

The '*Pseudocrioceras* interval' and adjacent beds at La Bédoule (SE France): implications to highest Barremian/lowest Aptian biostratigraphy

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Key words: Ammonoidea, *Pseudocrioceras* interval, Deshayesitidae, Barremian/Aptian boundary, SE France.

Biostratigraphical investigation of the marly limestones of the La Bédoule area (SE France) has revealed a rich macrofaunal interval in four different sections, mainly consisting of the ammonite genera *Pseudocrioceras* and *Barremites*. A detailed study of the immediately under- and over-lying beds shows that in all four sections, the *Pseudocrioceras* interval, unambiguously equivalent to the *Pseudocrioceras coquandi* Zone of Busnardo (1984), occurs stratigraphically between a late Barremian heteroceratid fauna (*Colchidites* aff. *tsholashensis* (Rouchadze), *Martelites* aff. *vulanensis* (Egoian), *Simionescites* aff. *simionescui* Avram) of the *Martelites sarasini* Zone (Hoedemaeker et al., 1993) and an earliest Aptian deshayesitid fauna (*Deshayesites antiquus* Bogdanova, *D. oglanlensis* Bogdanova, *D. weissiformis* Bogdanova) of the *Dehayesites tuarkyricus* Zone (Bogdanova, 1983).

These new data should play a critical role in the definition of the Barremian/Aptian boundary.

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Introduction

In the vicinity of Marseilles (SE France), between the Cassis railway-station and the locality of La Bédoule, marly limestones constitute a historical and stratigraphical reference for the lower Aptian (the so-called Bedouliau of Toucas, 1888). Successively studied by Matheron (1842, 1878-1880), Reynes (1861), Hebert (1871), Toucas (1888), Roch (1927), Blanc (1958), Flandrin (1965), Fabre-Taxy, Moullade & Thomel (1965), Moullade Taxy & Tronchetti, 1980, and Busnardo (1984), these beds yielded, and still contain, a rich fauna of ammonites (some of them regarded as types of index-species). Initially subdivided in two zones by Kilian & Reboul (1915) and Roch (1927), then considered as belonging to a single zone by Fabre-Taxy et al. (1965), the lower Aptian of La Bédoule was subdivided by Busnardo (1984) into seven ammonite zones; from

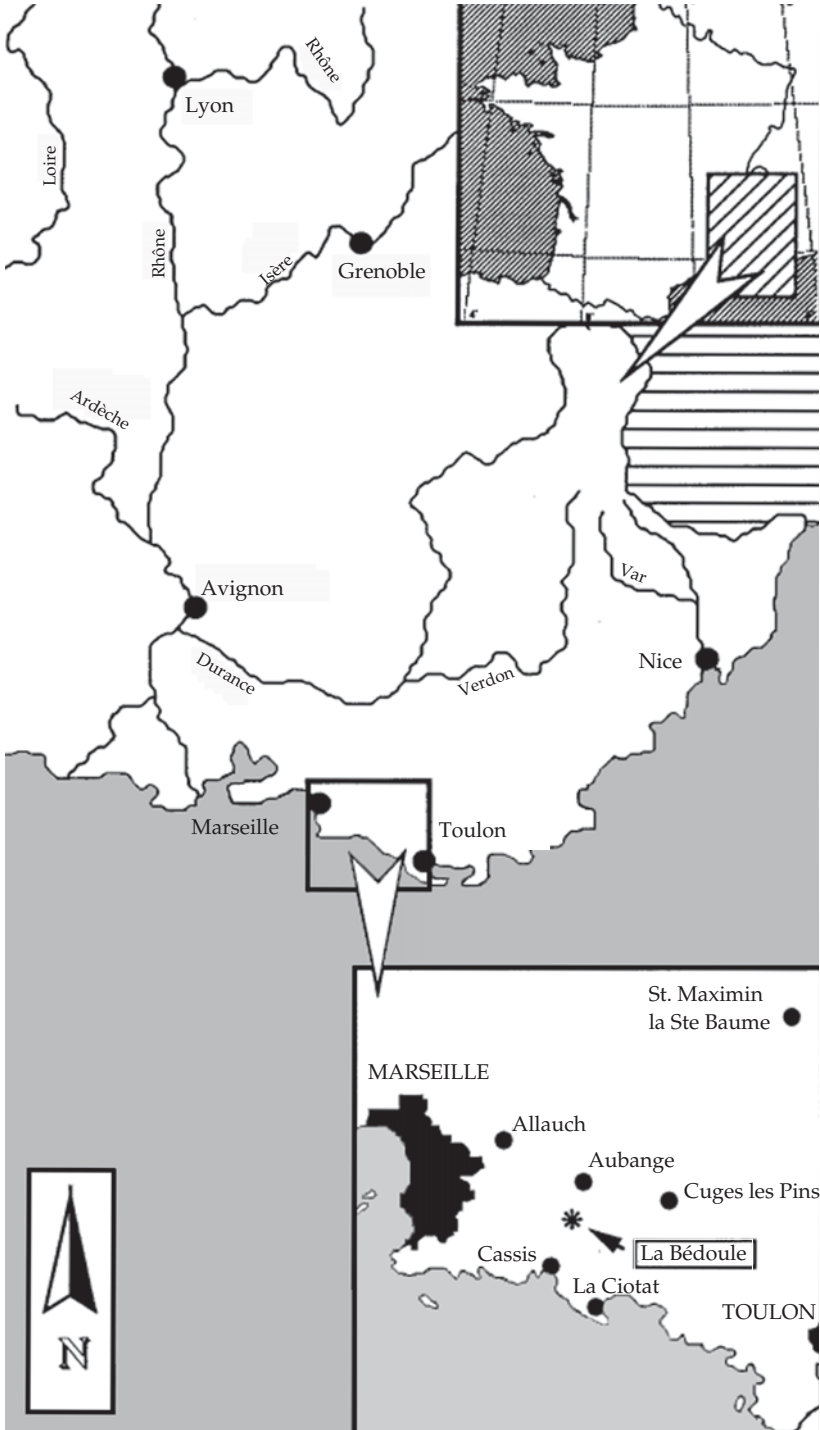


Fig. 1. Geographical location of the studied area (Marseille-La Bédoule).

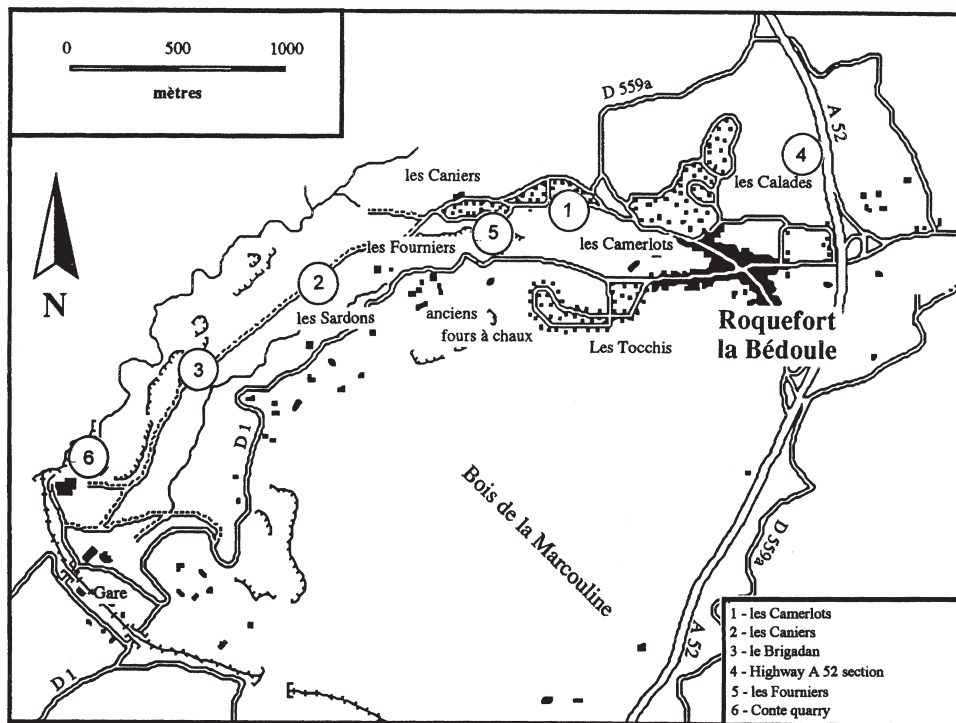


Fig. 2. Location of the studied sections in the La Bédoule area.

bottom to top the 'Prodeshayesites', *Pseudocrioceras coquandi*, *Deshayesites consobrinus*, *Ancyloceras matheroni*, *Roloboceras hambrovi*, *Deshayesites grandis*, and *Tropaeum bowerbanki* Zones. Because of the difficulties in using some of these zones away from the stratotype of la Bédoule (Comte quarry) such a division was not maintained at the first Workshop of the Lower Cretaceous Cephalopod Team of IGCP Project 262 (Tethyan Cretaceous Correlation: Digne, 1990) (Hoedemaker & Bulot, 1990). The team preferred the biostratigraphical scheme used in Caucasian regions (Georgia, Turkmenistan), consisting of four zones (from bottom to top), the *Deshayesites tuarkyricus*, *D. weissii*, *D. deshayesi*, and *Dufrenoyia dufrenoyi* zones. This zonation was maintained and confirmed at the Second Workshop of the Lower Cretaceous Working Group of IGCP project 262 (Mula, 1992) and is used by us.

We have investigated (with the kind help of Busnardo, Moullade & Masse) four sections surrounding the la Bédoule locality: Les Caniers, Les Camerlots, Highway A 52, and Le Brigadan (Figs. 1-2). This has enabled us to describe a rich *Pseudocrioceras* level, equivalent to the *Pseudocrioceras coquandi* Zone of Busnardo (1984) (Delanoy et al., 1997; Ropolo et al., in press).

In the lowermost *Pseudocrioceras* beds, specimens of *Pseudocrioceras* aff. *waagenoides*, co-occurring with *Martelites* aff. *vulanensis* and *Simionescites* (= *Kutatissites*) aff. *simionescui* Avram, were collected. In the beds immediately below this interval, we found *Colchidites* aff. *tsholashensis* (Rouchadze).

The beds immediately above the *Pseudocrioceras* interval have yielded a fauna of Deshayesitidae assigned to the *tuarkyricus* Zone of the earliest Aptian. As, according to Rawson (1983), the FAD (first appearance datum) of the genus *Deshayesites* represents the best criterion for defining the lower limit of the Aptian Stage, our new observations led us to question the exact stratigraphical position of the *Pseudocrioceras* level, and consequently, of the Barremian/Aptian boundary in the stratotypical area. Concerning the upper limit of the *tuarkyricus* Zone, and the early *weissi* Zone, we collected ammonites in the Fourniers Section, on the northern side of the D1 road.

Stratigraphy

The '*Pseudocrioceras* interval' and the lower part of the *tuarkyricus* Zone

Because individual beds can be correlated between Les Caniers, Les Camerlots and Le Brigadan, we have applied a common bed-numbering system to these sections.

Les Caniers section (Fig. 3)

Between Cassis and Roquefort la Bédoule, the D1 road snakes across a continuous succession of calcareous beds assigned to the lower Aptian, followed, on the southern side and above the old lime kilns, by dark grey marly levels of the Gargasian (upper Aptian). On the ridge which overhangs the northern side of the D1 another road, then a little lane located between Les Caniers quarter and the Comte quarry, leads to an outcrop along the right border of a small runnel flowing from La Bedoule to Cassis.

