

AMMONITES FROM THE TYPE SANTONIAN AND ADJACENT PARTS OF NORTHERN AQUITAINE, WESTERN FRANCE

by W. J. KENNEDY

ABSTRACT. The ammonite fauna of the Santonian stage in its type area and adjacent parts of northern Aquitaine is revised, and five species recognized: *Placenticerus polyopsis* (Dujardin, 1837), *P. paraplanum* Wiedmann, 1978, *Texanites (Texanites) gallicus* Collignon, 1948, *Eulophoceras austriacum* (Summesberger, 1979) and *Boehmoceras loescheri* Riedel, 1931. The Santonian corresponds to the range zone of *P. polyopsis*, the *P. syrtale* of European authors, a view already expressed by A. de Grossouvre in 1901; no finer zonal division based on ammonites is recognizable.

THE Santonian is the middle division of the now redundant Senonian Stage. The latter term was introduced by Alcide d'Orbigny in 1843; the former by Henri Coquand in 1857. Saintes was mentioned by d'Orbigny as a typical area for the Senonian in the *Cours Elementaire* (1852, pp. 669–691); it and its environs—Saintoinge—give the Santonian its name. The original definition of the Santonian was as follows (Coquand 1857b, p. 749):

Deuxième étage.—Santonien.

Craie tendre avec silex (*Pleurotomaria santonesa*, d'Orb., *Rhynchonella vespertilio*, d'Orb., *R. intermedia*, Coquand, *Terebratulina Nanclasi*, Coq., *Micraster laxoporus*, d'Orb., *Hemiaster stella*, Desor, *Salenia geometrica*, Agass.).

The stratotypes of the Santonian are localities cited by Coquand in 1856 for his 'Troisième sous-étage' of the 'Première étage' (which he subsequently named Santonian). They are 'les bords de la Charente jusqu' aux côtes qui, à partir de Gimeux, Genté, Ségonzac, dessinent une bourrelet saillant parallèle aux dernières rides de la craie inférieure. Ce plain, qui prend le nom de *Petit-Champagne* . . . Une excellente étude de ce système peut se faire dans les environs du Château de Malberchie' (Coquand 1856, pp. 86–87). 'Road-side sections at Javrezac' are not the only locality mentioned specifically by Coquand, as van Hinte (1979) claims.

In 1859, Coquand listed the fauna of his Santonian, recording the following ammonites (p. 978), none of which has been traced: (1) *Ammonites Bourgeoisii* d'Orbigny, 1850; this is a Coniacian *Protexanites* (Kennedy 1984a p. 105, pl. 23, figs. 1–4, 7–9; pl. 24, figs. 1–8; pl. 26, figs. 4 and 5; text-figs. 32, 33, 34, 35A–E, 36B, C, E, F). (2) *A. Orbignyi* d'Archiac, 1843; this is unrecognizable. (3) *A. polyopsis* Dujardin, 1837; this is an exclusively Santonian *Placenticerus* (Kennedy and Wright 1983 p. 856, pls. 86–88; text-figs. 1–4; see below). (4) *A. santonensis* D'Orbigny, 1850; this is a *Neoptychites cephalotus* (Courty, 1860) of the Turonian (Kennedy and Wright 1979 p. 676, pl. 86, figs. 4 and 5). (5) *A. coniacensis* Coquand, 1859; this was described as follows:

'Hauteur, 65 millim.; diamètre transversal, 55 millim. Coquille comprimée, assez largement ombiliquée, spire formée de tours convexes, ornée de côtes alternativement simples et bifides, chaque tour possède cinq rangées de tubercules; la première disposée autour de l'ombilic, deux médianes et deux près du pourtour externe; celle qui est la plus rapprochée du dos et qui termine les côtes est saillante. Dos caréné, carène tranchante logée entre deux sillons.

Cette espèce a été toujours confondue avec l' *A. varians*.—Cognac, Malberchie, Épagnac.'

COQUAND 1856 "1 ^{re} nomenclature"	COQUAND 1857, 1858 "2 ^e nomenclature"	COQUAND 1857 "3 ^e nomenclature"	ARNAUD 1877
1 ^{er} ETAGE 5e horizon de Rudistes 3 ^e sous-étage Craie tendre, à silex	2 ^e ETAGE: SANTONIEN Craie tendre avec silex <u>Pleurotomaria Santonesa</u> , <u>Janira Truellei</u> , <u>Spondylus</u> <u>hippuritorum</u> , <u>Rhynchonella</u> <u>vespertilio</u> , <u>Rhynchonella</u> <u>intermedia</u> , <u>Terebratula</u> <u>Nanciast</u> , <u>Micraster</u> <u>laxoporus</u> , <u>Hemiaster stella</u> , <u>Salenia geometrica</u>	2 ^e ETAGE: SANTONIEN 7e horizon de Rudistes <u>Micraster brevis</u> , <u>Spondylus</u> <u>truncatus</u> , <u>Rhynchonella</u> <u>vespertilio</u> , <u>Radiolites</u> Arnaudi	Calcaire noduleux, glaucconieux <u>Conoclypeus ovum</u> Marnes et grès supérieurs <u>Ostrea acutirostris</u> , <u>Sphaerulites Hoeninghausi</u> Marnes à <u>Ostrea</u> <u>vesicularis</u> et <u>Ostrea</u> <u>proboscidea</u> Marnes et grès inférieurs <u>Rhynchonella deformis</u> , <u>Botriopygus</u>

TABLE 1. Correlation of previous subdivisions of the Santonian in northern Aquitaine.

This is a very clear description of a *Texanites* (*Texanites*) but is insufficiently detailed to determine which species is described. In the absence of type specimens I regard it as a *nomen dubium*. (6) *Baculites incurvatus* Dujardin, 1837; this is a Coniacian-Santonian species (Kennedy 1984a p. 143, pl. 32, figs. 12, 15-19; pl. 33, figs. 1-22; text-figs. 41 and 42F-M). (7) *Scaphites constrictus* d'Orbigny, 1842; the correct author is J. Sowerby, 1817; the species is a Maastrichtian *Hoploscaphites* (Kennedy 1986a p. 64, pl. 13, figs. 1-13, 16-24; pl. 14, figs. 1-38; pl. 15; text-figs. 9 and 11A-H).

Arnaud (1862-1897) refined the stratigraphy of the Cretaceous of the Aquitaine Basin, and his vast collections form the basis of the present study.

