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***Pseudoshastrioceras bersaci* nov. sp.
(Ammonoidea, Gassendiceratinae),
and new ammonite biohorizon
for the Upper Barremian of southeastern France**

Didier BERT* ¹

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Abstract: Research in the Feraudianus Subzone of the Sartousiana Zone of the Barremian stage led to the discovery of a new species of *Pseudoshastrioceras*: *P. bersaci* nov. sp. Its study provides evidence concerning the developments of the latest Gassendiceratinae BERT *et alii*, 2006, and the relationship between the genus *Pseudoshastrioceras* DELANOY, 1998, and *Gassendicerat* BERT *et alii*, 2006. In particular, this new species is derived from *Pseudoshastrioceras magnini* (DELANOY, 1992) by a minor revision in the processes of ontogenesis (retardation of ornamentation - neoteny). However, the evolution towards *Pseudoshastrioceras autrani* DELANOY, 1998, implies a "failure" in this process that may possibly be related to parallel changes in environmental conditions. On the other hand, the very closely defined stratigraphic position of *Pseudoshastrioceras bersaci* nov. sp., and its position in the anagenetic lineage of *Pseudoshastrioceras*, demonstrates its interest as a biostratigraphic marker: a new Bersaci Biohorizon is proposed; it is located between the Magnini and the Autrani biohorizons.

Key Words: Ammonitinae; *Pseudoshastrioceras*; Gassendiceratinae; Upper Barremian; Sartousiana Zone; Feraudianus Subzone; biozotation; southeastern France.

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R sum  : *Description de Pseudoshastrioceras bersaci nov. sp. (Ammonoidea, Gassendiceratinae), et nouveau biohorizon ammonitique pour le Barr mien sup rieur du Sud-Est de la France.*- Des recherches dans la sous-zone   Feraudianus ont permis la d couverte d'une nouvelle esp ce de *Pseudoshastrioceras*: *Pseudoshastrioceras bersaci* nov. sp. Son  tude apporte des  l ments concernant l' volution des derniers Gassendiceratinae BERT *et alii*, 2006, ainsi que sur les relations entre les genres *Pseudoshastrioceras* DELANOY, 1998, et *Gassendicerat* BERT *et alii*, 2006. En particulier cette nouvelle esp ce est issue de *Pseudoshastrioceras magnini* (DELANOY, 1992) par des processus d'alt ration de l'ontog nese (retardation de l'ornementation - n ot nie). En revanche, l' volution vers *Pseudoshastrioceras autrani* DELANOY, 1998, implique une "rupture" de ce processus qui pourrait  ventuellement  tre mise en parall le avec les variations des conditions environnementales. D'autre part, la position stratigraphique tr s pr cise de *Pseudoshastrioceras bersaci* nov. sp., ainsi que sa position dans la lign e anag n tique des *Pseudoshastrioceras*, montrent son int r t en tant que marqueur biostratigraphique : le nouveau biohorizon   Bersaci est propos  ; il est situ  entre les biohorizons   Magnini et   Autrani.

Mots-Clefs : Ammonitinae ; *Pseudoshastrioceras* ; Gassendiceratinae ; Barr mien sup rieur ; Zone   Sartousiana ; Sous-zone   Feraudianus ; biozotation ; Sud-Est de la France.

I - Introduction

The Upper Barremian was intensively researched as part of the revision of the Hemihoplitidae conducted by one of us (DB). Many ammonites were collected from levels previously reported as being poor in fossils. Some of our results have been published (BERT & DELANOY, 2000; BERT *et alii*, 2006, 2009). The continuation of this research in the median levels of the Feraudianus Subzone (Sartousiana Zone) have resulted in a better understanding

of the dynamics of the ammonite faunas. In particular the collection of a large homogeneous sample of specimens of the genus *Pseudoshastrioceras* DELANOY, 1998, of which a paleontological study is presented here, provides new elements concerning the evolution of the last Gassendiceratinae BERT *et alii*, 2006, and establishes a new biostratigraphic marker. The biochronological framework used for this work (Upper Barremian) is that proposed recently by BERT *et alii* (2008).

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We had previously recognized (BERT & DELANOY, 2000; BERT *et alii*, 2006, p. 181) several stages of ornamentation that recur frequently in most Hemihoplitidae SPATH, 1924, at the different stages of ontogenic development. These stages are defined as follows:

1. Usually restricted to the younger whorls of the shell, the "heberti" type of stage features a sub-octagonal section of the whorls, and a more or less radial ornamentation consisting mostly of simple fine ribs, only slightly differentiated and regularly tri-tuberculated. This developmental stage is named for its occurrence in the taxon "*Ezeiceras heberti* (FALLOT, 1884) [*nomen dubium*]" of which the specimen-type is from a now inaccessible polyzonal bed. The specimen is only the nucleus, 27 mm in diameter, of an indeterminate individual of the Hemihoplitidae. Indeed, almost all the Hemihoplitidae less than 30 mm in diameter show this stage which is so similar in all specimens that speciation is then not possible (BERT & DELANOY, 2000; BERT *et alii*, 2006).
2. The "barremense" stage is generally distinguishable by an alternation of main tri-tuberculated ribs and of thinner intermediary ribs that are highly variable in appearance and in number. But this "standard" stage differs among the *Pseudoshasticrioceras* DELANOY, 1998, by the greater prominence of the interlayer ribs and their lesser number (see description). The name of this stage is derived from *Barrancyloceras barremense* (KILIAN, in KILIAN & LEENHARDT, 1895) of which the type specimen, from the Gardenazza area (Tyrol), was featured by UHLIG in 1887 (Pl. 4, fig. 3). This is a fragmentary specimen (almost 90 mm in diameter) on which the type-ornament is on the last half-whorl preserved.
3. The name of the "camereiceras" type ornament is based on the morphology and type of ornament known in adults, or pre-adult, of the genus *Camereiceras* DELANOY, 1990. The morphology features a very characteristic oval compressed section with a broad base and flanks converging to a narrow venter. The ribs are less differentiated and blunter than in the previous stage, so peri-umbilical and lateral tubercles are very weak or absent. In contrast, peri-ventral tubercles are very well marked, regular, claviform, and their arrangement flanks the venter in a very characteristic way.

II. Study of *Pseudoshasticrioceras bersaci* nov. sp.

Systematics:

Order: Ammonoidea ZITTEL, 1884
Sub-order: Ammonitina HYATT, 1889
Super-family: Ancyloceratoidea GILL, 1871
Family: Hemihoplitidae SPATH, 1924
Sub-family: Gassendiceratinae BERT *et alii*, 2006
Genus: *Pseudoshasticrioceras* DELANOY, 1998

Type-species: *Pseudoshasticrioceras magnini* (DELANOY, 1992), in DELANOY (1992, Pl. 24, fig. 1).

Pseudoshasticrioceras bersaci nov. sp.

(Pls. 1 - 6)

Synonymy:

? **1964.** *Crioceratites (Emericeras) hoheneggeri* (UHLIG, 1883) - THOMEL, Pl. 5, figs. 2-3.

v **1992.** *Emericeras* sp. gr. *magnini* sp. nov. - DELANOY, Pl. 25, fig. 1a-d.

v **1992.** *Emericeras* aff. *magnini* sp. nov. - DELANOY, Pl. 26, fig. 1; Pl. 27, fig. 1; Pl. 29, figs. 2-3.