Beds 72-74: *Ancyloceras breve* (d'Orbigny), *A. urbani* (Neumayr & Uhlig), *A. sp.*

Beds 75-80: a rich fauna of *Pseudocrioceras* (*P. fasciculare*, *P. aff. waagenoides*, *P. waageni*, *P. coquandi*, *P. provinciale*, *P. duvalianum*, *P. lobjanidzei*, together with *Barremites strettostoma* (Uhlig), *Simionescites aff. simionescui* and *Heminautilus sanctaerucis* Conte.

Beds 81-83: the first Deshayesitidae (*Deshayesites antiquus*, *D. oglanlensis* Bogdanova, *D. weissiformis*). We interpret bed 81 as the initial level of the *tuarkyricus* Zone.

Bed 84: *Procheloniceras* sp., *Audouliceras* sp., *Deshayesites oglanlensis*, *D. aff. tuarkyricus* Bogdanova, *Deshayesites luppovi*, *D. antiquus*, *D. weissiformis*.

Beds 85-89: *Deshayesites* sp., *Deshayesites weissiformis*, *D. oglanlensis*, *Audouliceras* sp.

Beds 90-92: *Deshayesites aff. tuarkyricus*, *D. oglanlensis*, *D. luppovi*.

Above bed 92, access to the outcrops becomes difficult because the vegetation is very dense.

Les Camerlots section (Fig. 4)

In a trench excavated for laying on water in the 'Camerlots' area, a section was measured (Fig. 4) and numerous ammonites collected.

Beds 71-79: *Martelites aff. vulanensis*, *Simionescites aff. simionescui*, *Pseudocrioceras fasciculare*, *P. waageni*, *P. coquandi*, *P. provinciale*, *Audouliceras* sp., *Acrioceras ex gr. furcatum* (d'Orbigny), *Pseudohaploceras liptoviense* (Zeuchner).

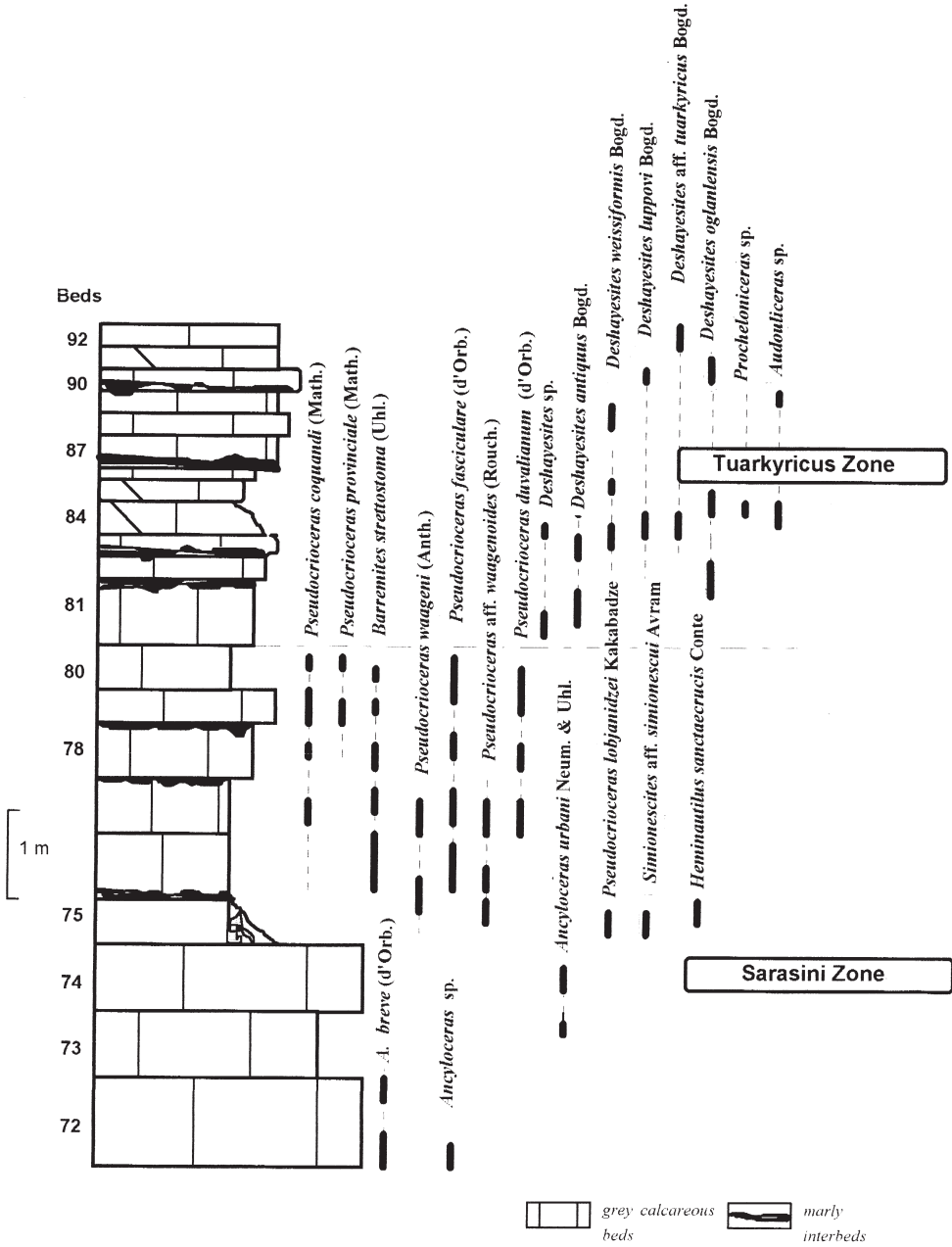


Fig. 3. Stratigraphical distribution of the ammonite fauna in the Caniers section.

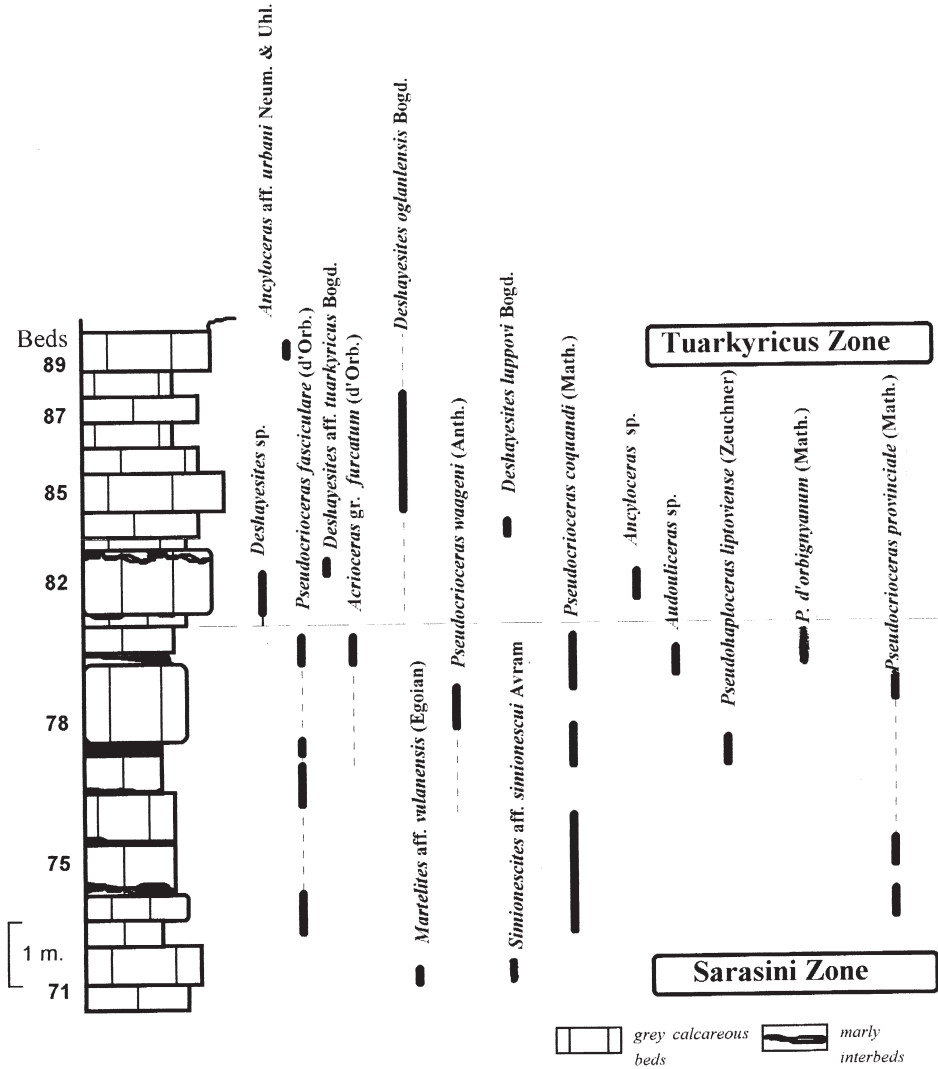


Fig. 4. Stratigraphical distribution of the ammonite fauna in the Camerlots section.

Bed 80: *Procheloniceras pachystephanum* (Uhlig), *Pseudocrioceras orbignyianum*, *P. fasciculare*, *P. coquandi*, *Acrioceras* ex gr. *furcatum*.

Beds 81-89: *Deshayesites* aff. *tuarkyricus*, *D. oglanlensis*, *Deshayesites* sp., *Deshayesites lupповi*, *Ancylloceras* sp. In bed 89 we found *Ancylloceras* aff. *urbani* (Neumayr & Uhlig).

Highway A 52 Section (Fig. 5)

On both sides of highway A 52, East of La Bédoule, abrupt cliffs composed of decimetric beds form interesting outcrops for the study of the highest Barremian/lowest Aptian boundary beds.

