327-328, Pl. 8, fig. 87 [teratological specimen: *nom. dub.*].
- pt 1841 *Belemnites pistilliformis* BLAINVILLE; DUVAL-JOUVE, Pl. 8, figs. 10 (?), 13-16.
- pt 1841 *Belemnites subfusiformis* RASPAIL; DUVAL-JOUVE, Pl. 9, figs. 2, 13-14.
- pt 1861 *Belemnites pistilliformis* BLAINVILLE; LORIOU, Pl. I, fig. 2.
- pt 1922 *Belemnites (Aulacobelus) pistillirostris* PAVLOW; TOMITCH, p. 7, 18, 22.
- pt? + 1984 *Hibolites piriformis* n. sp. GAYTE, Pl. I, fig. 8 [-unpublished-: *nom. nud.*].
- + 1997 *Hibolites* cf. *pistiformis* (BLAINVILLE); BARABOSHKIN & YANIN, p. 15 [nom. null.; *nom. dub.*].
- 2004 "*Belemnites*" *pistilliformis* RASPAIL; JANSSEN & FÖZY, p. 37-38, Pl. II, fig. 8; Pl. III, fig. 3.

Remarks: Includes (specifically indeterminate) juvenile to immature specimens of *Hibolites* spp. but also juvenile to immature

specimen of the genera *Vaunagites* and *Adiakritobelus*.

Range: Essentially Late Valanginian – late Early Barremian.

Genus? species?

- ? 1951 *Belemnites bicanaliculatus* BLAINVILLE; PETKOVIC & MARKOVIC, p. 23-24, Pl. I, fig. 4.

Remarks: One very small hibolitoïd rostrum with faint lateral impressions, morphologically comparable with the Early - earliest Late Valanginian (*S. verrucosum* "Horizon") genus *Mirabelobelus* JANSSEN & CLÉMENT, 2002. It occurs in the *S. sayni* Zone of the Collet des Boules. A comparable specimen has been collected at the same stratigraphical interval in the Hauterivian outerslope deposits of Tornajo Mt., municipality of Lorca, southeast Spain. Superficially it resembles certain small species of the Tithonian - earliest Berriasian group of *Pseudobelus* (?) gr. *fischeri* COMBÉMOREL & MARIOTTI, 1990. However, this attribution is at the moment still not certain, for it might represent some small morph of a juvenile, a new, or a teratological species of the genus *Hibolites*. The Serbian specimen apparently comes from Hauterivian sedimentary deposits (PETKOVIC & MARKOVIC, 1951, p. 24). Probably, the species described as *Belemnites (Duvalia) grasianus* DUVAL by these authors is comparable with *Duvalia* cf. *maioriana* STOYANOVA-VERGILOVA *sensu* JANSSEN & FÖZY (2004). However, the cephalopod fauna they described (*loc. cit.*, p. 41) appears to contain both Valanginian, Hauterivian and/or Barremian elements.

Stratigraphic occurrence: *Subsaynella sayni* Zone (early Late Hauterivian).

Genus *Hibolites*
DENYS de MONTFORT, 1808

***Hibolites fusoides* (LAMARCK, 1822)**

(Pl. 1, figs. 2-7)

- 1822 *Belemnites fusoides* LAMARCK, p. 592.
- 1918 *Belemnites fusoides* (LAMARCK); FAVRE, p. 6, Pl. I, fig. 6 [= LAMARCK, 1822].
- ? 1984 *Hibolites subfusiformis* (RASPAIL); GAYTE, Pl. I, fig. 3.
- 1995 *Pseudohibolites fusoides* (LAMARCK); RIEGRAF, p. 102.
- ? 2004 *Hibolites subfusiformis* (RASPAIL); JANSSEN & FÖZY, Pl. II, fig. 17.

Remarks: The type seems to be from Saint-Paul-Trois-Châteaux (southwest of Clansayes, Drôme, France). According to FAVRE (1918) the species could be one of the Hauterivian group of *Belemnites (Belemnopsis) pistilliformis* BLAINVILLE, I agree. *Belemnites subconicus* var. [b] of LAMARCK is from the same locality. Forms in this variety includes specimens from the Aptian of

Saint-Paul-Trois-Châteaux and an Early Jurassic species which could not have come from that area (FAVRE, 1918, p. 6). However, specimens A and B figured by FAVRE (1918, Pl. 1, figs. 1-2) are morphologically comparable to *Adiakritobelus* and in my opinion could with an equal degree of validity be referred to this Late Valanginian to earliest Hauterivian genus. I have no knowledge of the geology of the Saint Paul-Trois-Château area, but according to ROMAN (1932, p. 17-21) and the "Carte Géologique Détaillée de la France 1:50.000" (type 1922; XXX-39, map no.890, Valréas) no Aptian/Albian sedimentary rocks are exposed

near St. Paul-Trois-Châteaux but only in the Clansayes area. The "marnes grises à Bélemnites" (Valanginian-Hauterivian) are exposed far to the north and east, some of them in a glauconitic, neritic facies. So, mistakes concerning the origin of this material have been made in the past, probably already in LAMARCK's time. Depending on the range of morphological variation in the species, the belemnite figured by JANSSEN & FÖZY, 2004 (Pl. II, fig. 17; apparently from the *A. radiatus* or *C. loryi* Zone) might be of this species too. At least it has the typical fusiform outline but appears to have no alveolar groove.

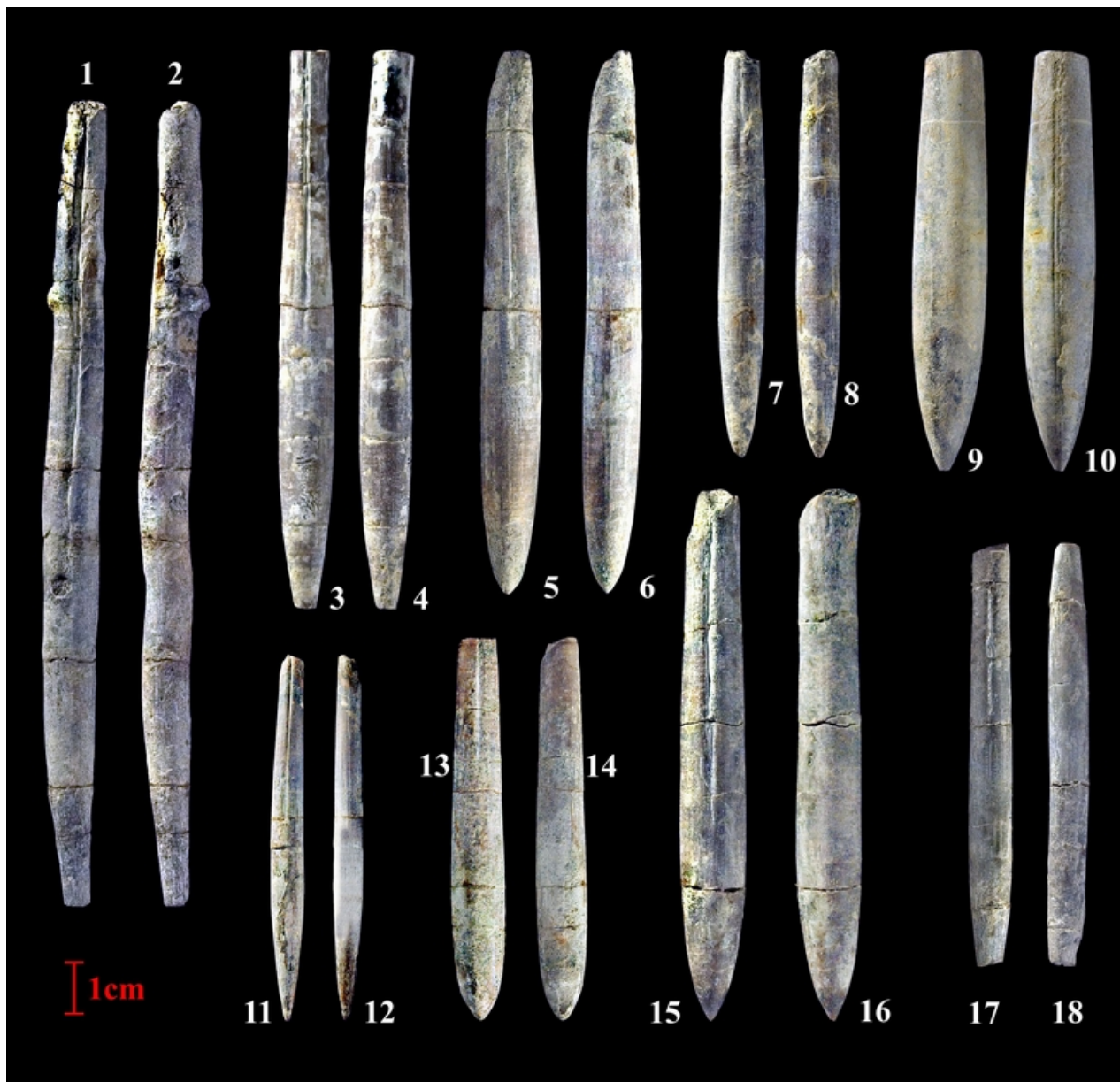


Plate 2 (Valanginian-Hauterivian; *Hibolithes*): Figs. 1-2.- *Hibolithes longior* SHVETSOV, 1913, RGM 288.328, CB079, V/H boundary. Figs. 3-4.- *Hibolithes longior* SHVETSOV, 1913, RGM 288.835, ALL116, top *Acanthodiscus radiatus* Zone ("*Leopoldia buxtorfi* Subzone"). Figs. 5-6.- *Hibolithes longior?* SHVETSOV, 1913, RGM 288.467, CL096, *Acanthodiscus radiatus* Zone. Figs. 7-8.- *Hibolithes longior* SHVETSOV, 1913, RGM 288.474, CL097c-d, *Crioceratites loryi* Zone. Figs. 9-10.- *Hibolithes jaculooides* SWINNERTON, 1937, RGM 560.599, Cheiron, *Karakaschiceras pronecostatum* Subzone. Figs. 11-12.- *Hibolithes longior?* SHVETSOV, 1913 (juv.), RGM 288.352, CB079, V/H boundary. Figs. 13-14.- *Hibolithes longior?* SHVETSOV, 1913, RGM 288.332, CB085-087, *Crioceratites loryi* Zone. Figs. 15-16.- *Hibolithes longior?* SHVETSOV, 1913, RGM 288.331, CB085-087, *Crioceratites loryi* Zone. Figs. 17-18.- *Hibolithes longior* SHVETSOV, 1913, RGM 560.609, Angles, ANG386, *Acanthodiscus radiatus* Zone.

