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NEW EARLY BATHONIAN BIGOTITINAE AND ZIGZAGICERATINAE (AMMONOIDEA, MIDDLE JURASSIC)

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Abstract. Several tens of Lower Bathonian *Bigotites* from Digne-Castellane region (SE France) and Cabo Mondego area (Portugal) have been reviewed. Three species have been distinguished in the lowermost subzone of the Zigzag Zone (Parvum Subzone) just above the boundary Bajocian to Bathonian: *B. diniensis* Sturani [M+m], *B. sturanii* sp. nov. [M+m] and *B. mondegoensis* sp. nov. [M+m]. In the Bas Auran area, a chronocline from evolute, strongly ribbed and constricted forms (including *B. sturanii* and *B. diniensis)* to involute forms with blunt, moderately prominent ribbing and weak constrictions (including *B. mondegoensis)* can be recognized. The shared taxa *B. mondegoensis* sp. nov. and possibly *B. diniensis* Sturani permit detailed subdivision and correlation to be established between ammonite fossil assemblages of Parvum Subzone in the Lusitanian and Alpine basins. A separate genus of Zigzagiceratinae, *Protozigzagiceras* g. nov., is proposed to encompass *P. torrensi* (Sturani) as type species. These new palaeontological data about the youngest members of Bigotitinae and the oldest members of Zigzagiceratinae are of biochronostratigraphic importance for the subdivision and correlation of the basal Bathonian Zigzag Zone. Three successive biohorizons can be identified at the Parvum Subzone in Bas Auran (French Alpine Basin) and Cabo Mondego (Lusitanian Basin): Diniensis, Mondegoensis and Protozigzagiceras biohorizons.

Riassunto. Vengono revisionate diverse decine di esemplari di ammoniti appartenenti ad ammoniti del genere *Bigotites* del Batoniano inferiore della regione di Digne-Castellane (Francia SE) e dell'area di Cabo Mondego (Portogallo). Tre specie sono distinte nella Sottozona a Parvum, alla base della Zona a Zigzag, al di sopra del limite Baiociano-Batoniano: *B. diniensis* Sturani [M+m], *B. sturanii* sp. nov. [M+m] and *B. mondegoensis* sp. nov. [M+m]. Nell'area del Bas Auran viene riconosciuto un cronoclino con transizione da forme evolute, fortemente costate e dotate di costrizioni *(B. sturanii* e *B. diniensis)* verso forme involute con coste tozze e moderatamente prominenti *(B. mondegoensis).* I taxa comuni alle due aree *B. mondegoensis* sp. nov. e possibilmente *B. diniensis* Sturani permettono dettagliate suddivisioni e correlazioni tra le associazioni fossili ad ammoniti della Sottozona a Parvum nei bacini alpino e lusitanico. Viene istituito un nuovo genere di Zigzagiceratinae, *Protozigzagiceras* g. nov., che ha *P. torrensi* (Sturani) come specie tipo e comprende esemplari dotati di ombelico aperto e stadio zigzagiceratino precoce e presenti nella parte sommatale della Sottozona a Parvum: per questi viene formulata una proposta filogenetica innovativa di derivazione degli Zigzagiceratinae dai Leptosphinctinae di inizio Batoniano. Questi nuovi dati riguardanti i rappresentanti piu recenti di Bigotitinae e quelli piu antichi di Zigzagiceratinae presentano grande importanza per la suddivisione biostratigrafica e la correlazione cronostratigrafica della Zona a Zigzag alla base del Batoniano, anche ai fini della proposta di selezione del G.S.S.P, del Piano Batoniano nell'ambito delle iniziative della International Subcommission on the Jurassic Stratigraphy dell'I.U.G.S. Tre successivi bio-orizzonti sono stati individuati nella Sottozona a Parvum delle sezioni del Bas Auran (Bacino Subalpino Francese) e di Cabo Mondego (Bacino Lusitanico): bio-orizzonti a Diniensis, Mondegoensis and Protozigzagiceras.