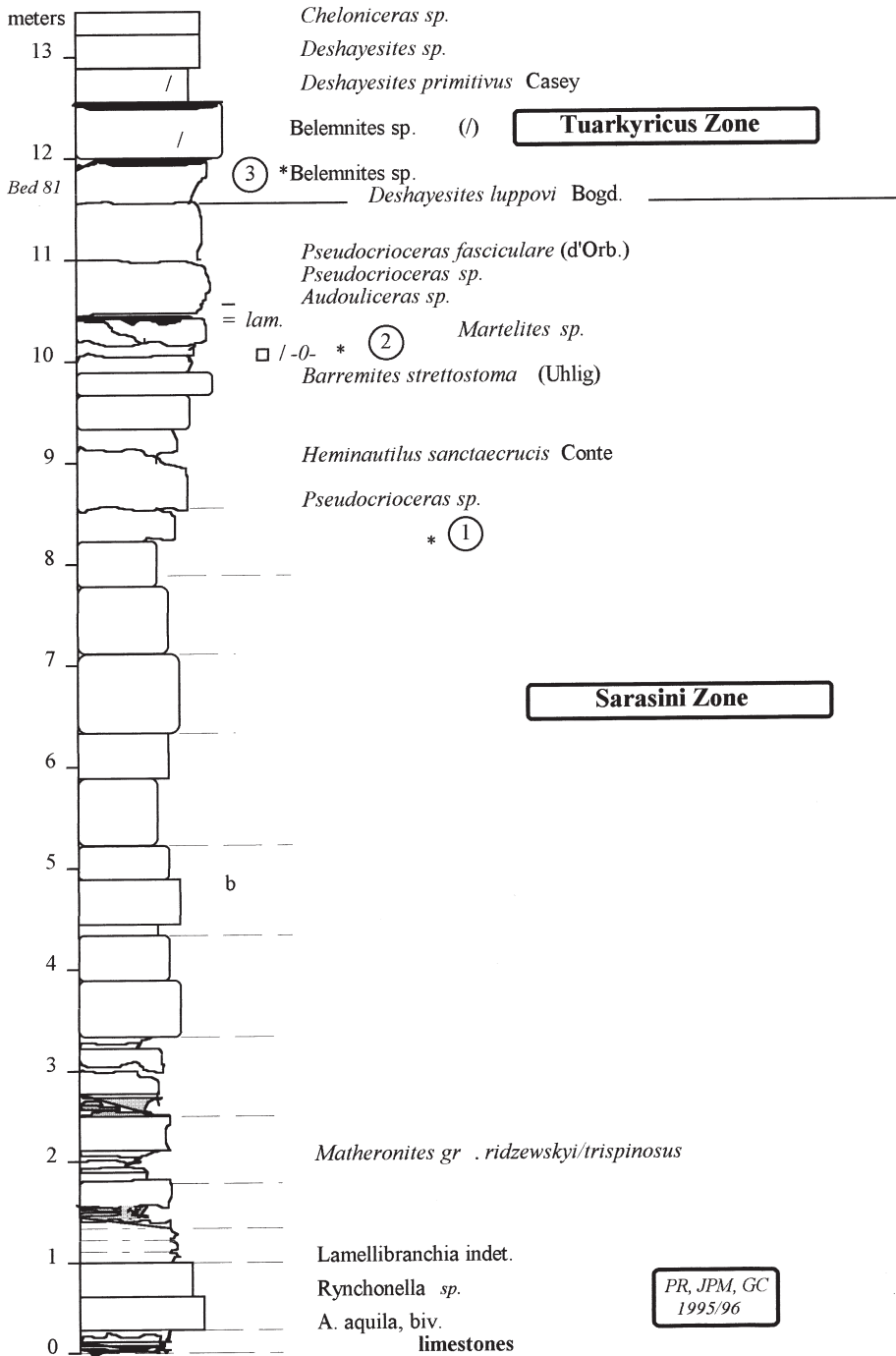


Fig. 5. Stratigraphical distribution of the ammonite fauna in the Highway A 52 Section.

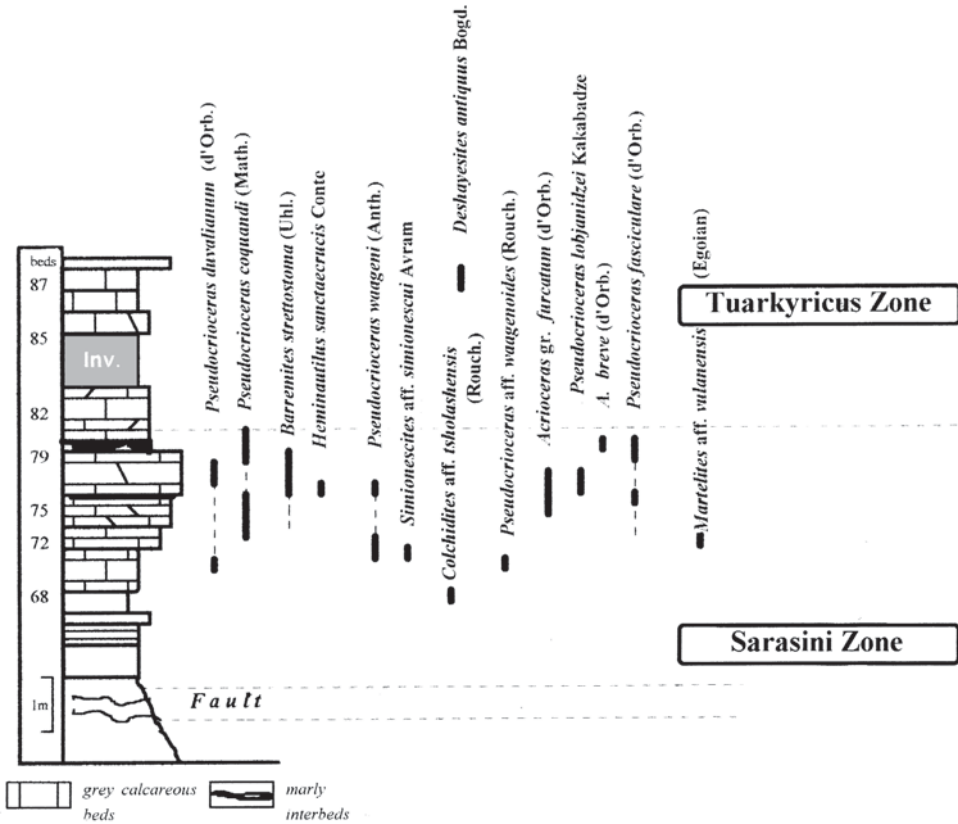


Fig. 6. Stratigraphical distribution of the ammonite fauna in the Le Brigadan section.

On the left side of the highway, on the way to Marseille, along a little lane we collected successively: 'Matheronites' ex gr. *ridzewskyi/trispinosus*, *Barremites* sp., *Barremites strettostoma*, *Audouliceras* sp., *Pseudocrioceras* sp., *Pseudocrioceras fasciculare*, *Deshayesites luppovi*, *Deshayesites primitivus* Casey, and *Deshayesites* sp. In this section we have not made an exhaustive description of the beds. The fauna is poorer than in the other sections. However, we could observe the superposition of the *Deshayesites* level on the *Pseudocrioceras* interval and we were able to collect 'Matheronites' ex gr. *ridzewskyi/trispinosus* which seems to mark the lowest level of the *Pseudocrioceras* beds.

Le Brigadan Section (Fig. 6)

In outcrops on the right side of the runnel which flows between La Bédoule and Cassis, 500 m north of the stratotype section (Comte quarry), we again found the *Pseudocrioceras* interval. From the runnel to the lane, we met:

Bed 68: 0.8 m of white limestone with *Colchidites* aff. *tsholashensis*.

Beds 69-71: *Simionescites* sp., *S.* aff. *simionescui*, *Pseudocrioceras duvalianum*, *P.* aff. *waagenoides*.

Bed 72: *Pseudocrioceras* aff. *waagenoides*, *P. coquandi*, *Martelites* aff. *vulanensis*.

Beds 73-75: *Pseudocrioceras coquandi*, *P. fasciculare*, *Acrioceras* ex. gr. *furcatum*.

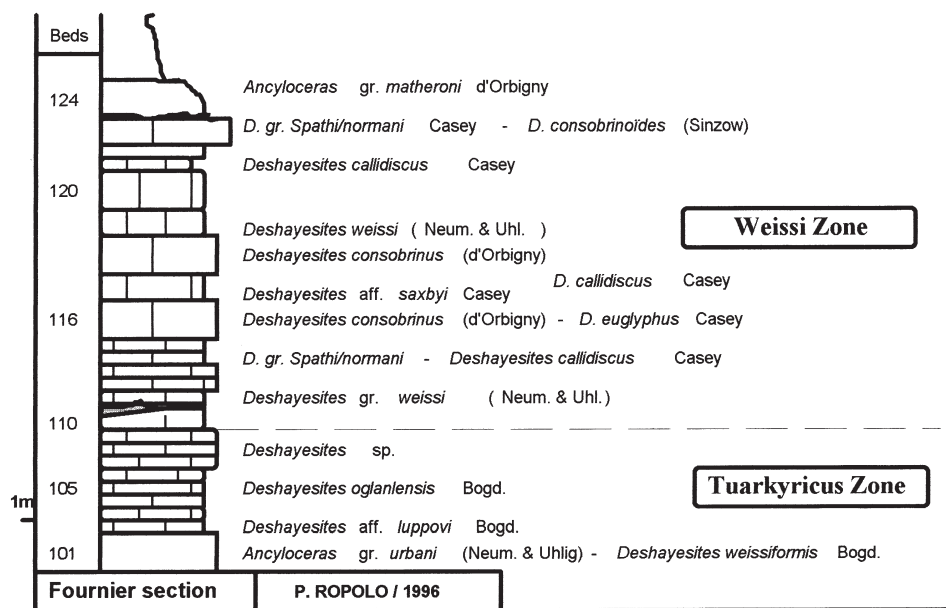


Fig. 7. Upper part of the *tuarkyricus* Zone and lower part of the *weissi* Zone in the Fourniers Section.

Beds 77-79: *Barremites strettostoma*, *Acrioceras* ex gr. *furcatum*, *Pseudocrioceras fasciculare*, *P. duvalianum*, *P. coquandi*, *P. lobjanidzei*, *Ancyloceras breve* (d'Orbigny), *Heminautilus sanctaecrucis*.

Bed 80: *Pseudocrioceras coquandi*.

On the top of the outcrops we collected large specimens of *Deshayesites antiquus*.

Upper boundary of the *tuarkyricus* Zone and the *weissi* Zone

Les Fourniers (Fig. 7)

During building works for a villa, on the left side of the D1 road, between Cassis and La Bédoule, we investigated the top of the *tuarkyricus* Zone and the *weissi* Zone:

Beds 101-109: *Ancyloceras* ex gr. *urbani*, *Deshayesites weissiformis*, *D. aff. luppovi*, *D. oglanlensis*, *Deshayesites* sp.

Bed 110: the first *Deshayesites* of the *weissi* group. We take the base of this bed to mark the base of the *weissi* Zone.

Beds 114-116: *Deshayesites* ex gr. *spathi/normani*, *D. callidiscus* Casey, *D. consobrinus* (d'Orbigny), *D. euglyphus* Casey, *D. aff. saxbyi* Casey.

Beds 118-123: *Deshayesites callidiscus*, *D. weissi* (Neumayr & Uhlig), *D. ex gr. spathi/normani* and a big recurved hook of an *Ancyloceras* ex gr. *matheroni* d'Orbigny.

Sysyematic descriptions

Most of the *Pseudocrioceras* and other ammonites described here are in the authors' collections. There are some uncatalogued *Pseudocrioceras* in the Tourment and Saludes

collections. We have examined type material in the d'Orbigny collection in the Muséum National d'Histoire Naturelle, Paris (MNHN) and the Matheron collection in the Musée d'Histoire Naturelle de Marseille (MHNM) ('Musée Longchamp').

All photographs on the plates are by Delanoy (D), Gonnet (G) and Ropolo (R).

In the descriptions below we use standard morphological terms. The meaning of the following symbols is (always measured in mm):

H = total height of the shell

h3 = height of the oral part

h2 = height of the whorl at the last suture-line

h1 = initial height of the shell

Ds = diameter of the initial whorls

U = width of umbilicus

Lc = length of the chamber

Lp = length of the phragmocone

I = hiatus between the initial whorls and the oral part

S = space between the shaft and the buccal part

Family Ancyloceratidae Gill, 1871
Subfamily Ancyloceratinae Gill, 1871
Genus *Pseudocrioceras* Spath, 1924

Type-species — *Scaphites abichi* Simonovich & Batsevich, 1873.