His initial division of the stage (1877b, p. 3) was:

2^e série: *Santonien*

18. Marnes et grès inférieurs: *Rhynchonella deformis*; *Botriopygus*
19. Marnes à *Ostrea vesicularis* et *O. proboscidea*
20. Marnes et grès supérieurs: *Sphaerulites Hoeninghausi*, *Ostrea acutirostris*;
21. Calcaire noduleux glauconieux; *Conoclypeus ovum*.

A letter system replaced this in the summary diagram at the end of this work, and was the basis of all later modifications, summarized in Table 1 herein.

De Grossouvre (1894) used Arnaud's Collections for his revision of the ammonites of the 'Craie Supérieur', referring specimens to the Arnaud letter divisions and recognizing a Santonien Inférieur and Supérieur in his tabulation of ranges. In 1901 de Grossouvre repeated Arnaud's letter system in his account of the 'Craie de l'Aquitaine' (pp. 351 et seq.). He records *Mortoniceras serratomarginatum* Redtenbacher, *M. texanum* Roemer, *Placenticeras syrtale*, and *Baculites incurvatus* from M¹, *M. texanum* and *P. syrtale* from M², the latter extending to N². In his summary chapter 22 (Classification des couches supracrétacées, p. 751 et seq.), the Santonian is defined as follows (p. 795): 'Le Santonien comprend les couches situées au-dessus du Coniacien et inférieurs à la zone à *Placenticeras bidorsatum*, par laquelle débute le Campanien; *Pl. syrtale* existe sur toute la hauteur de cet étage, on pourrait encore le définir comme constituant l'assise du *Pl. syrtale*.' From his work in the Corbières, de Grossouvre recognised what would now be called

ARNAUD 1877	ARNAUD 1883	DE GROSSOUVRE 1901							
		ZONES	AQUITAINE						
Marnes et grès santonien supérieurs <table style="display: inline-table; vertical-align: middle; margin-left: 10px;"> <tr> <td style="font-size: 2em; vertical-align: middle;">}</td> <td style="vertical-align: middle;">N^c Calcaire glauconieux à <u>Conoclypeus ovum</u></td> </tr> <tr> <td style="font-size: 2em; vertical-align: middle;">}</td> <td style="vertical-align: middle;">N^b Banc à <u>Ostrea acutirostris</u></td> </tr> <tr> <td style="font-size: 2em; vertical-align: middle;">}</td> <td style="vertical-align: middle;">N^a Grès à <u>Sphaerulites Hoeninghausi</u></td> </tr> </table>	}	N ^c Calcaire glauconieux à <u>Conoclypeus ovum</u>	}	N ^b Banc à <u>Ostrea acutirostris</u>	}	N ^a Grès à <u>Sphaerulites Hoeninghausi</u>	N ² Grès ou calcaire marneux, avec ou sans silex, et géodes de quartz <u>Ammonites polyopsis, etc.</u> N ¹ Calcaire marneux avec silex, passant à des marnes grises ou verdâtres, pétries d'Ostracées <u>O.vesicularis, etc.</u> M ² Calcaire marneux ou noduleux grès calcaire <u>Ammonites polyopsis, etc.</u> M ¹ Calcaire marneux arénacé <u>Ammonites coniacensis, etc.</u>	Placenticerasesyrtale	Calcaire sableux à Rudistes Marnes à Ostracées
}	N ^c Calcaire glauconieux à <u>Conoclypeus ovum</u>								
}	N ^b Banc à <u>Ostrea acutirostris</u>								
}	N ^a Grès à <u>Sphaerulites Hoeninghausi</u>								
Marnes à <u>Ostrea vesicularis</u> et <u>Ostrea proboscidea</u>		Mortonicerasesyrtale	Banc à Botriopygus Couches à <u>Ammonites texanum</u>						
Marnes et grès santonien inférieurs <u>Botriopygus Toucasanus</u>									

assemblage zones within the Santonian, a lower one characterized by the occurrence of *Mortoniceras texanum*, and an upper one with *P. syrtale* and *Pachydiscus isculensis* as indices (table 35, following p. 830) or with *Placenticerasesyrtale* alone as index (tables 36-39, following p. 830). A *texanum* + *syrtale* Zone were recognized by Haug (1911), while the Colloque sur le Crétacé Supérieur held in 1959 (Dalbiez 1960) recognized a *texanus* Zone below and a *syrtale-isculensis* Zone above.

As I have noted elsewhere (Kennedy 1984b, 1985) neither *P. syrtale* nor *M. texanum* occur in France, while in Aquitaine it is only possible to define the Santonian in ammonite terms by the appearance of *Texanites* (*Texanites*) and as the range zone of *P. polyopsis* Dujardin, 1837 (= *syrtale* of European authors); I have traced only five surviving texanitids from the Santonian in Aquitaine: they are recorded from M¹, M², and N². I have seen no specimens referable to *Paratexanites serratomarginatus* (Redtenbacher, 1873), recorded by de Grossouvre and by Gillard (1944) from M¹; elsewhere I have suggested it to be exclusively Upper Coniacian in France (Kennedy 1984a, p. 117, pl. 23, figs. 5 and 6; pl. 26, figs. 1-3; pl. 27, figs. 1-7; text-fig. 35F, G), and de Grossouvre (1901) ultimately concluded that Santonian *P. serratomarginatus* were actually *P. emscheris* (Schlüter, 1876), I have equally seen none of these from Aquitaine, nor of the Coniacian *Protexanites bourgeoisii* (d'Orbigny, 1850) noted from the Lower Santonian by de Grossouvre in 1894 (table, p. 86).

The ammonite distributions from the present work can be summarized as follows:

<i>Placenticerasesyrtale</i> (Dujardin, 1837)	M ¹	M ²	N ¹	N ²
<i>P. paraplanum</i> Wiedmann, 1978	—	—	—	N ²
<i>T. (Texanites) gallicus</i> Collignon, 1948	M ¹	M ²	—	—
<i>Eulophoceras austriacum</i> (Summesberger, 1979)	—	—	—	N ²
<i>Boehmoceras loescheri</i> Riedel, 1931	—	M ²	N ¹	—

I see no possibility of subdividing the Santonian in ammonite terms in Aquitaine, a disappointing result when compared with the results from my revision of the Coniacian Kennedy (1984a) and Campanian of the region (Kennedy 1986b).