Denomination: This species is dedicated to our colleague S. BERSAC of Vence (France).

Holotype: Specimen n° AR76, collection BERT (Pl. 1, figs. 1-2).

Type-locality: The LAC section, in the Méouille area, near Saint-André-les-Alpes (Alpes-de-Haute-Provence, France - Figs. 1 - 2) previously illustrated by BERT *et alii*, 2008, Fig. 4.

Bed-type: Bed n° 257 from LAC section (Fig. 2).

Geographic distribution: *Pseudoshasticrioceras bersaci* nov. sp. is known to date only in the southeastern France, in both basinal and distal platform areas.

Stratigraphic distribution: All the specimens from the Vocontian Basin come from a bed above the Magnini Biohorizon. This level is taken to be the base of the Bersaci Biohorizon (new, this work). It is located in the middle part of the Feraudianus Subzone (Sartousiana Zone) of the Upper Barremian, between the Magnini and Autrani biohorizons (BERT *et alii*, 2008).

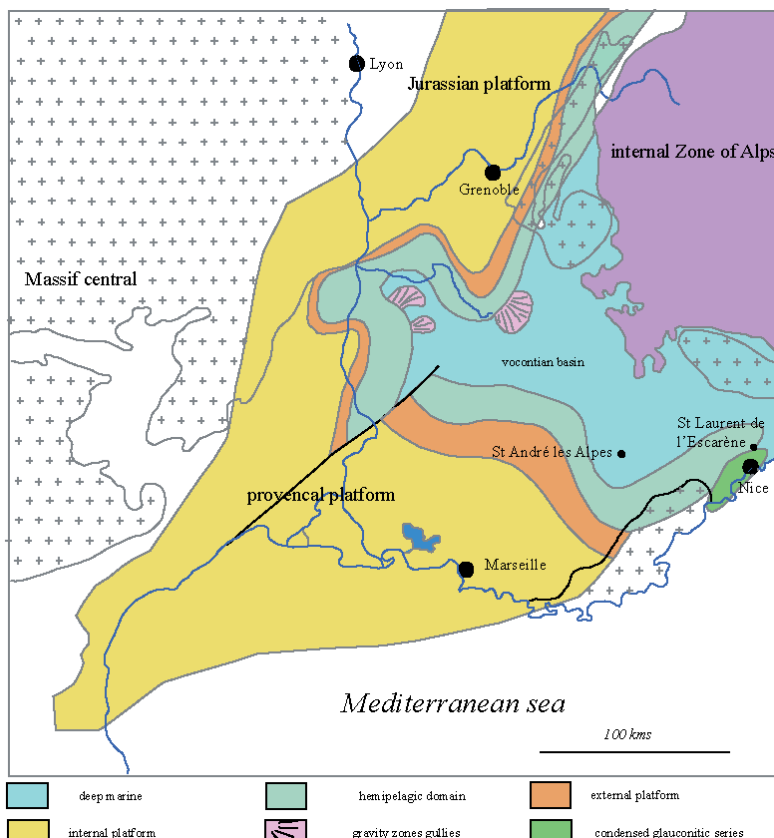


Figure 1: Barremian paleogeography of southeastern France and location of the area studied (from ARNAUD, 2005).

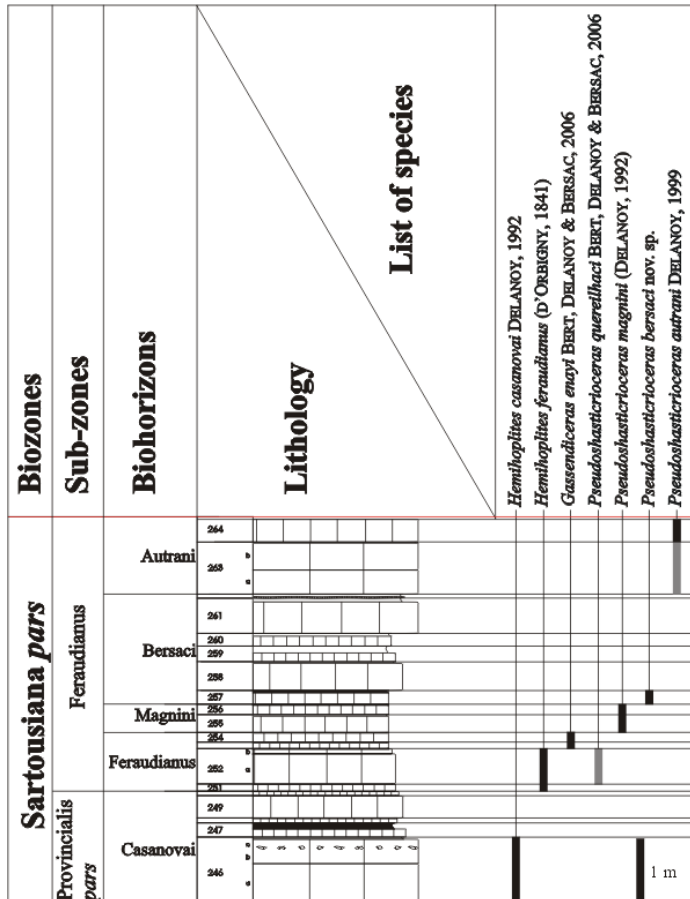
Figure 1 : Cadre paléogéographique du Sud-Est de la France et localisation du secteur d'étude (d'après ARNAUD, 2005).

Diagnosis: Shell weakly uncoiled; with rapid growth in height, the section always higher than wide. Ornamentation always well marked. Three successive ontogenic stages are known: (1) in the inner whorls, a sub-octagonal section ("heberti" stage); (2) after 25 mm in diameter, the whorls increase in height and the section is compressed further. Ornamentation is trituberculated main ribs, with only a few broad intermediary ribs, which join the main ribs at the top of the flanks (an alternative to the "barremense" stage); (3) up to 100 mm in diameter, compressed oval section with broader base and sides converging towards the venter. Ornamentation blunt with lateral and periumbilical tubercles which tend to disappear ("camereiceras" stage).

Material studied (N = 6): Of all the specimens collected, four were from the pelagic domain in the Angles historical stratotype area (Vocontien Basin, area of Saint-André-les-Alpes, Alpes-de-Haute-Provence, southeastern France - Fig. 1): specimen n° AM30 and AR76 are from that section bed LAC/257 (BERT collection); n° 28416 (DELANOY collection) and n° MOR 079 (BERSAC collection) were collected from the interval between beds 194B and 196 of La Grau de Moriez site (see DELANOY, 1997b, p. 233). The other two specimens come from bed 4B4 of the Saint-Laurent de l'Escarène section, Alpes-Maritimes (see DELANOY, 1992), which is on a distal platform: n° EM 108 and EM 109 (MASCARELLI collection) are casts in the DELANOY's collection.

