

Problems in the identity of "*Crioceras*" *barremense* KILIAN, 1895 (Ancyloceratida, Late Barremian), and their proposed resolution

Didier BERT ^{1*}

Robert BUSNARDO ²

Gérard DELANOY ³

Stéphane BERSAC ⁴

Abstract: The study of "*Crioceras*" *barremense* KILIAN was undertaken as a part of the revision of the Hemihoplitidae. This species was considered "classic" and has been used as the index of an Upper Barremian subzone; this usage raises a number of problems. The type specimen from Tyrol was a fragment described and illustrated by UHLIG as *Crioceras* sp. ind. aff. *roemeri*. This specimen could not be retrieved, and a topotype could not be collected. Our study revealed that there is both a biostratigraphic hiatus and important differences between conceptions of this species: (1) that ascribed UHLIG's type specimen (Upper Barremian, Tyrol), (2) KILIAN's concept of the specimen he found and named "*Crioceras*" *barremense* (probably a *Camereiceras* from the uppermost levels of the Vandenheckei Subzone or from the basal Sartousiana subzone of the Nauvin site, southeastern France) and (3) current interpretations of authors, who often synonymize the type specimen with *Gassendiceras alpinum* (d'ORBIGNY), which occurs in the middle of the Vandenheckei Subzone. So there is a real confusion concerning the synonymy of "*Crioceras*" *barremense*. The age of UHLIG's type specimen is too imprecise and its preservation too fragmentary to be reliably identifiable, because the same morphology and ornamentation exist in several species of other genera. Therefore, we recommend the use of the species "*Crioceras*" *barremense* KILIAN be avoided, in particular as an index, along with that of the genus *Barrancyloceras* VERMEULEN for which "*C.*" *barremense* is used as reference. Some species formerly assigned to this genus have been referred to the genus *Gassendiceras* BERT *et alii*. Consequently, we also recommend the Barremense *auctororum* Subzone be renamed the Alpinum Subzone (new) [index-species: *Gassendiceras alpinum* (d'ORBIGNY)], without changing its limits as currently defined. The lower limit of this subzone is indicated by the first occurrence of *Gassendiceras alpinum* (a new biohorizon, introduced here), a common, easily identifiable species with a well-defined stratigraphic range.

Key Words: Taxonomy; Ammonitinae; Gassendiceratinae; Upper Barremian; Vandenheckei Biozone; Alpinum Subzone / Biohorizon; biozonation; southeastern France.

Citation: BERT D., BUSNARDO R., DELANOY G. & BERSAC S. (2010).- Problems in the identity of "*Crioceras*" *barremense* KILIAN, 1895 (Ancyloceratida, Late Barremian), and their proposed resolution.- *Carnets de Géologie / Notebooks on Geology*, Brest, Article 2010/01 (CG2010_A01)

Résumé : *Le problème de l'identité de "Crioceras" barremense KILIAN, 1895 (Ancyloceratida, Barrémien supérieur), et ses possibles solutions.*- Dans le cadre de la révision des Hemihoplitidae, l'étude de "*Crioceras*" *barremense* KILIAN a été entreprise. Cette espèce a été considérée comme "classique" et utilisée comme indice pour une sous-zone du Barrémien supérieur, et cela pose un certain nombre de problèmes. Son spécimen-type est un fragment qui provient du Tyrol et qui a été décrit et illustré par UHLIG sous *Crioceras* sp. ind. aff. *roemeri* UHLIG. Ce spécimen n'a pas été retrouvé et aucun topotype n'a pu être collecté. Notre étude a révélé qu'il existe un écart biostratigraphique et une différence d'interprétation importante entre la conception (1) du type de UHLIG (Barrémien supérieur, Tyrol), (2) la conception qu'avait KILIAN des spécimens qu'il a nommé "*Crioceras*" *barremense* (probablement un *Camereiceras* du sommet de la zone à Vandenheckei ou de la base de la

¹ * Corresponding author

Place de l'Église, F-04170 La Mure-Argens (France);
Université de Bourgogne, UMR CNRS 5561, "Biogéosciences", 6 bd Gabriel, F-21000 Dijon (France)
paleo-db@orange.fr

² Le Méruzin, F-69370 Saint-Didier-au-Mont-d'Or (France)

³ Département des Sciences de la Terre, Université de Nice-Sophia-Antipolis, Faculté des Sciences, 28 avenue Valrose, F-06108 Nice Cedex 2 (France)
delanoy@unice.fr

⁴ Résidence le Villeneuve A, place du Grand Jardin, F-06140 Vence (France)

Manuscript online since April 4, 2010

zone à Sartousiana du gisement de Nauvin, Sud-Est de la France), et (3) l'interprétation des auteurs plus récents qui est souvent à redéterminer sous *Gassendicerias alpinum* (d'ORBIGNY) présent au milieu de la sous-zone à Vandenneckeï. Il y a donc une réelle confusion autour de "*Crioceras*" *barremense*. L'âge de son spécimen-type est trop imprécis et sa conservation trop fragmentaire pour permettre une détermination fiable puisque sa morphologie et son ornementation sont communes à plusieurs espèces de genres différents. En conséquence, nous recommandons de ne plus utiliser l'espèce "*Crioceras*" *barremense* KILIAN, en particulier comme espèce indice, de même que le genre *Barrancyloceras* VERMEULEN auquel elle sert de référence. Une partie des espèces anciennement attribuées à ce genre sont à reclasser parmi les *Gassendicerias* BERT *et alii*. Dans ces conditions, nous recommandons également le remplacement la Sous-zone à Barremense *auctorum* par la Sous-zone à Alpinum (nouvelle) [espèce indice : *Gassendicerias alpinum* (d'ORBIGNY)], sans modification des limites acceptées. Elle débute par le Biohorizon à Alpinum (nouveau) qui présente l'avantage d'être basé sur une espèce fréquente, facile à déterminer et stratigraphiquement très bien localisée.

Mots-Clefs : Taxinomie ; Ammonitinae ; Gassendiceratinae ; Barrémien supérieur ; Biozone à Vandenneckeï ; Sous-zone / Biohorizon à Alpinum ; biozonation ; Sud-Est de la France.

I. Introduction and statement of problem

The study of "*Crioceras*" *barremense* KILIAN, 1895 [by recent authors usually classified as *Barrancyloceras barremense* (KILIAN)] was undertaken as a part of the revision of the Hemihoplitidae conducted by one of us (DB), about which several contributions have been published (BERT & DELANOY, 2000, 2009; BERT *et alii*, 2006, 2008). This species, considered "classic" by many authors, has served as the index for a subzone of the Upper Barremian, but presents many problems.

"*Crioceras*" *barremense* was introduced without diagnosis by KILIAN in KILIAN & LEENHARDT (1895). The reference includes only an indication of the locality where it was found, a lithostratigraphic level, and a reference to an older illustration UHLIG (1887, Pl. 4, fig. 3 refigured here on Pl. 1, fig. 1). Uhlig's specimen, which became later the holotype of the species, is from an imprecise stratigraphic level near Gardenazza (Tyrol) and is only a fragment. Despite the search by one of us (RB), this type specimen could not be found. Owing to divergent interpretations of the species by various authors, it has become clear that there is much confusion and a lack of consensus about the identity of this taxon.

To understand the original ideas of KILIAN (in KILIAN & LEENHARDT) concerning "*Crioceras*" *barremense*, we revisited the Nauvin site (Moustiers Sainte-Marie, Alpes de Haute-Provence, southeastern France - Fig. 1) from which his specimens came (KILIAN & LEENHARDT, 1895, p. 10-11). Here we try to understand the true identity of KILIAN's species, and to draw the necessary conclusions.

II. The Nauvin site

KILIAN in introducing the taxon "*Crioceras*" *barremense* (in KILIAN & LEENHARDT, 1895, p. 10-11) refers to UHLIG's figure (1887, Pl. 4, fig. 3), which he considered conspecific with his own specimens, which, unfortunately were neither figured or described. All were collected in litho-

logic unit 19 bis of the Nauvin site (Moustiers Sainte-Marie area, Alpes de Haute-Provence, southeastern France - Fig. 1). In order better to understand the identity of the original "*Crioceras*" *barremense* KILIAN, one of us (DB) studied the sites of the Gorges du Verdon area, and particularly that of Nauvin.