Introduction

Lower Bathonian ammonite fossil assemblages from Europe include scarce specimens of *Bigotites,* restricted to the basal Bathonian Zigzag Zone. However, they are relatively common (less than 5.0%) in several outcrops of Alpine and Lusitanian basins. More than ninety specimens coming from SE France and Portugal

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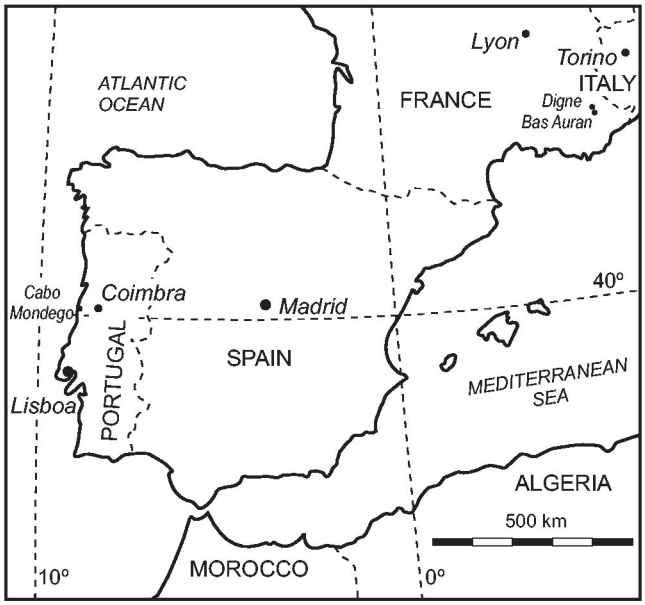


Fig. 1 - Geographical location of the study areas in SE France and Portugal.

have been studied (Figs. 1, 2, 3). The main purpose of the present paper is to provide a systematic distinction of three species of Bathonian *Bigotites* recorded in the Western Tethys. The widespread distributed species *B. mondegoensis* sp. nov. and possibly *B. diniensis* Sturani, as well as the first representatives of a new genus of Zigzagiceratinae, support the subdivision and correlation of Parvum Subzone in Lusitanian and Alpine basins.

Systematic palaeontology

The subfamily Bigotitinae, formerly including *Bigotites, Bigotella, Vermisphinctes, Prorsisphinctes, Spathia* (?) and *Stomphosphinctes* (?), was established by Westermann (1956) as belonging to the family Parkinsoniidae (Buckman, 1920 in 1909-30) and superfamily Perisphinctaceae (Steinman, 1890). However, Arkell (1957, 1958 in 1951-59) did not accept the subfamily Bigotitinae and attributed *Bigotites* (including *Bigotella, Pseudobigotella, Haselburgites* and *Bajocisphinctes)* to the subfamily Leptosphinctinae (Arkell 1950) within the family Perisphinctidae (Steinmann, 1890; cf. Arkell 1957; Pavia 1973; Galacz 1980; Besnosov & Mikhaylova 1981; Callomon in Donovan et al. 1981; Besnosov 1982; Besnosov & Kutuzova 1982; Sandoval 1983; Besnosov