► **Figure 2:** Distribution of the ammonites in the LAC section *pars* (Méouille area, Saint-André-les-Alpes, Alpes-de-Haute-Provence). In grey are the specimens found in stratigraphically equivalent strata (outside the main section).

Figure 2 : Répartition des faunes dans la coupe LAC *pars* (secteur de Méouille, Saint-André-les-Alpes, Alpes-de-Haute-Provence). En grisé, les espèces trouvées en place latéralement dans d'autres coupes, mais dans des niveaux corrélables banc par banc.



Measurements: See Table.

n° Specimen	D	H	E	O	H/D	E/D	O/D	E/H	O/H	N/2	N	spiral gap	α°
AR76 (holotype) Pl. 1, figs. 1-2	c. 190	-	-	-	-	-	-	-	-	-	-	-	
	158	59.9	-	59.6	0.38	-	0.38	-	0.99	-	-	0	
	121.5	43.3	27.9	52.7	0.36	0.18	0.43	0.47	1.22	-	-	0	120°
	77.12	25.3	21	33	0.33	0.17	0.43	0.48	1.30	15	30	0	180°
MOR 079 Pl. 3, fig. 2	73.2	27	15.5	33.5	0.37	0.21	0.46	0.57	1.24	-	-	2.8	
	45.9	15.74	7.8	21.8	0.34	0.17	0.47	0.50	1.39	-	-	1.15	190°
28416 Pl. 6, fig. 2	80.4	28.7	18.1	34.5	0.36	0.23	0.43	0.63	1.20	17	36	2.8	
	66.2	23.3	14.3	28.0	0.35	0.22	0.42	0.61	1.20	19	38	2.6	70°
	47.8	18.2	13.1	23.4	0.38	0.27	0.49	0.72	1.29	18	38	1.4	90°
EM 108 Pl. 4, fig. 1 Pl. 5, fig. 1	189	70	-	75.4	0.37	-	0.40	-	1.08	23	43	4	90°
	149.6	58.1	32	58.2	0.39	0.21	0.39	0.55	1.00	23	41	2.5	90°
	115.2	43	27.7	47.2	0.37	0.24	0.41	0.64	1.10	20	38	2	90°
	87	32.4	23	35	0.37	0.26	0.40	0.71	1.08	18	36	3.5	90°
	68	24.1	-	30	0.35	-	0.44	-	1.24	18	36	2	90°
	52.9	19.3	-	23.4	0.36	-	0.44	-	1.21	17	-	-	
EM 109 Pl. 2, fig. 1 Pl. 3, fig. 1	175	61.2	-	73.2	0.35	-	0.42	-	1.20	21	38	3	
	138.4	50.5	34	55.9	0.36	0.25	0.40	0.67	1.11	20	36	-	90°
	113.2	42.5	29	45.2	0.38	0.26	0.40	0.68	1.06	17	-	-	90°
	88	31.54	23.5	35	0.36	0.27	0.40	0.75	1.11	16	-	-	90°
Average					0.36	0.23	0.42	0.61	1.17				
Standard deviation					0.01	0.04	0.03	0.09	0.11				
Coefficient of variation (%)					4.09	16.09	7.07	15.23	9.16				

Description: Three specimens are more than 175 mm in diameter, but none has an adult body chamber, all are septate throughout. The shell is weakly uncoiled (sometimes even with sub-joined whorls) and a spiral gap generally weak. All are less than 3.5 mm in width (average relative umbilicus of $O/D = 0.42$). The growth in height is rapid (Table) with an average relative height of $H/D = 0.36$. In contrast, the growth in thickness remains low, even if the difference in the kind of preservation in samples from the basin and from the platform are taken into account, for the average thickness ratio is only $E/D = 0.23$. Nevertheless, the section remains much higher

than wide ($E/H = 0.61$ on average) and tends to become greater with growth. In Fig. 3, the average curves of the relations between the measured values of H , E and O in relation to the diameter are in agreement with the allometric relationship $Y = bX^a$. However, for $H = f(D)$ [$R^2 = 0.99$ with p around 0.1] and $E = f(D)$ [$R^2 = 0.86$ with p around 0.3], a values are close to 1, so we may consider the growth of these characters as almost isometric. Thus relative-height and relative-thickness are fairly constant in relation to the diameter. In contrast, for $O = f(D)$ [$R^2 = 0.99$ and $p < 0.001$ - Fig. 3] and $O = f(H)$ [$R^2 = 0.98$ and $p < 0.001$ - Fig. 4], there is a lower value of a . This is linked to the

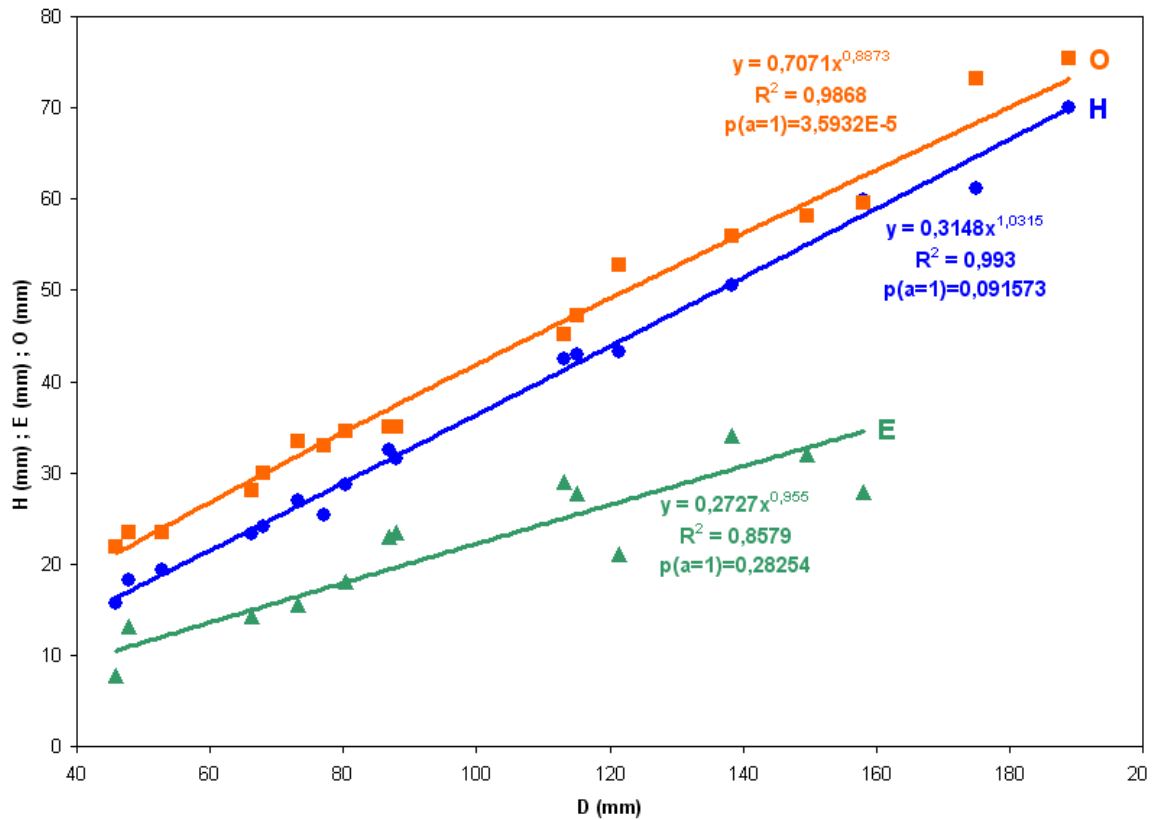


Figure 3: Representation of *H*, *E* and *O* in function of the diameter (*D*) for *Pseudoshastrioceras bersaci* nov. sp.
Figure 3 : Représentation de *H*, *E* et *O* en fonction du diamètre (*D*) pour *Pseudoshastrioceras bersaci* nov. sp.