In Nauvin local tectonic deformation and the current state of the outcrops does not permit construction of a detailed stratigraphic column, but the lithological units KILIAN & LEENHARDT (1895) saw are still clearly visible. The Barremian is present above the uppermost Hauterivian with *Pseudothurmania* (unit 17 of KILIAN & LEENHARDT). Unit 18 has yielded lower Barremian faunas up to the Pulchella Biozone. The overlying glauconitic level (No. 18 bis) is well-known throughout the northern sector of the Gorges du Verdon. It has been assigned the Lower Compressissima Biozone (Savoie ravine near Castellane; Majastre area - BERT, 2009).

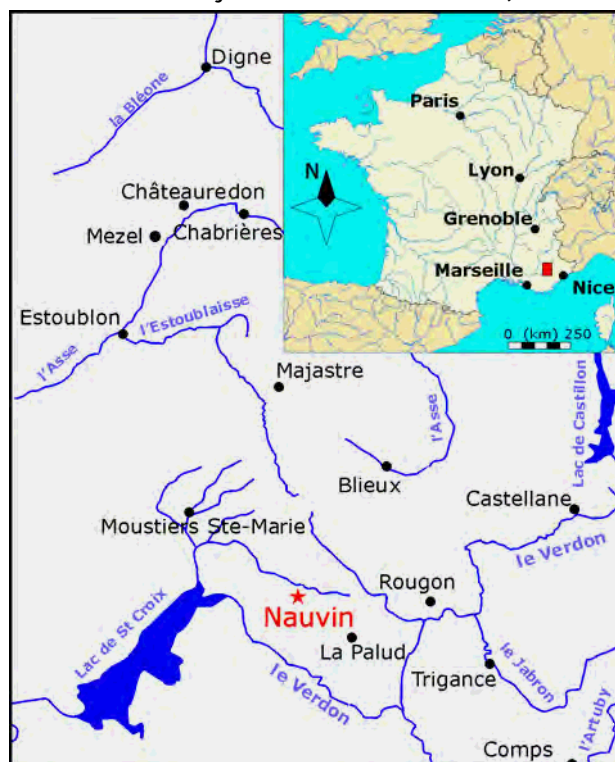


Figure 1: Location of the area investigated.
Figure 1 : Localisation géographique.

Stages	Biozones	Subzones	Biohorizons
Upper Barremian	Giraudi	Waagenoides	
		Sarasini	
			Puzosianum
		Giraudi	
			Emerici
			Giraudi
	Autrani		
	Sartousiana	Feraudianus	Bersaci
			Magnini
			Feraudianus
			Casanovai
		Provincialis	
			Provincialis
		Limentinus	Sartousiana
			Limentinus
			Marchandi
			Breistrofferi
	Vandenheckei	Alpinum (new)	
			Alpinum (new)
		Vandenheckei	

Figure 2: Proposed biozonal scheme, after BERT *et alii*, 2008, and REBOULET *et alii*, 2009, amended. The new units are in red; the age of set 19 bis of the Nauvin site (Alpes-de-Haute-Provence, southeastern France) is in green.

Figure 2 : Échelle biostratigraphique proposée. En rouge les nouvelles unités et en vert l'âge du niveau 19 bis de Nauvin (Alpes-de-Haute-Provence, Sud-Est de la France).

The base of the Upper Barremian (Lower Vandenheckei Biozone and the lower limit of the Barremense *auctorum* Subzone) is usually present in deposits of the Gorges du Verdon, but fossils are scanty, in particular at the Nauvin site. At this locality, strata comprising unit 19 of KILIAN & LEENHARDT are highly bioturbated and tectonized. The few fossils collected are very poorly preserved: belemnites, a remnant of Nautilus, and some indeterminate Barremitidae.

On the other hand, at Nauvin unit 19 bis, which provided KILIAN and LEENHARDT specimens of "*Crioceras*" *barremense*, is very fossiliferous. Just above the "bed with small *Barremites*" in the middle part of the Vandenheckei Biozone (see BERT, 2009), a succession of three calcareous beds yielded *Camereiceras marchandi*

(BERT & DELANOY, 2000) [m & M = micro and macroconchs] in its lower part and *Camereiceras limentinus* (THIEULOY, 1979) [m & M] (Pl. 2, fig. 2) in its upper part. These ammonites characterize the top of the Vandenheckei and the base of the Sartousiana biozones (Marchandi and Limentinus biohorizons - Fig. 2). Unit 19 bis continues with a few beds that could be partly dated as the Provincialis Subzone. The citation of *Pulchellia sellei* KILIAN, 1889, by KILIAN & LEENHARDT confirms this zonal attribution. As in all the sections of the Verdon area, the top of the Barremian limestone is represented by a reworked glauconitic and ferruginous level. It is overlain by a glauconitic sandy-marlstone of probably Aptian age (COTILLON, 1971).

Although often fragmentary, some of the *Camereiceras* specimens found in level 19 bis of Nauvin are reminiscent of UHLIG's picture on which KILIAN's "*Crioceras*" *barremense* was based. In the light of these observations, it is quite possible that KILIAN's specimen could be a *Camereiceras* DELANOY, 1990. This possibility is supported by the morphological similarity of Uhlig's picture to that of some representatives of *Camereiceras*, which have shells with non-contiguous whorls (BERT & DELANOY, 2000; BERT *et alii*, 2006).

III. Paleontological discussion

Crioceras sp. ind. aff. *roemeri* in UHLIG, 1887, and "*Crioceras*" *barremense* KILIAN, 1895

UHLIG (1887) figures a crioconic ammonite of the KLIPSTEIN collection from Gardenazza (Tyrol), which he identified as *Crioceras* sp. ind. aff. *roemeri* NEUMAYR & UHLIG, 1881. The figured specimen is a fragmentary ammonite 90 mm in diameter consisting of half a whorl and a small part of the inner whorl with only a few ribs. From the outset UHLIG insists on his specimen's being too fragmentary to serve as a basis for the introduction of a new species ("Of this beautiful species I have only an incomplete specimen, so that I do not dare to propose a more precise determination." [translation pars, UHLIG, 1887, p. 96-97]), because, as he notes "The suture line, the inner whorls and the body chamber are unknown." (translation pars, UHLIG, 1887, p. 96). This kind of ornamentation, which is typical of the Ancyloceratoidea *s.l.*, has been described as the "barremense stage" in the ontogeny of many discrete genera and species by BERT *et alii* (2006). As stated by UHLIG (1887, p. 95-96), the ornamentation consists of a regular alternation of trituberculate and non-tuberculate ribs. The tuberculated main ribs are larger and stronger, and have three tubercles. Between certain pair of tuberculate main ribs, there is a slightly weaker rib, which has only two tubercles: a lateral and a ventrolateral one. Between each tritubercu-

late main and bituberculate intermediate ribs there may be a thin inermous interrib. The ventrolateral tubercles of all the main and intermediate ribs are elongated into clavi. The whorl section is higher than wide and the flanks converge toward the venter; the whorl section is similar to that of *Camereiceras* or *Pseudoshastrioceras* (see BERT *et alii*, 2006). Although UHLIG did not specify the stratigraphic level of his specimen, recent authors regard this species as occurring in the basal Upper Barremian (middle part of the Vandenheckei Biozone), based primarily on the subsequent interpretation of the specimens figured by SIMIONESCU (1899) as "*C. barremense*".

UHLIG's picture (refigured here on Pl. 1, fig. 1), served KILIAN as the foundation for introducing almost ten years later the species "*Crioceras*" *barremense* KILIAN (p. 10-11). KILIAN & LEENHARDT could have collected identical specimens in the Upper Barremian of the Moustier Sainte-Marie area (at Nauvin - Fig. 1). But despite the morphological similarity of certain *Camereiceras* from the Nauvin site (see above) to the Tyrolean specimen figured by UHLIG, there is no evidence that UHLIG's and KILIAN's specimens are the same species.