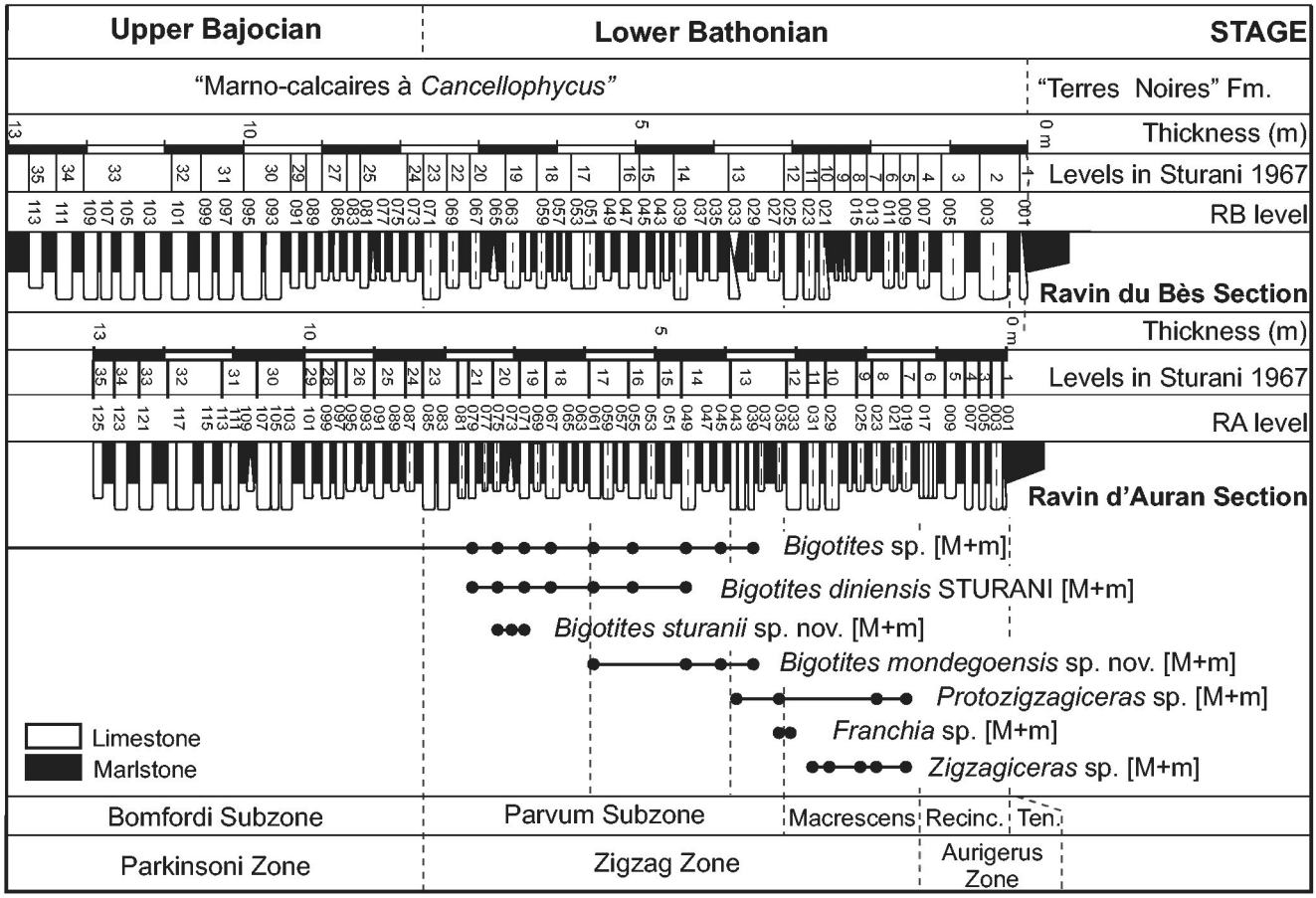


Fig. 2 - Stratigraphical distribution of *Bigotites, Protozigzagiceras* g. nov., *Franchia* and *Zigzagiceras* in Ravin d'Auran and Ravin du Bès sections (France). The range line of *Bigotites* sp. displays the occurrence of fragmentary specimens of undeterminable species and the stratigraphic constancy of this genus through the section. Biostratigraphic logs from Fernández-López 2007.

& Mitta 1995,1998,2000). *Bigotites, Bajocisphinctes* and *Microbajocisphinctes* show relatively simple sutures and may be actually considered as representatives of the subfamily Bigotitinae and family Perisphinctidae, a group of West Tethyan Perisphinctidae branched off by proterogenesis from *Leptosphinctes* [M] - *Cleistosphinctes* [m] of complex sutures, which occur in the Bajocian Garantiana and Parkinsoni zones (Fernández-López 1985, 1987). The youngest Bathonian records of *Bigotites* [M+m] appear to be from Portugal and Spain, at the lower part of the Macrescens Subzone (Elmi et al. 1971; Fernández-López 1988; Mangold 1990; O'Dogherty et al. 2006; Fernández-López et al. 2006a; level 90FD31 in Fig. 3).

The material studied in the present work is stored in two collections:

- Coll. SRFL&MHH: Fernández-López & Henriques Collection in "Departamento de Ciências da Terra e Centro de Geociencias" at the Coimbra University (Portugal). The inventory number of specimens quotes the section, the locality and the bed of the succession: e.g. 02CM172 refers to a fossil sampled in Section 02 of Cabo Mondego from bed 142.

- Coll. PU: palaeontological collections of the "Museo di Geologia e Paleontologia" of the Torino University (Italy) currently stored at the Dipartimento di Scienze della Terra. Specimens are marked with the acronym PU and a progressive registration number. Source of sampling is indicated with bed number within sections reported by initials: BA, sections of the Bas Auran area (lithostratigraphical column of Sturani 1967); RB, Ravin du Bès section; RA, Ravin d'Auran section; RR, Ravin des Robines.

Genus *Bigotites* Nicolesco, 1918

Type species: *"Bigotella petri"* Nicolesco (1917, p. 167, pl.1, figs. 4-5).

Synonymy: *Pseudobigotella* Lemoine (1918), *Haselburgites* Buckman (1920 in 1909-30).