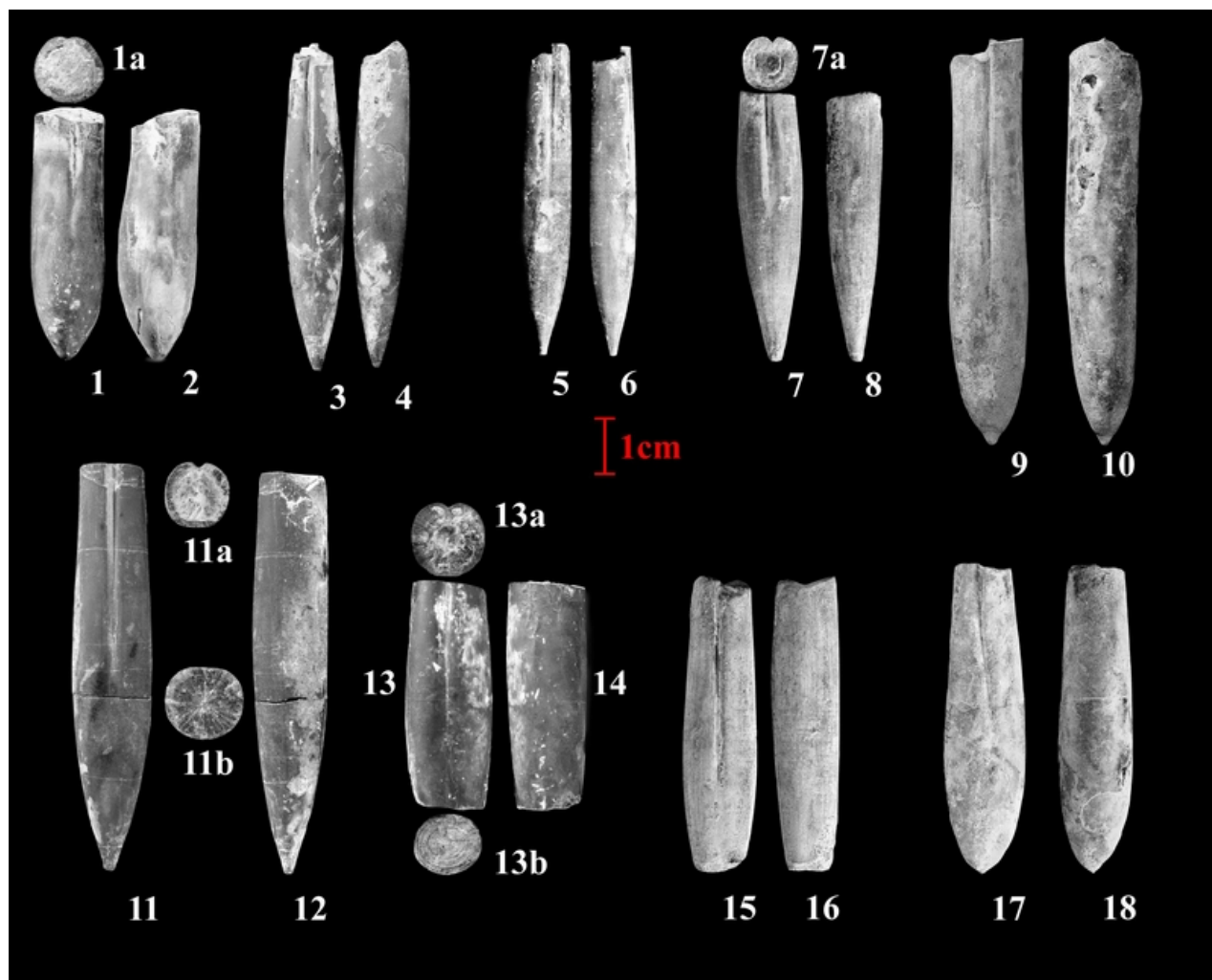


Plate 3 (Valanginian-Hauterivian; *Adiakritobelus*): Figs. 1-2.- *Adiakritobelus*? sp. (ter.), RGM 214.706, Angles, ANG337-338, *Varlheidites peregrinus* Subzone. Fig. 1a.- Cross-section in alveolar opening. Figs. 3-4.- *Adiakritobelus brevirostris* (RASPAIL, 1829), RGM 214.714, Vergol, VGL149e-150, *Olcostephanus nicklesi* Subzone. Figs. 5-6.- *Adiakritobelus brevirostris* (RASPAIL, 1829), RGM 214.731, Vergol, VGL154b-155, *Olcostephanus nicklesi* Subzone. Figs. 7-8.- *Adiakritobelus brevirostris* (RASPAIL, 1829), RGM 214.780, CL095, V/H boundary. Fig. 7a.- Cross-section in alveolar opening. Figs. 9-10.- *Adiakritobelus minaret* (RASPAIL, 1829), RGM 214.990, CL095, V/H boundary. Figs. 11-12.- *Adiakritobelus minaret* (RASPAIL, 1829), RGM 214.741, Angles, ANG358-359, *Olcostephanus nicklesi* Subzone. Fig. 11a.- Cross-section in alveolar opening. Fig. 11b.- Cross-section near maximum outline. Figs. 13-14.- *Adiakritobelus minaret* (RASPAIL, 1829), RGM 214.715, Vergol, VGL154-158, *Olcostephanus nicklesi* Subzone. Fig. 13a.- Cross-section in alveolar opening. Fig. 13b.- Cross-section in apical part. Figs. 15-16.- *Adiakritobelus minaret* (RASPAIL, 1829), RGM 214.782, CB079, V/H boundary. Figs. 17-18.- *Adiakritobelus*? sp., RGM 214.850, CL095, V/H-boundary.

Geographic occurrence: Les Allaves and Peyroules area (Clausson, Collet des Boules, Alpes de Haute-Provence), Moulezan, Gard (GAYTE, 1984), and possibly Hungaria.

Stratigraphic occurrence: Early Hauterivian (late *A. radiatus* - *L. nodosoplicatum/cruasense* zones).

Hibolites cf. jaculoides
SWINNERTON, 1937

(Pl. 2, figs. 9-10)

- non 1829 *Belemnites symmetricus* RASPAIL, p. 324-325, Pl. 8, fig. 90 (fide MUTTERLOSE, 1978).
non 1829 *Belemnites pistilliformis* BLAINVILLE; RASPAIL, Pl. 8, fig. 102 (fide MUTTERLOSE, 1978).

- non 1849 *Belemnites subfusiformis* RASPAIL; QUENSTEDT, Pl. 29, figs. 41 [= *pistilliformis* RASPAIL], 42 [= *H. gr. subfusiformis* RASPAIL], 43 [= *pistilliformis* RASPAIL] (fide MUTTERLOSE, 1978).
pt? 1857 *Belemnites pistilliformis* BLAINVILLE; OOSTER, Pl. 2, figs. 9-10, 11 (?).
non 1898 *Belemnites jaculum* PHILLIPS; SIMIONESCU, p. 108-109, Pl. I, figs. 5-6.
non 1913 *Hibolites jaculiformis* SHVETSOV, p. 52, Pl. II, figs. 5-6; Pl. III, figs. 4, 11-12 (fide MUTTERLOSE, 1978).
? 1915 *Belemnites jaculum* PHILLIPS; JEKELIUS, p. 117, Pl. X, fig. 3.
* 1937 *Hibolites jaculoides* SWINNERTON, p. xxv (pro *Belemnites jaculum* PHILLIPS non FAURE-BIGUET).

- pt ? 1970 *Hibolites jaculoides* SWINNERTON;
STOYANOVA-VERGILOVA, p. 16-17, Pl. II,
figs. 4-6.
- pt 1978 *Hibolites jaculoides* s.s. SWINNERTON;
MUTTERLOSE, p. 99-102, Pl. 3, figs. 1-
3; Pl. 4, figs. 1-3, 5; Pl. 5, fig. 4; Pl.
6, fig. 1 (pars cum syn.).
- 2002 *Hibolites* cf. *jaculoides* SWINNERTON;
JANSSEN & CLÉMENT, p. 514, 515, 521.
- 2002 *Hibolites* sp. nov. JANSSEN & CLÉMENT,
p. 514 (most probably juvenile
specimens).

Remarks: Only few valid records of this species have been published in the Mediterranean Tethys region. Generally, it is thought to be misidentified as *Hibolites* gr. *subfusiformis* RASPAIL or *Belemnites pistilliformis* BLAINVILLE.

Stratigraphic occurrence: Latest *S. verrucosum* Subzone to early *O. nicklesi* Zone (normal occurrence; Fig. 16) and scattered appearances in strata of earliest Hauterivian age (Les Allaves) and possibly also in the lower part of the *S. sayni* Zone of the Peyroules area. The oldest occurrences in the Boreal-Atlantic region are not yet resolved from a stratigraphical point of view, but it appears that the range of this species in the two palaeogeographical areas is not the same!

Geographic occurrence: In addition its well-known distribution in the Boreal-Atlantic, this species is also found in the northern margins of the Mediterranean Tethys and in parts of the Russian Platform.

Hibolites josephinae (HONNORAT-BASTIDE, 1890)

- 1890 *Belemnites Josephinae* nov. sp.
HONNORAT-BASTIDE, p. 465-466, figs.
1-5.
- pt ? 1966 *Hibolites longior* SCHWETZOFF;
DRUSHCHITS & MIKHAYLOVA, p. 117 [Late
(st) Hauterivian] (non p. 120, 121
[Early? Hauterivian]).
- 2004 *Hibolites* cf. *josephinae* (HONNORAT-
BASTIDE); JANSSEN & FÖZY, p. 44, Pl. II,
fig. 15.

Remarks: This elongated cylindrical species was found in outcrops of Late Hauterivian age near La Bégude (France). In this area a succession is visible (see DAVID, 1979) comparable to that of the sequence of Late Hauterivian age in the Peyroules area. It is quite possible that part of the Late Hauterivian group of belemnites comprised in *Hibolites longior* SHVETSOV should be grouped within *Hibolites josephinae* (see below).

Stratigraphic occurrence: Latest *S. sayni* through *P. ligatus* Zone (Late Hauterivian).

Hibolites longior SHVETSOV, 1913

(Pl. II, figs. 1-5, 6 (?), 7, 8 (?), 11, 12 (?),
13, 14 (?), 15-17 & 18 (?))

- pt 1861 *Belemnites pistilliformis* BLAINVILLE;
LORIOU, p. 17-18, Pl. I, fig. 1.
- * 1913 *Hibolites longior* n. sp.; SHVETSOV, p.
51-52, 68, Pl. III, figs. 2a (LT *fide*
STOYANOVA-VERGILOVA, 1970), b/e, c/f,
d/g.
- 1939 *Hibolites longior* SCHWETZOFF;
KRYMGOL'TS, p. 10-11, Pl. I, fig. 7.
- pt 1964 *Hibolites longior* SCHWETZOFF;
STOYANOVA-VERGILOVA, p. 138, 144 (?),
145 (pars).
- pt 1966 *Hibolites longior* SCHWETZOFF;
DRUSHCHITS & MIKHAYLOVA, p. 120-121
[Early? Hauterivian] (non p. 117 [Late
(st) Hauterivian]).
- pt ? 1970 *Hibolites longior* SCHWETZOFF;
STOYANOVA-VERGILOVA, p. 13-14, Pl. III,
figs. 1-2 (?), 3.
- 1984 *Hibolites subfusiformis* (RASPAIL)
morphé B; GAYTE, Pl. I, fig. 1.
- 1984 *Hibolites subfusiformis* (RASPAIL)
morphé A; GAYTE, Pl. I, fig. 2.
- ? 1984 *Hibolites dumasi* n. sp. morphé A
GAYTE, Pl. I, fig. 4 [-unpublished-:
nom. nud.].
- pt 1994 *Hibolites longior* SCHWETZOFF; VAŠIČEK
et alii, p. 24, 80 [Early Hauterivian].
- non 1994 *Hibolites longior* SCHWETZOFF; VAŠIČEK
et alii, p. 24 (pars), 43, 80 (pars), Pl.
25, figs. 7-8 [Late Hauterivian].
- 1995 *Pseudohibolites longior* (SCHWETZOFF);
RIEGRAF, p. 103.
- 1997 *Hibolites* cf. *longior* SCHWETZOFF;
BARABOSHKIN & YANIN, p. 15 [Late
Valanginian].
- non 2002 *Hibolites longior* SCHWETZOFF;
TOPCHISHVILI *et alii*, p. 64-65, Pl. VI,
figs. 1-2 [latest Hauterivian; =
Hibolites sp. nov. gr. *cigaretus*
STOYANOVA-VERGILOVA, 1965].
- 2004 *Hibolites longior* SHVETSOV; JANSSEN &
FÖZY, p. 37, Pl. II, figs. 20-21 (pars
cum syn.).

Remarks: The material of SHVETSOV [SCHWETZOFF] is from the "Calcaire à *Duvalia bipartita*, *Duv. polygonalis*, *Hoplites amblygonius*, etc." from Abkhazia (western Georgia). At first these cephalopods were thought to indicate a Valanginian and Hauterivian age. However, subsequently this limestone was considered to represent only the Late Hauterivian (ERISTAVI, 1961; DRUSHCHITS & MIKHAYLOVA, 1966). The belemnites in it: *Duvalia bipartita* (= *Pseudobelus* (gr.) *brevis* PAQUIER) and *Duvalia polygonalis* (= ? *Pseudoduvalia trabiformis*) would indeed indicate "mid" Hauterivian beds. Either *Hibolites longior* has a fairly long stratigraphic range, or two or more species are involved (see above). Clearly, *H. longior* occurs in strata of earliest Hauterivian

age and, as can be judged from the synonymy, I prefer to restrict the species to the latest (?) Valanginian - earliest Hauterivian interval. Individuals from strata of Late Hauterivian age are referred to one of these three species: *Hibolithes* gr. *subfusiformis* RASPAIL, *Hibolithes josephinae* (HONNORAT-BASTIDE) or *Hibolithes* gr. *cigaretus* STOYANOVA-VERGILOVA. The specimen listed as *Hibolithes longior?* differs from the type in that the alveolar groove is shorter. These variants are most probably within the limits of intra-specific variation. *Hibolithes longior* clearly differs from *Hibolithes subfusiformis* (RASPAIL) and *Hibolithes subfusiformis* RASPAIL. Juvenile specimens of *H. longior* s.s. are much more elongated and show (generally) a marked, longer alveolar groove than the questionable variant does. Juvenile specimens of *H. subfusiformis* RASPAIL are of the *Belemnites pistilliformis*-type and show no, or at most a very faint, alveolar groove. Like most species of *Hibolithes*, excluding *H. subfusiformis* (RASPAIL) with its spindle-like rostrum, the rostrum is hastate and during ontogeny this feature becomes more and more pronounced. *Hibolithes* (gr.) *cigaretus* appears more robust than the relative slender *H. longior*, is much less elongated, and has a pronounced rather long alveolar groove. *H. josephinae* is an elongated rather slender, well rounded (in cross-section) belemnite, with a long but faint alveolar groove.

Stratigraphic distribution: Latest Valanginian (?) - earliest Hauterivian.

***Hibolithes* sp. 1**

(Pl. 1, figs. 12-13)

? 1849 *Belemnites pistilliformis* BLAINVILLE; QUENSTEDT, Pl. 29, fig. 44.

Remarks: A relative short fusiform rostrum with a well developed alveolar groove and a pointed to mucronate apex. All cross-sections show rounded outlines. Whether it is a new species or a teratological specimen of *H. gr. subfusiformis* RASPAIL is not known at the moment (see below). Superficially it shows some morphological similarities to *Rhopaloteuthis*-like species. Unfortunately, the provenance of QUENSTEDT's specimen is uncertain. However, it is indicated to have come from the Castellane area.

Stratigraphic occurrence: Earliest *S. sayni* Zone (early Late Hauterivian).

***Hibolithes* sp. (gr. *subfusiformis* RASPAIL)**

(Pl. 1, figs. 8-11, 18-19)

? 1800 "bélemnite en massue" SAGE, Pl. II, fig. 3.