In 2000, during several visits, one of us (RB) searched the Gardenazza site (Tyrol), and careful collection permitted us to retrieve several interesting specimens of the lower Upper Barremian (Vandenheckei Biozone). Two of them have an ornamental ontogenic stage of the "barremense type" and are very close to UHLIG's specimen; but despite these similarities

they are probably different genera (one of them is assigned to *Toxancyloceras*). These later observations at the type locality, clearly do not resolve the status of "*Crioceras*" *barremense* KILIAN, 1895. So only the original depiction of UHLIG (1887) defines this species. Unfortunately, the holotype seems to have been lost. It was not found in the Vienna collections (war), or in those of Strasbourg (fire).

Finding a topotype in the type locality, more complete than and exactly like that of UHLIG's figure is problematic, because UHLIG's specimen is very similar to several species that have the same type of ornamentation and / or shell shape, and occur at several levels of the Vandenheckei and Sartousiana biozones. In particular, interesting comparisons can be made with the recently described *Pseudoshastrioceras bersaci* BERT & DELANOY, 2009. A comparison of this species from the Feraudianus Subzone (Bersaci Biohorizon) with the type specimen of "*Crioceras*" *barremense* shows them to be perfectly identical in both the whorl section (compressed oval with broad base and with sides converging towards the rather narrow venter) and in ornamentation (trituberculate main ribs with ventrolateral clavi and various intermediate and intercalatory ribs) and with the same diameter (approximately 50 mm to 90 mm). Measurements of the shape of the shell, taken directly from picture, are also very similar to those of *Pseudoshastrioceras bersaci* (see Table 1 for comparisons of the averages, see also BERT & DELANOY, 2009, p. 4).

	H/D	E/D	O/D	E/H	O/H	spiral gap (mm)
Average of <i>Pseudoshastrioceras bersaci</i>	0.36	0.23	0.42	0.61	1.17	1.98
Average of the UHLIG specimen	0.39	0.28	0.43	0.71	1.09	3

Table 1: The averages of the ratios of the shell parameters of *Pseudoshastrioceras bersaci* BERT & DELANOY, 2009, and the type of "*Crioceras*" *barremense* KILIAN, 1895, taken from the UHLIG's picture (1887, Pl. 4, fig. 3; here Pl. 1, fig. 1).

Tableau 1 : Moyennes des rapports des paramètres de la coquille de *Pseudoshastrioceras bersaci* BERT & DELANOY, 2009, et du type de "*Crioceras*" *barremense* KILIAN, 1895, d'après la figuration originale de UHLIG (1887, Pl. 4, fig. 3 ; ici Pl. 1 , fig. 1).

Given the fragmentary state of UHLIG specimen, it could also be compared in the same manner and for the same reasons with *Gassendiceras alpinum* (d'ORBIGNY, 1850) [= *Crioceras alpinum* d'ORBIGNY, 1850 - see below] (Fig. 4 ; Pl. 1, fig. 2; Pl. 3, figs. 1-3; Pl. 4, fig. 2), *Gassendiceras quelquejeui* BERT *et alii*, 2006 (Pl. 2, fig. 1), *Gassendiceras enayi* BERT *et alii*, 2006, *Gassendiceras coulletae* BERT *et alii*, 2006, *Pseudoshastrioceras magnini* (DELANOY, 1992), with macroconches of *Camereiceras marchandi* (BERT & DELANOY, 2000), with some specimens of *Camereiceras limentinus* (THIEULOY, 1979) [Pl. 2, fig. 2], and with other *Came-*

reiceras of the upper Vandenheckei Biozone the whorls of which may not be contiguous (under study). The affinities of its ornamentation with that of the genus *Pachyhemihoplites* DELANOY, 1992, are also quite large. Also with respect to morphology and ornament some more recent Ancyloceratidae may be compared for example, *Pseudocrioceras* SPATH, 1924. In this respect the figure of the type specimen of *Pseudocrioceras orbignyanus* (MATHERON, 1842) by DELANOY & BULOT (1990, Pl. 1, fig. 3) is very demonstrative.

The interpretation of SIMIONESCU

In 1899 SIMIONESCU figured two specimens from the Saint-André-les-Alpes area (Alpes-de-Haute-Provence, southeastern France), which he attributed to "*Crioceras*" *barremense* KILIAN (refigured here Pl. 3, fig. 2-3). The original specimens (n° UJF-ID 161 and 162) are deposited at the Dolomieu Institute of Grenoble, and casts are preserved in the collections of the Geological Laboratory of Lyon. They have "flanks slightly convex, adorned with numerous ribs that depart from the umbilicus, widening towards the siphonal region where most of them are interrupted or much attenuated. On the inner whorls almost every rib bears three tubercles of which the middle ones are located near the siphonal tubercles; on the last whorl the trituberculate ribs are variably spaced and separated by simple ribs, bi- or monotuberculate" (translation pars, SIMIONESCU, 1899, p. 14). Recent authors generally refer the most complete specimen (Pl. 1, fig. 4, here Pl. 3, fig. 2) from Méouilles (Saint-André-les-Alpes) to "*Crioceras*" *barremense* KILIAN, 1895. At first sight it seems quite similar to UHLIG's figure, but it is actually compressed *post-mortem*. SIMIONESCU's specimens differ essentially from that of UHLIG in their display of stronger and broader main trituberculate ribs, lower rib density, slower growth in whorl height, and a very different whorl section (visible on the specimen figured Pl. 3, fig. 3). These differences, which are consistent with those of specimens collected in the same geographic area, lead us to change the SIMIONESCU's identification to *Gassendicerias alpinum* (d'ORBIGNY, 1850). This variable species is abundant in southeastern France, both in the basin and on the borders of the platforms (revision in progress - Fig. 4 ; Pl. 1, fig. 2; Pl. 3, figs. 1-3; Pl. 4, fig. 2) in levels dated as the middle of the Vandennecke Biozone (here the Alpinum Biohorizon at the base of the new Alpinum Subzone - Fig. 2).

In the neritic deposits of the Gorges du Verdon area (Rougon, Trigance area - Fig. 1), all levels of this age are included in lithological unit 19 of KILIAN & LEENHARDT (1895). But this level is not fossiliferous in Nauvin, and the specimens studied by KILIAN (*in* KILIAN & LEENHARDT, 1895) came from the overlying 19 bis level (see above - Fig. 2). And in Nauvin one subzone is absent between the level of KILIAN's specimen and the level of the ammonites usually classified as *Barrancyloceras barremense* (KILIAN, 1895). Thus, the specimens of "*Crioceras*" *barremense* collected by KILIAN (probably *Camereiceras*) does not approximate the interpretations of SIMIONESCU (1899) or those of recent authors (CONTE, 1989; DELANOY, 1990, 1992; AVRAM, 1995; COMPANY *et alii*, 1995, 2008; VERMEULEN, 2005).

It appears that since the work of SIMIONESCU (1899), *Gassendicerias alpinum* (d'ORBIGNY, 1850) is the species with which "*Crioceras*" *barremense* KILIAN, 1895, has been confused most often. First, the d'ORBIGNY species is relatively almost unknown: it was never cited by KILIAN or by contemporary authors; COTTREAU (1937) was the first to figure the type-specimen of *G. alpinum* in his review of the types of d'ORBIGNY's Prodrôme [refigured here Fig. 4 ; Pl. 3, fig. 1, type-specimen, n° 5406 of d'ORBIGNY's collection]. On the other hand, the type of ornamentation visible on UHLIG's specimen is also present in the species figured in d'ORBIGNY's Prodrôme (1850) and exists as well as in many species of Hemihoplitidae and Ancyloceratidae of various ages. This brought us (BERT *et alii*, 2006) to name this widely recognizable level in the development of ornamentation the "barremense stage". It occurs in many species at different levels of ontogeny. This is an important feature in the evolution of this group.

Compared to *Gassendicerias alpinum* (d'ORBIGNY, 1850), UHLIG's type specimen has a more compressed whorl section with flanks converging towards a narrowed siphonal area. D'ORBIGNY's species too has a stronger ornamentation with larger tubercles. These parameters are liable to great variability, and some slender specimens, either compressed or crushed *post-mortem*, may be closer to the type figure of "*Crioceras*" *barremense* KILIAN, 1895 (in UHLIG, 1887, Pl. 4, fig. 3).