Diagnosis: Macro- and microconchs of medium to large size (Dmax.= 45-500 mm). Planulate coiling, subcircular to subrectangular whorl section. Strongly ribbed and constricted, blunt primaries and prorsiradiate secondaries, with smooth band on venter, segmentally enlarging after the constrictions. The ventral smooth band and the displacement of the secondaries on both sides of it are more conspicuous at the beginning of each developmental segment. In contrast, the ventral smooth band almost disappears and the secondaries become increasingly stronger at the end of each developmental segment. Nuclei or early whorls typically with nodes in the bifurcation of the primary ribs. Suture line with suspensive lobe not strongly retracted.

Discussion. Sexual dimorphs of *Bigotites* have been recognized by different authors (Mangold 1971a, b; Pavia 1973, p. 138; Galácz 1980, p. 105; Fernández-López 1985, p. 460; Fernández-López et al. 2006a). Macroconchs bear simple aperture, and a smooth body chamber at the end of the ontogenic development. Microconchs with lateral lappets show isocostate ribbing

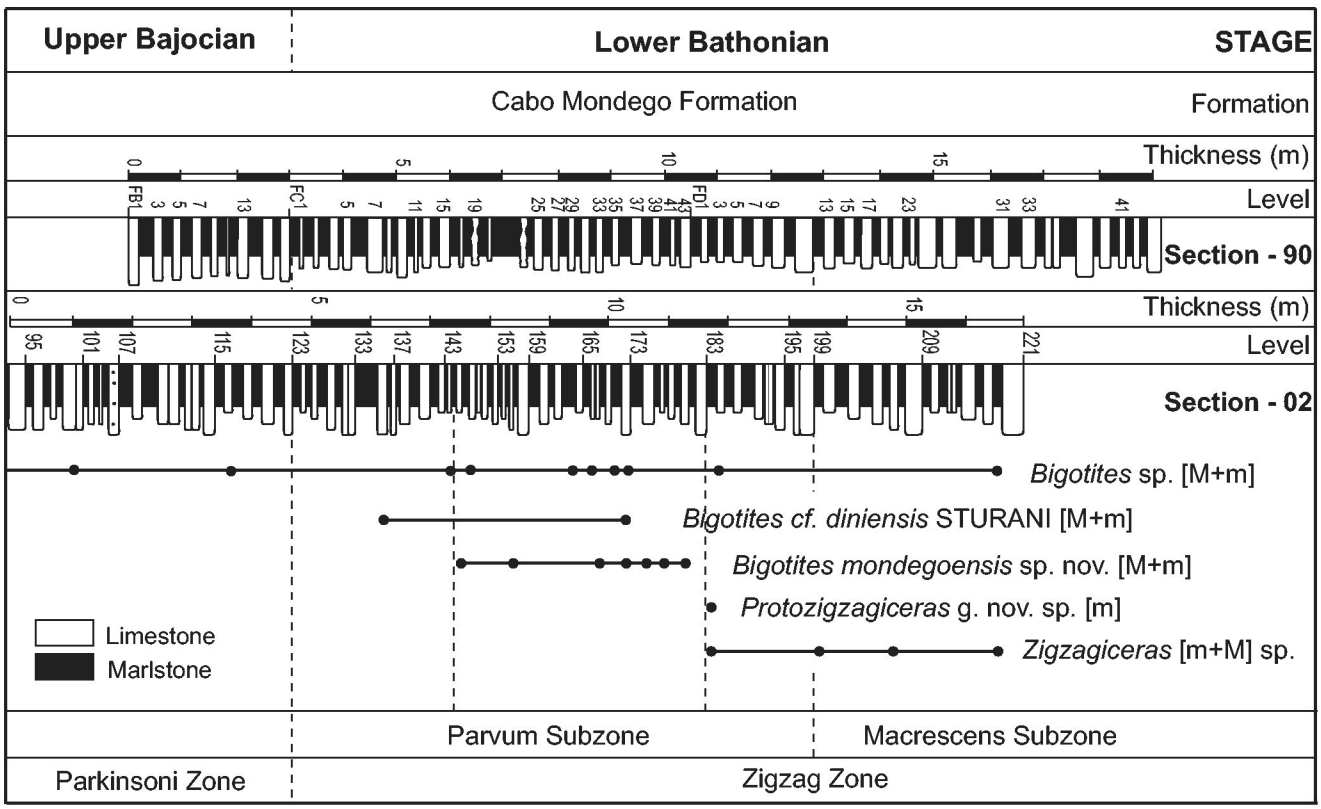


Fig. 3 - Stratigraphical distribution of *Bigotites, Protozigzagiceras* g. nov. and *Zigzagiceras* in Cabo Mondego sections (Portugal). Modified after Fernández-López et al. (2006a).

up to the end of the ontogenic development, and a more compressed section as well. The maturity of the specimens is indicated by the uncoiling of the umbilical seam, associated with an increasing compression of the whorl sections in the microconchs.