Low diversity and small numbers of individuals are an obvious explanation for this. There are striking differences in stratigraphic ranges of taxa common to Aquitaine and the richly ammoniferous sequences of the Corbières (Aude), as noted by de Grossouvre (1901) and Bilotte and Collignon (1983), so that some environmental limitation on ammonite occurrence might be involved. To this must be added the marked coarsening in resolution of ammonite zones in successive stages of the Upper Cretaceous. Taking the time scales of Odin (1985) and Snelling (1985) and the standard zonations for the Upper Cretaceous stages in north-west Europe proposed by Kennedy (1984*b*), average zonal durations are as follows: Cenomanian (4 Ma) 0.57 Ma; Turonian (4 Ma) 0.75 Ma; Coniacian (2 Ma) 0.5 Ma; Santonian (3 Ma) 3 Ma; Campanian (11 Ma) 2.7 Ma. No zonal division based on ammonites can be recognized in the Maastrichtian (7 Ma) of north-west Europe at this time. A 3 Ma *polyopsis* Zone for all of the Santonian is thus of the same order of duration as the succeeding Campanian zones recognized in Aquitaine.

Location of specimens. The following abbreviations are used to indicate the location of specimens mentioned in the text:

EMP: École des Mines, Collections, now at the Université Claud Bernard, Lyon.

FSL: Université Claude Bernard, Lyon.

GPIB: Geological and Palaeontological Institute, Bonn.

SP: Collections of the Sorbonne, now housed in the Université Pierre et Marie Curie, Paris.

Suture terminology. The system of Wedekind (1916) as revised by Kullmann and Wiedmann (1970) is used here. E = external lobe, L = lateral lobe, U = umbilical lobe, I = internal lobe.

Dimensions. All dimensions are given in millimetres; D = diameter, Wb = whorl breadth, Wh = whorl height, and U = umbilicus; c = costal and ic = intercostal. Figures in parentheses refer to dimensions as a percentage of diameter. The term *rib index* as applied to heteromorphs is the number of ribs in a distance equal to the whorl height at the mid point of the interval counted.

Synonymies. Only citations which include illustrations of material or important systematic, stratigraphic, or geographic information are included.

SYSTEMATIC PALAEOLOGY

Order AMMONOIDEA Zittel, 1884, pp. 355, 392

Suborder AMMONITINA Hyatt, 1889, p. 7

Superfamily HOPLITACEAE H. Douvillé, 1890, p. 290

[*Nom. correct.* Wright and Wright, 1951, p. 21 (*pro* Hoplitida Spath, 1922a, p. 95, *nom. transl. ex* Hoplitidae Douvillé, 1890, p. 290)]

Family PLACENTICERATIDAE Hyatt, 1900, p. 585

[= Hypengonoceratinae Chiplonkar and Ghare, 1976, p. 2; Baghiceratinae Chiplonkar and Ghare, 1976, p. 3]

Genus PLACENTICERAS Meek, 1876, p. 462

[see Kennedy and Wright 1983, p. 869 for synonymy]

Type species. *Ammonites placenta* DeKay, 1828, p. 278, by original designation by Meek, 1876, p. 462.

Placenticerias polyopsis (Dujardin, 1837)

1837 *Ammonites polyopsis* Dujardin, p. 232, pl. 17, fig. 12.

1983 *Placenticerias polyopsis* (Dujardin, 1837); Kennedy and Wright, p. 856, pls. 86-88; text-figs. 1-4 (with full synonymy).

1983 *Placenticerias syrtale* (Morton); Collignon, p. 200, pl. 6, fig. 1.

- 1983 *Stantonoceras guadaloupe* (Roemer); Collignon, p. 201, pl. 6, fig. 3.
 1983 *Stantonoceras guadaloupe* (Roemer) var. *quadrata* de Grossouvre; Collignon, p. 201, pl. 6, fig. 2.
 1983 *Stantonoceras depressum* (Hyatt); Collignon, pl. 202, pl. 7, fig. 2.
 1985 *Placenticeras polyopsis* Dujardin; Kennedy, pl. 2, figs. 7-10.

Lectotype. The original of Dujardin 1837, pl. 17, fig. 12a, a juvenile macroconch from the 'Craie Tufau' of Touraine, France; designated by Kennedy and Wright 1983, p. 856; present whereabouts unknown.

Material. Numerous specimens. SP unregistered *ex* Arnaud Collection, from Assise M¹, Larat; M², L'Ombre, Miremont, Colombier du Miremont, Ribérac, Périgueux, route d'Agonac (Périgueux), Beaulieu (Siolac, Souterrain de Beaulieu), St Léon-sur-Vezère, Champagnac-de-Belair, Versannes, Épagnac, Puygaty, Rognac; M¹⁻² at Angoumac, Cognac; N¹⁻², St Caprais, N² at Arcivaux, Saintes, Foquebrune, and Sarlat, route d'Eyzies. EMP *ex* Boucheron Collection, from La Valette. M. Séronie-Vivien Collection: SX62, from Mater (= *Stantonoceras guadaloupe* in Séronie-Vivien 1972, text-fig. 26); 5579e, 80e, Castelfadézé (= *S. guadaloupe* in Séronie-Vivien 1972, p. 88); SU2B, 2c, from l'Amblardie (= *S. guadaloupe* in Séronie-Vivien 1972, p. 78); J. P. Platel Collection: three specimens from Agonac.

Discussion. The Aquitaine material noted above adds nothing to the detailed description of the species given by Wright and Kennedy (1983).

Occurrence. Widespread in Aquitaine, ranging from low in M¹ to N². Also known from Touraine, Corbières, the Beausset Basin (Var) in France, Austria, the Germanies, and the Tombigbee Sand Member of the Eutaw Formation in Alabama. See detailed discussion by Wright and Kennedy (1983).

Placenticeras paraplanum Wiedmann, 1978

Plate 80, figs. 1-3, 8-10

- 1978 *Placenticeras paraplanum* Wiedmann, p. 666, pl. 1, figs. 3 and 4; text-fig. 2a.
 1979 *Placenticeras paraplanum* Wiedmann; Summesberger, p. 152, pl. 13, figs. 53-57; text-figs. 38 and 39.
 1985 *Placenticeras* aff: *paraplanum* Wiedmann; Amédro and Hancock, p. 24 *et seq.*, text-fig. 11a-c, f, g.

Holotype. By original designation, the original of Wiedmann 1978 pl. 1, figs. 3 and 4; text-fig. 2A, from the Upper Santonian Gosau Beds of the Gosau Basin, Austria.