Remarks on the genus *Barrancyloceras* VERMEULEN, 2000

The genus *Barrancyloceras* is based on the species *barremense* KILIAN, 1895. It was proposed by VERMEULEN & BERT (1998 - *nomen nudum*) and again by VERMEULEN (2000, p. 127) for forms that have an "usually tripartite coiling" (sic) but no adult or adequately complete specimen is yet known. Its diagnosis was emended thereafter (VERMEULEN, 2006) by introducing the genus *Leroyceras* VERMEULEN, 2006, for forms "with shell probably tripartite" (sic) (p. 156). It differs from *Barrancyloceras* of which the shell could possibly be "just spiralled" after all (p. 157). It should be noted that the type species of *Leroyceras* is *L. mascarelli* (VERMEULEN, 2005), known only by its type specimen in which only the young whorls are visible. This specimen is clearly a junior synonym of *Gassendicerias alpinum* (d'ORBIGNY, 1850).

In order to resolve differences in the interpretation of *Barrancyloceras barremense* (KILIAN, 1895) VERMEULEN (2004) proposed a neotype (refigured here on Pl. 4, fig. 1), which has been challenged and invalidated by KLEIN *et alii* (2007, p. 223). This specimen was re-proposed several times (VERMEULEN, 2005; VERMEULEN & LAZARIN, 2007), but it remains invalid

because of its failure to comply with the rules of the International Code of Zoological Nomenclature (ICZN, art. 75, see KLEIN *et alii*, 2007, notes 196 and 197, p. 223 and 225). Moreover, this specimen differs too much from UHLIG's figure (here Pl. 1, fig. 1) to serve as a basis for a renewed acceptance of the taxon *barremense* KILIAN, 1895: the clavi of its ventrolateral tubercles do not have the same shape, the growth of whorl height is less, and its whorl section is elliptical, not as in the UHLIG's figure. VERMEULEN & LAZARIN (2007, p. 37), state that the differences between their neotype and UHLIG's specimen are due to compression *post-mortem* of the latter. But there is nothing to support this hypothesis, although UHLIG himself wrote (1887, p. 96) that his specimen is very weakly deformed. The few characteristics that the two specimens have in common (alternating main trituberculated and intermediary ribs, attenuation of the ornamentation on the venter) are known to be characteristic of the Hemihoplitidae and Ancyloceratidae families and cannot be the sole reason for its acceptance. Note that the similarity between the juvenile stages of the holotype and the neotype described by VERMEULEN & LAZARIN (2007, p. 36) cannot be taken into account, for this stage is not preserved in the holotype.

IV. Biostratigraphy

Based on the presence of a particular ornamental stage in some heteromorphic ammonites (here designated the "barremense stage"), BUSNARDO proposed in 1984 a Barremense Biozone at the base of the Upper Barremian. At the Digne-les-Bains meeting of the IUGS Lower Cretaceous Ammonite Working Group, the KILIAN Group (HOEDEMAEKER & BULOT, 1990), the choice of this species as the index of a biozone was challenged, because of its difficulty in its interpretation. It was replaced by a Vandenheckei Biozone (Fig. 2). Later, COMPANY *et alii* (1995) proposed a Barremense Biohorizon in the upper part of the Vandenheckei Biozone. VERMEULEN (2003, p. 46) placed that biohorizon in his Sayni Biozone (=Vandenheckei Biozone) in about the same position as COMPANY *et alii* had. In a recent Neuchâtel meeting of the KILIAN Group (REBOULET *et alii*, 2006), a Barremense Subzone was added in the upper part of the Vandenheckei Biozone. Later this position was found unacceptable by REBOULET *et alii* (2007 unpublished, 2009) and BERT *et alii* (2008) who nevertheless proposed the temporary maintenance of the Barremense Subzone, awaiting a thorough review of its index species, with emphasis on the recently proposed interpretations of *Barrancyloceras barremense* (KILIAN, 1895), and the lack of consensus (DELANOY, 1992; COMPANY *et alii*, 1995, 2008; VERMEULEN, 2004, 2005; VERMEULEN & LAZARIN, 2007).

As an exact match with the holotype of *Barrancyloceras barremense* (KILIAN, 1895) has not yet been found this species cannot be used as index species. Therefore, we propose replacement of the unusable Barremense Subzone by the Alpinum Subzone (this work - Fig. 2) as the upper part of the Vandenheckei Biozone. Accepted subzonal boundaries do not have to be changed, so changes in the biostratigraphic scheme are avoided (see BERT *et alii*, 2008).

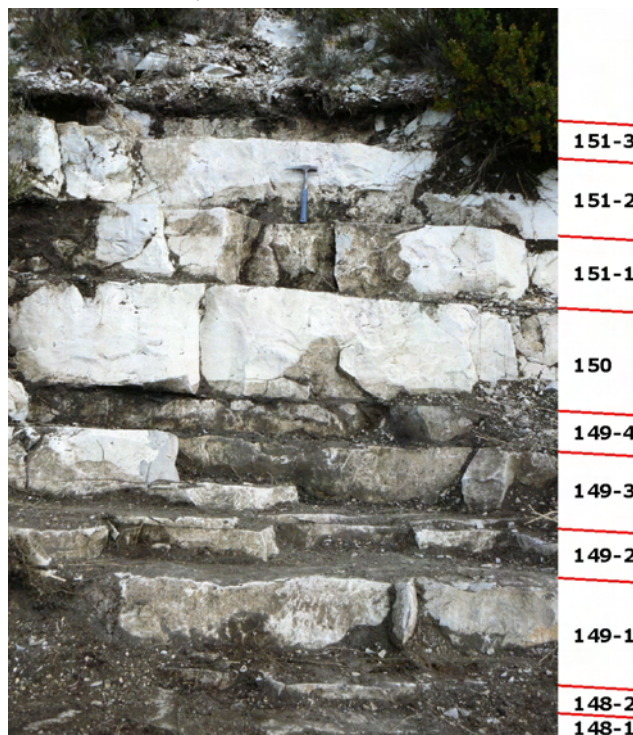


Figure 3: Lithology of the Alpinum Biohorizon (bed 151-2) in the Angles historical stratotype.

Figure 3: Succession lithologique de l'horizon à Alpinum (banc 151-2) dans le stratotype historique d'Angles.

Alpinum Subzone (new)

Index species: *Gassendiceras alpinum* (d'ORBIGNY, 1850) was figured for the first time by COTTREAU (1937), and its revision is currently in progress (Fig. 4 ; Pl. 1, fig. 2; Pl. 3, figs. 1-3; Pl. 4, fig. 2).

Status: the lower limit of the Alpinum Subzone is fixed at the base of the Alpinum Biohorizon (new - Fig. 2). This choice has several advantages:

- *Gassendiceras alpinum* (d'ORBIGNY, 1850) is present in abundance both in the basins and on the platform edges;
- despite its variability, this species is easily identifiable, making it easy to use even by non-specialists;
- its appearance is synchronous in all the sections we have studied in southeastern France;
- the limits of this subzone correspond to those already adopted for the Barremense

auctorum Subzone since its index species was often confused by the authors with *B. barremense* (KILIAN) and,

- *Gassendicerias alpinum* (d'ORBIGNY, 1850) presents a broad geographical distribution; it has been recognized in France, Spain, Romania and Morocco.

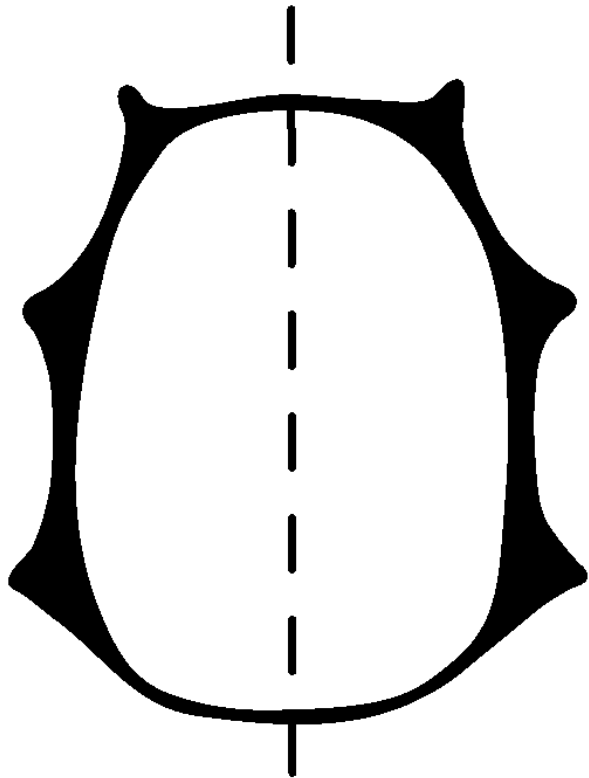


Figure 4: Whorl section of the holotype of *Gassendicerias alpinum* (d'ORBIGNY, 1850), specimen n° 5406 of the d'ORBIGNY's collection from Angles (National Museum of Natural History).