Several nominal species of *Bigotites* have been proposed:

B. petri (Nicolesco 1917, pl. 4, figs. 4-5; 1932, p. 23, pl. 2, figs. 2-4).

B. haugi (Nicolesco 1917, pl. 4, fig. 1; 1932, p. 17, pl. 1, fig. 1).

B. tuberculatus (Nicolesco 1917, p. 161, pl. 4, fig. 2; 1932, p. 19, pl. 1, figs. 2-4).

B. pulcher (Nicolesco 1917, p. 165; pl. 4, fig. 3; 1932, p. 21, pl. 2, fig. 1).

B. gentili (Nicolesco 1917, p. 170, pl. 4, fig. 6; 1932, p. 25, pl. 4, figs. 1-4).

B. lanquinei (Nicolesco 1917, p. 173, pl. 4, fig. 7; 1932, p. 17, pl. 4, figs. 5-6, pl. 5, figs. 1-2).

B. thevenini (Nicolesco 1917, p. 176, pl. 4, figs. 8-9; 1932, p. 30, pl. 6, figs. 1-4).

B. admirandus (Buckman 1921 in 1909-30, pl. 203A-B).

B. trifurcatus Buckman (1926 in 1909-30, pl. 622).

B. acurvatus Wetzel (1937, p. 96, pl. 10, fig. 12).

B. pusillus Wetzel (1937, p. 96, pl. 10, fig. 13).

B. diniensis Sturani (1967, p. 40, pl. 18, fig. 1; pl. 16, fig. 4).

As to comparable Lower Bathonian dimorphic couples, differences are as follows:

Bajocisphinctes [M] - *Microbajocisphinctes* [m] differ by being of lower adult size, more compressed, fine-ribbed, with primaries less prominent but more acute, typically with relatively simple sutures. *"Bigotites" lenki,* proposed by Schmidtill & Krumbeck (1931, p. 884, pl. 9, fig. 2) shows morphological features of *Bajocisphinctes* (Fernández-López 1985, p. 487; 1987).

Planisphinctes [m] - *Lobosphinctes* [M] lack the smooth band on venter enlarging segmentally after the constrictions, as well as the relatively simple sutures and the nodes in the bifurcation of the primary ribs characteristic of *Bigotites* [M+m]. The sutures of *Planisphinctes* [m] - *Lobosphictes* [M] show a slender first lateral and a strongly retracted suspensive lobe.

A further microconch of the Bajocian/Bathonian boundary, *Phaulozigzag* [m], results to be combined with the macroconch provisionally cited as *Lobosphinctes*? [M] by Fernández-López et al. (2006a, p. 261, fig. 9). These dimorphs (both lacking parabolic nodes) show more involute shells and rather finer ribbing than the *Planisphinctes* [m] - *Lobosphinctes* [M] dimorphic pair, although they share similar complex suture pattern.

Procerites [M] - *Siemiradzkia* [m] show parabolic nodes in the earliest whorls.

Zigzagiceras [m] - *Procerozigzag* [M] and *Franchia* [M+m] show a zigzag stage of ribbing characteristic of the earliest whorls of Zigzagiceratinae. Suture lines in specimens of the dimorphic couple *Zigzagiceras* [m] - *Procerozigzag* [M] are relatively complex also. However, representatives of *Franchia* [M+m] display simple sutures and suspensive lobe not strongly retracted.