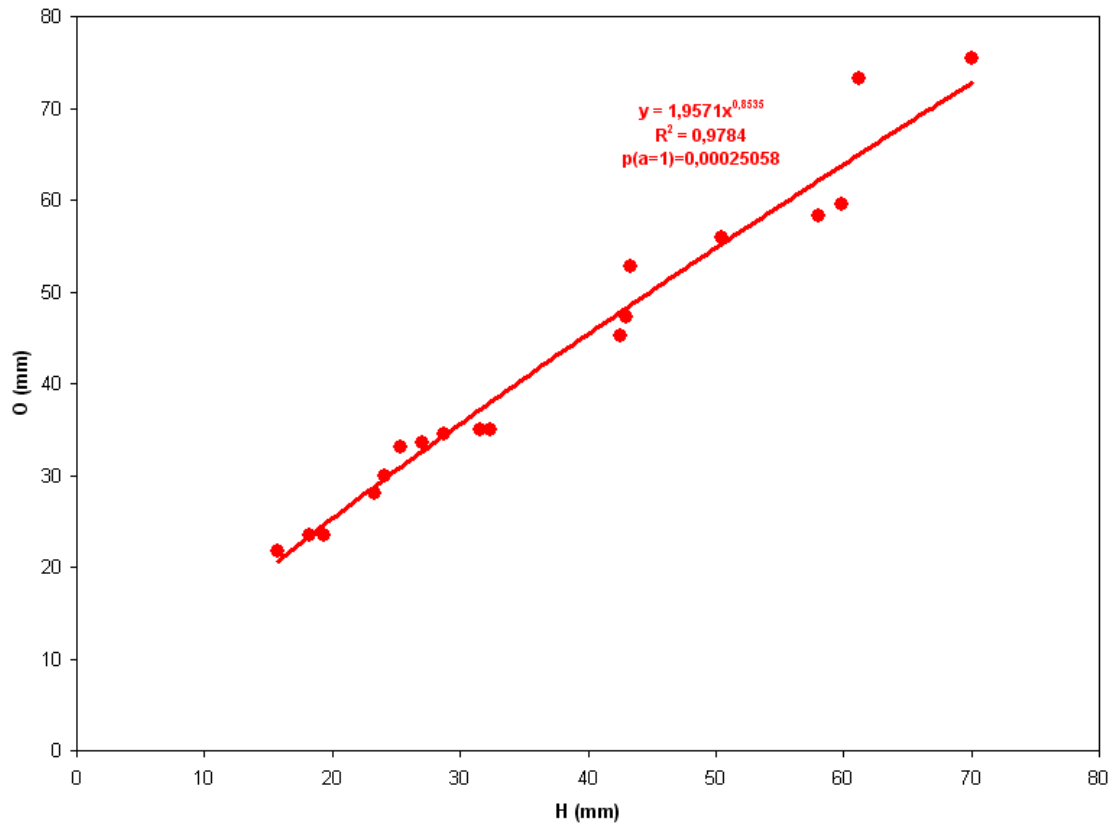


Figure 4: Representation of the umbilicus (*O*) in function of whorl height (*H*) for *Pseudoshastrioceras bersaci* nov. sp.
Figure 4 : Représentation de l'ombilic (*O*) en fonction de la hauteur du tour (*H*) pour *Pseudoshastrioceras bersaci* nov. sp.

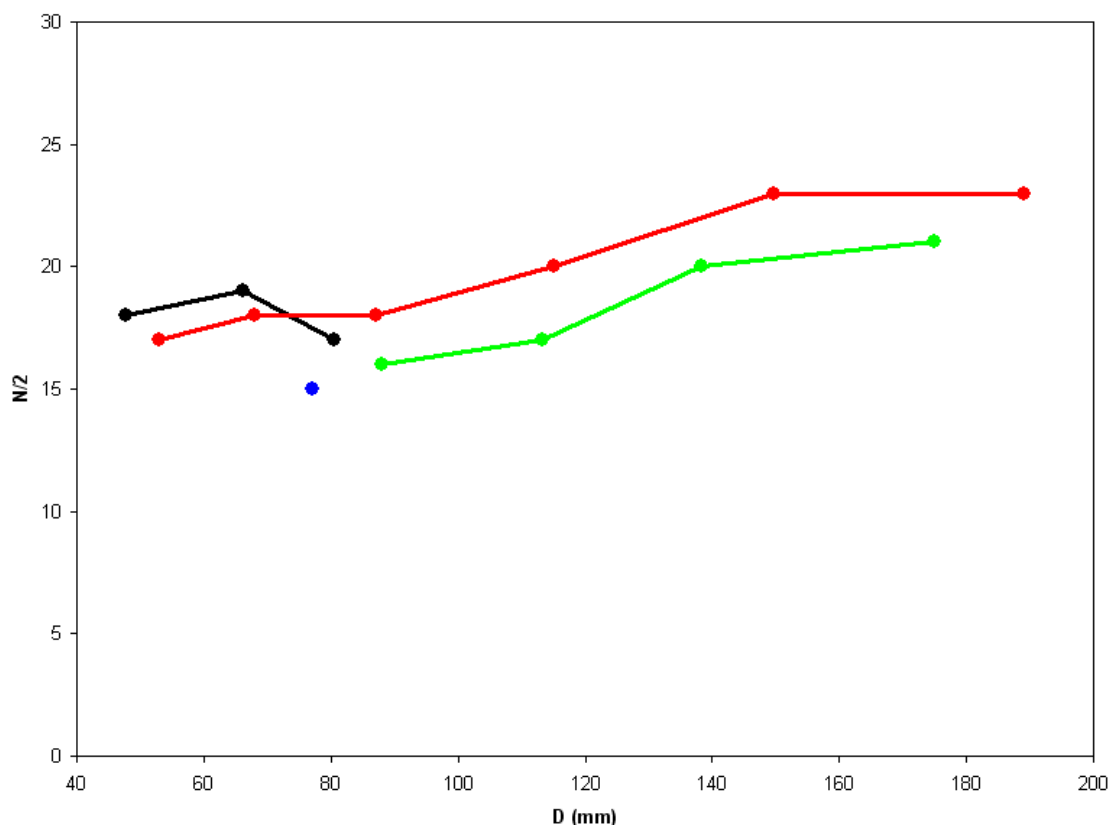


Figure 5: Representation in the number of ribs per half-turn of whorl ($N/2$) depending on the diameter (D) for *Pseudoshastrioceras bersaci* nov. sp.