+ 1829 *Belemnites rugosus* RASPAIL, p. 322-323, Pl. 8, fig. 89 [nom. dub.].

pt 1841 "deformed *Belemnites subfusiformis*" RASPAIL; DUVAL-JOUVE, Pl. 10, figs. 11-24.

1913 *Hibolites* sp. SHVETSOV, p. 53, 68, Pl. II, fig. 3.

Remarks: Teratologic specimens of *H. gr. subfusiformis* RASPAIL are common. Apparently, predation (synecological; see MIETCHEN *et alii*, 2005) and accumulation (environmentally induced stress) was relatively high, especially in the hemipelagic deposits.

Stratigraphic occurrence: These teratological morphs occur throughout the sedimentary rocks but appear to be especially abundant near the boundary between the Early and Late Hauterivian.

***Hibolithes subfusiformis* (RASPAIL, 1829)**

(Pl. 1, figs. 14-17)

1829 *Belemnites subfusiformis* RASPAIL, p. 325, Pl. 8, fig. 93.

pt 1841 *Belemnites subfusiformis* RASPAIL; DUVAL-JOUVE, Pl. 9, figs. 3 (?), 7, 11.

non 2004 *Hibolithes subfusiformis* (RASPAIL); JANSSEN & FÖZY, Pl. II, fig. 17 (pars cum syn.).

Remarks: Only morpho-typical specimens are included, *i.e.* specimens with a true spindle-like (subfusiform) outline. Specimens with fusiform (lanceolate or hastate) morphs are referred to *H. gr. subfusiformis* RASPAIL or to *Hibolithes fusoides* (LAMARCK, 1822).

Stratigraphic occurrence: *S. sayni* through earliest *P. ligatus* zones (Late Hauterivian).

***Hibolithes* gr. *subfusiformis* RASPAIL (= pars *Belemnites jaculum* PHILLIPS, non FAURE-BIGUET, 1819 nec SWINNERTON, 1937)**

(Pl. 1, figs. 20-21)

+ 1819 *Belemnites clava* FAURE-BIGUET, p. 48-49 [nom. dub.].

? + 1819 *Belemnites index* FAURE-BIGUET, p. 50 [nom. dub.].

+ 1819 *Belemnites striatus* FAURE-BIGUET, p. 53-54 [nom. dub.].

+ 1829 *Belemnites praemorsus* RASPAIL, p. 325-326, Pl. 6, fig. 27 [teratological specimen: nom. dub.].

1829 *Belemnites symmetricus* RASPAIL, p. 324-325, Pl. 8, fig. 90 [nom. obl.].

+ 1829 *Belemnites pistilliformis* RASPAIL, p. 327, Pl. 8, figs. 98-102.

pt 1841 *Belemnites pistilliformis* BLAINVILLE; DUVAL-JOUVE, Pl. 8, figs. 11-12.

pt 1841 *Belemnites subfusiformis* RASPAIL; DUVAL-JOUVE, Pl. 9, figs. 1, 8-9, 12.

pt 1841 "deformed *Belemnites subfusiformis*" RASPAIL; DUVAL-JOUVE, Pl. 10, figs. 25-26.

- 1886 *Belemnites inopinatus* n. sp. ROTHPLETZ, p. 168, Pl. XIV, figs. 17-17.a.
- ? 1984 *Hibolites dumasi* n. sp. morphe B GAYTE, Pl. I, fig. 4 [-unpublished-: *nom. nud.*].
- 2004 *Hibolites subfusiformis* (RASPAIL); JANSSEN & FÖZY, Pl. II, fig. 17 (pars cum syn.).

Remarks: This group includes species like

Hibolites symmetricus (RASPAIL, 1829), and probably *Hibolites dumasi* GAYTE, 1984 [-unpublished-: *nom. nud.*], *Hibolites subfusiformis* RASPAIL, among others. Also see remarks in JANSSEN & FÖZY (2004, p. 42-43).

Stratigraphic occurrence: This group of belemnites appears first in the Early Hauterivian and disappears in the earliest Barremian (*Nicklesi pulchella*/*Kotetišvilia nicklesi* zones).

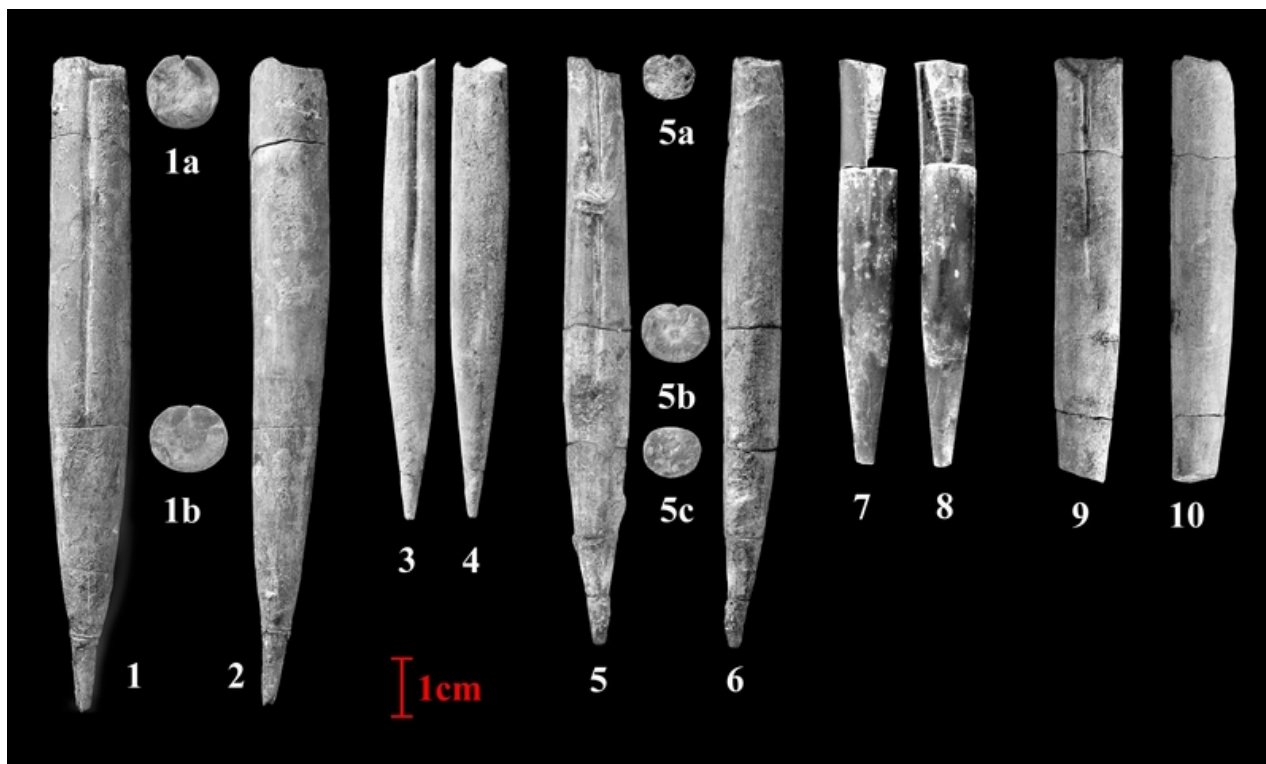


Plate 4 (Valanginian-Hauterivian; *Adiakritobelus*): Figs. 1-2.- *Adiakritobelus peyroulesensis* sp. nov. holotype, RGM 214.798, CB079, V/H boundary. Fig. 1a.- Cross-section in alveolar opening. Fig. 1b.- Cross-section near end of alveolar groove. Figs. 3-4.- *Adiakritobelus peyroulesensis* sp. nov. paratype, RGM 214.787, CB078, V/H boundary. Figs. 5-6.- *Adiakritobelus peyroulesensis* sp. nov. topotype, RGM 214.796, CB079, V/H boundary. Fig. 5a.- Cross-section in alveolar opening. Fig. 5b.- Cross-section near maximum diameter. Fig. 5c.- Cross-section in apical part. Figs. 7-8.- *Adiakritobelus peyroulesensis* sp. nov. topotype, RGM 214.758, Vergol, VGL170, *Criosarasinella furcillata* Zone. Figs. 9-10.- *Adiakritobelus* cf. *peyroulesensis* sp. nov. topotype, RGM 214.895, CL095, V/H boundary.

Genus *Vaunagites* COMBEMOREL & GAYTE, 1981

Remarks: In my opinion *Belemnites pistilliformis* BLAINVILLE, 1827, and *Vaunagites pistilliformis* COMBEMOREL & GAYTE, 1981, should be considered discrete species. However, part of BLAINVILLE's specimens could be referred to the genus *Vaunagites*, but all of those figured are apical parts only (see *Belemnites pistilliformis* BLAINVILLE).

Stratigraphic occurrence: Latest Valanginian through earliest Hauterivian (early *A. radiatus* Zone only). A closely related group occurs in the *C. loryi* Zone, however, most probably these are related to *Hibolites longior* SHVETSOV.

Vaunagites sp.

- pt ? 1827 *Belemnites pistilliformis* BLAINVILLE, p. 98-99, non Pl. 5, figs. 14-15 *nec* figs. 16-17.
- 1981 *Vaunagites pistilliformis* (BLAINVILLE); COMBEMOREL & GAYTE, p. 107-108, Pl. 1, figs. 1-4, 8-9 (pars cum syn.).

Remarks: Incomplete and immature specimens are virtually inseparable from immature *H. gr. subfusiformis* RASPAIL or *Belemnites pistilliformis* BLAINVILLE. In general, *Vaunagites* is distinguishable because it has a very elongated rounded rostrum with no, or virtually no alveolar groove.

Stratigraphic occurrence: *Teschenites callidiscus* Subzone (see GAYTE, 1984) through *A. radiatus* Zone (COMBEMOREL & GAYTE, 1981); latest Valanginian to earliest Hauterivian. This species seems to be rare or could not be recognized in our material, and is included in

Belemnites pistilliformis BLAINVILLE. Here, it appears to be present only in the "middle" of the *A. radiatus* Zone.

**Genus *Adiakritobelus*
JANSSEN & FÖZY, 2004**

Remarks: A genus that partially replaces the invalid (manuscript name) genus *Combemorelites* GAYTE, 1984 [-unpublished-: *nom. nud.*; see JANSSEN & FÖZY, 2004, p. 35-36]. The species are characterized by mature growth-stages that show either a hibolitoïd outer-morphology or a mesohibolitoïd outer-morphology. Hibolitoïd-morphs display mainly rounded to slightly depressed cross-sections. Most mesohibolitoïd-morphs are more strongly depressed in cross-section. Juvenile to immature specimens are in general hibolitoïd. The alveolar areas are generally rounded in cross-section but may show a tendency toward becoming subquadrangular. The alveolus occupies from one-third to two-third of the length of the rostrum. However, in some species it is shorter and the alveolar cavity is always shallow with respect to the length of the alveolus. The position of the alveolar-line shifts between a central and a dorsal position but is generally on the dorsal side. Some species show a poorly defined to clearly flattened area in the ventral region. The apical area is always depressed, while the apex may be obtuse, pointed or even very elongated. The rostrum varies: subfusiform, fusiform or elongated. The splitting surface shows a slit more or less comparable with that of the Late Barremian - Early Aptian genus *Mesohibolites s.s.*, and curves forwards, *i.e.* towards the alveolar opening, in an arcuate curve. Lateral lines, when visible, appear to be comparable to those of *Hibolites*. They run parallel approximately from the alveolar opening to the apex. Exceptionally, three parallel lines can be seen. Mature specimens often have a mucronate apex.

Species included: Hibolitoïd-morphs include *Adiakritobelus robustus* (DUVAL-JOUVE, 1841; = *Combemorelites mariae* GAYTE, 1984 [-unpublished-: *nom. nud.*]), *Adiakritobelus rogeri* (DELATTRE, 1952), and *Adiakritobelus gayteae* sp. nov. (pro *Hibolites piriformis* GAYTE, 1984 [-unpublished-: *nom. nud.*]), while mesohibolitoïd-morphs include *Adiakritobelus brevirostris* (RASPAIL, 1829), *Adiakritobelus minaret* (RASPAIL, 1829), and *Adiakritobelus peyroulesensis* sp. nov. (see Table II for differences between the species).

Stratigraphic occurrence: Late Valanginian (*V. peregrinus* Zone) to earliest Hauterivian (early *A. radiatus* Zone only). However, in the upper part of the *K. pronecostatum* Subzone and the base of the *V. peregrinus* Subzone, teratological? (Pl. 3, figs. 1-2) specimens occur that most probably represent the ancestor of this genus.

***Adiakritobelus brevirostris*
(RASPAIL, 1829)**

(Pl. 3, figs. 3-8)

- * 1829 *Belemnites brevirostris* RASPAIL, p. 321-322, Pl. 8, fig. 80 [HT by MT].
- 1829 *Belemnites navicula* RASPAIL, p. 321, Pl. 8, fig. 79 [immature].
- ? 1829 *Belemnites oblongus* RASPAIL, p. 322, Pl. 8, fig. 82.

Remarks: Specimens of this species came from the glauconitic beds (Valanginian-Hauterivian) near La Lagne (east of Castellane).