Material. SP unregistered *ex* Arnaud Collection, from Assise N², Arcivaux, Saintes (Charente-Maritime); from Assise N², Beillant (Charente-Maritime); FSL, six specimens from the autoroute sections west of Saintes (details in Amédro and Hancock 1985).

Dimensions.

	<i>D</i>	<i>Wb</i>	<i>Wh</i>	<i>Wb : Wh</i>	<i>U</i>
SP, Arcivaux	84.2 (100)	25.5 (30.3)	39.7 (47.1)	0.64	17.0 (20.2)

Description. All specimens are ill-preserved composite moulds. Coiling moderately evolute, with 55 % of previous whorl covered. Whorl section compressed (*Wb* : *Wh* ratio 0.64), with greatest breadth at umbilical shoulder. Umbilicus small (20 % of diameter), shallow, conical, with flat, outwards-inclined wall. Umbilical shoulder narrowly rounded; inner flanks broadly rounded, outer flanks flattened, convergent. Venter narrow, concave with sharp shoulders at smallest diameter visible, broad, with shoulders blunter and broadly arched venter on outermost phragmocone whorl. Flank ornament distinctive, with markedly convex distant very broad ribs with steep apical face but apertural face that merges imperceptibly with flank; a strong furrow precedes each rib, and may develop into a marked constriction (Pl. 80, fig. 2), so that the shell surface has the step-like topography of a tiled roof. Flank ornament strengthens progressively through ontogeny, and, on the outer phragmocone whorl, is accompanied by blunt outer ventrolateral clavi, 9-10 per half whorl.

Sutures ill-exposed, typical for genus.

Discussion. The striking convex course of the flank ornament, furrows/constrictions plus late appearance of clavi separate this species from all other European forms referred to the genus. The

early whorls show a striking resemblance to those of the much larger species *P. bidorsatum* (Roemer, 1841) (see revision in Kennedy 1986b). Indeed, Amédro and Hancock (1985) regarded some of the present specimens as transitional to *P. canaliculatum* (Hyatt, 1903), a synonym of *P. bidorsatum*. The adult ornament of the two is highly distinctive, but the similarity of early growth stages suggests that *bidorsatum* is a hypermorphic giant derivative of *paraplanum*.

Occurrence. Assise N² in Aquitaine; high Santonian of the Corbières (Aude); Upper Santonian of the Gosau Basin, Austria.

Superfamily ACANTHOCERATACEAE de Grossouvre, 1894, p. 22

[*nom. correct.* Wright and Wright 1951, p. 24 (*pro* Acanthoceratida Hyatt 1900, p. 585, *nom. transl. ex* Acanthoceratidae Hyatt 1900, p. 585, *nom. correct. ex* Acanthoceratidés de Grossouvre, 1894)]

Family COLLIGNONICERATIDAE Wright and Wright, 1951, p. 30

[*nom. subst. pro* Prionotropidae Zittel, 1895, p. 530; *Prionotropis* Meek, 1876, p. 453, *non* Fieber, 1853, p. 127; = *Collignoniceras* Breistroffer, 1947; = Prionocyclidae Breistroffer, 1947, *ex* *Prionocyclus* Meek, 1876, p. 298, ineligible as family type]

Subfamily TEXANITINAE Collignon, 1948, p. 54 (9)

[*nom. transl.* Wright 1957, p. L429 *ex* Texanitinae Collignon, 1948, p. 54(9)]

Genus TEXANITES Spath, 1932, p. 379

Type species. *Ammonites texanus* Roemer, 1852, p. 31, pl. 3, fig. 1, by original designation.

Subgenus TEXANITES (TEXANITES) Spath, 1932, p. 379

Texanites (Texanites) gallicus Collignon, 1948

Plate 80, figs. 4-7; Plate 81, figs. 1-6

- 1894 *Mortonicerias texanum* F. Römer sp.; de Grossouvre, p. 80, pl. 16, figs. 2 and 4; pl. 17, fig. 1.
 1948 *Texanites texanus* Roemer var. *gallica* Collignon, p. 75 (30), pl. 8 (2), fig. 1.
 1963 *Texanites texanus gallica* Collignon, 1948; Young, p. 81, pl. 38, figs. 3 and 4.
 1966 *Texanites gallicus* Collignon; Collignon, p. 78, pl. 487, fig. 1964; pl. 508, fig. 2020; pl. 509, fig. 2020.
 1970 *Texanites gallicus* (Collignon); Matsumoto, pp. 267, 270, 272.
 1980 *Texanites texanus* s. l. (Roemer, 1852); Klinger and Kennedy, p. 162 (*pars*), text-figs. 124 and 125.
 1982 *Texanites gallicus* Collignon; Martinez, p. 121, pl. 20, figs. 1 and 2.
 1983 *Texanites gallicus* Collignon, 1948; Collignon, p. 203.
 1985 *Texanites (Texanites) gallicus* Collignon, 1948; Kennedy, pl. 2, figs. 3-6.