Figure 5 : Représentation du nombre de côtes par demi-tour de spire ($N/2$) en fonction du diamètre (D) pour *Pseudoshastrioceras bersaci* nov. sp.

decrease of O/H with respect to the diameter: The progression of this parameter is thus slightly allometric and the average width of the umbilicus increases in proportion with the diameter and the height of the whorl. The analysis of the dispersion parameters reveals that in all cases the clouds of points are weakly scattered around the average, homogeneous and without a breaking slope, thus indicating a harmonic growth. The coefficients of determination R^2 are still very high. The standard deviations (Table) are very low and highly correlated with each other. We notice, however, that the coefficients of variation present certain disparities: around 5%, and in all are less than 10%, for reports of H and O calculations. But they are more than 15% for the relations involving E , which is quite high in comparison to values given above. This result was anticipated due to the taphonomic differences: thinner by post mortem compression in the basin and uncompressed, thicker, on the distal platform. In any case there is no bimodality in the clouds of points of these diagrams, thus demonstrating the perfect uniformity of the sample with regard to growth parameters.

The ornamentation is always well marked and increases slightly quantitatively with greater diameter (Fig. 5). Two extremes of morphology with respect to robustness (covariance) can be recognized all connected by intermediaries, but that fact does not influence

the ontogenic succession. Three successive stages can be recognized during growth.

- The first observations were made from specimens 15 mm in diameter. This stage is very similar to the "heberti" stage recognizable in most Hemihoplitidae and defined above (see BERT *et alii*, 2006). The section is very characteristic, sub-octagonal scarcely taller than wide; the ornamentation is already very close to that of the next stage, but more regular.
- Beginning at a diameter of 25 mm there is a variant of the "barremense" stage with strongly trituberculated ribs. The height of the whorls tends to increase and the section becomes increasingly higher and compressed: the umbilical wall is generally quite high, the peri-umbilical area is inclined and grades gradually to the rounded flanks, then to the venter which is quite narrow and pinched. The ornamentation is composed of main trituberculated ribs, slightly inclined backward and wider at the top of the flanks than at their base, with rare interlayer ribs. The first tubercle is at the base of the flanks, slightly above the peri-umbilical area. It is quite small and well marked in the inner whorls, and it may be slightly elongated in the direction of the rib that supports it. The lateral conical tubercle is

positioned in the upper third of the flanks. In the inner whorls the latter is equal in size and prominence to the peri-umbilical tubercle; however in the more robust specimens (n° AR76, Pl. 1, figs. 1-2; EM 109, Pl. 2, fig. 1; Pl. 3, fig. 1a-b; MOR 079, Pl. 3, fig. 2) it tends to become dominant, but conversely is less marked than the basal tubercle in the more slender specimens (n° EM 108, Pl. 4, fig. 1; Pl. 5, fig. 1a-b; 28416, Pl. 5, fig. 2; Pl. 6, fig. 2a-b). The external tubercle is the most important: its base is as wide as that of the rib which supports it; it is pinched in the direction of coiling, thus making it claviform, and it is topped by a very short flat triangular spine. On the venter, the main ribs are very wide and blunt. The intermediary ribs are scarce, quite broad, and more or less join the main ribs starting at the margino-ventral area. The presence of some peri-umbilical bifurcations determines a V-rib conformation.

- The last stage ("camericeras" stage) known is attained at a diameter of 90-95 mm in the slender forms (n° EM108, Pl. 4, fig. 1; Pl. 5, fig. 1a-b), and at around 100-110 mm in the more robust forms (n° EM 109, Pl. 2, fig. 1; Pl. 3, fig. 1a-b; AR76; Pl. 1, figs. 1-2). The section becomes very characteristic: a compressed oval with a broader base and flanks that converge to the narrow venter. The ornamentation is blunter with the ribs less differentiated and more widely blunt than in the previous stage. The lateral and then the peri-umbilical tubercle gradually disappear. Instead, the peri-venter tubercles become more important, because of the widening of the ribs at the top of the flanks, and they are distributed on both sides of the venter in a very characteristic way, rather like that of some representative adults or sub-adults of *Camericeras* DELANOY, 1990.

The suture line is very difficult to trace in most of our specimens, especially those from the basin (partial dissolution), but it is fairly denticulate and seems to show a trifid lateral lobe, asymmetric and broad-based (n° EM 109).

Variability: WESTERMANN (1966), used BUCKMAN's work (1892) on the Sonninnidae (Early Bajocian), that clarified in ammonites the "laws" of covariation based mainly on the relationship between the width of the section and the strength of the ornamentation. Since then, numerous studies have demonstrated that BUCKMAN's "First Law" can be extended to ammonoids ranging in age from Paleozoic to Cretaceous (see MORARD & GUEX, 2003, Tab. 1 for a summary). Overall, the sample studied here is very homogeneous, especially in the succession of its ontogenic stages, but using "BUCKMAN'S Law" in a more detailed study shows

it to be quite variable. Thus, two main morphologies are recognized, based on the relative robustness of the ornamentation. But, because of differences in both the mode of preservation and the degree of post mortem compression it is not possible here to demonstrate a correlation between habitat and development of ornamentation as is usually the case. Variability in the ornamentation density is quite small and very homogeneous (Fig. 5). At most, the forms with a more robust ornamentation tend to have fewer ribs.

In conclusion, the variability in shell and ornament, including all intermediaries, falls within the limits generally accepted for ammonites of the range of variability of a single species.

Differential diagnosis: The sample studied here has all the characters of the genus *Pseudoshasticrioceras* DELANOY, 1998. In particular it is very close to the type-species of the genus, *Pseudoshasticrioceras magnini* (DELANOY, 1992), of which one specimen is figured here for comparison (Pl. 6, fig. 1). This species differs essentially from ours in the duration of the successive stages of ontogeny. The tuberculated stage of the type "barremense" lasts longer and exists in specimens with an average diameter of up to 100 mm rather than 50 mm (discriminated character). The "heberti" type ontogenic stage is a little longer too.

Compared to *Pseudoshasticrioceras quereilhaci* BERT *et alii*, 2006, the differences from our species are more pronounced, for the tuberculated stage of *P. quereilhaci* is even smaller than in the type-species. In addition, the stage with a high section of the "camericeras" type occurs later in the growth of our sample.

Pseudoshasticrioceras murphyi (DELANOY, 1992) is very different from the specimens studied here, for it has no trace of the tuberculated stage of the "barremense" type, at least to when the diameter is greater than 20-25 mm. The ribs are always thinner than those of our specimens.

The adult of *Pseudoshasticrioceras autrani* DELANOY, 1998, is smaller (around 100 mm in diameter) and the "barremense" stage, with trituberculated ribs, is smaller than in our specimens (up to 40-55 mm in diameter); also its coiling is narrower.

A comparison of the specimens studied here with other species of the genus shows that the succession of, and especially the duration of, ontogenic stages makes it original morphologically. So we propose the name *Pseudoshasticrioceras bersaci* nov. sp. to identify it.