Stratigraphic occurrence: This species is present in the phosphatic conglomerate, at the base of the glauconitic sediments that characterize the Valanginian-Hauterivian boundary in the Peyroules area. In the deeper water deposits of the Vocontian Basin it occurs from the *V. peregrinus* Zone up to the base of the *C. furcillata* Zone (*e.g.* beds 338a-b to 363 of the Angles Valanginian Hypostratotype section (= AVHS)).

***Adiakritobelus minaret*
(RASPAIL, 1829)**

(Pl. 3, figs. 9-16)

- * 1829 *Belemnites minaret* nob. RASPAIL, p. 324, Pl. 8, fig. 94 [HT by MT].
- 1829 *Belemnites fusus* RASPAIL, p. 322, Pl. 8, fig. 81 [immature].
- ? 1858 *Belemnites minaret* RASPAIL; PICTET & LORIOU, p. 7-8, Pl. I bis, fig. 8.
- pt 1915 *Belemnites minaret* RASPAIL; KILIAN & REBOUL, p. 26

Remarks: The type specimen is from the glauconitic (Valanginian-Hauterivian) beds near La Lagne (east of Castellane). See Table II, for its distinction from other species.

Stratigraphic occurrence: The phosphatic conglomerate at the base of the glauconitic sediments that characterize the Valanginian-Hauterivian boundary in the Peyroules area. In the deeper-water deposits its range is rather short. It occurs from bed 346a through bed 358-359 (upper part of the *O. nicklesi* Zone) of the AVHS.

***Adiakritobelus peyroulesensis* sp. nov.**

(Pl. 4, figs. 1-2 (HT), 3-4 (paratype), 5-6 (see OOSTER, 1863, Pl. A, fig. 3), 7-10; Pl. 9, figs. 5-6)

- 1841 *Belemnites subfusiformis* RASPAIL var. γ DUVAL-JOUVE, Pl. 9, fig. 10.
- pt 1841 *Belemnites Platyurus* DUVAL-JOUVE, p. 73-74 [the locality La Garde], non Pl. 11, figs. 1-4.
- pt 1863 *Belemnites semicanaliculatus* BLAINVILLE, variété OOSTER, p. 3-4, Pl. A, figs. 2, 3 (?), 4.

- ? 1897 *Belemnites beskidensis* NEUMAYR & UHLIG; ROMAN, p. 123.
 ? 1897 *Belemnites (Hibolites) beskidensis* UHLIG; ROMAN, p. 129.
 ? 1922 *Belemnites Beskidensis* UHLIG; TOMITCH, p. 14.
 ? 1922 *Belemnites cf. gladiiformis* UHLIG; TOMITCH, p. 14.

Derivation of name: Named after the geographical area of the community of Peyroules (Alpes de Haute-Provence, France).

Holotype: RGM 214.798 (Pl. 4, figs. 1-2).

Types: RGM 214.798 [HT, mature], RGM 214.787 (immature) and RGM 214.995 (juvenile).

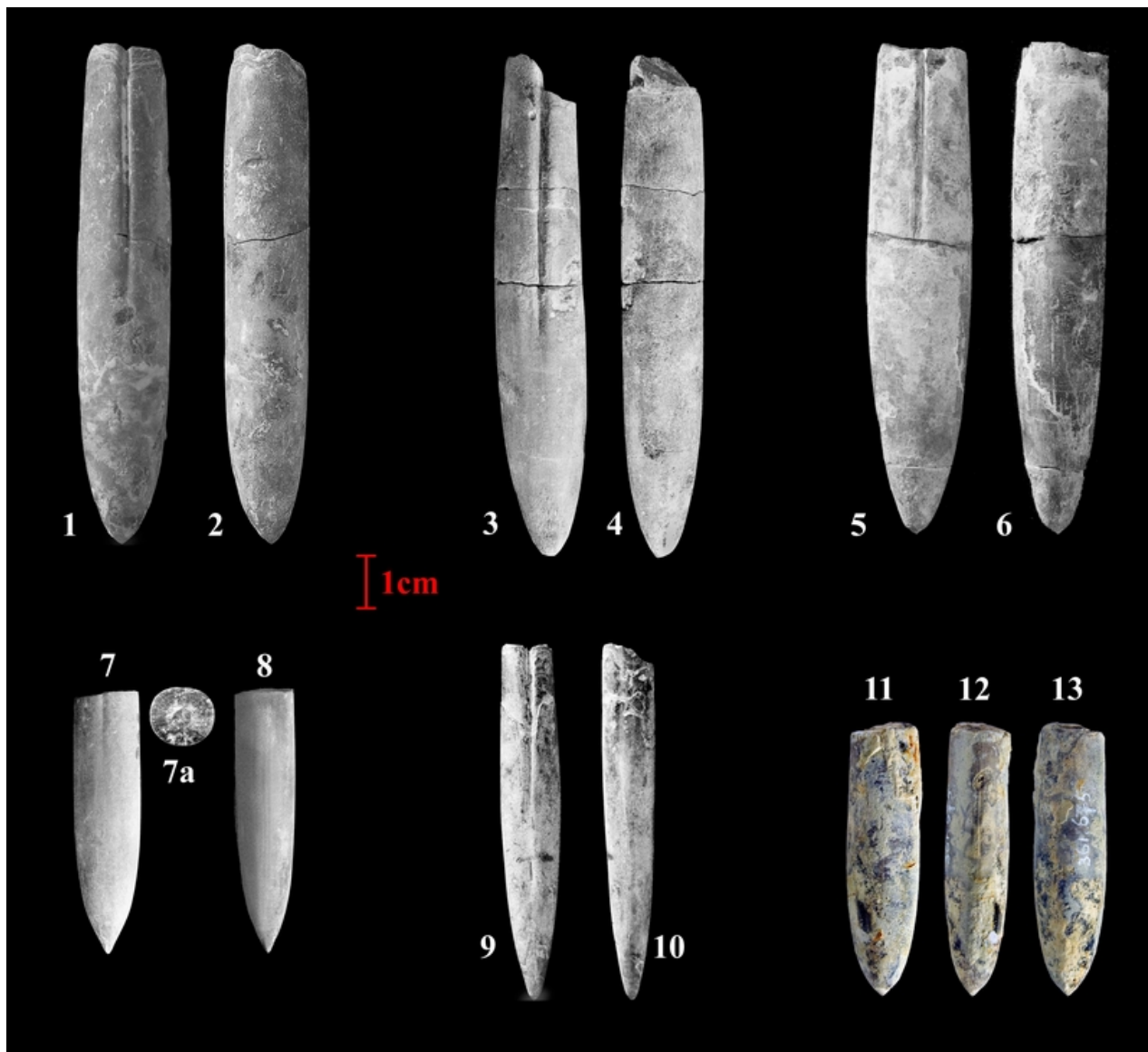


Plate 5 (Valanginian-Hauterivian; *Adiakritobelus*): Figs. 1-2.- *Adiakritobelus robustus* (DUVAL-JOUVE, 1841) topotype, RGM 214.803, CL095, V/H boundary. Figs. 3-4.- *Adiakritobelus robustus* (DUVAL-JOUVE, 1841) topotype, RGM 214.913, CL095, V/H boundary. Figs. 5-6.- *Adiakritobelus robustus* (DUVAL-JOUVE, 1841), RGM 214.804, LLG102, V/H-boundary. Figs. 7-8.- *Adiakritobelus cf. robustus* (DUVAL-JOUVE, 1841), RGM 214.778, Angles, ANG393, *Acanthodiscus radiatus* Zone. Fig. 7a.- Cross-section in alveolar part. Figs. 9-10.- *Adiakritobelus robustus* (DUVAL-JOUVE, 1841) (imm.) topotype, RGM 214.989, CB079, V/H boundary. Figs. 11-13.- *Adiakritobelus cf. robustus?* (DUVAL-JOUVE, 1841), RGM 361.675, Tornajo (southeastern Spain), B130 (-131), late *Teschenites callidiscus* (?) Subzone.

Type stratum: Latest Valanginian - earliest Hauterivian glauconite bed CB79 (Collet des Boules).

Material: From Angles, RGM 214.765 (ANG373-381) and unregistered material; Cheiron, RGM 560.587 (CHE377a2top); Clausson, RGM 214.789a-793e, 214.794, 214.799, 214.870-872, 214.880, 214.884,

214.891-896, 214.904-906, 214.921-922, 214.927, 214.934, 214.937, 214.994-996, 215.000, 288.371, 288.373, 288.375 (CL095); Collet des Boules, RGM 214.787 (CB078), RGM 214.788, 214.791a-c, 214.795-798, 214.800, 214.845, 214.852-854; La Charce RGM 214.766 (LC166-167); Ravin du Mal Bouisset, RGM 560.526, 560.536-538 (RMB097); Vergol, RGM 214.755 (VGL163-164, latest *O. nicklesi* Zone),

214.756 (VGL167b-168), 214.757-758 (VGL170), 214.759 (VGL172b) all *C. furcillata* Zone, 214.760 (VGL185, *T. callidiscus* Subzone), 214.767-768 (VGL169-169a1, *C. furcillata* Zone).

Description: Very elongated rostrum, due to the stretched apical area. Rostrum is more or less spindle-like in immature specimens, while in mature specimens the maximum diameter of the cross-section is near the beginning of the elongate, conical alveolus. The alveolar groove is long, the alveolar cavity short, the beginning of the alveolus is centrally placed. Apical area initially depressed, flattened dorso-ventrally but towards the apex it becomes more and more rounded. The alveolar part is rounded to angular. These characteristics results in a mesohibolitoid type of rostrum.

Remarks: The mesohibolitoid types like *Adiakritobelus brevirostris* (RASPAIL) and *Adiakritobelus minaret* (RASPAIL) differ from the new species due to their more obtuse outer morphology and shorter overall rostrum.

Stratigraphic distribution: Only a few specimens were collected from the AVHS and Cheiron sites, where they appear to be restricted to the latest Valanginian. However, in other successions (Vergol, La Charce) the species first occurs in the sediments that characterize the uppermost part of the *O. nicklesi* Zone. Most commonly, it is associated with the glauconitic deposits in the Peyroules area. It appears to range from the top of the *O. nicklesi* Zone to the base of the *T. callidiscus* Subzone, being most abundant in the *C. furcillata* Subzone of the deeper-water deposits.

***Adiakritobelus robustus* (DUVAL-JOUVE, 1841)**

(Pl. 5, figs. 1-6, 7-8 (cf.), 9-10, 11-13 (cf.); Pl. 9, figs. 1-2 [NT])

- 1841 *Belemnites subfusiformis* RASPAIL var. δ , *robustus* DUVAL-JOUVE, p. 69, Pl. 9, figs. 5-6.
- 1922 *Belemnites* (cf.) *Fallauxi* UHLIG; TOMITCH, p. 14.
- + 1984 *Combemorelites mariae* n. sp. GAYTE, p. 101-102, Pl. 2, figs. 4-5 [-unpublished-: *nom. nud.*].
- 1993 *Hibolites subfusiformis* var. *robustus* (DUVAL-JOUVE); AUTRAN, p. 57, 66.
- 2004 *Adiakritobelus* n. gen., n. sp. JANSSEN & FÖZY, Pl. II, figs. 11-12.

Remarks: DUVAL-JOUVE (1841, p. 71) noted that these belemnites occur only in the glauconitic deposits, among others, in the Peyroules area. The material presented here shows various ontogenetic stages.

Stratigraphic occurrence: In the phosphatic

conglomerate at the base of the glauconitic strata that characterize the Valanginian-Hauterivian boundary in the Peyroules area, and in the early *A. radiatus* Zone of the Les Allaves area. A specimen from Angles is from bed 393 (*A. radiatus* beds; Pl. 5, figs. 7-8). It is restricted to the earliest Hauterivian. The Hungarian specimen figured by JANSSEN & FÖZY (2004) occurred either in uppermost Valanginian or lowermost Hauterivian sedimentary rocks.

Geographical occurrence: France, Hungary (JANSSEN & FÖZY, 2004), and Spain (Tornajo, see Pl. 5, figs. 11-13).

***Adiakritobelus rogeri* (DELATTRE, 1952)**

(Pl. 6, figs. 1-4, 5-6 (immature), 7-8 (juvenile); Pl. 9, figs. 3-4)

- ? + 1829 *Belemnites rimosus* RASPAIL, p. 318-319, Pl. 8, fig. 68 [teratological specimen: *nom. dub.*].
- 1952 *Hibolites rogeri* n. sp. DELATTRE, p. 42-43, Pl. II.a, figs. 1-3.
- 1984 *Combemorelites rogeri* (DELATTRE); GAYTE, p. 102-104, Pl. 2, figs. 6-9 [-unpublished-: *comb. nud.*].
- 1989 *Hibolites cigaretus* STOYANOVA-VERGILOVA; MICHALÍK & VAŠÍČEK, Pl. 3, fig. 1.
- 1993 *Hibolites rogeri* DELATTRE; AUTRAN, p. 57, 73.
- 1994 *Hibolites cigaretus* STOYANOVA-VERGILOVA; VAŠÍČEK *et alii*, p. 79, Pl. 25, figs. 3-4 [= MICHALÍK & VAŠÍČEK, 1989].
- 1995 *Pseudohibolites rogeri* (DELATTRE); RIEGRAF, p. 105.

Remarks: Type specimens are from the Peyroules area.