Figure 4 : Section de tour de l'holotype de *Gassendicerias alpinum* (d'ORBIGNY, 1850), spécimen n° 5406 de la collection d'ORBIGNY, d'Angles (Muséum National d'Histoire Naturelle).

Alpinum Biohorizon (new)

Index species: *Gassendicerias alpinum* (d'ORBIGNY, 1850) (Fig. 4 ; Pl. 1, fig. 2; Pl. 3, figs. 1-3; Pl. 4, fig. 2).

Status: this biohorizon is defined by the appearance of its index species, and its upper limit is set at the end of its acme zone. In the Barremian stratotypical area (Angles, south-eastern France), the Alpinum Biohorizon is at the top of a good lithological marker: a thin succession of thick, resistant chert-bearing beds, clearly visible in the topography (Fig. 3). In the LAC section (at Saint-André-les-Alpes near the Angles area, southeastern France - BERT *et alii*, 2008) this biohorizon is located in bed n° 209, the lateral equivalent of bed n° 151-2 in the Angles historical stratotype.

Faunal assemblages: *Gassendicerias alpinum* (d'ORBIGNY, 1850) is fairly well represented in

the sections. It is associated with *Heinzia sayni* (HYATT, 1903), *Kotetishvilia fischeuri* (JOLEAUD, 1912), *Toxancyloceras* cf. *vandenheckei* (ASTIER, 1851), *Silesites vulpes* (COQUAND in MATHERON, 1878), *Acantholytoceras* aff. *longispinum* (UHLIG, 1883) [m & M], *Eulytoceras phestus* (MATHERON, 1878), *Dissimilites trinodosus* (d'ORBIGNY, 1842), and many Barremitidae.

V. Conclusions

Study of the Nauvin site shows that there is a significant difference in interpretation between the UHLIG's (1887) picture of the holotype of "*Crioceras*" *barremense sensu* KILIAN (*in* KILIAN & LEENHARDT, 1895), and recent authors' conception of this species. Some recent interpretations are quite divergent and commonly their specimens should be referred to *Gassendicerias alpinum* (d'ORBIGNY, 1850). Paradoxically, all authors agree on a Late Barremian age for the species: the middle of the Vandenheckei Biochronozone. But at the Nauvin site from which the specimens studied by KILIAN came, similar forms occur in the latest strata of the Vandenheckei Biozone, and even at the base of the Sartousiana Biozone. The specimens studied by KILIAN probably are another group (*Camereiceras*) rather than "*Crioceras*" *barremense* KILIAN, 1895, the one commonly accepted.

The type specimen of this species (lost?) from Tyrol, figured by UHLIG in 1887, is imprecisely dated. This lack of precision and its fragmentary state hinder a matching of the holotype by another specimen. Even if one excludes species with a similar morphology (ornamental stage of "barremense" type) but not from the basal Upper Barremian, as accepted by authors, the species *barremense* KILIAN may be assignable to at least three discrete genera: *Gassendicerias* BERT *et alii*, 2006, *Pseudoshastrioceras* DELANOY, 1998, or *Camereiceras* DELANOY, 1990.

Given the above data, it becomes clear that "*Crioceras*" *barremense* KILIAN, 1895, is one of those taxa of older literature, their identity consistently misinterpreted because of the fragmentary state of the type specimens, and the existence of ontogenetic stages of which the ornament is very similar in several species. Their stratigraphic level and the sites of their finding are unknown or vague. Consequently, in the absence of new data (rediscovery of the holotype, or discovery of a valid topotype), we recommend avoidance of the use henceforward of "*Crioceras*" *barremense* KILIAN, 1895, in particular as an index species. The same recommendation applies to the genus *Barrancyloceras* VERMEULEN, 2000, for which "*C.*" *barremense* is used as reference. Some species that were assigned to "*Barrancyloceras*" should be classified as *Gassendicerias* BERT *et alii*,

2006, primarily because of their close phyletic relationships to *Gassendicerias* of the *quelquejeui* group: in particular, this applies to *Gassendicerias alpinum* (d'ORBIGNY, 1850). Finally, we recommend replacement of the Barremense *auctorum* Subzone by the Alpinum Subzone (new) [index-species: *Gassendicerias alpinum* (d'ORBIGNY, 1850)], at the base of which is the Alpinum Biohorizon (new). This biohorizon is based on a common species which is easy to recognize. Moreover, these changes do not modify known subzone boundaries.

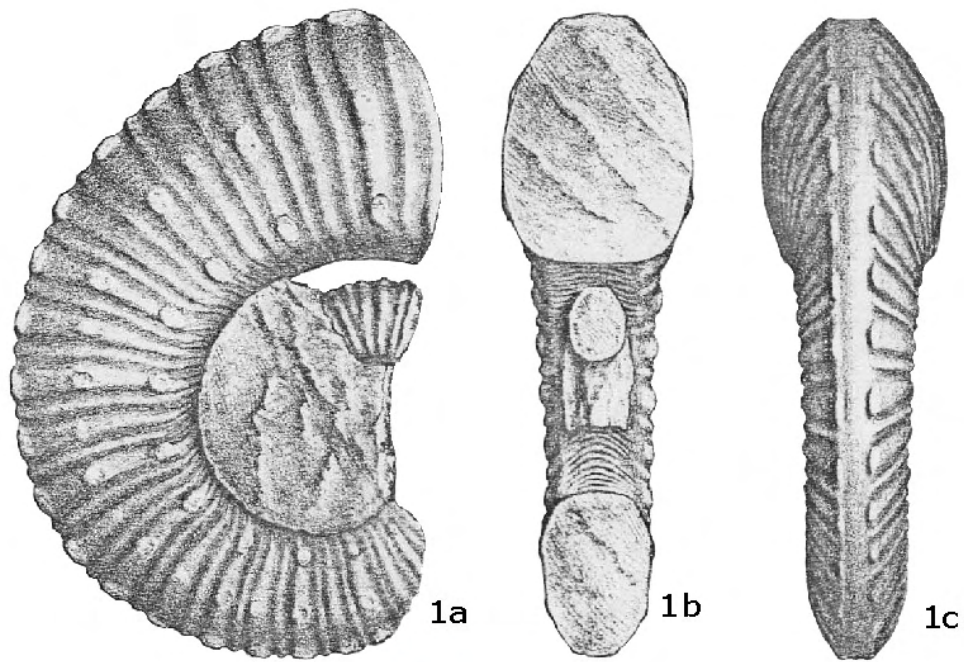
Acknowledgments

We particularly wish to express our gratitude to Mr. Abel PRIEUR for giving us an almost unlimited access to the collections of the Department of Earth Sciences, University Claude Bernard Lyon 1. Mrs. Myette GUIOMAR, of the Réserve Géologique de Haute-Provence is thanked for allowing us to study the sites situated on its territory. We also thank Philip HOEDEMAEKER and Miguel COMPANY for their constructive remarks on the manuscript. We warmly and especially thank Nestor SANDER who kindly corrected our English in the final version.