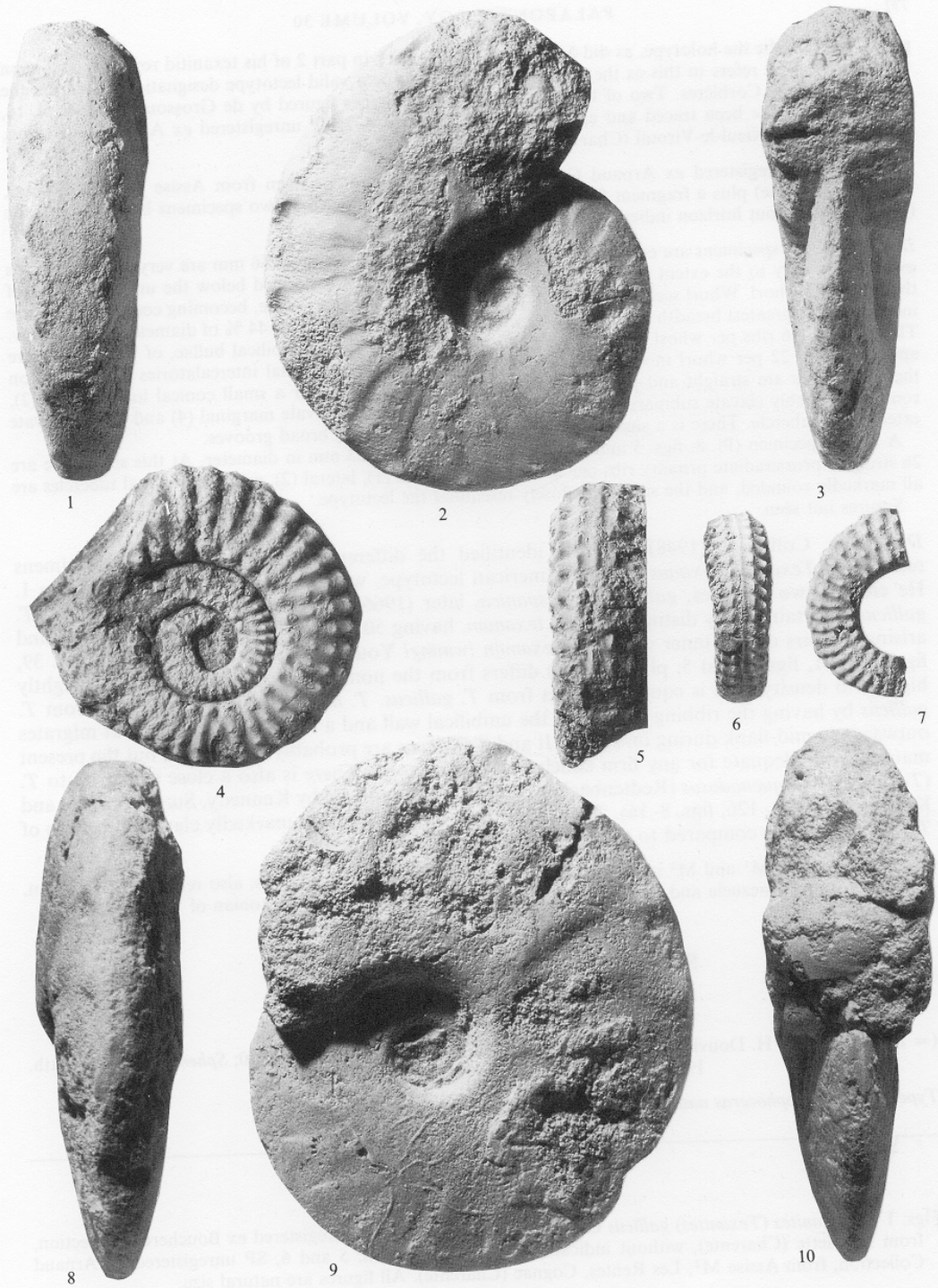
Types. Collignon cites French, Venezuelan, Italian, Bulgarian, and Madagascan specimens in his text and synonymy, but failed to select a holotype. Young (1963, p. 81) presumed the original of de Grossouvre (1894,

EXPLANATION OF PLATE 80

Figs. 1-3, 8-10. *Placenticerias paraplanum* Wiedmann, 1978. 1-3, FSL A362, from the Upper Santonian of Autoroute Cutting S2, west of Saintes (Charente-Maritime). 8-10, SP unregistered *ex* Arnaud Collection, from Assise N², Arcivaux, Saintes (Charente-Maritime).

Figs. 4-7. *Texanites (Texanites) gallicus* Collignon, 1948. SP unregistered *ex* Arnaud Collection, two paralectotypes, figured by de Grossouvre 1894, pl. 16, figs. 2 and 4, from Assise M², Nieul-le-Virouil (Charente-Maritime).

All figures are natural size.



KENNEDY, *Placenticerias*, *Texanites* (*Texanites*)

pl. 17, fig. 1) to be the holotype, as did Martinez (1982, p. 121); in part 2 of his texanid revision, Collignon (1948, p. 42 (99)) refers to this as the 'type', which I take to be a valid lectotype designation; it is from the Santonian of the Corbières. Two of the three small paralectotypes figured by de Grossouvre (1894, pl. 16, figs. 2 and 4) have been traced and are shown in Pl. 80, figs. 4-7; SP unregistered *ex* Arnaud Collection, from Assise M², Nieul-le-Virouil (Charente-Maritime).

Material. SP unregistered *ex* Arnaud Collection, an unregistered specimen from Assise M¹, Les Rentes, Cognac (Charente) plus a fragment from M¹, Sergéac. EMP unregistered: two specimens labelled Lavalette (Charente), without horizon indicated, *ex* Boucheron Collection.

Description. All specimens are composite moulds. Juveniles to a diameter of 66 mm are very evolute, whorls overlapping only to the extent that the marginal tubercle (4) is just concealed below the umbilical seam of the preceding whorl. Whorl section as wide as high at smallest diameter visible, becoming compressed as size increases, with greatest breadth at lateral (2) tubercle. Umbilicus broad (up to 44 % of diameter) and shallow. There are 32-36 ribs per whorl. They arise, singly or in pairs, at sharp umbilical bullae, of which there are approximately 22 per whorl in the best-preserved specimen, with occasional intercalatories arising low on the flank. Ribs are straight and prorsiradiate across the flanks, and bear a small conical inner lateral (2), rounded to feebly clavate submarginal (3), larger, rounded to feebly clavate marginal (4) and strong clavate external (5) tubercle. There is a sharp siphonal keel, flanked by deep, broad grooves.

A larger specimen (Pl. 8, figs. 5 and 6) is badly crushed, and 123 mm in diameter. At this size, there are 26 straight, prorsiradiate primary ribs per whorl; the umbilical (1), lateral (2), and submarginal tubercles are all markedly rounded, and the specimen closely resembles the lectotype.

Sutures not seen.

Discussion. Collignon (1948) correctly identified the differences between European specimens referred to *Texanites texanus* and the American lectotype, which is shown here in Text-figure 1. He erected two varieties, *gallica* and *hispanica*, later (1966) elevating them to specific rank. *T. gallicus* is certainly very distinct from *T. texanum*, having 50 % more ribs, markedly crowded and arising in pairs on the inner whorl. *T. texanum twiningi* Young, 1963 (p. 82, pl. 38, fig. 5; pl. 39, fig. 1; pl. 41, figs. 2 and 5; pl. 48, fig. 4) differs from the nominate subspecies only in its slightly higher rib density, and is equally distinct from *T. gallicus*. *T. hispanicus* is held to differ from *T. gallicus* by having the ribbing arising on the umbilical wall and a lateral (2) tubercle that migrates outwards to mid-flank during ontogeny. It and *T. gallicus* are probably conspecific, but the present material is inadequate for any firm conclusion on the point. There is also a close similarity to *T. (Texanites) quinquenodosus* (Redtenbacher, 1873), recently revised by Kennedy, Summesberger and Klinger (1981) (p. 126, figs. 8-16). They differ most obviously in the markedly clavate tubercles of *T. quinquenodosus* compared to the rounded tubercles in *T. gallicus*.