Stratigraphical occurrence: In the phosphatic conglomerate, at the base of the glauconitic sediments that characterize the Valanginian-Hauterivian boundary in the Peyroules area. In the AVHS it is found in the beds 362 to 387 (*C. furcillata* through early *A. radiatus* Zone).

***Adiakritobelus (?) gayteae* sp. nov.**

(Pl. 6, figs. 9-10)

- pt 1965 *Hibolites* aff. *obtusirostris* (PAVLOW); STOYANOVA-VERGILOVA, p. 153-154, Pl. II, fig. 1 (non, cum syn.).
- pt ? + 1984 *Hibolites piriformis* n. sp. GAYTE, p. 94-96, Pl. 1, figs. 6-7, 8 (non?) (cum syn.) [-unpublished-: *nom. nud.*].

Derivation of name: Named after Dominique GAYTE.

Holotype: RGM 214.909 (Pl. 6, figs. 9-10).

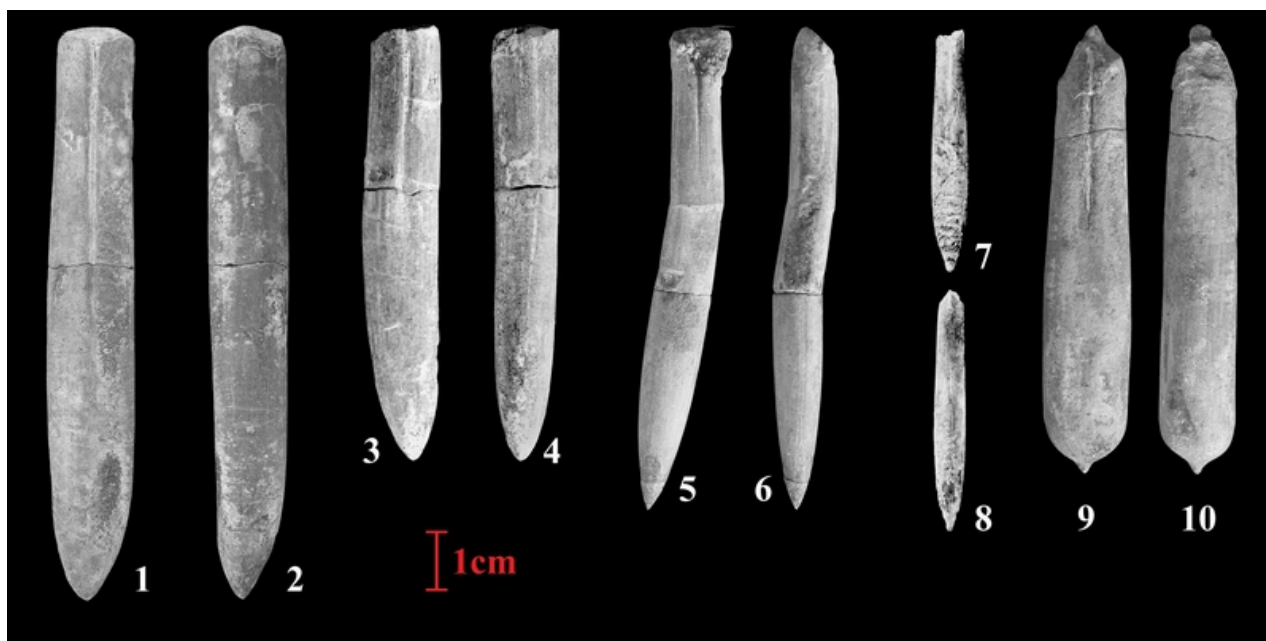


Plate 6 (Valanginian-Hauterivian; *Adiakritobelus*): Figs. 1-2.- *Adiakritobelus rogeri* (DELATTRE, 1952) topotype, RGM 214.926, CL095, V/H boundary. Figs. 3-4.- *Adiakritobelus rogeri* (DELATTRE, 1952) topotype, RGM 214.897, CL095, V/H boundary. Figs. 5-6.- *Adiakritobelus rogeri* (DELATTRE, 1952) imm. topotype, RGM 214.910, CL095, V/H boundary. Figs. 7-8.- *Adiakritobelus* sp. (gr. *rogeri* (DELATTRE, 1952)) (juv.), RGM 214.963, Vergol, VGL119-124, *Karakaschiceras pronecostatum* Subzone. Figs. 9-10.- *Adiakritobelus* (?) *gayteae* sp. nov. holotype, RGM 214.909, CL095, V/H boundary.

Type stratum: Uppermost Valanginian - lowermost Hauterivian glauconite bed CL095 (Clausson).

Description: Rostrum hibolitoid with a characteristic flattened ventral side, better developed and more visible in mature or gerontic specimens (see HT). The apex is mucronate and the maximum width of the rostrum is close to the apex. As a result the overall aspect is that of a rostrum which tapers down to the alveolar opening. The alveolar area is round, due to the absence of the flattened ventral side and generally a well-marked but narrow alveolar groove is visible. The alveolus is shallow and may attain about half the length of the alveolar groove, but is generally much shorter. Immature rostra have a hibolitoid appearance, with a ventral flattening less pronounced than that of mature specimens and a mucron is absent. The juvenile stages are virtually impossible to distinguish from *Belemnites pistilliformis* BLAINVILLE.

Material: Clausson, RGM 214.875, 214.900, 214.909, 214.915, 214.940, 288.363, 288.364 (CL095); La Lagne RGM 288.720 (LLG102), 288.725 (LLG098); Les Allaves RGM 560.513 (ALL113-114), 560.514 (ALL113-114).

Remarks: The species is most probably related to *Adiakritobelus* rather than to *Hibolites*. It was described as having been collected from the *A. radiatus* beds of Clarensac (Gard, France) in the manuscript of GAYTE (1984).

Stratigraphic occurrence: Late (?) *C. furcillata* (latest Valanginian) - earliest *A.*

radiatus Zone (earliest Hauterivian).

***Adiakritobelus* spp.**

pt	1841	"deformed <i>Belemnites subfusiformis</i> " RASPAIL; DUVAL-JOUVE, Pl. 10, figs. 1-8, 9-10 (?) [teratological].
	1842	<i>Belemnites semicanaliculatus</i> d'ORBIGNY; MATHERON, p. 37 (?), 38-39, 259.
?	1858	<i>Belemnites platyurus</i> DUVAL-JOUVE; DUCRET, p. 161.
?	1863	<i>Belemnites semicanaliculatus</i> BLAINVILLE, variété OOSTER, p. 3-4, Pl. A. fig. 1 (= ? gr. <i>rogeri</i> DELATTRE).
	1872	<i>Belemnites minaret</i> RASPAIL; ROUVILLE, p. 729-730.
	1876	<i>Belemnites Minaret</i> RASPAIL; DUMAS, p. 316-317, 369.
	1878	<i>Belemnites minaret</i> RASPAIL; ESCHER von der LINTH, p. 41, 159.
	1880	<i>Belemnites minaret</i> RASPAIL; SARRAN d'ALLARD, p. 337, 338.
	1887	<i>Hastites (Hibolites) minaret</i> RASPAIL; MAYER-EYMAR, p. 76, 78.
	1892	<i>Belemnites</i> cf. <i>Fallauxi</i> UHLIG; NICKLÈS, p. 40, 47-48, 50.
	1892	<i>Belemnites</i> cf. <i>minaret</i> RASPAIL; NICKLES, p. 40, 47-48, 51.
	1912	<i>Belemnopsis</i> cf. <i>minaret</i> RASPAIL; BLAYAC, p. 170.
	1919	<i>Belemnites semicanaliculatus</i> BLAINVILLE; RODIGHIERO, p. 57.
	1922	<i>Hibolites Minaret</i> RASPAIL; FALLOT, p. 121.
?	1922	<i>Belemnites Carpathicus</i> UHLIG; TOMITCH.

- p. 14 [or? *H. longior* SHVETSOV].
- 1923 *Mesohibolites minaret* RASPAIL; FALLOT & TERMIER, p. 82.
- 1925 *Belemnites minaret* RASPAIL; EDER, p. 35.
- 1936 *Mesohibolites* aff. *minaretiformis* SCHWETZOFF; BREISTROFFER, p. 136.
- 1956 *Belemnites* cf. *fallauxi* UHLIG; DUPUY DE LÔME & SÁNCHEZ LOZANO, p. 216.
- 1956 *Mesohibolites minaret* RASPAIL; DUPUY DE LOME & SANCHEZ LOZANO, p. 216.
- 1960 *Mesohibolites minaret* RASPAIL; VYALOV *et alii*, p. 11.
- 1961 *Mesohibolites minaret* RASPAIL; TRIGUEROS MOLINA & NAVARRO ALVARGONZÁLEZ, p. 14.

Remark: This is a list of the belemnites that for the most part have been attributed erroneously to the Barremian genus *Mesohibolites*. Based on the published lists of faunas that accompanied these species, most probably they can be referred to the Valanginian-Hauterivian genus *Adiakritobelus*. However, specific attribution seems to be impossible. They include specimens recorded by various researchers in Valanginian-Hauterivian successions in the whole of the western Mediterranean area.

Family Duvaliidae PAVLOW, 1914

Genus *Duvalia* BAYLE, 1878

Duvalia binervia (RASPAIL, 1829)

(Pl. 7, figs. 1-6, 7-8 (gr.), 9-10 (gr.); Pl. 9, figs. 7-8 [NT])

- * 1829 *Belemnites binervius* RASPAIL, p. 304-305, Pl. 6, fig. 6 [HT by MT].
- 1829 *Belemnites distans* RASPAIL, p. 305-306, Pl. 6, fig. 7.
- 1829 *Belemnites truncatus* RASPAIL, p. 305, Pl. 6, fig. 9.
- 1829 *Belemnites elegans* RASPAIL, p. 306, Pl. 6, fig. 10.
- ? 1829 *Belemnites linearis* RASPAIL, p. 306, Pl. 6, fig. 11.
- pt 1841 *Belemnites hybridus* DUVAL-JOUVE, Pl. 3, figs. 3-4 (gerontic), 5 (gerontic? or teratological?), 9-12, 14-16 (?).
- non 1879 *Belemnites Ehlerti* HERMITE, p. 317-318, Pl. IV, figs. 6-7.

Remarks: The material (Pl. 9, figs. 7-8; RGM 560.594) from strata of Late Valanginian age near Cheiron (bed CHE345, *O. nicklesi* (Sub)Zone, Valanginian), is chosen to be topotypical. Juvenile to immature specimens of *Duvalia oehlerti* (HERMITE) are comparable to *D. binervia* but mature species of *D. oehlerti* are larger, more elongated with a well developed alveolus.

Stratigraphic occurrence: Latest Early Valanginian ("*N. neocomiensis*" beds *sensu*

ATROPS & REBOULET, 1993, in the *S. verrucosum* Subzone) through earliest Hauterivian (early *A. radiatus* Zone).

Duvalia dilatata (BLAINVILLE, 1827)

- pt 1827 *Belemnites dilatatus* BLAINVILLE, p. 99-100, Pl. 5, fig. 18 [LT] (non Pl. 3, fig. 13; = early/mid Jura species).
- + 1829 *Belemnites triquetor* RASPAIL, Pl. 7, fig. 46 [teratological specimen: *nom. dub.*].
- + 1829 *Belemnites amorphus* RASPAIL, Pl. 7, fig. 49 [*nom. nud.*].
- 1829 *Belemnites emarginatus* RASPAIL, Pl. 7, figs. 50-51.
- 1829 *Belemnites mitraeformis* RASPAIL, Pl. 7, fig. 52.
- + 1829 *Belemnites mitra* RASPAIL, Pl. 7, fig. 53 [teratological specimen: *nom. dub.*].
- + 1829 *Belemnites difformis* RASPAIL, Pl. 7, fig. 54 [teratological specimen: *nom. dub.*].
- 1829 *Belemnites apiculatus* RASPAIL, Pl. 7, fig. 56.
- 1829 *Belemnites sinuatus* RASPAIL, Pl. 7, figs. 59-60.
- 1829 *Belemnites spathulatus* RASPAIL, Pl. 7, fig. 61.
- 1829 *Belemnites complanatus* RASPAIL, Pl. 7, figs. 63-64.
- 1829 *Belemnites angustus* RASPAIL, Pl. 7, fig. 66 [juvenile].
- pt ? 1830 Heteromorphi RASPAIL, Pl. 2, fig. 19.
- pt 1841 *Belemnites dilatatus* BLAINVILLE; DUVAL-JOUVE, Pl. 4, figs. 2, 4-6 (?).
- 1861 *Belemnites dilatatus* BLAINVILLE; LORIOU, p. 18-19, Pl. I, fig. 3.

Remarks: Specimens of this species appear especially abundant in the sequences around the Early-Late Hauterivian.

Stratigraphic occurrence: (Latest *A. radiatus*?)/*C. loryi* through *P. ohmi* Zone (Early Hauterivian to latest Hauterivian).

Duvalia gervaisiana (DUMAS, 1876)

(Pl. 8, figs. 3-4)

- + 1872 *Belemnites Gervaisianus* ROUVILLE, p. 729, 730 [*nom. nud.*].
- pt 1876 *Belemnites Gervaisianus* DUMAS, p. 369, Pl. 1, figs. 2-3 (type missing *vide* GAYTE, 1984, p. 113).
- ? 1907 *Duvalia crimica* nov. sp. KARAKASH, p. 20, Pl. 1, fig. 8.
- 1984 *Duvalia gervaisiana* (DUMAS); GAYTE, p. 112-114, Pl. 3, fig. 2.