Distribution: *Bigotites* is a characteristic genus of West Tethyan Perisphinctidae scarcely mentioned, apart of certain Bajocian species from southern areas of Europe, in Britain (Arkell 1959 in 1951-59, Callomon & Cope 1995, Chandler et al. 2001), Germany (Dietze et al. 2004, Dietze & Dietl 2006), France (Mangold 1971a,b, Mangold & Rioult 1997, Rioult et al. 1997), Portugal (Fernández-López et al. 2006a,b), Iberian Basin (Fernández-López 1985, 1987), Subbetic Basin (Sandoval 1983, Sandoval et al. 2001), Subalpine Basin (Sturani 1967, Pavia 1973, Torrens 1987, Innocenti et al. 1990), Western Carpathians (Schlögl et al. 2005), Hungary (Galácz 1980), Caucasus and Great Balkhan (Besnosov & Mitta 1998, 2000). First repre-

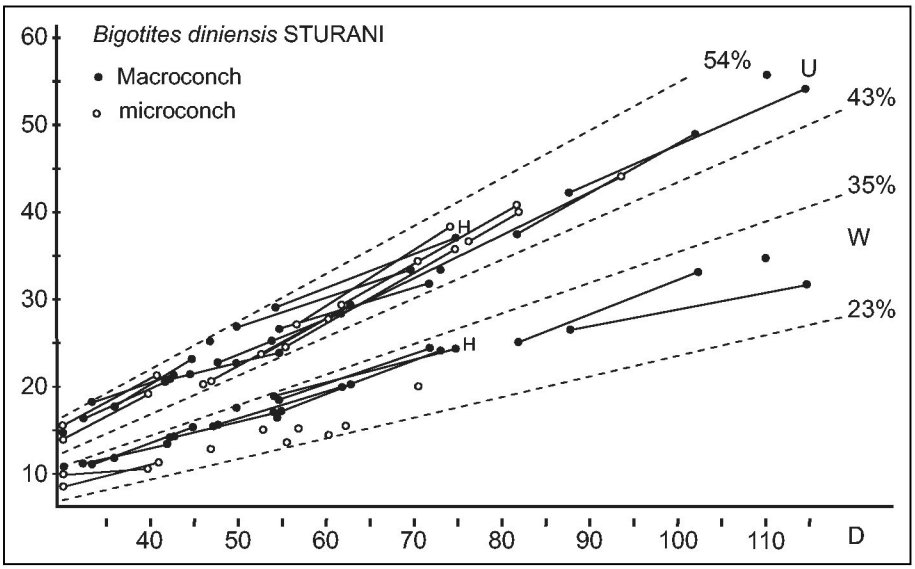


Fig. 4 - Bivariate scatter for *Bigotites diniensis* Sturani. Plot of umbilical width (U) and whorl width (W) against shell diameter (D). H = holotype.

sentatives of the genus occur in the Bajocian Garantiana Biochron of Mediterranean and Submediterranean provinces. Bathonian specimens of *Bigotites* studied in the present work correspond to three species: *B. diniensis* Sturani, *B. sturanii* sp. nov., *B. mondegoensis* sp. nov.

Bigotites diniensis Sturani [M + m]

Pl. 1, figs 1-6

1967 *Bigotites diniensis* n. sp. Sturani, p. 40, pl. 16, figs. 4a-b (paratype), pl. 18 figs, 1a-b (holotype).

Material: 32 specimens from the Parvum Subzone of Digne-Castellane region have been studied. 6 from Chaudon section (Sturani 1967): PU31606[M], PU31607[M], PU31609[M], PU31610[M], PU31611[M], PU31612[M]. 18 from Bas Auran area: bed BA14 (PU31614[M], PU111311[m]), bed BA16 (PU111281[m]), bed BA17 (PU111267[m], PU111268[M?]), bed BA18 (PU111259[M?]), bed BA19 (PU111249[m], PU111251[m], PU111254[M]), bed BA20 (PU111147[m], PU111152[M], PU111165[m], PU111166[m], PU111243[m], PU111244[m]), interval BA20-17 (PU111545[m]), bed RA75 (PU111543[m]), bed RA079 (PU111541[M]). 1 from La Blache section: PU111448[M] (Puma 1975). 6 from La Palud section (Innocenti et al. 1990): PU111449[m], PU111450[m], PU111451[M], PU111452[M], PU111453[m?], PU111454[m?].

Origin of the name: From *Dinium,* the Latin name of Digne, region which yielded the syntypes of the species.

Type specimens: There are four syntypes from the Parvum Subzone of Chaudon (Pl. 1, figs. 1-4). The holotype PU31606 figured by Sturani (1967, pl. 18, fig.l) is refigured here in Plate 1, figs. 1a-b. The paratype PU31607 figured by Sturani (1967, pl. 16, fig. 4) is refigured in Plate 1, figs. 4a-c.

Type horizon: The penultimate limestone bed of the "Marno-calcaires à *Cancellophycus* auctt.", below the "Terres Noires" Formation. The highest bed of the marly-limestone alternation in Chaudon was correlated with bed 12 of the Bas Auran Section by Sturani (1967 p. 14), and the type horizon of *B. diniensis* was attributed to the Convergens Subzone (equivalent to the Parvum Subzone).