Synonymy

1924 *Pseudocrioceras* Spath, p. 78.

1933 *Ancyloceras* Rouchadze p. 212.

1938 *Pseudocrioceras* Anderson, p. 205.

1938 *Pseudocrioceras* Roman, p. 353.

1949 *Crioceras* (*Pseudocrioceras*) Jenne, p. 623.

1957 *Pedioceras* (pars) Arkell et al., p. 208.

1958 *Pseudocrioceras* Orlov, p. 104.

1958 *Ancyloceras* Orlov, p. 105 (pars).

1978 *Pseudocrioceras* Kakabadze, p. 34.1.

1981 *Pseudocrioceras* Kakabadze, p. 101.

1990 *Pseudocrioceras* Delanoy & Bulot, p. 15.

1996 *Pedioceras* (pars) Wright, p. 214.

1997 *Pseudocrioceras* Kakabadze & Hoedemaeker, p. 68.

Description — Tripartite heteromorph ammonite. The shell is composed of an initial variably coiled spiral (whorls can be coiled so that the venter of one is just about in contact with the dorsum of the next, or can be more open) followed by a short straight or gently curved shaft and a short hook.

The sculpture consists on initial whorls, of fine delicate flexuous or straight ribs, then marginal tubercles appear, followed by umbilical and lateral tubercles. At a more advanced ontogenetic stage, the spire shows either bi- or trituberculate major ribs alternating with intermediate non-tuberculate ribs, or fasciculate ribs starting from peri-umbilical tubercles or bullae. All the ribs are interrupted on the siphonal part, where they form tuberculiform bulges.

The shaft and the hook are more robustly ribbed. Thick trituberculate major ribs bearing strong lateral, ventral and umbilical tubercles are separated by one to four intermediate ribs. Ventral tubercles are more developed and often take the form of big 'clavi'.

Discussion — We place the following taxa in *Pseudocrioceras*:

- Pseudocrioceras abichi* (Simonovich & Batsevich, 1873)
- Pseudocrioceras anthulai* (Eristavi, 1955)
- Pseudocrioceras coquandi* (Matheron, 1878)
- Pseudocrioceras coquandi* var. *imerica* (Rouchadze, 1933)
- Pseudocrioceras densecostatum* Kakabadze, 1981
- Pseudocrioceras dichotomum* (Rouchadze, 1933)
- Pseudocrioceras duvalianum* (d'Orbigny, 1840)
- Pseudocrioceras fasciculare* (d'Orbigny, 1840)
- Pseudocrioceras gogodanense* (Rouchadze, 1933)
- Pseudocrioceras kornebaense* Kakabaze, 1981
- Pseudocrioceras kutatysiense* (Rouchadze, 1933)
- Pseudocrioceras lobjanidzei* Kakabadze, 1981
- Pseudocrioceras orbignyianum* (Matheron, 1842)
- Pseudocrioceras phasiense* (Rouchadze, 1933)
- Pseudocrioceras provinciale* (Matheron, 1878)
- Pseudocrioceras sahariense* (Rouchadze, 1933)
- Pseudocrioceras simitiense* Kakabadze & Thieuloy, 1991
- Pseudocrioceras sparsicostatum* (Eristavi, 1955)
- Pseudocrioceras steinmanni* (Simonovich & Batsevich, 1873)
- Pseudocrioceras waageni* (Anthula, 1900)
- Pseudocrioceras waageni rouchadzei* Dimitrova, 1967
- Pseudocrioceras waageni* var. *sapitshkiensis* (Rouchadze, 1933)
- Pseudocrioceras waagenoides* (Rouchadze, 1938)

Pseudocrioceras fasciculare (d'Orbigny, 1840)

Pl. 1, figs. 1-2; Pl. 2, fig. 2.

1840 *Ammonites fascicularis* d'Orbigny — p. 117, pl. 29, fig. 1-2.

1910 *Ancyloceras fasciculare* (d'Orbigny) — Kilian, 1907-1913, p. 274, infrapaginal note.

? 1927 *Ancyloceras fasciculare* (d'Orbigny) — Roch, p. 29, pl. 5.

Holotype — Because of its measurements and ornament, specimen no. 5355 A2 in the d'Orbigny Coll. (MNHN, Paris), appears to be the original of d'Orbigny's (1840) figure. This is taken to be the holotype.

Locus typicus — La Bédoule; it was collected in the bluish limestones.

Material — Eight complete specimens: RG/1403, RG/1406, RG/1409, RG/1411, RG/1423, RG/1424, RG/1428 (Gonnet coll.); FG/200 (Gondran coll.).

Description — The holotype is a flat, badly-preserved shell (D = 122 mm, E = 24 mm H = 43 mm) without the shaft and the hook, which was considered by Kilian (1912) as the initial whorls of an '*Ancyloceras*'. Ornament consists of distant groups of three or four flexuous fasciculated ribs rising from round and strong umbilical tubercles. These ribs are always interrupted on the venter by a smooth siphonal band.

Almost all the *P. fasciculare* we have collected have the same sculpture on the spiral as the lectotype, with strong peri-umbilical tubercles from which a bundle of four or five sinuous ribs starts. The ribs do not continue on the venter: the siphonal area seems to be smooth. The section is subrectangular in the inner whorls, then becomes oval to subcircular.

The shaft can be more or less short, straight or slightly curved. On any major rib, a big, round or conical dorsal tubercle, a stronger lateral tubercle and an elongated claviform tubercle are often well-developed. On the hook, the tubercle strength varies from mere swellings to marked, sharp excrescences.

Discussion — From La Bédoule, Roch (1927) described and illustrated a big tripartite ammonite with shaft and hook, which he interpreted as d'Orbigny's species. The shaft is very short (100 mm) for a diameter of 200 mm (total height of the shell = 355 mm). There are, in fact, some ornamental differences with the type. Ribs are more numerous and thicker, tubercles are less prominent. The shaft shows the ornament characteristic of most *Pseudocrioceras* species, i.e major trituberculate ribs with two intermediate ribs. On the terminal part intermediate ribs disappear or are indistinct while ventral tuberculation becomes strong.

Measurements

	H	h3	h2	h1	Ds	U	Lc	Lp	I
RG/1403	278	67.2	67	3	182	77	280	450	53
RG/1406	284	71.2	59.3	5	185	78	308	457	70
RG/1409	305	91	76.2	4.5	212	82.1	327	415	89
RG/1411	302	76.1	75	4	208	87.2	292	445	74
RG/1423	293	72	66.2	4.2	156	68	296	452	93
RG/1424	245	68	65	3	125	42	256	350	50
RG/1428	330	85	75	3.5	170	75	370	501	85
FG/200	232	62	58	2.8	<125	45	291	—	75

Distribution — Uppermost Barremian; Les Caniers, beds 76-80; Les Camerlots, beds 73-80; Le Brigadan, beds 75-79.

Pseudocrioceras fasciculare (d'Orbigny, 1840) morphotype *bituberculatus* nov.
Pl. 4, figs. 1-2; Fig. 9.

Material — Eight specimens: RG/582, RG/1404, RG/1436-1438, RG/1440-1442 (Gonnet coll.).

Description — This new morphotype is very variable, but differs from the 'normally' ornamented form only by a bituberculate sculpture on the spire. At a variable whorl height (between 10 and 20 mm) a lateral tubercle is developed. Two or three radial ribs rise from this tubercle. In the lower part of the whorl, a slight swelling joins the two tubercles. One or two ribs may be inserted in the interval between umbilical tubercles. The whorl section is subrectangular to oval.

On the spire, ornament can consist of a pair of relatively strong and prominent tubercles giving rise to a group of two or three short ribs. One or two ribs are interca-

lated between the pairs of tubercles. Sometimes the lateral tubercle is absent at first but appears at a later growth stage. Ribs can be fine or thick, radial or slightly flexuous. On the shaft and on the hook, the sculpture is identical to *Pseudocrioceras fasciculare*.

Discussion — At first we considered this bituberculate form as a separate species. But the discovery of a specimen bearing on one side of the spire the typical fasciculated pattern of the species and on the other side a bituberculate pattern, allowed us to regard those ornamental differences as a polymorphic feature. We found this form principally in the uppermost part of the *Pseudocrioceras* interval.

Measurements

	H	h3	h2	h1	Ds	U	Lc	Lp	I
RG/582	332	65	61	4	115	77	280	450	50
RG/1404	255	64	53	5	125	78	308	457	63
RG/1436	305	91	76.2	4.5	212	82.1	327	415	89
RG/1437	318	82	74	4	168	58	335	495	75
RG/1438	296	70	68	4	150	68	290	450	83
RG/1440	242	68	66	3	165	55	237	242	52
RG/1441	332	88.7	76	3.5	200	87.5	400	504	81
RG/1442	235	64	60	2.8	132	48	283	416	80

Locus typicus — La Bédoule.

Distribution — Uppermost Barremian; Les Caniers, beds 76-77; Le Brigadan, beds 77-78.

Pseudocrioceras duvalianum (d'Orbigny, 1842)

Pl. 3, figs. 1-2; Pl. 12, fig. 2; Pl. 13, fig. 2.

1842 *Ancyloceras duvalianus* — d'Orbigny, pl. 124, figs. 1-4.

Holotype — Specimen MNHN 5415 in the d'Orbigny collection (MNHN, Paris), is taken to be the original of d'Orbigny's (1840, pl. 124, figs. 1-4) restored figure.

Locus typicus — La Bédoule.

Material — Nine specimens: RG/576, RG/577, RG/693, RG/1405, RG/1407, RG/1408, RG/1418, RG/1421, RG/1422 (Gonnet coll.).

Description — Tripartite ammonite with ancyloceratid coiling and closed spiral. Whorl section subrectangular. Sculpture on the spire consists at first of fine radial ribs with ventral tubercles (on certain specimens they can be slightly flexuous). Then groups of 2 or 3 ribs appear, starting from feeble umbilical bullae. On the base of the shaft ribs are radial and enlarged trituberculate costae appear at irregular intervals. On the shaft, 1 or 2 simple intermediaries without tubercles separate consecutive trituberculate costae. On the hook intermediaries disappear.

Discussion — In 1842, d'Orbigny described and illustrated (pl. 124, figs. 1-4) a tripartite shell with an incomplete spire, a curved shaft and a final hook, under the name *Ancyloceras duvalianus*. Ornament, on this visibly restored picture, consists of

periodic, heavy, trituberculate major ribs followed by two or three intermediaries between each pair. In d'Orbigny's collection, there is a very poorly preserved specimen (MNHN 5415) which bears the label '*Ancyloceras duvalianus* (d'Orb.) (= *Crioceras cruasense* Kilian)'. It is a curved shaft with an incomplete broken hook and a fragment of spire. Sculpture resembles that of d'Orbigny's illustration, and shows the typical ventral tuberculation: two rows of small, elongate claviform tubercles. Flanks are flat, the section is subrectangular. The spire bears fine straight or slightly flexuous ribs bundled in groups of two or three (never more), rising from a feeble bulla or a stretched tubercle in the umbilical area. This sculpture matches that of an incomplete spire in d'Orbigny's collection (MNHN 5355) that was classified first as *Ancyloceras fasciculare*, and then labelled by an anonymous hand as '*Pseudocrioceras cf. fascicularis*'. Judging by its preservation, this specimen was found probably in the Conte quarry, near the railway-station of Cassis. We relate this very characteristic piece of spire to numerous specimens of *P. duvalianum* that we collected in the La Bedoule area and which present the same ornamental differences with *Pseudocrioceras fasciculare* (d'Orbigny) sensu stricto.