Occurrence. Assise M¹ and M² in Aquitaine, Lower Santonian of the Corbières; also recorded from Spain, Bulgaria, ?Italy, Venezuela and Zululand and from the Lower and Middle Santonian of Madagascar.

Family SPHENODISCIDAE Hyatt, 1900, p. 585
 Subfamily SPHENODISCINAE Hyatt, 1900, p. 585
 (= Libycoceratinae Zaborski, 1982, p. 306)
 Genus *Eulophoceras* Hyatt, 1903, p. 85

(= *Praelibycoceras* H. Douvillé, 1912, p. 315; *Pelecodyscus* Van Hoepen, 1921, p. 30; *Sphenodiscoceras* Spath, 1921, p. 242; *Skoumalia* Summesberger 1979, p. 141)

Type species. *Eulophoceras natalense* Hyatt, 1903, p. 86, pl. 11, figs. 2-6.

EXPLANATION OF PLATE 81

Figs. 1-6. *Texanites (Texanites) gallicus* Collignon, 1948. 1-4, EMP unregistered *ex* Boucheron Collection, from Lavalette (Charente), without indication of precise horizon; 5 and 6, SP unregistered *ex* Arnaud Collection, from Assise M², Les Rentes, Cognac (Charente). All figures are natural size.



KENNEDY, *Texanites* (*Texanites*)



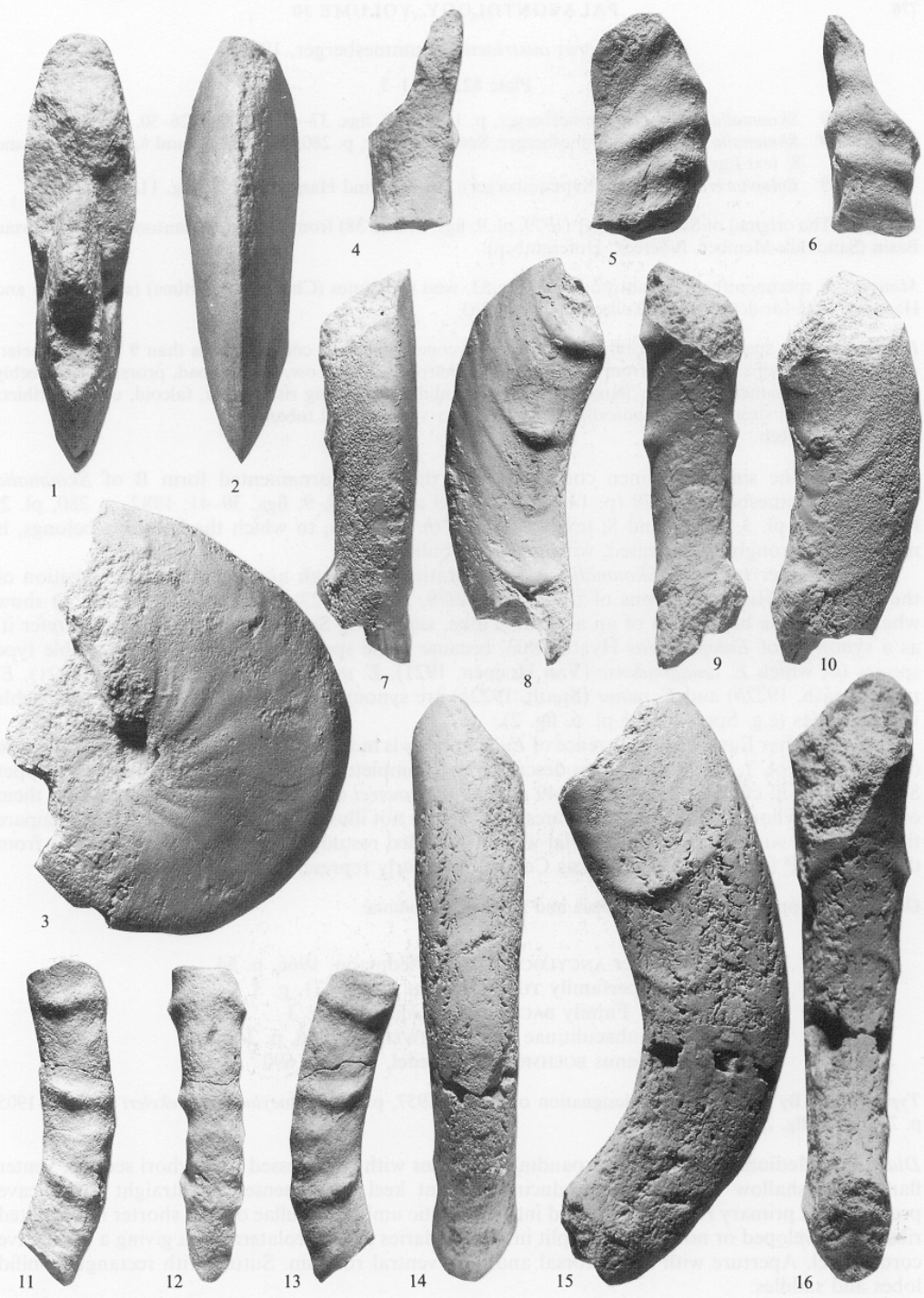
TEXT-FIG. 1. *Texanites (Texanites) texanus* (Roemer, 1851). The lectotype, GPIB 45a, the original of Roemer's pl. 3, fig. 1, from Austin, Texas. The original is 144 mm in diameter.

EXPLANATION OF PLATE 82

Figs. 1–3. *Eulophoceras austriacum* (Summesberger, 1979). FSL A363, from the Upper Santonian of Autoroute Cutting S2, west of Saintes (Charente-Maritime).

Figs. 4–16. *Boehmoceras loescheri* Riedel, 1931. All SP unregistered, ex Arnaud Collection; 4–6, 11–13, from Assise N¹, Charmant (Charente); 7–10, 14–16, from M², Nieul-le-Virouil (Charente-Maritime).

All figures are natural size.