Type locality: Chaudon, Alpes de Haute Provence, South-East France. In the upper course of the Ravin de la Coueste (= Ravin des Ozoards of ancient authors), at the place called "le Touert", midway between the village of Chaudon and the Col de Corobin (Col de la Clappe of ancient authors), some five hundred metres West of this col.

Repository: Museo di Geologia e Paleontologia of the Torino University (Italy).

Diagnosis: Evolute *Bigotites* (U/D= 43-54 % in post-juvenile stages up to 115 mm in size) with isodiametric to slightly compressed section, respectively in macro- and microconchs, and with acute and prominent ribbing.

Measurements:

Specimen	M - m	D (mm)	H (mm)	h	W (mm)	w	U (mm)	u	W/H	Ni/2	Ne/2	Ne/Ni
PU31609	M	115.0	36.2	0.31	31.2	0.27	53.4	0.46	0.86	23	47	2.0
		88.7	28.4	0.32	26.0	0.29	42.0	0.47	0.92	22	43	2.0
PU111541	M	110.0	32.5	0.30	35.0	0.32	55.5	0.50	1.08	25	51	2.0
PU31611	M	102.4	33.1	0.32	32.8	0.32	48.6	0.47	0.99	18	39	2.2
		82.0	23.8	0.29	24.9	0.30	37.0	0.45	1.05	18	– – –	– – –
PU31610	M	75.3	24.0	0.32	23.7	0.31	33.2	0.44	0.99	19	44	2.3
		54.2	17.2	0.32	17.1	0.32	24.1	0.44	0.99	18	– – –	– – –
PU31606	M	75.2	22.5	0.30	24.2	0.32	36.8	0.49	1.08	15	34	2.3
		54.0	17.5	0.32	19.2	0.36	28.8	0.53	1.10	15	– – –	– – –
PU111147	m	71.0	23.0	0.32	20.1	0.28	32.2	0.45	0.87	17	32	1.9
PU111254	M	63.0	21.9	0.35	19.9	0.32	29.2	0.46	0.91	18	– – –	– – –
PU111448	M	62.0	20.7	0.33	19.4	0.31	28.3	0.46	0.94	16	34	2.1
		48.0	15.3	0.32	15.4	0.32	23.0	0.48	1.01	18	34	1.9
PU111449	m	61.0	18.7	0.31	14.4	0.24	27.5	0.45	0.77	23	– – –	– – –
PU111165	m	56.7	11.3	0.20	15.1	0.27	27.1	0.48	1.34	20	44	2.2
PU111244	m	56.0	17.6	0.31	13.5	0.24	24.6	0.44	0.77	19	– – –	– – –
PU111152	M	55.0	17.6	0.32	18.6	0.34	26.6	0.48	1.06	18	35	1.9
PU31612	M	55.0	20.3	0.37	17.3	0.31	23.6	0.43	0.85	23	43	1.9
PU111243	m	53.0	17.0	0.32	15.0	0.28	23.5	0.44	0.88	20	– – –	– – –
PU111451	M	48.0	13.1	0.27	15.4	0.32	25.3	0.53	1.18	22	– – –	– – –
PU111450	m	47.0	14.0	0.30	12.8	0.27	20.2	0.43	0.91	22	– – –	– – –
PU31614	M	45.0	12.4	0.28	15.3	0.34	23.2	0.52	1.23	17	30	1.8
PU31607	M	43.0	12.3	0.29	14.6	0.34	21.6	0.50	1.19	19	33	1.7
		33.5	9.7	0.29	11.5	0.34	18.5	0.55	1.19	17	27	1.6
PU111268	M?	42.0	13.0	0.31	13.7	0.33	20.8	0.50	1.05	18	– – –	– – –
PU111281	m	41.0	11.0	0.27	11.1	0.27	21.3	0.52	1.01	19	33	1.7
PU111311	M	40.0	14.8	0.37	10.9	0.27	19.0	0.48	0.74	17	– – –	– – –
PU111453	m?	30.0	10.0	0.33	11.3	0.38	14.6	0.49	1.13	17	– – –	– – –
PU111454	m?	23.0	6.6	0.29	8.2	0.36	11.5	0.50	1.24	17	30	1.8

Abbreviations: M= macroconch, m= microconch, D= shell diameter, H= whorl height, W= whorl width, U= umbilicus, Ni/2= primaries per half whorl, Ne/2= secondaries per half whorl.