More generally, when compared with species of the genus *Gassendiceras* BERT *et alii*, 2006, and especially with *Gassendiceras quelquejeui* BERT *et alii*, 2006, and *Gassendiceras enayi* BERT *et alii*, 2006, the representatives of the genus *Pseudoshasticrioceras* DELANOY, 1998, have a number of morphological and ornamental differences which, despite undeniable affinities, allow their distinction beyond dispute:

1. a narrower coiling which makes peri-venter spines shorter.
2. at equal diameters, the height of the whorls, and the rapidity of their growth during ontogeny, is always greater.
3. the ribs are less well differentiated, even at the "barremense" stage. In particular, the intermediate ribs (rarely totally inermous) are clearly less numerous and have the same aspect as the main ribs at the upper part of the flank, with the mark of a peri-ventral claviform tubercle.
4. the peri-umbilical bifurcations of the ribs are more numerous, especially with their very distinctive "V" shape.

Phyletic position and evolution: Stratigraphically (Fig. 2), *Pseudoshasticrioceras bersaci* nov. sp. immediately follows *Pseudoshasticrioceras magnini* (DELANOY, 1992) in the Magnini Biohorizon, and it precedes *Pseudoshasticrioceras autrani* DELANOY, 1998, in the Autrani Biohorizon.

As in many other groups of ammonites, the duration and the appearance of the different stages of ontogeny may be determinants in evolutionary trends (DOMMERGUES *et alii*, 1986). Thus, during time, there is a retardation (neoteny) of the stages of ornamentation between *Pseudoshasticrioceras quereilhaci* BERT *et alii*, 2006, *Pseudoshasticrioceras magnini* (DELANOY, 1992) and *Pseudoshasticrioceras bersaci* nov. sp., caused mainly by a lengthening of the trituberculated stage. It should be noted that the process appears to be reversed in the *Gassendiceras* where there is a reduction in the duration of the "barremense" stage over time (unpublished data).

Although data are still incomplete for these *Pseudoshasticrioceras* species and for *Pseudoshasticrioceras autrani* DELANOY, 1998, there is an abrupt reduction in duration of the "barremense" and "camereiceras" stages, and a sudden decrease in the adult size. This "failure" may parallel some extrinsic elements like the contemporary drop in sea level (sequence boundary SbB4 in ARNAUD, 2005) which preceded the marine transgression at the base of the Giraudi Biozone. These changes caused the morphological distinctions known among the representatives of the genus *Imerites* ROUCHADZÉ, 1933, now classified as *Gassendiceratinae* BERT *et alii*, 2006 (BERT *et alii*, 2008). New specimens (BERT *et alii*, 2009) clearly show a direct link between the latest *Pseudoshasticrioceras* and the first *Imerites*.

	Biozones	Sub-zones	Biohorizons
Upper Barremian	Giraudi	Waagenoides	
		Sarasini	
			Puzosianum
		Giraudi	
			Emerici
	Giraudi		
	Sartousiana	Feraudianus	Autrani
			Bersaci
			Magnini
			Feraudianus
		Provincialis	Casanovai
			Provincialis
	Limentinus		
Limentinus			
Marchandi			
Vandenheckei	Barremense	Breistrofferi	
	Vandenheckei		

Figure 6: Proposed biozonal scheme, after BERT *et alii*, 2008, and REBOULET *et alii*, 2009, amended. In red the Bersaci biohorizon (new).

Figure 6 : Biozonation proposée, d'après BERT *et alii*, 2008, et REBOULET *et alii*, 2009, modifié. En rouge le biohorizon à Bersaci (nouveau).

III. Biostratigraphy

Bersaci Biohorizon (new): *Pseudoshastrioceras bersaci* nov. sp. has a very limited and precise stratigraphic position as the successor, by anagenetic processes, of the index-species *Pseudoshastrioceras magnini* (DELANOY, 1992); so in the stratotype area (Vocontian Basin, southeastern France) its stratigraphic appearance is in conjunction with its biological appearance. This position and the necessity of establishing a complete high resolution biozone for the Barremian (REBOULET *et alii*, 2006, 2007; BERT *et alii*, 2008) lead us to propose *Pseudoshastrioceras bersaci* nov. sp. as a new biostratigraphic marker, a biohorizon, in the Vocontian Basin of southeastern France (Fig. 6). *Pseudoshastrioceras bersaci* nov. sp. characterizes the strata immediately above those of the Magnini Biohorizon. It should be noted that these beds are not distinguishable as such in the historical section of the stratotype near Angles, where deposits of this portion of the Upper Barremian are abnormal (gaps, faunal concentration, etc. - see BERT *et alii*, 2008). As already noted by DELANOY (1997b), the thickness of the deposits of the Feraudianus Subzone increases in the direction of Saint-André-les-Alpes, then toward Moriez and Barrême. In the sections near Saint-André-les-Alpes, the first appearance of *Pseudoshastrioceras bersaci* nov. sp. closely precedes the major beds of the Autrani Biohorizon (BERT *et alii*, 2008), at the top of the Feraudianus Subzone (Sartousiana Biozone), where *Pseudoshastrioceras autrani* DELANOY, 1998, and the first recognized *Heteroceras couletti* DELANOY, 1994, occur.

Index species: *Pseudoshastrioceras bersaci* nov. sp.

Status: This biohorizon is defined by the first appearance of its index-species (bed n° 257 in the LAC section, Fig. 2), and its upper limit is currently set at the base of the Autrani Biohorizon (bed n° 263 in the LAC section). It is also present in the GRY section, near Angles.

Faunal assemblages: The index-species, characterized in this work, is generally fairly well represented in the sections. It is associated with the "classic" fauna of the Feraudianus Subzone (DELANOY, 1997a, 1997b; BERT *et alii*, 2008): *Macroscaphites yvani* (PUZOS) macro and microconch, *Protetragonites crebisulcatus* (UHLIG), *Eulytoceras phestus* (MATHERON), *Silesites seranonis* (d'ORBIGNY), *Barremites difficilis* (d'ORBIGNY), etc.

IV. Conclusion

The discovery of *Pseudoshastrioceras bersaci* nov. sp. at a specific level of the Feraudianus Subzone provides a biostratigraphic marker which can serve as a new biohorizon for the Upper Barremian of southeastern France. This new biohorizon is

between the Magnini and the Autrani biohorizons. It is the result of the need for the establishment of the finest possible biostratigraphic framework, to further the study of the different ammonites groups in the Upper Barremian, and especially the Hemihoplitidae (BERT, in progress).

The description of this new species also provided a better understanding of the genus *Pseudoshastrioceras* DELANOY, 1998, and of its differences from the genus *Gassendiceras* BERT *et alii*, 2006, morphologically close, and from which it is very probably derived. The stages of ornamentation in these genera do indeed have the same ontogenic organization with the succession of "heberti", "barremense" and "camereiceras" stages. But there are a number of morphological differences (coiling, structure of the shell) and ornamentation (rarer and less differentiated interlayer ribs, and "V" shaped peri-umbilical bifurcations) in the successive stages, especially in the "barremense" type.