Measurements

	H	h3	h2	h1	Ds	U	Lc	Lp	I
RG/576	215	58.5	55.9	2	139.7	48.3	230	295	47.3
RG/577	230	61	61	3	138	52.8	237	365	48.7
RG/693	240	62.1	66.7	3	150.9	47.3	340.4	259	54.7
RG/1405	272	72	66	3.5	165	61.9	292	362	57
RG/1407	172	47.2	47.2	2.8	115	51	180	243	45
RG/1408	176	48.2	46.2	4	108	42	200	227	37
RG/1418	232	59.9	59.1	3.2	157	53	242	263	58
RG/1421	237	64.5	64.5	4	168	61	248	320	51
RG/1422	173	50	48.5	3.5	123	44	186	214	32

Distribution — Uppermost Barremian; Les Caniers, beds 77-80; Le Brigadan, beds 70-78.

Pseudocrioceras orbignyianum (Matheron, 1842)

Pl. 5, figs. 1-2.

- 1842 *Ancyloceras d'orbignyianus* — Matheron, pp. 265-266, pl. 41, fig. 2.
 non 1889 *Ancyloceras orbigny* Matheron — Haug, pp. 215-216, pl. 11, fig. 5.
 non 1899 *Crioceras orbigny* (Matheron) — Anthula, p. 125, pl. 12, fig. 2a-c.
 non 1960 *Ancyloceras d'orbignyianus* Matheron — Druschits, p. 292, pl. 34, figs. 1a-b.
 non 1981 *Pseudocrioceras d'orbignyianum* (Matheron) — Kakabadze, pl. 4, fig. 2a-b, pl. 18, fig. 3a-b.
 1990 *Pseudocrioceras orbignyianum* (Matheron) — Delanoy & Bulot, p. 16, pl. 1, fig. 3.

Lectotype — Matheron collection, MHNH 1989-36; designated by Delanoy & Bulot (1990, p. 16).

Locus typicus — La Bédoule.

Material — One complete, well-preserved specimen: RG/155 (Gonnet coll.).

Description — Matheron's (1842) original, a fragment collected from the 'Neocomian' of la Bédoule, is a piece of spire/start of the shaft of a sizeable specimen (length = 200 mm, width = 75 mm, whorl height = 42 mm), with slightly compressed flanks bearing large trituberculate major ribs and two thin inserted ribs.

Our specimen is the first complete one to be described. The shell is tripartite, with ancyloceratid coiling. The ornament is similar to that of the lectotype. Two sorts of ribs can be observed: thick, tuberculate major ribs grouped in twos or threes; and simple, intercalated ribs (1 to 3 between the major ribs) starting from a slight bulge on the ventral margin. All the ribs are radial to feebly proverse.

Tubercles appear progressively. At the end of the spire only the inner and lateral tubercles are visible on the major ribs. At the base of the shaft a strong margino-ventral, claviform tubercle appears. All the tubercles grow in prominence as size increases and all the ribs cross over the flat ventral region. However, the ribs which bear a claviform tubercle have a sort of roll on the siphonal band.

At the end of the spire, intercalated ribs disappear. On the shaft and on the hook, only trituberculate major ribs remain, rising from the inner tubercle in the lower quarter of the whorl.

Discussion — In 1889, Haug (pl. XI, fig. 5) illustrated under the name of '*Ancyloceras orbigny*' an incomplete, badly preserved fragment of a tripartite ammonite consisting of a curved piece of a trituberculate spire followed by the start of a bituberculate shaft. All the ribs had the same thickness. This specimen bears only a slight resemblance to Matheron's type. The same is true for Anthula's (1899, = *P. anthulai*), Druschits's (1960) and Kakabadze's (1981) illustrations which seem to represent the form figured by Haug.

Measurements

	H	h3	h2	h1	Ds	U	Lc	Lp	S
RG/155	414	98	89	12	193	141.5	424.9	627.5	85 252

Distribution — Uppermost Barremian; Les Camerlots, bed 80.

Pseudocrioceras coquandi (Matheron, 1878)

Pl. 9, figs. 1-2; Pl. 10, figs. 1-2.

- 1878 *Scaphites coquandi* — Matheron, pl. D 24.
 non 1933 *Ancyloceras coquandi* (Matheron) var. *imerica* — Rouchadze p. 216, pl. 8, fig. 2.
 1961 *Epancyloceras* (?) *coquandi* (Matheron) — Casey, p. 67, text-fig. 24.
 1984 *Pseudocrioceras coquandi* (Matheron) — Busnardo, pp. 291-292.

Holotype — Matheron coll., MHNM 1989-46.

Locus typicus — La Bédoule.

Material — Five specimens: RG/1420, RG/1426 (Gonnet coll.); PR/510, PR/570, PR/572 (Ropolo coll.).

Description — As is the case among most of the *Pseudocrioceras* of this level, ornament on the lower part of the shaft consists of large, strong trituberculate major ribs with one

or two intermediary non tuberculate ribs. On the upper part of the shaft and on the hook, inserted ribs can disappear at maturity. The shaft can be straight or gently curved.

The holotype shows one well-preserved side while the other is partially corroded. It consists of a spire with contiguous and relatively convolute whorls and slightly arched sides, without either shaft or hook (in contrast to the author's picture). Diameter reaches c. 152 mm. The simple ribs, almost radial on the umbilical area, become finely trituberculated from a diameter of 85 mm. The lateral tubercle is situated near the ventral one, about 2/3 of the way over the flank. At the end of the first whorl, ventral bulges appear every two or three ribs, becoming progressively stronger and tending to form major ribs. At the base of the shaft, ribs are more marked, and external tubercles become prominent. On the slightly concave dorsum, ribbing persists in fine, flexuous forwardly convex ribs.

Discussion — The species '*Scaphites coquandi*', dedicated by Matheron to his friend Coquand (creator of the Barremian Stage), was figured for the first time in *Recherches Paléontologiques dans le Midi de la France*, a huge projected monograph which never came into being. Only some plates drawn and printed in his own flat by the Provençal author were published.

In 1933, Rouchadze described a new variety of *Ancyloceras coquandi*, var. *imerica*, which differs from the type by an '... early uncoiling of the whorls and by stronger and less frequent ribs in the juvenile stage ...'.

Casey (1961) refigured Matheron's type under Spath's (1930) former designation of '*Epancyloceras coquandi*'.

This important ammonite, which characterizes the *Pseudocrioceras coquandi* Zone of Busnardo (1984), has been collected from the bottom to the top of the *Pseudocrioceras* interval.

Measurements

	H	h3	h2	h1	Ds	U	Lc	Lp	I
RG/1420	211	51.5	51.5	4	125	65	281	192	52
RG/1426	326	82	78	12	154	60	470	298	75
PR/510	238	78	76	—	172	123	346	352	68
PR/570	208	54	44.8	10.8	122	82	294	217	48
PR/572	—	—	57	5	125	66	328	—	—

Distribution — Uppermost Barremian; Les Caniers, beds 77-80; Les Camerlots, beds 73-80; Le Brigadan, beds 73-80.

Pseudocrioceras provinciale (Matheron, 1878)

Pl. 6, figs. 1-2; Pl. 7, figs. 1-2; Pl. 8, fig. 1.

1878 *Scaphites provincialis* — Matheron, pl. D-25, fig. 1a-d.

Lectotype — Matheron (1878) figured (without a diagnosis), two specimens of '*Scaphites provincialis*'. The more important form (fig. 1a-d) from La Penne (Bouches du Rhone) is here designated lectotype.

Locus typicus — La Penne (Bouches du Rhone).

Material — Six specimens: RG/588, RG/589, RG/1420, RG/1432, RG/1435, RG/1448 (Gonnet coll.).

Description — The lectotype shows a large spire followed by a straight, incomplete shaft. The whorl section is subquadrate. Ornament consists of large sinuous ribs, often bifurcated on the umbilical part, rising from transversely elongated feeble bullae, which become strong and round tubercles at the end of the phragmocone. On the shaft, bifurcated ribs alternate with one, two or three single ribs of the same thickness. All the ribs are radial or feebly flexuous.

Discussion — All the studied specimens show the same subquadrate section and the same ornamental pattern. However, as is the case for the other species of *Pseudocrioceras*, some features vary. On the lectotype, for example, bifurcate or single ribs are distinguishable at the transition of the spiral part and along the shaft which is incomplete and broken for half the length. On certain specimens, trituberculate major ribs appear more precociously. As size increases, there is a tendency towards a pattern of a strongly tuberculate rib followed by two, then only one, inserted ribs. On the hook those single non tuberculate ribs disappear.

Major ribs bear, particularly on the shaft, faint conical umbilical tubercles, which decline on the hook, becoming radially elongated bullae or disappearing on the apertural part. Very strong, rounded lateral tubercles occur at or slightly below midflank. On the siphonal area, co-occur elongate bullae and conical or radially elongate tubercles.

Measurements

	H	h3	h2	h1	Ds	U	Lc	Lp	I
RG/588	254	65	64	5	112	52	342	240	59
RG/589	285	76	72	5	110	70	471	340.4	60
RG/1432	280	74	66	5	133	40	345	323	71
RG/1435	238	63	62	8	125	42	330	275	50
RG/1448	232	59.9	59.1	6	127	53	263	242	58

Distribution — Uppermost Barremian; Les Carniers, beds 79-80; Les Camerlots, beds 74, 75, 78.

Pseudocrioceras waageni (Anthula, 1899)

Pl. 12, fig. 1.

1899 *Crioceras waageni* — Anthula, p. 126, pl. 13, fig. 1.

1913 *Ancyloceras waageni* (Anthula) — Sinzow, p. 104, pl. 5.

? 1967 *Ancyloceras waageni waageni* (Anthula) — Dimitrova, p. 58, pl. 25, fig. 1.

1981 *Pseudocrioceras waageni* (Anthula) — Kakabadze, Pl. 16, fig. 1.

Holotype — The original of Anthula, pl. 13, fig. 1.

Material — Two specimens: RG/1417, RG/1439 (Gonnet coll.).

Description — We refer two badly preserved specimens, with incomplete spire, to

this species. Ornament of our material is similar to that of the type. It consists of thick, radial, trituberculate major ribs which alternate with one or two fine, non-tuberculate minor ribs. All the ribs bifurcate on the umbilical wall. At the end of the phragmone, on the shaft and on the hook, secondary ribs tend to disappear.

Very strong, rounded siphonal and ventro-lateral tubercles occur, the latter at or slightly above mid-flank. More discrete umbilical tubercles probably represent the bases of short, wedge-shaped spines; these occur principally at the start of the shaft.

The whorl section is subtrapezoidal on the spire and becomes subquadrate at the aperture.

Discussion — It is not always easy to differentiate a spire of *P. waageni* from the inner whorls of *P. waagenoides* or *P. steinmanni*, which bear some ornamental resemblances. *P. waageni* has a larger umbilicus. Almost all of the major ribs bifurcate at a variable diameter and they are quickly followed by non-tuberculate minor ribs. The ribs of *P. steinmanni* are simple, stronger and more flexuous while those of *P. waagenoides* are finer.

