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

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Abstract: The study of "Crioceras" barremense KILIAN was undertaken as a part of the revision of the Hemihoplitidae. This species was considered "classical" 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 toptype 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 to be avoided, in particular as an index, along with that of the genus Barrancloceratidae VERMEULEN for which "C." barremense is used as an 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; Gassendicerae; Upper Barremian; Vandenheckei Biozone; Alpin Subzone / Biozon; biozonation; southeastern France.

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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. Ce spécimen n'a pas été retrouvé et aucun tootype 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
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 Gassendiceras alpinum (d'ORBIGNY) présent au milieu de la sous-zone à Vandenheckei. 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 ornamentation 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 Barrayloceras VERMEULEN auquel elle sert de référence. Une partie des espèces anciennement attribuées à ce genre sont à reclasser parmi les Gassendiceras BERT et frères. Dans ces conditions, nous recommandons également le remplacement la Sous-zone à Barremense auctorum par la Sous-zone à Alpinum (nouvelle) [espèce indice : Gassendiceras 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 Vandenheckei ; 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 Barrayloceras 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 frères, 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 refi-gured 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 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 (Savoye ravine near Castellane; Majastre area - BERT, 2009).

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 litholog 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 (Savoye ravine near Castellane; Majastre area - BERT, 2009).
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-Haut e-Provence, southeastern France) is in green.

The base of the Upper Barremian (Lower Vandenhecke 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 indeterminable 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 Vandenhecke 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 Vandenhecke 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 selli 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 (COTTILLON, 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 Pseudoshasticrioceras (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 toptotype 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 Pseudoshasticrioceras bersaci BERT & DELANOY, 2009. A comparison of this species from the Feradianus 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 narrower 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 Pseudoshasticrioceras bersaci (see Table 1 for comparisons of the averages, see also BERT & DELANOY, 2009, p. 4).

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<th>H/D</th>
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<tr>
<td>Average of Pseudoshasticrioceras bersaci</td>
<td>0.36</td>
<td>0.23</td>
<td>0.42</td>
<td>0.61</td>
<td>1.17</td>
<td>1.98</td>
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<tr>
<td>Average of the Uhlig specimen</td>
<td>0.39</td>
<td>0.28</td>
<td>0.43</td>
<td>0.71</td>
<td>1.09</td>
<td>3</td>
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Table 1: The averages of the ratios of the shell parameters of Pseudoshasticrioceras 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).

Given the fragmentary state of Uhlig specimen, it could also been 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 quelquejeu Bert et alii, 2006 (Pl. 2, fig. 1), Gassendiceras enayi Bert et alii, 2006, Gassendiceras couletae Bert et alii, 2006, Pseudoshasticrioceras magnini (Delanoy, 1992), with macroconches of Camereiceras marchandi (BERT & DELANOY, 2000), with some specimens of Camereiceras limentinus (Thieltjory, 1979) [Pl. 2, fig. 2], and with other Camereiceras 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 & Bulet (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 trituberculated ribs are variably spaced and separated by simple ribs, bi- or monotuberculation" (translation pars, SIMIONESCU, 1899, p. 14). Recent authors generally refer the most complete specimen (Pl. 1, fig. 4.; 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 Gassendiceras 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 Vandenheckei Biozone (here the 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; AGRAM, 1995; COMPANY et alii, 1995, 2008; VERMEULEN, 2005).

It appears that since the work of SIMIONESCU (1899), Gassendiceras 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 Prodrome [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 Prodrome (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 Gassendiceras 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 tripitate" (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 Gassendiceras 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 Hemi-hoplitidae 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 (Hoe De Maecker & 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 Barrancylloceras barremense (KILIAN, 1985), and the lack of consensus (Delany, 1992; Company et alii, 1995, 2008; Vermeulen, 2004, 2005; Vermeulen & Lazarin, 2007).

As an exact match with the holotype of Barrancylloceras 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
Subzone since its index species was often confused by the authors with B. barremense (KILIAN) and,

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

**Alpinum Biohorizon (new)**

*Index species:* Gassendiceras 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, southeastern 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:* Gassendiceras alpinum (d’ORBIGNY, 1850) is fairly well represented in the sections. It is associated with Heinzia sayni (HYATT, 1903), Kotetishvilia ficheuri (JOLEAUD, 1912), Toyancylcoceras cf. vandenheckei (ASTIER, 1851), Silestites 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 Gassendiceras 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: Gassendiceras BERT et alii, 2006, Pseudoshasticrioceras 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 toptotype), 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 Gassendiceras BERT et alii,
2006, primarily because of their close phyletic relationships to Gassendiceras of the quelguejeui group: in particular, this applies to Gassendiceras alpinum (d’Orbigny, 1850). Finally, we recommend replacement of the Barremense auctor Subzone by the Alpinum Subzone (new) [index-species: Gassendiceras 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.

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Bibliographic references

BERT D. & DELANOY G. (2009).- Pseudo- eaticriceras 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.


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), toptype, 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), toptype, spécimen n° AT36, collection BERT. Banc 151-2 du stratotype d'Angles (Alpes-de-Haute-Provence), Biohorizon à Alpinum (nouveau).
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 Breistroferi. 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 refigné 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 Barrancycloceras 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 Barrancycloceras 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).