KENNEDY, *Eulophoceras*, *Boehmoceras*

Eulophoceras austriacum (Summesberger, 1979)

Plate 82, figs. 1-3

- 1979 *Skoumalia austriaca* Summesberger, p. 141, pl. 9, figs. 37-41; text-figs. 26-30.
 1980 *Skoumalia austriaca* Summesberger; Summesberger, p. 280, pl. 2, figs. 5 and 6; pl. 3, figs. 7 and 8; text-figs. 5 and 6.
 1985 *Eulophoceras austriaca* (Summesberger); Amédéo and Hancock, p. 23, fig. 11*d, e*.

Holotype. The original of Summesberger (1979, pl. 9, figs. 37 and 38) from the Upper Santonian of the Gosau Basin (Sandkalk Member, Bibereck, Hofergraben).

Material. A specimen from the autoroute cutting S2, west of Saintes (Charente-Maritime) (see Amédéo and Hancock 1985 for details); FSL collections, no. A363.

Description. The specimen is a composite mould. Oxycone. Umbilicus comprises less than 9 % of diameter. A marked facet separates flank from a more obtuse, sharper venter. Low, faint, broad, prorsiradiate, feebly concave ribs ornament the inner flank but decline by mid-flank, giving rise to low, falcoid, concave riblets and striae which strengthen periodically into small inner ventrolateral tubercles.

Sutures not seen.

Discussion. The single specimen corresponds to the feebly ornamented form B of *Skoumalia austriaca* Summesberger, 1979 (p. 141, text-figs. 29 and 30; pl. 9, figs. 39-41; 1982, p. 280, pl. 2, figs. 5 and 6; pl. 3, figs. 7 and 8; text-figs. 5 and 6). Form A, to which the holotype belongs, is much more strongly ornamented, with umbilical bullae.

Summesberger regarded *Skoumalia* as Diaziceratinae although uncertain as to the position of the subfamily. His illustrations of the suture (1979, text-figs. 27, 28, 30; 1982, text-fig. 6) show what may be the beginnings of an adventive lobe, suggesting Sphenodiscinae, to which I refer it, as a synonym of *Eulophoceras* Hyatt, 1903, because some specimens of the highly variable type species (of which *E. amapondense* (Van Hoepen, 1921), *E. umzambiense* (Van Hoepen, 1921), *E. tenue* (Spath, 1922*b*) and *E. minor* (Spath, 1922*b*) are synonyms) have umbilical bullae and feeble ventral nodes (e.g. Spath 1922*b* pl. 6, fig. 2).

The only other European occurrence of *Eulophoceras* is in the Corbières (Aude), where Collignon (1983, p. 205, pl. 7, figs. 4 and 5) has described two completely smooth specimens from the Upper Santonian as *E. cf. miloni* Hourcq, 1949 and *E. grossouvrei* Collignon, 1983, differentiating them on details of whorl section and the sutures, which were not illustrated. It is not possible to compare them usefully with the present material without detailed restudy, although larger specimens from the region (SP unregistered *ex* Toucas Collection) clearly represent a different species.

Occurrence. Upper Santonian of Austria and northern Aquitaine.

Suborder ANCYLOCERATINA Wiedmann, 1966, p. 54

Superfamily TURRILITACEAE Gill, 1871, p. 3

Family BACULITIDAE Gill, 1871, p. 3

[= Eubaculitinae BRUNNSCHWEILER, 1966, p. 24]

Genus BOEHMOCERAS Riedel, 1931, p. 690

Type species. By the subsequent designation of Wright 1957, p. L220: *Ancyloceras krekeleri* Wegner, 1905 p. 210, pl. 8, fig. 2.

Diagnosis. Medium-sized rapidly expanding criocones with compressed oval whorl section, venter flanked by shallow depressions, producing a blunt keel. Ornamented by straight to concave prorsiradiate primary ribs, strengthened into crescentic umbilical bullae or not, shorter intercalated ribs well-developed or not; ribs may split into secondaries on ventrolateral area giving a distinctive corded keel. Aperture with short dorsal and long ventral rostrum. Suture with rectangular bifid lobes and saddles.

Discussion. Recent authors place *Boehmoceras* in the Family Phlycticrioceratidae Spath, 1926 (e.g. Wright 1957, p. L220; Summesberger 1979, p. 117). It appears, rather, to be a recoiled baculitid, as briefly noted elsewhere (Kennedy and Wright 1985, p. 142). The ornament of crescentic ribs, strengthened into dorsolateral bullae in *Boehmoceras loescheri* Riedel, 1931, is a typical *Baculites* feature, as is the rostrate aperture and suture with rectangular bifid elements. Specimens illustrated here (Pl. 82, figs. 7-10, 14-16) show remarkable resemblance to the Coniacian *B. incurvatus* Dujardin, 1837 (p. 232, pl. 17, fig. 13; see Kennedy 1984a, p. 143, pl. 32, figs. 12, 15-19; pl. 33, figs. 1-22; text-figs. 41 and 42f-m); some body chambers of this species are markedly curved (e.g. Kennedy 1984a, pl. 33, figs. 4 and 7) and the genus *Boehmoceras* is yet another example (albeit short-lived) of recoiling in heteromorphs. Resemblance to *Phlycticrioceras* Spath, 1926 is superficial only. That genus has clearly differentiated ventrolateral and siphonal tubercles and a far more intricately subdivided suture (De Grossouvre 1894, text-fig. 88; Kennedy 1984a, text-fig. 42e). Two species are currently referred to *Boehmoceras*, *B. krekeleri* (Wegner, 1905) known from the Upper Santonian of the Münster Basin, North Germany and the Gosau Basin, Austria, and *B. loescheri* Riedel, 1931 which has the same geographic distribution plus the present records from Arnaud's Assizes M² and N¹ at Nieuil-le-Virouil (Charente-Maritime) and Charmant (Charente) respectively. Previous illustrations and the material before me provide too small a sample to determine whether these species actually merit separation.

Occurrence. Mid-Upper Santonian. North Germany, Austria, and northern Aquitaine, France. Santonian of Alabama and Texas in the USA (W. A. Cobban, pers. comm.).

Boehmoceras loescheri Riedel, 1931

Plate 82, figs. 4-16; text-fig. 2

1931 *Boehmoceras löscheri* Riedel, p. 692, pl. 78, figs. 3-6.

1979 *Boehmoceras loescheri* Riedel; Summesberger, p. 119, pl. 2, figs. 15, 16, 18; text-figs. 9-12.