Measurements

	H	h3	h2	h1	Ds	U	Lc	Lp	I
RG/1417	273	77	68	14	181	78	287	388	—
RG/1439	230	65	63	12	150	65	342	375	59

Distribution — Uppermost Barremian; Les Caniers, beds 75-77; Le Brigadan, beds 71, 72, 77.

Pseudocrioceras aff. *waagenoides* (Rouchadze, 1938)

Pl. 11, fig. 1.

- aff. 1938 *Ancyloceras waagenoides* — Rouchadze, p. 181, pl. 5, fig. 2.
- aff. 1981 *Pseudocrioceras waagenoides* (Rouchadze) — Kakabadze, p. 105, pl. 22, fig. 2.
- aff. 1995 *Pseudocrioceras waagenoides* (Rouchadze) — Kakabadze & Kotetishvili, pp. 103-108.

Material — Two virtually complete specimens, PR/671, PR/672 (Ropolo coll.), plus 2 spires and 3 pieces of shaft (Ropolo coll.).

Discussion — Two badly preserved specimens with complete spire, shaft and hook, show the same basic pattern of ornament as the specimen illustrated by Kakabadze (1981, pl. 22, fig. 2). The ornament can be distinguished from that of *P. waageni* by the finer ribs and smaller tubercles. Each tuberculate major rib is followed by one to three radial inserted ribs.

The discovery of *P. aff. waagenoides* (index species in Georgia of the latest Barremian *waagenoides* horizon — Kakabadze & Kotetishvili, 1995) in the lower part of the *Pseudocrioceras* interval of La Bédoule seems very important. It allows a reasonable comparison of the La Bédoule sequence with the uppermost Barremian/lowermost Aptian horizons of Georgia and may permit, perhaps, a correlation of bed 76 of the La Bédoule sections with bed 10 of the Tvishi section (Kakabadze & Kotetishvili, 1995).

Distribution — Uppermost Barremian; Les Caniers, beds 75-77; Le Brigadan, bed 70.

Pseudocrioceras lobjanidzei Kakabadze, 1981

Pl. 11, fig. 2.

1981 *Pseudocrioceras lobjanidzei* — Kakabadze, p. 106, pl. 5, fig. 1.

Holotype — Kakabadze, pl. 5, fig. 1.

Material — Two specimens, PR/574, PR/674 (Ropolo coll.).

Description (of PR/674) — A large, trituberculate specimen with inner whorls of the spire masked by the preservation. A portion of the oral part, on the hook, is broken. Ornament consists, at first on the spire, of periodic, heavy, trituberculated major ribs which alternate with 1 to 5 radial, non-tuberculate intermediaries. Then the number of inserted ribs decreases from 3 to 5 on the middle of the spire to 3 to 1 on the shaft. Most ribs are single on the hook. Each major rib bears a strong ventral tubercle becoming claviform when adult, a prominent lateral tubercle and a rounded siphonal tubercle. On the dorsum, from one umbilical margin to the other, each rib (major or intermediary) bifurcates into two fine, delicate ribs bent forwards in a cupid's bow curve.

Discussion — In spite of some ornamental similarities, *P. lobjanidzei* differs from *P. waageni* by its whorl section, which is subquadrate on the juvenile part and subrectangular on the shaft. *P. waageni* is much more finely sculptured on the spire, with trituberculate major ribs followed by one or two intermediary ribs. *P. lobjanidzei* has thicker and more numerous intermediary ribs, and much earlier and stronger ventral and lateral tubercles forming regular rows.

Measurements

	H	h3	h2	h1	Ds	U	Lc	Lp	I
PR/674	262	76	72	—	155	75	262	256	68

Distribution — Uppermost Barremian; Les Caniers, bed 75; Le Brigadan, bed 77.

Family Deshayesitidae Stoyanov, 1949

Genus *Deshayesites* Kasansky, 1914

Type-species — *Ammonites deshayesi* Leymerie in d'Orbigny, 1842.

Discussion — Only the more important newly recorded species are described here; others are simply listed and illustrated.

Deshayesites oglanlensis Bogdanova, 1979

Pl. 17, figs. 1-2.

1979 *Deshayesites oglanlensis* — Bogdanova, pl. 2, fig. 5a-b.

1983 *Deshayesites oglanlensis* Bogdanova — Bogdanova, p. 136, text-fig. 5-6, pl. 1, figs. 1-9.

1995 *Deshayesites oglanlensis* Bogdanova — Delanoy, p. 74, pl. 2, fig. 1a-b.

1997 *Deshayesites oglanlensis* Bogdanova — Aguado et al., p. 317, fig. 7e.

Material — Ten complete specimens: PR-AB/270-278, AB/280 (Ropolo coll.).

Description — Of medium to large size (20-190 mm diameter). Whorls are rounded-subrectangular, with a relatively wide umbilicus, and flat or gently rounded flanks. All the specimens have the typical ornamentation of the species: thin, flexuous, fasciculate ribs on the initial and intermediate stage developed from peri-umbilical bullae. The ribs have essentially a sinusoidal form, inclined forward (proverse ribs) towards the aperture. They often bifurcate on the upper part of the flanks and form a sinus on the ventral part. On the adult stage they broaden out and become strong and radial.

Discussion — It is not always easy to identify *Deshayesites oglanlensis* with certainty. Most *Deshayesitidae* of the *tuarkyricus* Zone, except, perhaps, *D. antiquus*, are very densely ribbed, particularly on the phragmocone, and each rib presents a sigmoidal curve of varying flexuosity. But our examples are similar in form and in sculpture to the specimens illustrated by Bogdanova (1979, pl. 2, fig. 5; 1983, pl. 1, figs. 1-9).

Distribution — *tuarkyricus* Zone, lower Aptian; Les Caniers, beds 81-91; Les Camerlots, beds 85-87; Les Fourniers, bed 106.

Deshayesites antiquus Bogdanova, 1979

Pl. 16, figs. 1-3; Pl. 18, fig. 1.

1979 *Deshayesites antiquus* Bogdanova, pl. 1, fig. 4.

1983 *Deshayesites antiquus* Bogdanova, p. 139, text-fig. 7, pl. 2, figs. 5-6, pl. 3, fig. 8.

Material — Six specimens: PR-AB/279, AB/281-285 (Ropolo coll.).

Description — Bogdanova figured forms of medium size; we collected a specimen of 180 mm diameter, which seems to be the largest *D. antiquus* yet known. All our specimens have similar sculpture to Bogdanova's figured types: sigmoidal primaries and short, alternating secondaries on the flattened or slightly rounded flanks. Primaries generally bifurcate at mid flank, but some remain single. Near the aperture they are virtually straight; the forward arch of the ribs decreases during growth. Primaries are very strong on the lower part of the flanks, fade out on the umbilical wall but never disappear. The whorl section is oval to subrectangular.

Discussion — This form appears in the lowermost beds of the lower Aptian and extends up to the middle of the *tuarkyricus* Zone. It occurs in the Les Caniers section in about equal abundance with its contemporaries, *Deshayesites oglanlensis* and *Deshayesites luppovi*. It is less finely ribbed than the others species from this level.

Distribution — *tuarkyricus* Zone, lower Aptian; Les Caniers, beds 81-83; Le Brigadan, bed 87.

Deshayesites luppovi Bogdanova, 1979

Pl. 16, figs. 4-5.

1979 *Deshayesites luppovi* Bogdanova, pl. 1, figs. 5-6.

1983 *Deshayesites luppovi* Bogdanova — Bogdanova, p. 141, text-fig. 8, pl. 3, figs. 1-6.

Material — Seven specimens: PR-AB/286, AB/287, AB/290, AB/292-294, AB/ 297 (Ropolo coll.).

Description — The specimens are well preserved, small to medium sized, with subelliptical whorls, and gently convex flanks. Ribbing is very sinuous with sigmoidal primaries arched forward approximatively in the middle part of the flanks; one or two secondaries frequently bifurcate or trifurcate from primaries. Secondaries are variable in length; the point of union with primaries may be well above mid-flank (bifurcate ribs), or well below (trifurcate ribs). Sometimes, primaries form peri-umbilical bullae and they broaden out strongly before branching. The umbilicus is quite wide.

Discussion — The coiling of *D. luppovi* is slightly more evolute than that of *D. oglanlensis*; the ribs are stronger and more flexuous.

Distribution — *tuarkyricus* Zone, lower Aptian; Les Caniers, beds 84, 90; Les Camerlots, bed 84; Le Brigadan, Highway A52, bed 81; Les Fourniers, bed 102 (*D. aff. luppovi*).

Deshayesites weissiformis Bogdanova, 1983
Pl. 18, fig. 3.

1983 *Deshayesites weissiformis* — Bogdanova, p. 134, text-fig.4, p. 135, pl. 2, figs. 1-3; pl. 3, fig. 7.

Material — Three specimens, PR-AB/295, AB/297, AB/302 (Ropolo coll.).

Description — Evolute shell with a slightly rounded subrectangular section, thickest at lower third of flanks, and feebly convex venter. Ribbing dense and sinuous (c. 75 ribs on the last whorl), constituted of sigmoidal primaries starting from discrete peri-umbilical bullae and secondaries interposed between primary ribs, mostly singly or in pairs, sometimes in threes or fours. The point of origin of the secondaries, at first near the umbilical margin on the inner whorl, retreats up flank as growth proceeds and can move gradually to mid-flank at the end of the phragmocone.

Distribution — *tuarkyricus* Zone, lower Aptian; Les Caniers, beds 83, 85, 88.

The ammonite succession at La Bédoule

Because of the rarity and poor quality of the ammonite fauna, it is generally difficult to recognize a zonal scheme in the highest Barremian and lower Aptian of SE France. Typologic species are generally represented by poorly preserved or fragmentary small specimens. However, in the La Bédoule area, and particularly in the Les Caniers, Le Brigadan and Les Camerlots sections, the fauna is rich and specimens are generally well preserved. A synthesis of our investigations shows that three important ammonite families occur in succession, with only slight overlap: a lower level dominated by late Heteroceratidae; a *Pseudocrioceras* (Ancyloceratidae) level; and an upper level dominated by *Deshayesites*.

The lower level (beds 68-72) contains a *sarasini* Zone fauna, represented by *Colchidites* aff. *tsholashensis* (Pl. 3, fig. 3), *Martelites* sp., *Martelites* aff. *vulanensis* (Pl. 14, fig. 1; Pl. 15, figs. 1-2), *Simionescites* sp. and *Simionescites* aff. *simionescui* (Pl. 11, fig. 3; Pl. 13, fig. 3). This fauna overlaps in the top part with the first *Pseudocrioceras* (*P. aff. waagenoides*).

The *Pseudocrioceras* interval (beds 72-80) is equivalent to Busnardo's (1984)

'*coquandi* Zone'. Heteroceratidae disappear, giving way to Ancyloceratidae. The ammonite assemblage is represented by *Pseudocrioceras* aff. *waagenoides*, *P. waageni*, *P. coquandi*, *P. fasciculare*, *P. provincialis*, *P. duvalianum*, *P. lobjanidze*, *P. orbignyianum*, *Pseudohaploceras liptoviense*, *Pro-chelonicerus pachystephanum* (Pl. 7, fig. 3), *Barremites stretto-stoma* (Pl. 12, figs. 3-4), *Acrioceras* ex gr. *furcatum* (Pl. 1, fig. 3), *Acrioceras brevis* (Pl. 2, fig. 3), and *Ancyloceras* aff. *urbani* (Pl. 14, fig. 3); *Heminautilus sanctaerucis* also occurs.