Remarks: Compared to *Duvalia binervia* (RASPAIL) this species shows a much larger, much more elongate rostrum and a well-marked, relatively deep alveolus. The constriction in the alveolar area is scarcely visible or nearly absent. Juvenile to immature specimens also have this characteristic and thus

can be distinguished from the more slender and well-constricted juvenile and immature *binervia*-specimens. Moreover, apparently characteristically, the alveolar area is initially bent slightly to the ventral side. The alveolar groove is well developed but relatively short. Compared to *Duvalia dilatata* (BLAINVILLE) the species appears stouter, *i.e.* less compressed and is more regular in outline in mature stages, and lacks a well-marked constriction in juvenile

and immature specimens. Furthermore its stratigraphic distribution is discrete, preceding that of the *Duvalia dilatata*-group.

Stratigraphic occurrence: The uppermost Valanginian (?) - lowermost Hauterivian glauconitic deposits at Clausson. According to GAYTE (1984), it is known only from the lowermost Hauterivian *A. radiatus* beds in the Gard (south of France). It probably occurs in the Crimea (Biassala) too.

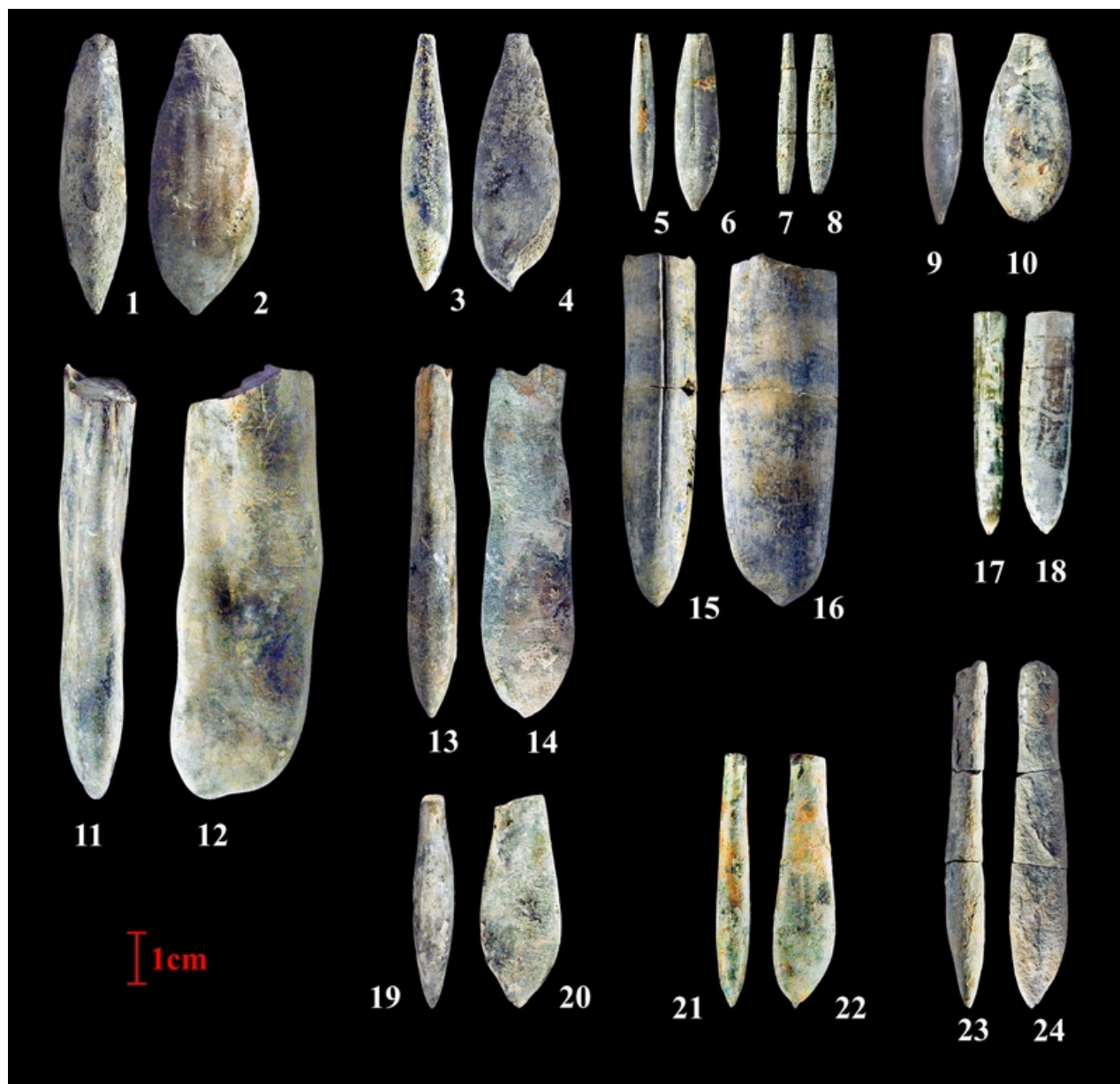


Plate 7 (Valanginian-Hauterivian; *Duvalia*): Figs. 1-2.- *Duvalia binervia* (RASPAIL, 1829) gerontic, RGM 288.571, CL095, V/H boundary. Figs. 3-4.- *Duvalia binervia* (RASPAIL, 1829) topotype, RGM 560.593, CHE361-362, *Criosarasinella furcillata* Zone. Figs. 5-6.- *Duvalia binervia* (RASPAIL, 1829) juv./imm. topotype, RGM 560.588, CHE342-a, *Olcostephanus nicklesi* Subzone. Figs. 7-8.- *Duvalia* sp. juv. (gr. *binervia*? (RASPAIL, 1829)), RGM 288.343, CB085, *Crioceratites loryi* Zone. Figs. 9-10.- *Duvalia* gr. *binervia* (RASPAIL, 1829), RGM 288.526, CL095, V/H boundary. Figs. 11-12.- *Duvalia variegata* (RASPAIL, 1829) gerontic topotype, RGM 288.637, CL095, V/H boundary. Figs. 13-14.- *Duvalia variegata* (RASPAIL, 1829) topotype, RGM 288.636, CL095, V/H-boundary. Figs. 15-16.- *Duvalia maioriana* STOYANOVA-VERGILOVA, 1965, RGM 288.648, Clausson (west), free specimen. Figs. 17-18.- *Duvalia maioriana* STOYANOVA-VERGILOVA, 1965, RGM 345.565, Río Argos (Spain), A43-44, *Lyticoceras nodosopicatum* Zone. Figs. 19-20.- ?*Duvalia* sp. 1 (imm.), RGM 288.599, CL095, V/H boundary. Figs. 21-22.- *Duvalia* sp. 3 (gr. *binervia* (RASPAIL, 1829)), RGM 288.584, CL095, V/H boundary. Figs. 23-24.- *Duvalia* sp. 3 (gr. *binervia* (RASPAIL, 1829)), RGM 560.590, CHE378mid, *Acanthodiscus radiatus* Zone.

***Duvalia* aff. *hybrida*
(DUVAL-JOUVE, 1841)**

(Pl. 8, figs. 17-18)

- ? 1965 *Duvalia hybrida* (DUVAL-JOUVE); STOYANOVA-VERGILOVA, p. 190-191, text-fig. F, Pl. VIII, fig. 5 (? or *Pseudoduvalia polygonalis* (BLAINVILLE)).

Remarks: Probably ancestral to the genus *Pseudoduvalia*. It represents one of the last of the group of species related to the Late Valanginian - earliest Hauterivian *Duvalia binervia* (RASPAIL).

Stratigraphic occurrence: Latest *A. radiatus* through *C. loryi* Zone (earliest Hauterivian).

***Duvalia maioriana*
STOYANOVA-VERGILOVA, 1965**

(Pl. 7, figs. 15-16, 17-18 (imm.); Pl. 8, figs. 19-20)

- ? 1951 *Belemnites (Duvalia) grasianus* DUVAL-JOUVE; PETKOVIC & MARKOVIC, p. 23, Pl. I, fig. 1.
- ? 1965 *Duvalia dilatata maioriana* subsp. nov. STOYANOVA-VERGILOVA, Pl. VI, figs. 1-2.
- pt ? 1965 *Duvalia binervia* (RASPAIL); STOYANOVA-VERGILOVA, Pl. V, fig. 4 (?).
- 1995 *Duvalia dilatata maioriana* STOYANOVA-VERGILOVA; RIEGRAF, p. 111 (recte *maioriana*).
- 2004 *Duvalia* cf. *maioriana* STOYANOVA-VERGILOVA; JANSSEN & FÖZY, Pl. II, figs. 6-7, 18-19 (but only a part of the species in their synonymy).

Remarks: Only three free specimens were collected from the sections investigated here. They are from the glauconitic beds in the Clausson area (the westernmost of the sections studied, see Fig. 2). Most probably they come from strata in that area dated latest Early Hauterivian. At the moment the species is not yet well understood. For instance, it seems to show a wide variation with respect to its alveolar groove and has a relative deep alveolus. Its outline is much more regular than those of mature morphs of *D. dilatata* and *D. dilatata binervioides*. It occurs over a broad geographical area (Bulgaria, France, Hungary, Morocco, Serbia, and Spain). An immature specimen from the Río Argos (Spain) is figured on Pl. 7, figs. 17-18.

Stratigraphic occurrence: In the *L. nodosoplicatum* through *S. sayni* / *P. ligatus* zones (latest Early to early Late Hauterivian).

***Duvalia* sp. 1**

(Pl. 7, figs. 19-20 (imm.?))

- + 1984 *Duvalia valnagensis* n. sp. GAYTE, p. 109-111, Pl. 3, figs. 3-4 [-unpublished-: *nom. nud.*].

- + 1998 *Duvalia vaunagensis* [GAYTE]; RIEGRAF *et alii*, p. 264 [*nomen correctum*; *nom. nud.*].

Remarks: This species is one of the *Duvalia* gr. *binervia* (RASPAIL) offshoots. But both immature and mature specimens can be distinguished quite easily from *Duvalia binervia* for the species has a very pronounced dorsally bended knick in the alveolar region. Otherwise juvenile to immature specimens are much like *binervia*-morphs. As the material from the investigated sections is too sparse, the species is listed here only with an open nomenclature.

Stratigraphic occurrence: Latest *C. furcillata* (Late Valanginian) through early *A. radiatus* Zone (earliest Hauterivian). GAYTE (1984) mentions its being from the *T. callidiscus* beds of the Gard.

***Duvalia* sp. 2**

- + 1984 *Duvalia clapiti* n. sp. GAYTE, p. 111-112, Pl. 3, figs. 5-8 [-unpublished-: *nom. nud.*].

Remarks: As GAYTE (1984) indicated in her manuscript, these belemnites appear to be intermediate between the *binervia*- and *dilatata*-groups.

Stratigraphic occurrence: According to GAYTE (1984) it is from the *T. callidiscus* beds of the Gard (top of the *C. furcillata* Zone; latest Valanginian).

***Duvalia* sp. 3**

(Pl. 7, figs. 21-24)

Remarks: This species is one of the *Duvalia binervia* (RASPAIL) group. It differs in that it appears to be more elongated and has a well-defined alveolus in most of the available material. The alveolar area is more or less comparable to that of *Duvalia* sp. 2, so it may be related to, or a variation of that species. But it appears to be more dilated than *Duvalia* sp. 2. Only few specimens could be collected, in the same beds as *Duvalia* sp. 2.

Stratigraphic occurrence: Latest *C. furcillata* (late *T. callidiscus* beds at Cheiron) through mid *A. radiatus* Zone (Les Allaves), besides in the glauconitic deposits at Clausson (CL095).

***Duvalia* sp. 4**

(Pl. 8, figs. 5-6)

- ? pt 1841 *Belemnites hybridus* DUVAL-JOUVE, Pl. III, figs. 7-8.

Remarks: Most probably this form is one of the larger morphs of the variations around *Duvalia* gr. *binervia* (RASPAIL). Like *Duvalia variegata* (RASPAIL) it has a tendency towards the Hauterivian *dilatata*-group (perhaps close to *D. maioriana*) or *Duvalia* sp. 2. The well-compressed rostrum tapers downward with the

apex (almost mucronate) more or less in the middle. Only two specimens were collected, both on the west side of the Clausson area. One is only an apical part, but has the characteristic tapering aspect. In lateral view the ventral side bends much more rapidly, but still relatively gradually, towards the apex as compared to the less pronounced curvature of the dorsal side, but together they give the rostrum the typical tapering aspect. The remains of an alveolar groove are visible and a large alveolar opening appears to be present. The alveolar cavity begins well before the alveolar groove starts. This species is not known from the literature, nor has it been collected in other sections.

Stratigraphic occurrence: In the glauconitic deposits at Clausson. Due to the paucity of this species the only information available is that it was found in the uppermost Valanginian - Lower Hauterivian glauconitic deposits at Clausson.