Bibliographic references

- AVRAM E. (1995).- Lower Cretaceous (Valanginian-Early Aptian) ammonite succession in the Svinita region (SW Rumania).- *Géologie Alpine*, Grenoble, Mémoire H.S. n° 20 (1994), p. 113-167.
- BERT D. (2009).- Description de *Artareites landii* nov. (Ammonoidea) du Barrémien supérieur de Majastre (Sud-Est de la France) et discussion sur les Helicancyllidae HYATT, 1894.- *Annales de Paléontologie*, vol. 95, p. 139-163.
- BERT D. & DELANOY G. (2000).- Considérations nouvelles sur quelques représentants barrémiens de Puchelliidae DOUVILLÉ, 1890 et des Hemihoplitidae SPATH, 1924 (Ammonoidea).- *Annales du Muséum d'Histoire Naturelle de Nice*, t. XV, p. 63-89.
- BERT D. & DELANOY G. (2009).- *Pseudoshasticrioceras bersaci* nov. sp. (Ammonoidea, Gassendiceratinae), and new ammonite biohorizon for the Upper Barremian of southeastern France.- *Carnets de Géologie / Notebooks on Geology*, Article 2009/02 (CG2009_A02), 22 p.
- BERT D., DELANOY G. & BERSAC S. (2006).- Descriptions de représentants nouveaux ou peu connus de la Famille des Hemihoplitidae SPATH, 1924 (Barrémien supérieur, Sud-Est de la France) : conséquence taxinomique et phylétiques.- *Annales du Muséum d'Histoire Naturelle de Nice*, t. XXI, p. 179-253.
- BERT D., DELANOY G. & BERSAC S. (2008).- Propositions pour un nouveau découpage biozonal ammonitique, et nouveaux biohorizons pour le Barrémien supérieur.- *Carnets de Géologie / Notebooks on Geology*, Brest, Article 2008/03 (CG2008_A03), 18 p.
- BUSNARDO R. (1984).- Ammonites in Chapitre Crétacé inférieur. Synthèse géologique du Sud-Est de la France.- *Mémoire du Bureau des Recherches Géologiques et Minières*, Orléans, 125 : 292-294.
- BUSNARDO R. & COTILLON (1964).- Stratigraphie du Crétacé inférieur dans la région des gorges du Verdon (Basse-Alpes et Var).- *Comptes Rendus Sommaires des Séances de la Société Géologique de France*, Paris, fasc. 8, p. 321-322.
- COMPANY M., SANDOVAL J. & TAVERA J.M. (1995).- Lower Barremian ammonite biostratigraphy in the Subbetic Domain (Betic Cordillera, southern Spain).- *Cretaceous Research*, London, vol. 16, n° 2-3, p. 243-256.
- COMPANY M., SANDOVAL J., TAVERA J.M., AOUTEM M. & ETTACHFINI M. (2008).- Barremian ammonite faunas from the western High Atlas, Morocco - biostratigraphy and palaeobiogeography.- *Cretaceous Research*, London, vol. 29, n° 1, p. 9-26.
- CONTE G. (1989).- Fossiles du plateau d'Albion.- *Alpes de Lumière*, Forcalquier, n° 99, p. 1-72.
- COTILLON (1971).- Le Crétacé inférieur de l'Arc subalpin de Castellane entre l'Asse et le Var, stratigraphie et sédimentologie.- *Mémoires du B.R.G.M.*, Orléans, n° 68, p. 1-313.
- COTTREAU (1937).- Types du Prodrôme de paléontologie stratigraphique universelle de d'ORBIGNY.- *Annales de Paléontologie*, tome 26, fasc. 1-2, p. 17-48.
- DELANOY G. (1990).- *Camereiceras* nov. gen. (Ammonoidea, Ancyloceratina) du Barrémien supérieur du Sud-Est de la France.- *Geobios*, Villeurbanne, n° 23, fasc. 1, p. 71-93.
- DELANOY G. (1992).- Les ammonites du Barrémien supérieur de Saint-Laurent de l'Escarène (Alpes-Maritimes, Sud-Est de la France).- *Annales du Muséum d'Histoire Naturelle de Nice*, t. IX, 148 p.
- DELANOY G. & BULOT L.G. (1990).- Révision des types et figures des collections MATHERON et REYNES. 3. genres *Acrioceras*, *Heteroceras*, *Kutatissites* et *Pseudocrioceras* (Ancyloceratina, Cephalopoda).- *Mésogée*, Marseille, vol. 50, p. 15-21.
- HOEDEMAEKER P.J. & BULOT L. (1990).- Preliminary Ammonite zonation for the Lower Cretaceous of Mediterranean Region.- *Géologie Alpine*, Grenoble, n° 66, pp. 123-127.
- KILIAN W. & LEENHARDT F. (1895).- Sur le Néocomien des environs de Moustiers S^{te}-Marie (Basses-Alpes).- *Bulletin de la Société géologique de France*, Paris, (3ème Série), t. XXIII, fasc. 3, p. 970-981.
- KLEIN J., BUSNARDO R., COMPANY M., DELANOY G., KAKABADZE M., REBOULET S., ROPOLO P., VASICEK Z. & VERMEULEN J. (2007).- Lower Cretaceous Ammonites III Bochiianitidae, Protancyloceratoidea, Ancyloceratoidea,

- Ptychoceratoidea. In: RIEGRAF W. (ed.), Fossilium Catalogus I: Animalia.- Backhuys Publishers, Leiden, 381 p.
- ORBIGNY A. d' (1850).- Prodrome de paléontologie stratigraphique universelle des animaux mollusques et rayonnés faisant suite au cours élémentaire de paléontologie et de géologie stratigraphique. Vol. 2.- Masson, Paris, 428 p.
- REBOULET S. (reporter), ATROPS F., BERT D., BULOT L., BUSNARDO R., DELANOY G. & VERMEULEN J. (2007, unpublished).- Zonation Hauterivien – Barrémien.- Compte rendu de la réunion des biostratigraphes français du KILIAN Group (IUGS Lower Cretaceous Ammonites Working Group), Digne-les-Bains (2 Mai 2007), 14 p.
- REBOULET S. & HOEDEMAEKER P.J. (reporters), AGUIRRE URRETA M.B., ALSEN P., ATROPS F., BARABOSKIN E.Y., COMPANY M., DELANOY G., DUTOUR Y., KLEIN J. LATIL J.L., LUKENEDER A., MITTA V., MOURGUES F.A., PLOCH I., RAISOSSADAT N., ROPOLO P., SANDOVAL J., TAVERA J.M., VAŠÍČEK Z., VERMEULEN J., ARNAUD H., GRANIER B. & PREMOLI-SILVA I. (2006).- Report on the second international meeting of the IUGS Lower Cretaceous Ammonite Working Group, the "KILIAN Group" (Neuchâtel, Switzerland, 8 September 2005).- *Cretaceous Research*, London, vol. 27, n° 5, p. 712-715.
- REBOULET S. & KLEIN J. (reporters), BARRAGAN R., COMPANY M., GONZALEZ-ARREOLA C., LUKENEDER A., RAISOSSADAT S.N., SANDOVAL J., SZIVES O., TAVERA J.M., VAŠÍČEK Z. & VERMEULEN J. (2009).- Report on the 3rd International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the "KILIAN Group" (Vienna, Austria, 15th April 2008).- *Cretaceous Research*, London, vol. 30, n° 2, p. 496-502.
- SIMIONESCU I. (1899).- Note sur quelques ammonites du Néocomien français.- *Annales de l'Université de Grenoble*, vol. 11, fasc. 3, p. 1-16.
- UHLIG V. (1887).- Ueber neocom Fossilien vom Gardenzazza in Südtirol nebst einen Anhang über das Neocom von Ischl.- *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, Wien, Band 37, Heft 1, p. 69-108.
- VERMEULEN J. (2000).- Nouvelles données sur les répartitions stratigraphiques, les évolutions et les classifications de trois familles d'ammonites du Crétacé inférieur.- *Géologie Alpine*, Grenoble, n° 75, p. 123-132.
- VERMEULEN J. (2003).- Etude stratigraphique et paléontologique de la famille des Pulchellidae (Ammonoidea, Ammonitina, Endemocerataceae).- *Géologie Alpine*, Grenoble, Mémoire HS (2002) n° 42, pp. 1-332.
- VERMEULEN J. (2004).- Vers une nouvelle classification à fondement phylogénétique des ammonites hétéromorphes du Crétacé inférieur méditerranéen. Le cas des Crioceeratitidae GILL, 1871 *nom. correct.* WRIGHT, 1952, des Emericiceratidae fam. nov. et des Acrioceratidae fam. nov. (Ancylocerataceae GILL, 1871).- *Rivière Scientifique*, Nice, vol. 88, p. 69-92.
- VERMEULEN J. (2005).- Boundaries, ammonite fauna and main subdivisions of the stratotype of the Barremian.- *Géologie Alpine*, Grenoble, série spéciale "colloques et excursions", n° 7, p. 147-173.
- VERMEULEN J. (2006).- Nouvelle classification à fondement phylogénétique des ammonites hétéromorphes du Crétacé inférieur.- *Annales du Muséum d'Histoire Naturelle de Nice*, t. XXI, p. 137-178.
- VERMEULEN J. & BERT D. (1998).- Sur l'ammonitofaune du Barrémien de la Saurée près de Tourette-Levens (Alpes-Maritimes, France).- *Rivière Scientifique*, Nice, vol. 82, p. 77-88.
- VERMEULEN J. & LAZARIN P. (2007).- Nouvelles données sur les Ancyloceratoidea GILL, 1871 (Ancyloceratina WIEDMANN, 1966 *emend.* VERMEULEN, 2005) du Barrémien supérieur et de l'Aptien inférieur.- *Annales du Muséum d'Histoire Naturelle de Nice*, t. XXII, p. 27-86.