Above bed 80 the genera *Pseudocrioceras* and *Barremites* disappear and never occur with Deshayesitidae, which first appear in bed 81. The first Deshayesitidae are characteristic of the *tuarkyricus* Zone of the lower Aptian in the Transcaucasian realm: *Deshayesites* aff. *tuarkyricus*, *D. oglanlensis*, *D. antiquus*, *D. lupповi*, and *D. weissiformis*, together with rare *Audouliceras* sp. and *Prochelonicerus* sp. So we consider the boundary between beds 80 and 81 to represent the Barremian/Aptian boundary at La Bédoule.

We have not found *Prodeshayesites* (which seems to be a typical Boreal genus) in the La Bédoule area. Confusion has arisen in the published literature since specimens attributed to the Deshayesitidae (under various names: *Parahoplites*, *Prodeshayesites*), often cited from SE France but never described or illustrated, come from levels below the *Pseudocrioceras* interval (as here defined). The discovery of *Martelites* aff. *vulcanensis* in bed 71 of the Camerlots section, and of *Martelites* ex gr. *marteli* Conte in bed 52 of the Comte quarry, that is to say at the base of the *coquandi* Zone of Busnardo (1984), could explain this confusion. According to previous papers, this last level should contain only Deshayesitidae, interpreted as *Parahoplites* by Roch (1927) and Fabre-Taxy et al. (1965), or as *Prodeshayesites* by Masse (1976) and Busnardo (1984). But there are many morphological convergences and ornamental similarities between a *Martelites* whose inner whorls are not preserved and a *Deshayesites* or *Prodeshayesites* (Delanoy et al., 1997). This is the case, for example, for *Prodeshayesites* cf. *bodei* from Saint-Pierre les Martigues (Masse & Thieuloy, 1975), or for Monier's (1986) *Prodeshayesites* sp. The first is probably a *Martelites* (Thieuloy, pers. comm., 1996), the second is conspecific with *M. martelli* Conte. Concerning '*Prodeshayesites* cf. *tenuicostatus*' (Delanoy, 1991, collected in bed 482 of the Angles section), Delanoy (1995, p. 73) himself recognises that this specimen is probably a *Deshayesites* sp.

Discussion

Recognition of these three successive faunas at La Bédoule facilitates a correlation with the uppermost Barremian/lowermost Aptian of the Trans-Caspian area, Georgia, the Northern Caucasus and Turkmenia (Fig. 8), and this casts light on the age of the French faunas. In particular, the exact age of the large heteromorph ammonites named 'large *Ancyloceras*' during the 19th century, and now assigned to *Pseudocrioceras*, has long remained imprecise. Many authors (Matheron, 1878; Anthula, 1899; Kilian, 1907-1913; Kilian & Reboul, 1915; Roch, 1927; Rouchadze, 1933, 1938; Eristavi, 1955; Casey, 1961; Dimitrova, 1967; Kakabadze, 1978), in many parts of the world, have assigned an Aptian age to species now placed in *Pseudocrioceras*. However, several others (Kakabadze, 1981 — southern ex-USSR; Kakabadze & Thieuloy, 1991 — Colombia; Kakabadze & Kotetischvili, 1995 — Georgia; Kakabadze & Hoedemaeker,

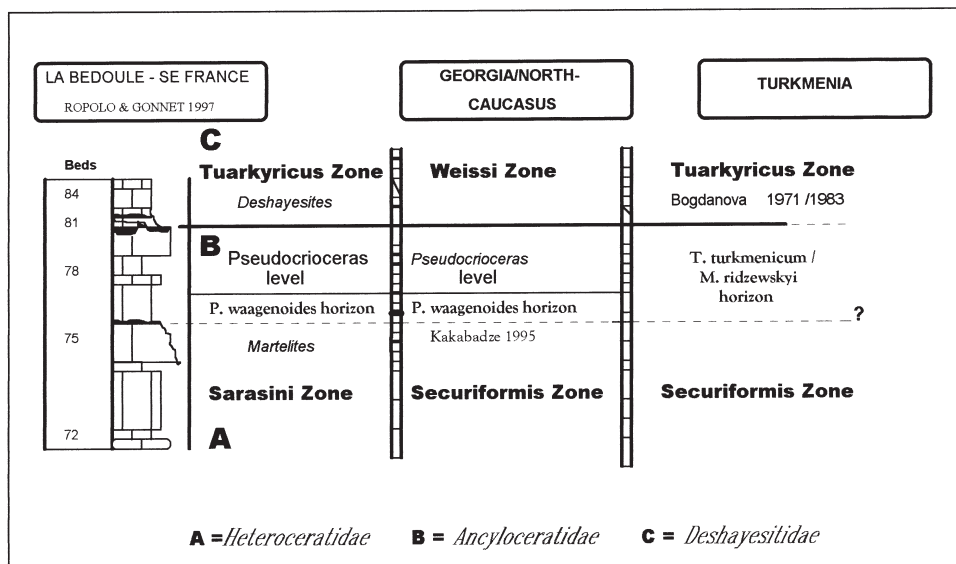


Fig. 8. Suggested biostratigraphical correlation of uppermost Barremian - lowermost Aptian of La Bedoule (SE France) and the Caucasian/Turkmenian regions.

1997 — Colombia) showed that various species of *Pseudocrioceras* first appear (and/or only occur) in latest Barremian beds.

Following Russian and Georgian work (e.g. Kakabadze, 1971; Kotetishvili, 1970) and French investigations (Conte 1989; Delanoy 1994, 1995; Delanoy et al., 1997), it is now recognised that the family Heteroceratidae evolved during the Late Barremian and did not extend into the Aptian. Hence in assessing the age of *Pseudocrioceras* it is important to note that:

(1) Specimens of the genera *Colchidites* and *Martelites* (probably = *Heteroceras bifurcatum* auct.) occur in the beds immediately underlying the *Pseudocrioceras* interval and in the lower part of the *Pseudocrioceras* interval itself in the Les Caniers and Le Brigadan sections.

(2) Specimens of *Martelites* ex gr. *marteli* Conte were found in bed 52 of the Comte quarry.

(3) *Pseudocrioceras* aff. *waagenoides* occurs in the lower part of the *Pseudocrioceras* level in the Les Caniers and Le Brigadan sections. According to Kakabadze & Kotetishvili (1995), *P. waagenoides* characterizes the highest Barremian horizon in Georgia, which is equivalent to the *Turkmeniceras turkmenicum* Zone of Turkmenistan (Central Asia). Also, in the Les Camerlots and Le Brigadan sections, *Simionescites* aff. *simionescui* occurs. This species is found below the first occurrence of *Deshayesites* in Bulgaria (Stoykova, 1992). The occurrence of the genus *Simionescites* (= *Kutatissites*) in the Upper Barremian of SE France is well documented (Thieuloy, 1976; Delanoy & Bulot, 1990; Delanoy, 1994, 1996).

(4) According to Drushchits (1963) no Deshayesitidae co-occur with *Acrioceras* ex gr. *furcatum* in the North Caucasus and Daghestan areas. Kotetishvili (pers. comm., 4th workshop, 1997) confirmed that in Georgia, no Deshayesitidae occur in the

Pseudocrioceras interval. Despite preceding assertions (Delanoy et al., 1997), recent investigations in the La Bédoule area confirm these observations. The *Deshayesites* fauna appears in bed 81 and never co-occurs with the heteromorphs. It includes: *Deshayesites* aff. *tuarkyricus*, *D. oglanlensis*, *D. antiquus*, *D. luppovi*, *D. weissiformis* and *D. primitivus*. All but the last species are characteristic of the lowest Aptian zone in Turkmenistan — the *tuarkyricus* Zone (Bogdanova, 1971, 1983). *D. antiquus* is considered by Bogdanova & Tovbina (1994) as one of the early representatives of the genus *Deshayesitidae*, and '.. the deposits where it occurs, as the oldest Aptian deposits ..'.

This is the first time that the *tuarkyricus* Zone has been clearly established in SE France. We have recognized the lower and upper limits of the zone in the Les Caniers and Les Fourniers sections respectively. According to Rawson (1983), the lower boundary of the *tuarkyricus* Zone and, therefore, the lower boundary of the Aptian Stage may be drawn on the basis of the FAD of these first *Deshayesitidae*.

We conclude that the genus *Pseudocrioceras* characterizes a constant level in the Tethyan Realm, of Barremian age. Its persistence over an extensive geographical territory (SE France, the Caucasus, Georgia, Bulgaria, Colombia, etc.) demonstrates that it could be used, alone or with associated ammonites, as a new marker to define the boundary interval. Hence future work should provide sufficient palaeontological and stratigraphical data to solve the Barremian/Aptian boundary problem.

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Plate 1

Figs. 1-2. *Pseudocrioceras fasciculare* (d'Orbigny, 1840)

1: Holotype, d'Orbigny coll. MNHN 5355 A2, Paris, labelled 'Bédoulian (lower Aptian), Cassis' (D, $\times 0.75$); 2: Gonnet coll. RG/1403, uppermost Barremian, Les Caniers section (bed 77), La Bédoule (G, $\times 0.45$).

Fig. 3. *Acrioceras* ex gr. *furcatum* (d'Orbigny, 1842); Saludes coll., uppermost Barremian, Le Brigadan section (bed 75), La Bédoule (R, $\times 0.75$).



Plate 2

Fig. 1. *Acrioceras* sp.; Saludes coll., uppermost Barremian, Le Brigadan section (bed 76), La Bédoule (R, $\times 0.75$).

Fig. 2. *Pseudocrioceras fasciculare* (d'Orbigny, 1840); Gonnet coll. RG/1498, uppermost Barremian, Les Caniers section (bed 80), La Bédoule (G, $\times 0.38$).

Fig. 3. *Acrioceras breve* (d'Orbigny, 1842); Saludes coll., uppermost Barremian, Le Brigadan section (bed 79), La Bédoule (R, $\times 0.75$).



Plate 3

Figs. 1-2. *Pseudocrioceras duvalianum* (d'Orbigny, 1840)

1: Piece of spire, d'Orbigny coll., MNHN 5395, Paris, labelled '*Pseudocrioceras* cf. *fascicularis* (d'Orbigny), Bédoulian (lower Aptian), Cassis' (D, $\times 0.75$); 2: Gonnet coll. RG/1421, uppermost Barremian, Les Caniers section (bed 78), La Bédoule (G, $\times 0.50$).

Fig. 3a-b. *Colchidites* aff. *tsholashensis* (Rouchadze, 1933), Saludes coll., Le Brigadan section (bed 68), La Bédoule (R, $\times 0.75$).