This contribution, and the recognition of certain ontogenic heterochronies in its development, has furnished a better understanding of the evolution of *Pseudoshastrioceras*. They are an intermediate between the *Gassendiceras*, with which they occur jointly in the Feraudianus Subzone (BERT *et alii*, 2006, 2008), and the *Imerites* that distinguish the more recent Giraudi Biozone. Further research is necessary to complete this evolutionary canvas, particularly to clarify certain points relationship between *P. bersaci* nov. sp. and *P. autrani* DELANOY, 1998, as well as the precise derivation of the *Pseudoshastrioceras* among the *Gassendiceras*.

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Bibliographic references

- ARNAUD H. (2005).- The South-East France Basin (SFB) and its Mesozoic evolution.- *Géologie Alpine*, Grenoble, (série spéciale "Colloques et Excursions"), n° 7, p. 5-28.
- BERT D. & DELANOY G. (2000).- Considérations nouvelles sur quelques représentants barrémiens de Puchelliidae DOUVILLE, 1890 et des Hemihoplitidae SPATH, 1924 (Ammonoidea).- *Annales du Muséum d'Histoire Naturelle de Nice*, t. XV, p. 63-89.
- 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

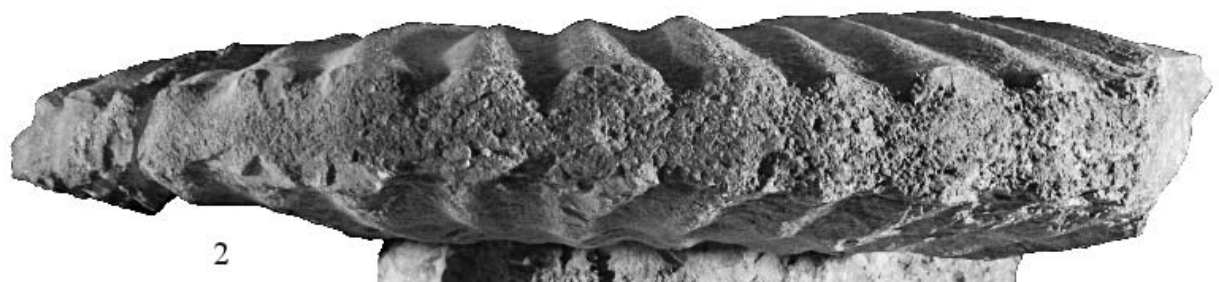
Plates

► **Plate 1:**

Pseudoshasticrioceras bersaci nov. sp.

Figs. 1-2: Specimen n° AR76 (holotype), BERT collection, from the bed LAC/257, Méouille near Saint-André-les-Alpes (Alpes-de-Haute-Provence, France).

Planche 1 : Figs. 1-2 : Spécimen n° AR76 (holotype), collection BERT, banc LAC/257 de Méouille près de Saint-André-les-Alpes (Alpes-de-Haute-Provence, France).



5 cm



► **Plate 2:**

Pseudoshasticrioceras bersaci nov. sp.

Fig. 1: Specimen n° EM 109, MASCARELLI collection, from the bed 4B4 of the deposit of Saint-Laurent de l'Escarène (Alpes-Maritimes, France).

Planche 2 : Fig. 1 : Spécimen n° EM 109, collection MASCARELLI, banc 4B4 de Saint-Laurent de l'Escarène (Alpes-Maritimes, France).



► **Plate 3:**

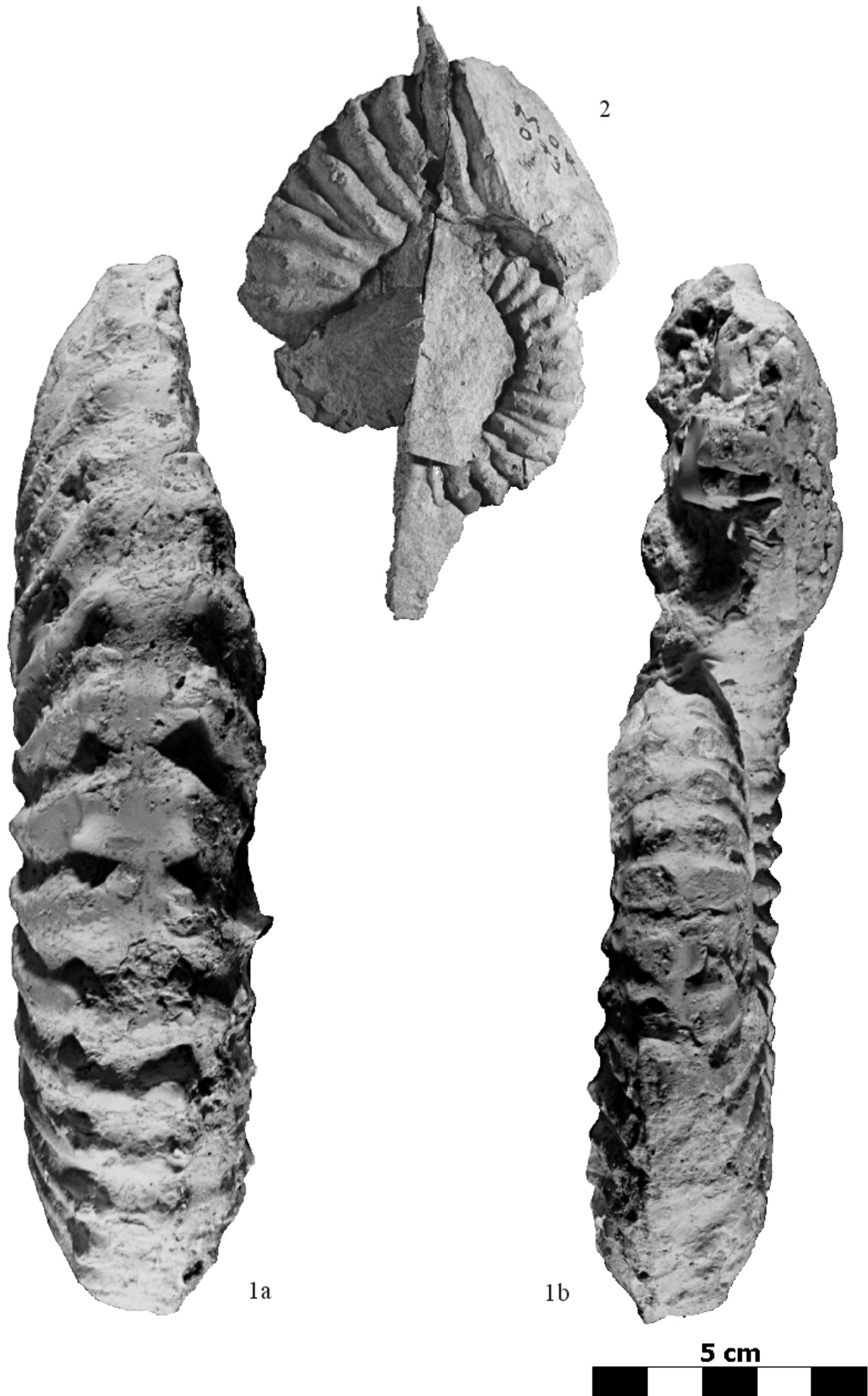
Pseudoshasticrioceras bersaci nov. sp.