◀ **Plate 1:**

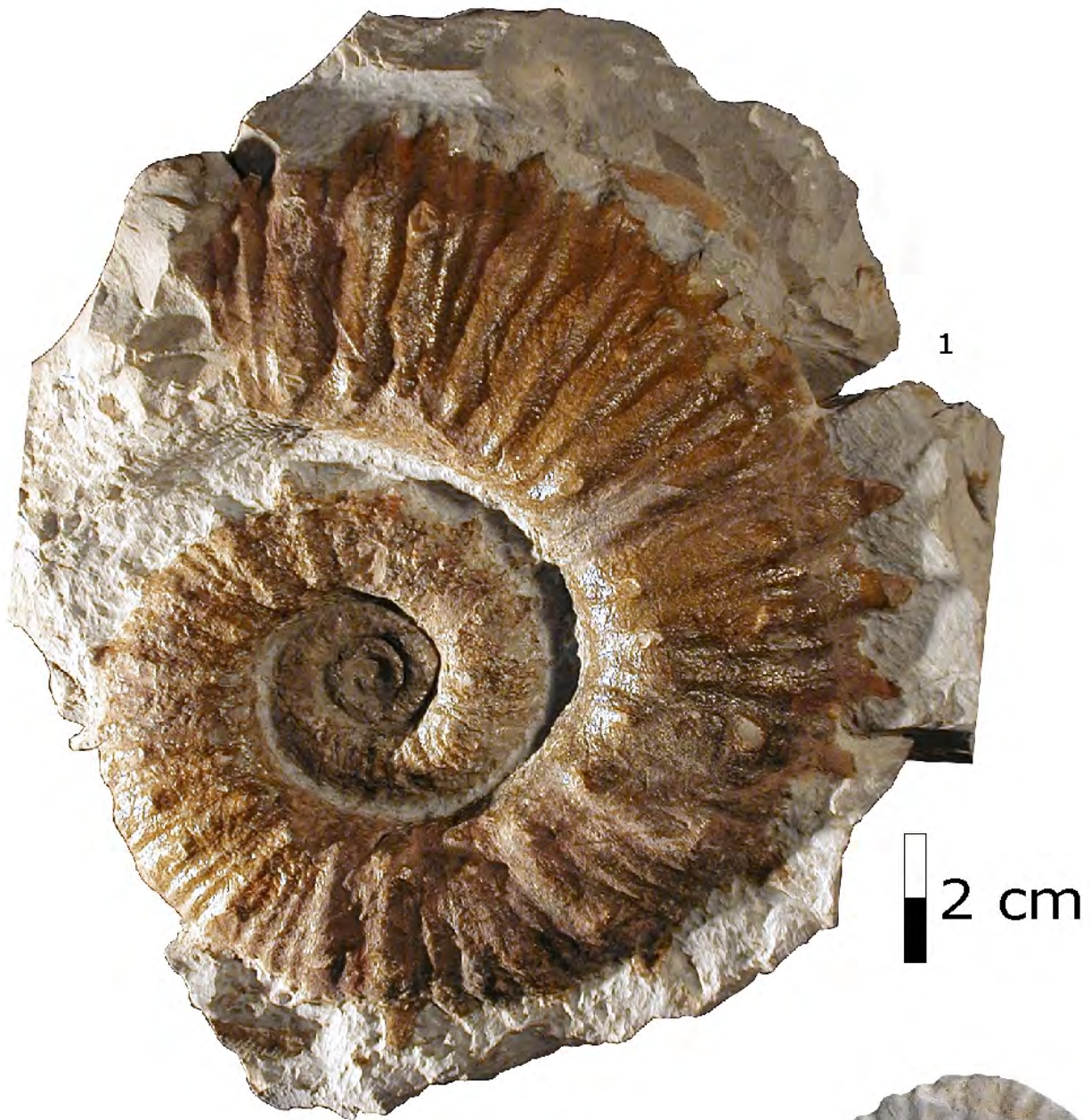
Fig. 1a-c: Duplicate of the picture of the holotype of "*Crioceras*" *barremense* KILIAN, 1895 in UHLIG (1887, Pl. 3, fig. 4).

Fig. 2: *Gassendiceras alpinum* (d'ORBIGNY, 1850), topotype, specimen n° AT36, BERT's collection, from bed 151-2 of the stratotype (Angles, Alpes-de-Haute-Provence), Alpinum Biohorizon (new).

Planche 1 :

Fig. 1a-c : Reproduction de la figure type de "*Crioceras*" *barremense* KILIAN, 1895 in UHLIG (1887, Pl. 3, fig. 4).

Fig. 2 : *Gassendiceras alpinum* (d'ORBIGNY, 1850), topotype, spécimen n° AT36, collection BERT. Banc 151-2 du stratotype d'Angles (Alpes-de-Haute-Provence), Biohorizon à Alpinum (nouveau).



1

2 cm



2a



2b



2c

◀ **Plate 2:**

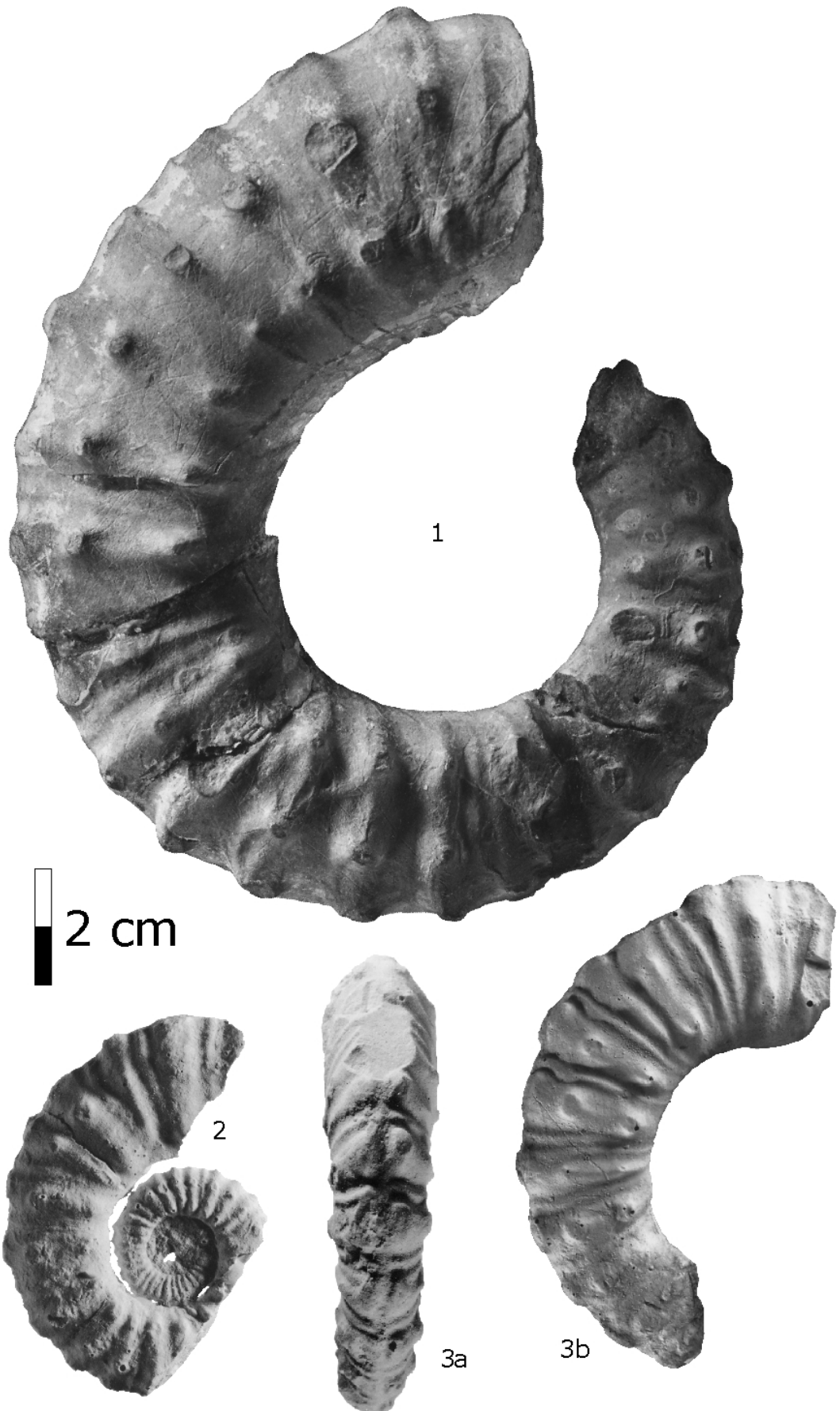
Fig. 1: Holotype of *Gassendiceras quelquejeui* BERT *et alii*, 2006, from bed 224 of the LAC section Saint-André-les-Alpes, Breistrofferi Biohorizon, southeastern France (see BERT *et alii*, 2008), figured here for comparison.