***Duvalia variegata* (RASPAIL, 1829)**

(Pl. 7, figs. 11-12 [NT], 13-14)

- 1829 *Belemnites variegatus* RASPAIL, p. 311, Pl. 7, fig. 55, Pl. 6, fig. 32 (median section).
- ? 1829 *Belemnites formosus* RASPAIL, p. 311, Pl. 7, fig. 58.
- non 1829 *Belemnites pseudo-formosus* RASPAIL, p. 315, Pl. 8, fig. 83 [= ? teratological Mesohibolitidae].
- pt 1841 *Belemnites hybridus* DUVAL-JOUVE, p. 51-54 (pars), Pl. 3, figs. 1 (?; juv.), 2 [forme typique: HT] (non Pl. 3, figs. 3-4 (= *D. binervia* (RASPAIL)), nec fig. 5 [= *D. binervia* (RASPAIL) ger.? or ter.?], nec fig. 6 [= *D. aff. gervaisiana* (DUMAS) in JANSSEN & CLEMENT, 2002], nec? figs. 7-8 [ter.? or *Duvalia* sp. 4 nov.?], nec figs. 9-16 [= *D. binervia*]. [note: DUVAL-JOUVE (1841, loc. cit. p. 10) indicates this specimen is from the "marnes à *Belemnites dilatatus*" (thus from the Hauterivian; ergo part of the material could be assigned to *Pd. gr. polygonalis* or *D. cf. maioriana*), while on p. 53 he says: "cette espèce se trouve exclusivement dans la couche chloriteuse, qui est la plus basse de l'étage à *Bélemnites*, ..." (this would be a typical observation regarding location in the glauconitic deposits)].
- 1973 *Duvalia hybrida* (DUVAL-JOUVE); COMBEMOREL, p. 148-149, Pl. 4, figs. 2-3.
- non ? 1984 *Duvalia binervia* morph. *hybrida* (DUVAL-JOUVE); GAYTE, Pl. 4, figs. 8-12.
- 1994 *Duvalia hybrida* (DUVAL-JOUVE); VASICEK et alii, p. 87, Pl. 29, figs. 10-12.
- non 1997 *Duvalia hybrida* (DUVAL-JOUVE); JANSSEN, p. 20-21, Pl. 4, fig. 5 (pars cum syn.).

Remarks: A topotype has been selected (Pl. 7, figs. 11-12 (RGM 288.637)) from the glauconitic bed CL095. A second, less mature specimen also came from the same stratum (Pl. 7, figs. 13-14) at Clausson. This species is often placed in synonymy with *Duvalia binervia* (RASPAIL). Herein, *Belemnites hybridus* DUVAL-JOUVE is believed to be a junior synonym of *Belemnites variegatus* RASPAIL. *Duvalia variegata* shows no apparent constriction in the alveolar region and it has a relative deep alveolus and a well developed alveolar groove. Juvenile to immature specimens might be confused, but "full-grown" specimens are much bigger and approach mature *Duvalia gr. dilatata* (BLAINVILLE) in appearance. However, in general *D. gr. dilatata* is much more regular in outline, while mature specimens of *D. variegata* have a most irregular outline with various bulges on the dorsal and ventral sides (note that this irregular aspect of the outline in *Duvalia* is a characteristic of gerontic specimens). However, some groups or species tend to be more bulgy than others, and especially among the *D. gr. dilatata* and in *D. binervia* this feature occurs commonly.

Stratigraphic occurrence: Latest V. *peregrinus* or earliest O. *nicklesi* through mid C. *furcillata* Subzone.

Genus *Pseudoduvalia* NAEF, 1922

***Pseudoduvalia polygonalis* (BLAINVILLE, 1827)**

(Pl. 8, figs. 7-10, 14-16)

- 1827 *Belemnites polygonalis* BLAINVILLE, p. 121-122, Pl. 5, fig. 11.
- 1830 *Tetragonolobi* RASPAIL, p. 87, Pl. 4, figs. 1-7.
- pt 1830 *Tetragoni* RASPAIL, p. 87, Pl. 4, figs. 8-9, 10 (?).
- 1841 *Belemnites isoscelis* DUVAL-JOUVE, Pl. 1, figs. 9-16.
- 1841 *Belemnites urnula* DUVAL-JOUVE, Pl. 2, figs. 1-5, 6 (?), 7.
- pt 1841 *Belemnites sicyoides* DUVAL-JOUVE, Pl. 2, figs. 16-17.

Remarks: Apparently, the most common species of the *Pseudoduvalia*, it varies widely in morphology. Its range appears to include the whole of the Mediterranean Tethys. Based on morphologic resemblances, this species is most probably derived from *Duvalia* aff. "*hybrida* (DUVAL-JOUVE)".

Stratigraphic occurrence: J. *jeannoti* Subzone through latest P. *ligatus* or early B. *balearis* Zone (late Early Hauterivian - early Late Hauterivian).

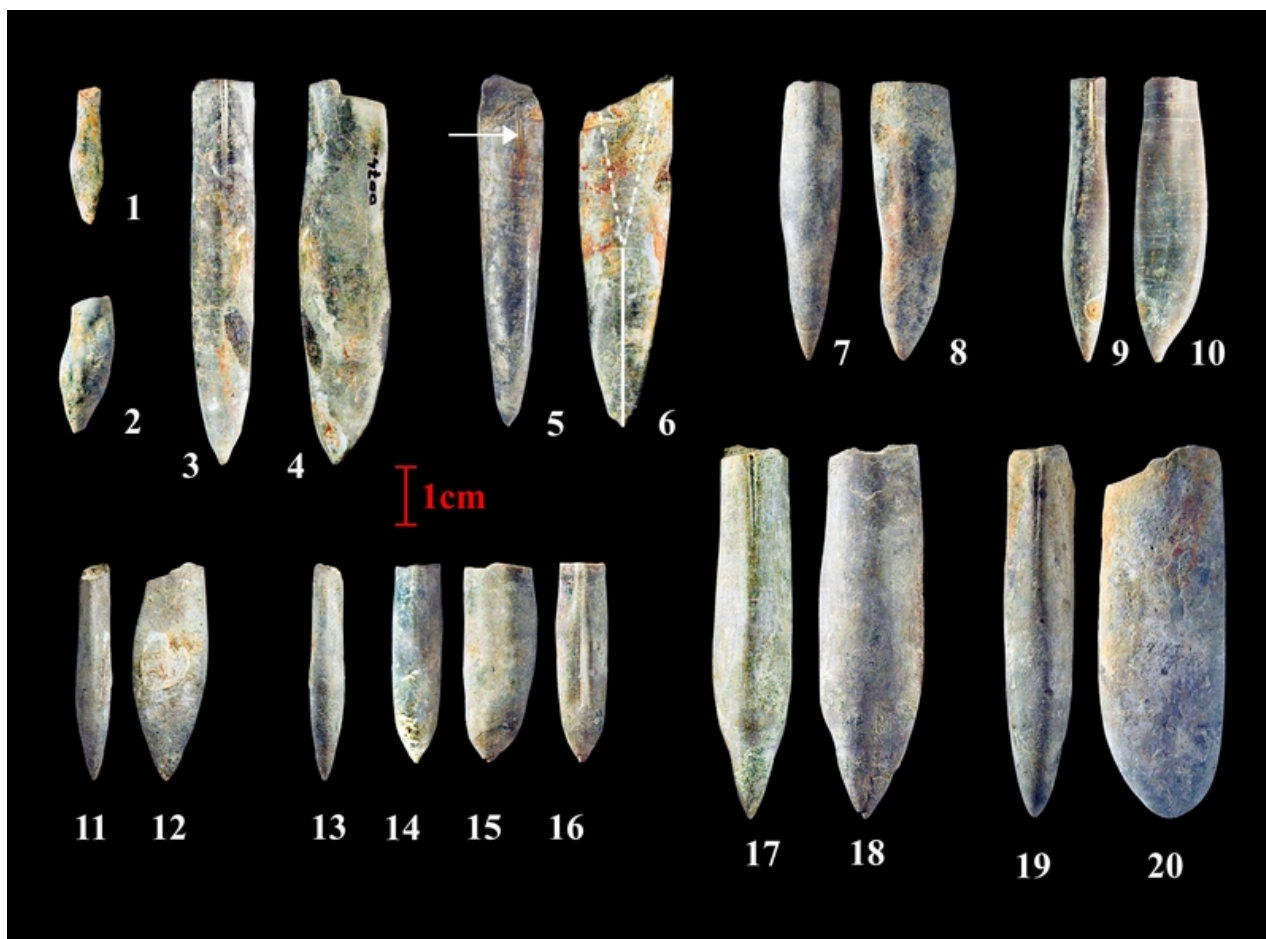


Plate 8 (Valanginian-Hauterivian; *Duvalia*): Figs. 1-2.- *Pseudoduvalia*? sp. (ter.?), RGM 288.679, CL095, Clausson (west). Figs. 3-4.- *Duvalia gervaisiana* (DUMAS, 1876), RGM 288.613, CL095, V/H boundary. Figs. 5-6.- *Duvalia* sp. 4, RGM 288.645, CL095, Clausson (west). Arrow indicates initiation of alveolar groove. Figs. 7-8.- *Pseudoduvalia polygonalis* (BLAINVILLE, 1827), RGM 288.677, CL102-104?, *Lyticoceras nodosoplicatum*? Zone. Figs. 9-10.- *Pseudoduvalia polygonalis* (BLAINVILLE, 1827), RGM 288.654, CL106-107, *Subsaynella sayni* Zone. Figs. 11-13.- *Pseudoduvalia rafaelli*? (STOYANOVA-VERGILOVA, 1965), RGM 288.777, La Bâtie, *Subsaynella sayni* Zone (free specimen). Figs. 14-16.- *Pseudoduvalia polygonalis* (BLAINVILLE, 1827), RGM 288.348, CB091, *Jeannoticeras jeannoti* Subzone. Figs. 17-18.- *Duvalia* aff. "*hybrida* (DUVAL-JOUVE, 1841)", RGM 288.347, CB087, *Crioceratites loryi* Zone. Figs. 19-20.- *Duvalia maioriana* STOYANOVA-VERGILOVA, 1965, RGM 288.649, Clausson (west), free specimen.

***Pseudoduvalia rafaelli*?**
(STOYANOVA-VERGILOVA, 1965)

(Pl. 8, figs. 11-13)

- + 1964 *Duvalia rafaelli* sp. nov. STOYANOVA-VERGILOVA, p. 138 [*nom. nud.*].
- + 1964 *Duvalia rafaelli* sp. nov. STOYANOVA-VERGILOVA, p. 146 [*nom. nud.*].
- * 1965 *Duvalia rafaelli* sp. nov. STOYANOVA-VERGILOVA, p. 201-202, text-figs. N-O, Pl. 2, figs. 3, 4 [HT], 5-6.
- + 1970 *Duvalia ravaeli* STOYANOVA-VERGILOVA; STOYANOVA-VERGILOVA, Pl. XXXIII, fig. 8.
- 1995 *Duvalia rafaelli* STOYANOVA-VERGILOVA; RIEGRAF, p. 111.
- 1998 *Duvalia rafaelli* STOYANOVA-VERGILOVA; RIEGRAF *et alii*, p. 264.
- 2004 *Pseudoduvalia rafaelli* (STOYANOVA-VERGILOVA); JANSSEN & FÖZY, p. 39, Pl. II, fig. 1 (cum syn.).

Remarks: Most probably a rare species. However, it may be a morph of *Pd. polygonalis*.

Stratigraphic occurrence: Latest (?) *L. nodosoplicatum*, latest *L. cruasense* beds, or earliest *S. sayni* Zone (latest Early Hauterivian or earliest Late Hauterivian).

Pseudoduvalia trabiformis
(DUVAL-JOUVE, 1841)

- pt 1830 Tetragoni RASPAIL, p. 87, Pl. 4, figs. 11-13.
- 1841 *Belemnites trabiformis* DUVAL-JOUVE, Pl. 2, figs. 8 (?), 9-12, 13-14 (?).
- pt 1841 *Belemnites sicyoides* DUVAL-JOUVE, Pl. 2, fig. 15.

Remarks: Clearly less numerous and less widely dispersed geographically than *Pd. polygonalis* (BLAINVILLE).

Stratigraphic occurrence: Mid *S. sayni* Zone through *P. ligatus* Zone (Late Hauterivian).