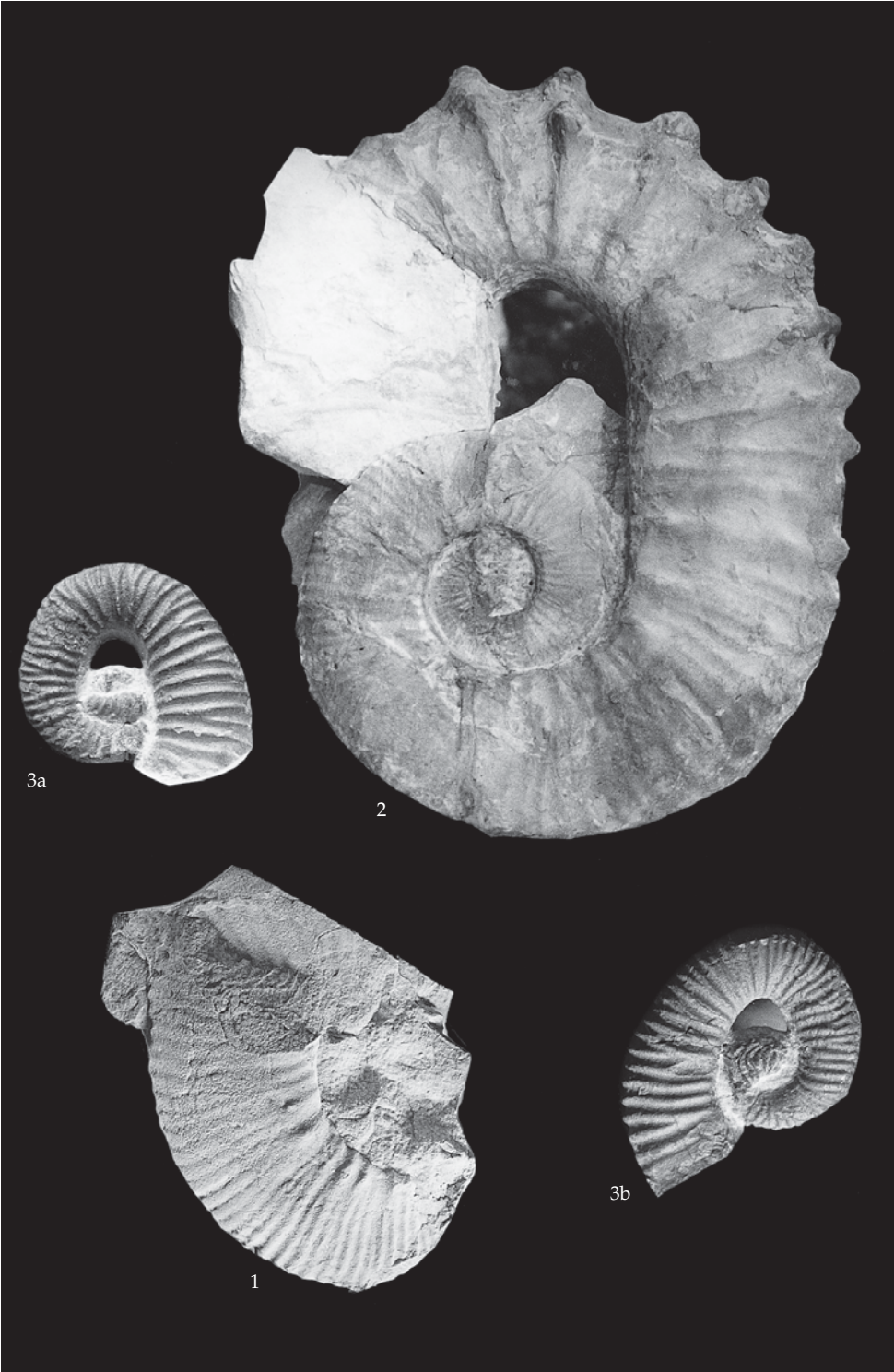


Plate 4

Figs. 1-2. *Pseudocrioceras fasciculare* (d'Orbigny, 1840) morph '*bituberculatus*' morph nov.

1: Gonnet coll. RG/582, uppermost Barremian, La Bédoule (G, × 0.50); 2: Gonnet coll. RG/1404, uppermost Barremian, Les Caniers section (bed 79), La Bédoule (G, × 0.50).

3. *Pseudocrioceras fasciculare* (d'Orbigny, 1840), Saludes coll., uppermost Barremian, Le Brigadan section (bed 75), La Bédoule (R, × 0.50).





Plate 5

Figs. 1-2. *Pseudocrioceras orbignyianum* (Matheron, 1842); Gonnet coll. RG/1251, uppermost Barremian, Les Camerlots section (bed 80), La Bédoule (G, $\times 0.56$); 1: right flank; 2: view of the ventral tuberculation on the lower part of the shaft.



Plate 6

Figs. 1-2. *Pseudocrioceras provinciale* (Matheron, 1878); cast of the holotype (right flank), MNHN, Paris, labelled 'lowermost Bedoulian of La Penne (Bouches du Rhône)' (D, $\times 0.75$); 2: dorsal view of the spire and ventral view of the shaft (D, $\times 0.75$).



Plate 7

Figs. 1-2. *Pseudocrioceras provinciale* (Matheron, 1878)

1: Tourment coll., uppermost Barremian, Les Camerlots section (bed 78), La Bédoule (R, $\times 0.38$); 2: Saludes coll., uppermost Barremian, Le Brigadan section (bed 79), La Bédoule (R, $\times 0.38$).

Fig. 3. *Procheloniceras pachystephanum* (Uhlig, 1883); Tourment coll., lowest Aptian, Les Camerlots section, La Bédoule (D, $\times 0.38$).



Plate 8

Fig. 1. *Pseudocrioceras provinciale* (Matheron, 1878); Gonnet coll. RG/588, uppermost Barremian, Les Caniers section (bed 79), La Bédoule (G, $\times 0.38$).



Plate 9

Figs. 1-2. *Pseudocrioceras coquandi* (Matheron, 1878)
1: Holotype, Matheron coll. no. 1889/46, MHN Marseilles, labelled 'Lower Aptian, Cassis' (R, $\times 0.38$);
2: Gonnet coll. RG/1411, uppermost Barremian, Les Caniers section (bed 79), La Bédoule (G, $\times 0.38$).



Plate 10

Figs. 1-2. *Pseudocrioceras coquandi* (Matheron, 1878)

1: Saludes coll., uppermost Barremian, Le Brigadan section (bed 79), La Bédoule, (R, $\times 0.38$); 2: Tourment coll., uppermost Barremian, Les Camerlots section (bed 75), La Bédoule (R, $\times 0.38$).

Plate 11

Fig. 1. *Pseudocrioceras* aff. *waagenoides* (Rouchadze, 1938); Ropolo coll. PR/573, uppermost Barremian, Le Brigadan section (bed 70), La Bédoule (R, $\times 0.38$).

Fig. 2. *Pseudocrioceras lobjanidzei* Kakabadze, 1981; Ropolo coll. PR/574, uppermost Barremian, Les Caniers section (bed 75), La Bédoule (R, $\times 0.38$).

Fig. 3. *Simionescites* aff. *simionescui* Avram, 1976; Tourment coll., uppermost Barremian, Les Caniers section, La Bédoule (D, $\times 0.56$).



Plate 12

Fig. 1. *Pseudocrioceras waageni* (Anthula, 1899); Gonnet coll. RG/1126, uppermost Barremian, Les Caniers section (bed 78), La Bédoule (G, $\times 0.38$).

Fig. 2. *Pseudocrioceras duvalianum* (d'Orbigny, 1840); Gonnet coll. RG/1460, uppermost Barremian, Les Caniers section (bed 79), La Bédoule (R, $\times 0.38$).

Figs. 3-4. *Barremites strettostoma* (Uhlig, 1883); Ropolo coll. PR/562, 563, uppermost Barremian, Les Caniers section (3, bed 76; 4, bed 79), La Bédoule (R, $\times 0.38$).



Plate 13

Fig. 1. *Pseudocrioceras* sp.; Tourment coll., lowest Aptian, Les Camerlots section, La Bédoule (R, $\times 0.38$).

Fig. 2. *Pseudocrioceras duvalianum* (d'Orbigny, 1840); Ropolo coll. PR/576, uppermost Barremian, Le Brigadan section (bed 77), La Bédoule (R, $\times 0.38$).

Fig. 3. *Simionescites* aff. *simionescui* (Avram, 1899); Saludes coll., uppermost Barremian, Le Brigadan section (bed 71), La Bédoule (R, $\times 0.38$).





Plate 14

Fig. 1. *Martelites* aff. *vulanensis* (Egojan, 1956); Tourment coll., uppermost Barremian, Les Camerlots section, La Bédoule (R, $\times 0.75$).



Plate 15

Figs. 1-2. *Martelites* aff. *vulanensis* (Egojan, 1956); Ropolo coll. PR/582, uppermost Barremian, Le Brigadan section (bed 72), La Bédoule (R, $\times 0.38$).

Fig. 3. *Ancyloceras urbani* (Neumayr & Uhlig, 1881); Ropolo coll. PR/584, uppermost Barremian, Les Caniers section, La Bédoule (R, $\times 0.38$).



Plate 16

Figs. 1-3. *Deshayesites antiquus* Bogdanova, 1979; Ropolo coll. AB/280, 281, 283, *tuarkyricus* Zone, lowest Aptian, Les Caniers section (beds 81, 83), La Bédoule (G, $\times 1.5$).

Figs. 4-5. *Deshayesites luppovi* Bogdanova, 1979; Ropolo coll. AB/292, 293, *tuarkyricus* Zone, lowest Aptian, Les Caniers section (bed 90), La Bédoule (G, $\times 1.5$).



Plate 17

Figs. 1-2. *Deshayesites oylanensis* Bogdanova, 1979; Ropolo coll. AB/270, 271, *tuarkyricus* Zone, lowest Aptian, Les Caniers section (beds 81, 84), La Bédoule (G, $\times 1.5$); possible dimorphism: 1: macroconch; 2: microconch.

Plate 18

Fig. 1. *Deshayesites antiquus* Bogdanova, 1979; Ropolo coll. AB/282, *tuarkyricus* Zone, lowest Aptian, Les Camerlots section, La Bédoule (R, $\times 0.38$); possible macroconch.

Fig. 2. *Deshayesites consobrinoides* (Sinzow, 1913); Saludes coll., *weissi* Zone, lower Aptian, Les Fourniers (R, $\times 0.75$).

Fig. 3. *Deshayesites weissiformis* Bogdanova, 1983; Ropolo coll. PR/302, *tuarkyricus* Zone, lowest Aptian, Les Caniers section (bed 88), La Bédoule (R, $\times 0.38$).

Fig. 4. *Deshayesites spathi* Casey, 1961; Tourment coll., *weissi* Zone, lower Aptian, Les Fourniers section, La Bédoule (R, $\times 0.38$).



Plate 19

Fig. 1. *Deshayesites consobrinus* (d'Orbigny, 1841); Ropolo coll. AB/351, *weissi* Zone, lower Aptian, Les Fourniers section (bed 116), La Bédoule (R, × 0.38).

Fig. 2. *Deshayesites callidiscus* Casey, 1961; Ropolo coll. AB/388, *weissi* Zone, lower Aptian, Les Fourniers section (bed 118), La Bédoule (R, × 0.38).

Fig. 3. *Deshayesites evolvens* Luppov; Ropolo coll. AB/362, *weissi* Zone, lower Aptian, Les Fourniers section (bed 116), La Bédoule (R, × 0.38).

Fig. 4. *Deshayesites consobrinoides* (Sinzow, 1913); Ropolo coll. AB/393, *weissi* Zone boundary, lower Aptian, Les Fourniers section (bed 123), La Bédoule (R, × 0.38).