Fig. 2a-c: *Camereiceras limentinus* (THIEULOY, 1979) of the set 19 bis from Nauvin (Alpes-de-Haute-Provence, southeastern France), Limentinus Biohorizon. Unnumbered specimen of COTILLON's collection (stored at the Faculty of Sciences of Lyon). The tubercles are not clearly visible in the figure due to the lighting, but they are in the same positions as those on the UHLIG, specimen (Pl. 1, fig. 1). Note that the three types of ribs described by UHLIG (1887) are represented on this specimen (see text).

Planche 2 :

Fig. 1 : Holotype de *Gassendiceras quelquejeui* BERT *et alii*, 2006, du banc 224 de la coupe LAC (cf. BERT *et alii*, 2008), Biohorizon à Breistrofferi. Il est figuré ici à titre comparatif.

Fig. 2a-c : *Camereiceras limentinus* (THIEULOY, 1979) du niveau 19 bis de Nauvin (Alpes-de-Haute-Provence, Sud-Est de la France), Biohorizon à Limentinus. Spécimen non numéroté de la collection COTILLON (conservé à la Faculté des Sciences de Lyon). Les tubercules sont peu visibles sur la figure en raison de l'éclairage, mais ils sont situés aux mêmes positions que sur le spécimen de UHLIG (Pl. 1, fig. 1). À noter que les trois types de côtes décrits par UHLIG (1887) sont présents sur ce spécimen (voir texte).



◀ **Plate 3:**

Fig. 1: Holotype of *Gassendiceras alpinum* (d'ORBIGNY, 1850), specimen n° 5406 of d'ORBIGNY's collection (National Museum of Natural History), from Angles (Alpes-de-Haute-Provence, southeastern France). Note that the fragmentary inner whorl figured by COTTREAU is probably not the same specimen and presumably not the same species. This fragment is not figured here, and it must not serve as a reference for *Gassendiceras alpinum* (d'ORBIGNY, 1850).

Fig. 2: *Gassendiceras alpinum* (d'ORBIGNY, 1850), specimens from Saint-André-les-Alpes (Alpes-de-Haute-Provence, southeastern France) figured by SIMIONESCU (1899, Pl. 1, fig. 4), n° UJF-ID 161, stored in the collections of the Institut Dolomieu (Grenoble).

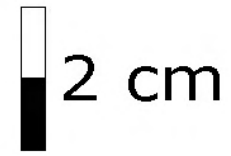
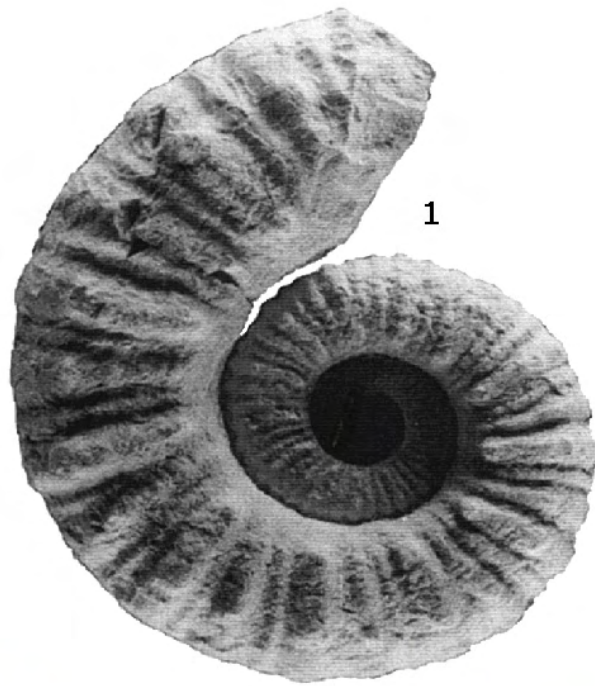
Fig. 3a-b: *Gassendiceras alpinum* (d'ORBIGNY, 1850), specimen from Saint-André-les-Alpes (Alpes-de-Haute-Provence, southeastern France) figured by SIMIONESCU (1899, Pl. 1, fig. 5), n° UJF-ID stored in the collections of the Institut Dolomieu (Grenoble).

Planche 3 :

Fig. 1a-b : Holotype de *Gassendiceras alpinum* (d'ORBIGNY, 1850), spécimen n° 5406 de la collection d'ORBIGNY (Muséum National d'Histoire Naturelle), d'Angles (Alpes-de-Haute-Provence, southeastern France). À noter que le fragment de tour interne figuré par COTTREAU n'appartient vraisemblablement pas au même individu, voire pas à la même espèce. Il n'a donc pas été refiguré ici et ne doit pas servir de référence pour *Gassendiceras alpinum* (d'ORBIGNY, 1850).

Fig. 2 : *Gassendiceras alpinum* (d'ORBIGNY, 1850), spécimen de Saint-André-les-Alpes figuré par SIMIONESCU (1899, Pl. 1, fig. 4), n° UJF-ID 161, déposé dans les collections de l'Institut Dolomieu (Grenoble).

Fig. 3a-b: *Gassendiceras alpinum* (d'ORBIGNY, 1850), spécimen de Saint-André-les-Alpes figuré par SIMIONESCU (1899, Pl. 1, fig. 5), n° UJF-ID, déposé dans les collections de l'Institut Dolomieu (Grenoble).



◀ **Plate 4:**

Fig. 1: The invalid neotype (see text) proposed by VERMEULEN (2005) for *Barrancyloceras barremense* (KILIAN, 1895). It is from bed n° 151-2 of the stratotype of the Barremian Stage (Angles, Alpes-de-Haute-Provence), Alpinum Biohorizon (new).

Fig. 2a-b: *Gassendiceras alpinum* (d'ORBIGNY, 1850), from set 15 of Rougon (Alpes-de-Haute-Provence). This specimen was cited as *Emericiceras roemeri* NEUMAYR & UHLIG in BUSNARDO & COTILLON, 1964. Unnumbered specimen of the COTILLON collection (stored at the Faculty of Sciences of Lyon).

Planche 4 :

Fig. 1 : Reproduction du néotype invalide (cf. texte) proposé par VERMEULEN (2005) pour *Barrancyloceras barremense* (KILIAN, 1895). Banc n° 151-2 du stratotype d'Angles (Alpes-de-Haute-Provence), Biohorizon à Alpinum (nouveau).

Fig. 2a-b : *Gassendiceras alpinum* (d'ORBIGNY, 1850) du niveau 15 de Rougon (Alpes-de-Haute-Provence, Sud-Est de la France). Spécimen cité sous *Emericiceras roemeri* NEUMAYR & UHLIG in BUSNARDO & COTILLON, 1964. Spécimen non numéroté de la collection COTILLON (déposé à la Faculté des Sciences de Lyon).