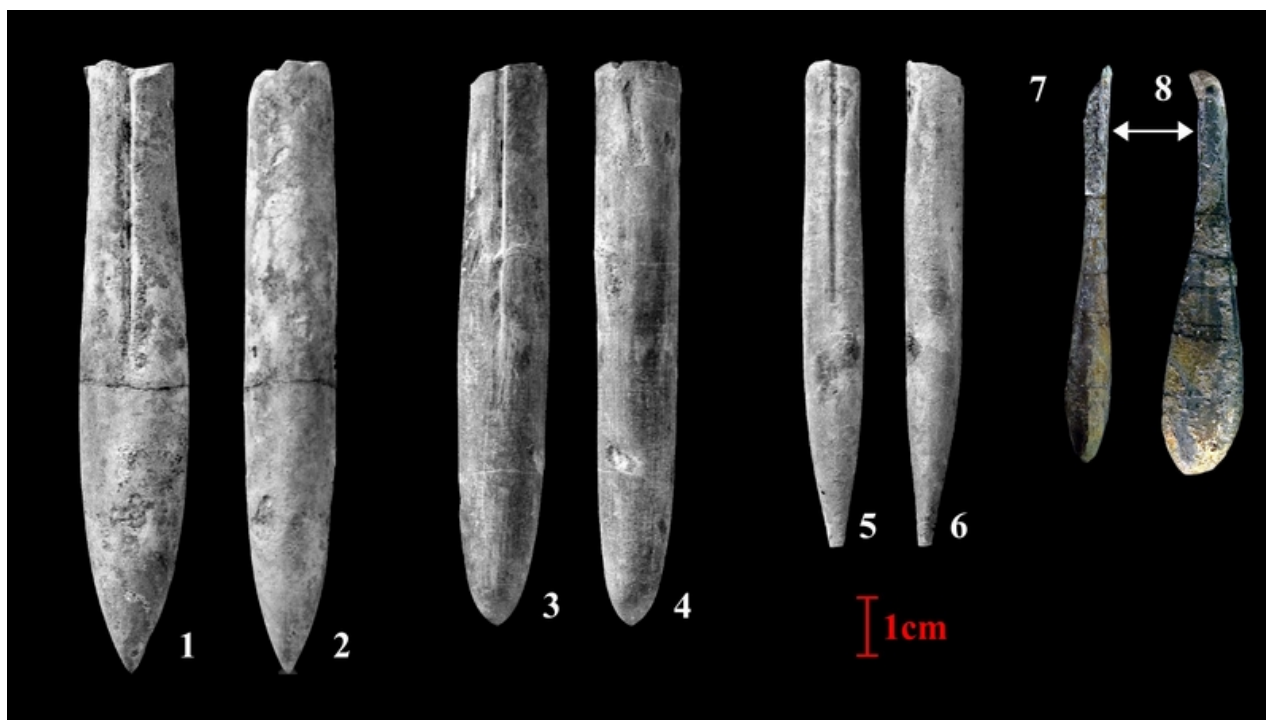


Plate 9: Figs. 1-2.- *Adiakritobelus robustus* (DUVAL-JOUVE, 1841) topotype, RGM 288.357, CL095, V/H-boundary. Figs. 3-4.- *Adiakritobelus rogeri* (DELATTRE, 1952) topotype, RGM 214.998, CL095, V/H-boundary. Figs. 5-6.- *Adiakritobelus peyroulesensis* sp. nov. topotype, RGM 215.000, CL095, V/H-boundary. Figs. 7-8.- *Duvalia binervia* (RASPAIL, 1829) topotype, RGM 560.594, CHE345, *Olcostephanus nicklesi* Subzone.

Genus *Pseudobelus* BLAINVILLE, 1827

Pseudobelus brevis PAQUIER, 1900

- non 1827 *Pseudobelus bipartitus* BLAINVILLE, p. 113, Pl. 5, fig. 19.
- + 1829 *Belemnites contortus* RASPAIL, p. 326-327, Pl. 6, figs. 28-29 [deformed specimen: *nom. dub.*].
- + 1830 *Belemnites bipartitus* DESHAYES, p. 128 [*nom. dub.*].
- 1830 *Belemnites bisulci* RASPAIL, p. 88, Pl. 2, figs. 20-21.
- pt 1841 *Belemnites bipartitus* BLAINVILLE; DUVAL-JOUVE, Pl. 1, figs. 3, 5 [LT *fide* VASICEK, 1978], 6.
- 1900 *Pseudobelus bipartitus* BLAINVILLE mut. *brevis* PAQUIER, p. 486-487, ii (palaeontological appendix).
- + 1963 *Pseudobelus bipartitus* var. *minor* PAQUIER; FLANDRIN, p. 18 [*nom. nud.*; *nom. dub.*].

Remarks: Apparently the latest taxon, and one of the smallest species of *Pseudobelus*.

Stratigraphic occurrence: Latest *J. jeannoti* Subzone through *S. sayni* Zone (late Early Hauterivian – early Late Hauterivian).

Pseudobelus sp. A

- 1861 *Belemnites bipartitus* (CATULLO), BLAINVILLE; LORIOU, p. 20, Pl. I, fig. 4.
- 1978 *Pseudobelus* aff. *brevis* PAQUIER; BORDEA *et alii*, p. 85, Pl. I, fig. 11.

2004

Pseudobelus sp. JANSSEN & FÖZY, p. 36-37, Pl. III, figs. 16-19 (with remarks and synonymy).

Remarks: This species precedes *Pseudobelus brevis* PAQUIER and succeeds *Pseudobelus jantikensis*? NERODENKO, 1986. It differs from *Pb. brevis* by its more elongated and more slender rostrum. *Pb. jantikensis*? appears to be more robust. It is obvious that juvenile and incomplete specimens (in general) can not be identified to a specific species. For further remarks see JANSSEN & FÖZY (2004, p. 36-37).

Stratigraphic occurrence: *C. furcillata* through *C. loryi* Zone; latest Valanginian – earliest Hauterivian.

The species are stored at the Museum of Natural History "Naturalis", Leiden (The Netherlands). The storage numbers are: RGM 214.701-214.753, RGM 214.755-214.826, RGM 214.828, RGM 214.830-214.832, RGM 214.835, RGM 214.837-214.952, RGM 214.959-214.980, RGM 214.987-215.000, RGM 288.001-288.377, RGM 288.401-288.679, RGM 288.701-288.781, RGM 288.792-288.900, RGM 560.501-560.926, RGM 561.019-561.502. A few specimens are not registered.

Conclusions

(1) An important change in the composition of the belemnite fauna takes place at both the genus and species levels in earliest Hauterivian times at the boundary between VaBA3 and HaBA1. The vertical distribution of Late Valanginian taxa from the succession deposited

in the deep water of the Vocontian basin are compared with those found in the condensed glauconitic beds that comprise the boundary between the Valanginian and Hauterivian stages in the Peyroules area. They show that latest Valanginian (in part reworked) and earliest Hauterivian species are abundant in the basal glauconitic deposits.

(2) A second, less significant change on the species level; and in the radiation of duvalid types of belemnites, takes place in the late Early Hauterivian; at the change from HaBA1, an interval of low diversity, to HaBA2.

(3) During late Early to Late Hauterivian times the composition of the belemnite fauna is more uniform. This period can be divided into three units (HaBA2a, HaBA2b and HaBA2c; Fig. 15). These units are distinguished according to the FO or absence of certain species. Since these characterizing species have a wide palaeogeographic distribution, they may be used to establish a biochronological zonation based on belemnites (but see (4)).

(4) The belemnite faunal associations and changes in their succession can be used to establish a zonation in the western part of the Mediterranean Tethys. However, due to the condensed and incomplete nature of the stratigraphic sequences under investigation, more data from deeper water environments are needed to establish a meaningful biozonation.

(5) Except in strata of the earliest Late Valanginian age, there is no indication of the presence of *Hibolites jaculoides* SWINNERTON in the Hauterivian rocks of the southern margins of the Vocontian Basin, except for possible scattered occurrences in the middle of the *A. radiatus* Zone of Les Allaves and lower part of the *S. sayni* Zone in the Peyroules area.

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sections		origin	range	remarks		
species	junior synonym					
I. Belemnitae petalopsides (leaf-like belemnites)						
<i>Duvalia emericii</i>	<i>pileus</i>	Cheiron area				
	<i>affinis</i>					
<i>Duvalia binervia</i>	<i>distans</i>	Cheiron area	Neocomiensis Subzone to base Radiatus Zone	topotype Pl.9, figs. 7-8 (CHE345, Nicklesi Zone)		
	<i>acinaformis</i>					
	<i>truncatus</i>					
<i>Duvalia elegans</i>		juvenile specimens of either <i>D. emericii</i> or <i>D. binervia</i>				
<i>Duvalia linearis</i>						
II. Belemnitae blachesii (belemnites from Blaches area, N of Castellane)						
of no importance for this work		Blaches	Jurassic-Neocomian			
III. Belemnitae blieuxii (belemnites from Blieux area, W of Castellane)						
of no importance for this work		Blieux	Aptian	<i>Neohibolites</i>		
IV(III). Belemnitae dilatati (dilatated belemnites)						
	<i>apiculatus</i>	Thorène	Hauterivian (except for the earliest part)	<i>Duvalia dilatata</i> (BLAINVILLE, 1827)		
	<i>complantus</i>					
	<i>apiculatus</i>	Robion				
	<i>emarginatus</i>	Blaches, Gréolières				
teratologic; nom. dub.	<i>mitra</i>	no locality				
	<i>difformis</i>					
	<i>triqueter</i>	Gréolières				
? teratologic	<i>mitraeformis</i>	no locality				
	<i>sinuatus</i>	La Lagne				
	<i>spathulus</i>					
<i>Duvalia convexus</i>		no locality	Hauterivian	= ? <i>Duvalia grasiana</i> (DUVAL-JOUVE, 1841)		
			Barremian - Aptian	= ? <i>Duvalia maioriana</i> STOYANOVA-VERGILOVA, 1965		
<i>Duvalia variegata</i>	<i>formosus</i>	Gréolières	Late Valanginian	Pl. 7, figs. 11-12 (Clausson, CLD95)		
		no locality				
juvenile	<i>augustus</i>	La Lagne	Hauterivian	<i>Duvalia gr. lata</i> (BLAINVILLE, 1827)		
	<i>pisciformis</i>					
teratologic; nom. dub.	<i>persona tonsoria</i>	no locality	Late Valanginian - Hauterivian	<i>Duvalia gr. lata</i> (BLAINVILLE, 1827) or <i>D. gr. binervia</i>		
immature ?	<i>bifurcatus</i>	Gréolières				
<i>Duvalia</i> sp. 1 ?	<i>delphinus</i>	La Lagne	Valanginian - Hauterivian	<i>Duvalia gr. binervia</i>		
	<i>ellipsoides</i>	no locality	Late Valanginian	? <i>Duvalia gr. binervia</i>		
V(IV). Belemnitae vermiculati (moulded [weathered] belemnites), not treated in this work						
nomen dubium?	<i>honorati</i>	Sisteron	Berriasian - Valanginian?	= ? <i>Duvalia gr. lata</i> (BLAINVILLE, 1827)		
VI(V). Belemnitae chamateulii (sordidi)						
nomen dubium	<i>attenuatus</i>	Chamateuil	Late Hauterivian - early Late Barremian	<i>Belemnites pistilliformis</i> BLAINVILLE		
	<i>incurvatus</i>			Mesohibolitidae undet.		
	<i>marginatus</i>			juvenile Mesohibolitidae		
	<i>pistilloides</i>					
teratologic; nom. dub.	<i>rimosus</i>					
nomen dubium	<i>depressus</i>			<i>Conohibolites</i>		
VII(VI). Belemnitae peronii (hideous belemnites)						
<i>Adiakritolebus brevirostris</i>		La Lagne and Gréolières	Late Valanginian	immature		
<i>Adiakritolebus minaret</i>	<i>fuscus</i>					
	<i>navicula</i>					
???	<i>oblongus</i>					
nomen dubium	<i>gemmatus</i>				Adiakritolebus?	juv.; ter.
	<i>rostratus</i>					
	<i>gibbosus</i>					
	<i>rugosus</i>	???	<i>Hibolites gr. subfusiformis</i> RASPAIL			
VIII(VII). Belemnitae claviformis						
<i>Adiakritolebus minaret</i>		La Lagne	Late Valanginian	no <i>Mesohibolites</i> !		
collective species	<i>pistilliformis</i>		Late Valanginian - Early Barremian		<i>Belemnites pistilliformis</i> BLAINVILLE	
	<i>crassior</i>					
	<i>crassissimus</i>					
teratologic; nom. dub.	<i>acuteus echini</i>		<i>Hibolites gr. subfusiformis</i> RASPAIL			
	<i>contortus</i>					
	<i>praemorsus</i>					

Table 1: Division of belemnites after RASPAIL (1829, 1830). Indicated are valid species, invalid species, synonyms, origin of material, approximate stratigraphical range, and some remarks.

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Description / Species		<i>robustus</i>	<i>rogeri</i>	<i>peyroulensis</i>	<i>brevirostris</i>	<i>minaret</i>	<i>gayteae</i>
Morph	hibolitoïd	±	+	-	-	-	±
	mesohibolitoïd	-	-	+	+	+	-
	subfusiform	-	-	+	+	-	-
	elongated	-	±	+	-	-	-
	fusiform	±	+	-	+	-	-
Groove	1/4	±	-	-	-	-	-
	1/3	+	±	±	-	-	±
	1/2	±	±	+	+	+	±
	2/3	-	-	+	+	+	-
Relative depths of the alveolus	very shallow	-	-	+	+	+	±
	shallow	+	±	-	-	-	±
	intermediate depth	-	±	-	-	-	-
	deep	-	-	-	-	-	-
Apex	obtused	±	±	-	-	±	+
	pointed	±	+	-	+	±	-
	elongated	-	-	+	-	-	-
Alveolus	rounded	+	+	±	-	±	±
	subquadrangular	-	-	±	+	±	±
Alveolar line	dorsal	+	+	-	+	?	?
	central	-	-	+	-	?	?
Ventrally flattened		±	-	±	-	-	+
Range	<i>Pronecostatum</i>	-	-	-	-	-	-
	<i>Peregrinus</i>	-	-	-	+	-	-
	<i>Nicklesi</i>	-	-	+	++	++	-
	<i>Furcillata</i>	-	+	++	+	+	?
	<i>Callidiscus</i>	?	+	+	-	-	+
	<i>Radiatus (base)</i>	+	+	?	-	-	+

Table 2: Short-key to *Adiakritobelus*-species. Key: ? unknown; -- not present; ± uncommon; + present.

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