Fig. 1a-b: Specimen n° EM 109, MASCARELLI collection, from the bed 4B4 of the deposit of Saint-Laurent de l'Éscarène (Alpes-Maritimes, France).

Fig. 2: Specimen n° MOR 079, BERSAC collection, from the gap of beds 194B to 196 of the deposit of La Grau de Moriez (Alpes-de-Haute-Provence, France).

Planche 3 : Fig. 1a-b : Spécimen n° EM 109, collection MASCARELLI, banc 4B4 de Saint-Laurent de l'Éscarène (Alpes-Maritimes, France).

Fig. 2 : Spécimen n° MOR 079, collection BERSAC, de l'intervalle de bancs 194B à 196 de La Grau de Moriez (Alpes-de-Haute-Provence, France).



► **Plate 4:**

Pseudoshasticrioceras bersaci nov. sp.

Fig. 1: Specimen n° EM 108, MASCARELLI collection, from the bed 4B4 of the deposit of Saint-Laurent de l'Escarène (Alpes-Maritimes, France).

Planche 4 : Fig. 1 : Spécimen n° EM 108, collection MASCARELLI, banc 4B4 de Saint-Laurent de l'Escarène (Alpes-Maritimes, France).



► **Plate 5:**

Pseudoshasticrioceras bersaci nov. sp.

Fig. 1a-b: Specimen n° EM 108, MASCARELLI collection, from the bed 4B4 of the deposit of Saint-Laurent de l'Escarène (Alpes-Maritimes, France).

Fig. 2: Specimen n° 28416, DELANOY collection, from the gap of beds 194B to 196 of the deposit of La Grau de Moriez (Alpes-de-Haute-Provence, France).

Planche 5 : Fig. 1a-b : Spécimen n° EM 108, collection MASCARELLI, banc 4B4 de Saint-Laurent de l'Escarène (Alpes-Maritimes, France).

Fig. 2 : Spécimen n° 28416, collection DELANOY, de l'intervalle de bancs 194B à 196 de La Grau de Moriez (Alpes-de-Haute-Provence, France).



1a



1b



2



► **Plate 6:**

Planche 6 :

Pseudoshastrioceras magnini (DELANOY, 1992)

Fig. 1: Specimen n° LAC 032, BERSAC collection, from bed LAC/256, Méouille near Saint-André-les-Alpes (Alpes-de-Haute-Provence, France).

Fig. 1 : Spécimen n° LAC 032, collection BERSAC, banc LAC/256 de Méouille près de Saint-André-les-Alpes (Alpes-de-Haute-Provence, France).

Pseudoshastrioceras bersaci nov. sp.

Fig. 2a-b: Specimen n° 28416, DELANOY collection, from the gap of beds 194B to 196 of the deposit of La Grau de Moriez (Alpes-de-Haute-Provence, France).

Fig. 2a-b : Spécimen n° 28416, collection DELANOY, de l'intervalle de bancs 194B à 196 de La Grau de Moriez (Alpes-de-Haute-Provence, France).



- 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 bio-horizons pour le Barrémien supérieur.- *Carnets de Géologie / Notebooks on Geology*, Brest, Article 2008/03 (CG2008_A03), 18 p.
- BERT D., DELANOY G. & CANUT L. (2009).- L'origine des *Imerites* ROUCHADZE, 1933 : résultat d'une innovation chez les Gassendiceratinae BERT, DELANOY & BERSAC, 2006 (Ammonoidea, Ancyloceratina).- *Annales de Paléontologie*, Paris, vol. 95, p. 21-35.
- BUCKMAN S.S. (1887-1907).- A monograph of the ammonites of the Inferior Oolite Series.- *Palaeontological Society*, London, 456 p.
- 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. (1994).- Les biozones à Feraudianus, Giraudi et Sarasini du Barrémien supérieur de la région stratotypique d'Angles-Barrême-Castellane (Sud-Est de la France).- *Géologie Alpine*, Grenoble, Mémoire H.S., n° 20, p. 279-319.
- DELANOY G. (1997a).- Biostratigraphie des faunes d'Ammonites à la limite Barrémien-Aptien dans la région d'Angles-Barrême-Castellane. Étude particulière de la Famille des Heteroceratidae (Ancyloceratina, Ammonoidea).- *Annales du Muséum d'Histoire Naturelle de Nice*, t. XII, 270 p.
- DELANOY G. (1997b).- Biostratigraphie haute résolution du Barrémien supérieur du Sud-Est de la France.- *Comptes Rendus de l'Académie des Sciences*, Paris, (Série II, Sciences de la Terre et des Planètes), t. 325, p. 689-694.
- DELANOY G. (1998).- *Pseudoshasticrioceras* gen. nov. : un nouveau genre d'ammonite hétéromorphes du Barrémien supérieur du Sud-Est de la France.- *Annales du Muséum d'Histoire Naturelle de Nice*, t. XIII, p. 431-439.
- DOMMARGUES J.-L., DAVID B. & MARCHAND D. (1986).- Les relations ontogénèse-phylogénèse : application paléontologiques.- *Geobios*, Villeurbanne, n° 19, fasc. 3, p. 335-356.
- FALLOT E. (1884) - Sur un gisement crétaqué fossilifère des environs de la gare d'Èze (Alpes-Maritimes).- *Bulletin de la Société géologique de France*, Paris, (3ème Série), t. XII, p. 289-300, Pl. IX.
- 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, p. 970-981.
- MORARD A. & GUEX J. (2003).- Ontogeny and covariation in the Toarcian genus *Osperleioceras* (Ammonoidea).- *Bulletin de la Société géologique de France*, Paris, t. 174, n° 6, p. 607-615.
- 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., RAISSOSSADAT N., ROPOLO P., SANDOVAL J., TAVERA J.M., VASICEK 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., RAISSOSSADAT 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.
- ROUCHADZE J. (1933).- Les ammonites aptiennes de la Géorgie occidentale.- *Bulletin de l'Institut géologique de Géorgie* (1932), Tbilisi, vol. 1, n° 3, p. 165-273.
- SPATH L.F. (1924).- On the ammonites of the Speeton Clay and the subdivisions of the Neocomian.- *Geological Magazine*, Cambridge, vol. 61, n° 716, p. 73-89.
- THOMEL G. (1964).- Contribution à la connaissance des céphalopodes crétaqués du Sud-Est de la France. Note sur les ammonites déroulées du Crétaqué inférieur vocontien.- *Mémoires de la Société géologique de France*, Paris, (Nouvelle Série), t. XXXVIII, Mémoire n° 101, 80 p.
- UHLIG V. (1887).- Ueber neocom Fossilien vom Gardenazza in Südtirol nebst einen Anhang über das Neocom von Ischl.- *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, Wien, Band 37, Heft 1, p. 69-108.
- WESTERMANN G.E.G. (1966).- Covariation and taxonomy of the Jurassic ammonite *Soninia adicra* (WAAGEN).- *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, Stuttgart, Band 124, Heft 3, p. 289-312.