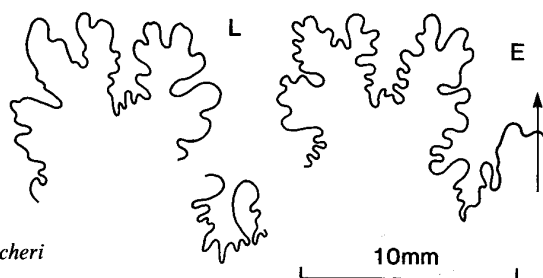
1983 *Boehmoceras* Kennedy and Wright, p. 866.

1985 *Boehmoceras* sp. Kennedy, pl. 2, fig. 1.

Types. Riedel's syntypes, if they survive, are in the collections of the Zentrales Geologisches Institut, Berlin. They are from the Upper Santonian of the Münster Basin, German Federal Republic.

Material. Five unregistered specimens in the SP Collections, ex Arnaud Collection. Two (Pl. 82, figs. 7-10, 14-16) are from Nieuil-le-Virouil (Charente-Maritime), one labelled M², the other M ?; three specimens (Pl. 82, figs. 4-6, 11-13 plus an unfigured fragment) are from Charmant (Charente), labelled N¹.

Description. The smallest specimen available is from Charmant, and has a maximum preserved whorl height of 12 mm. It is highly distorted and the original whorl section is compressed at the apical end but depressed at the apertural. Coarse primary ribs are separated by interspaces approximately equivalent to the whorl height. They are feeble and convex across the dorsum, strengthening into coarse concave crescentic dorsolateral bullae that give rise to strong primary ribs that sweep across the flank before declining somewhat over the venter.



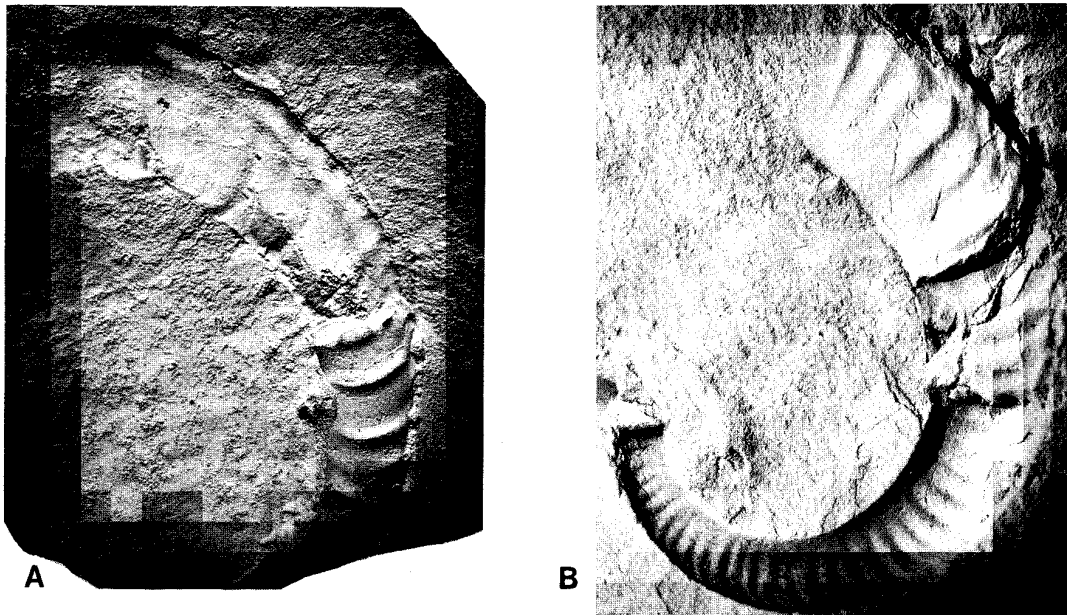
TEXT-FIG. 2. External suture of *Boehmoceras loescheri* Riedel, 1931.

One or two coarse, distant secondary ribs arise around mid-flank and cross the venter, without attaining the strength of the primaries. The unfigured fragment from Charmant is crushed but shows the same style of ribbing but with much weaker secondary ribs. The third fragment appears to be from close to the adult aperture and shows ribs that coarsen markedly over ventrolateral shoulders and venter (Pl. 82, figs. 4-6). The specimens from Nieul-le-Virouil are much better preserved undeformed internal moulds, one wholly the other part body chamber. The whorl section is compressed, with an intercostal whorl breadth to height ratio of 0.67-0.72, the dorsum broadly, the venter more narrowly rounded.

The primaries are very distant, feeble, and convex on the dorsum, sweeping back over the dorsolateral region and strengthening into crescentic dorsolateral bullae. These decline into concave ribs that project strongly forwards and decline over the venter.

Between are much finer secondaries, mere striae on the inner flank but strengthening over the venter. They appear distinctly scale-like in the body chamber fragment.

Suture line (text-fig. 2) with rectangular bifid lobes and saddles; moderately incised.



TEXT-FIG. 3A, B, *Boehmoceras krekeleri* (Wegner) Riedel, 1931, $\times 1$. Specimens are from the Santonian of the Münster Basin, German Federal Republic, and in the Probenarchiv, Bernau (photographs courtesy of Zentrales Geologisches Institut, per H. Summesberger). B is the original of Riedel 1931, pl. 77, fig. 4.

Discussion. Marked differentiation of ribbing in the Aquitaine material indicates it should be referred to *B. loescheri*. The only other species, *B. krekeleri* (Wegner, 1905) (p. 210, pl. 8, fig. 2; Riedel 1931, p. 691, pl. 77, figs. 3-5; pl. 78, figs. 1 and 2; Summesberger 1979, p. 118, pl. 2, fig. 14; text-figs. 7 and 8) presents certain problems of interpretation, as noted by Summesberger (1979), for the type appears to be lost. Specimens subsequently referred to *B. krekeleri* by Riedel (see text-fig. 3) show uniform, rather closely spaced ribs, without the same degree of differentiation into primaries and secondaries. As noted above these differences may be within the limits of intraspecific variation. Without more material, it is impossible to say.

Occurrence. Upper Santonian of the Münster Basin (Recklinghäuser Sandmergel), Gosau Basin, Austria (Sandkalk Member, Bibereck, Hofergraben 1); Assise M² and N¹ in northern Aquitaine.

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W. J. KENNEDY
Geological Collections
University Museum
Parks Road, Oxford OX1 3PW