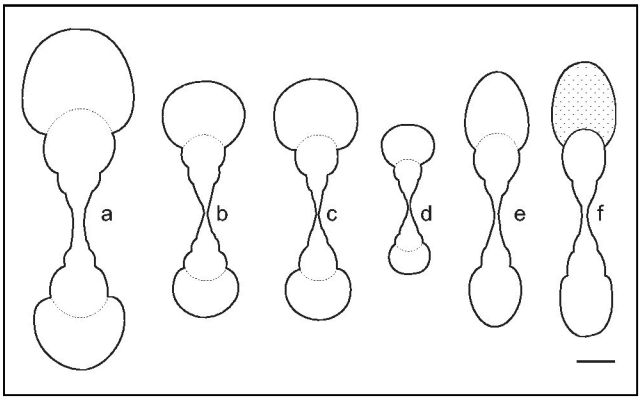


Fig. 5 - Cross sections through the phragmocones and body chamber (stippled) of *Bigotites diniensis* Sturani: a) specimen PU31611[M], paratype, Pl. 1, fig. 2; b) specimen PU31606[M], holotype, Pl. 1, fig. 1; c) specimen PU31610[M], topotype, Pl. 1, fig. 3; d) specimen PU31607[M], paratype, Pl. 1, fig. 4; e) specimen PU111243[m], Pl. 1, fig. 5; f) specimen PU111449[m], Pl. 1, fig. 6. Scale bar 1 cm.

Description. Adult shells of medium or large size, from microconchs reaching 94 mm of maximal diameter (Pl. 1, fig. 6) to macroconchs surpassing 100 mm and expected to reach several decimetres in diameter. No macroconchs are known possessing the complete body chamber. Evolute coiling, with values of umbilical ratio ranging from 43 to 54%, decreasing in the successive stages of the ontogenic development (Fig. 4; Pl. 1, fig. 2), except by egression of the umbilical seam in the adult body chamber (Fig. 4; Pl. 1, figs. 5-6). Whorls vary in section from low-oval, to subquadrate or subcircular contour and high-oval, with convex flanks (Fig. 5). The ribbing is sharp and strong. Ribs are rod-like, with a low proportion of simple ribs up to the beginning of the body chamber. There are about 15-22 primaries per half whorl, most of which biplicate, a few simple. The secondaries are less sharp; up to at least 50 mm diameter they are interrupted and displaced on both sides of a median smooth line (Pl. 1, fig. 4). The whorls increase by segments between more or less well marked constrictions, one or two every half a whorl. Suture line relatively simple, with suspensive lobe not strongly retracted (Fig. 6a).

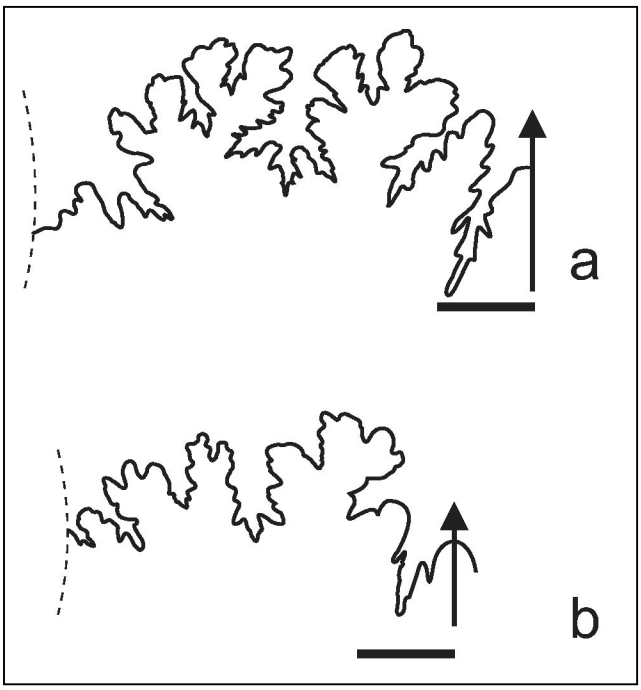


Fig. 6 - Septal suture of *Bigotites:* a) *B. diniensis* Sturani, specimen PU31607[M], paratype, Pl. 1, fig. 4; b) *B. mondegoensis* sp. nov., specimen 07BV174/3[m], paratype, Pl. 3, fig. 9. Scale bar 2 mm.

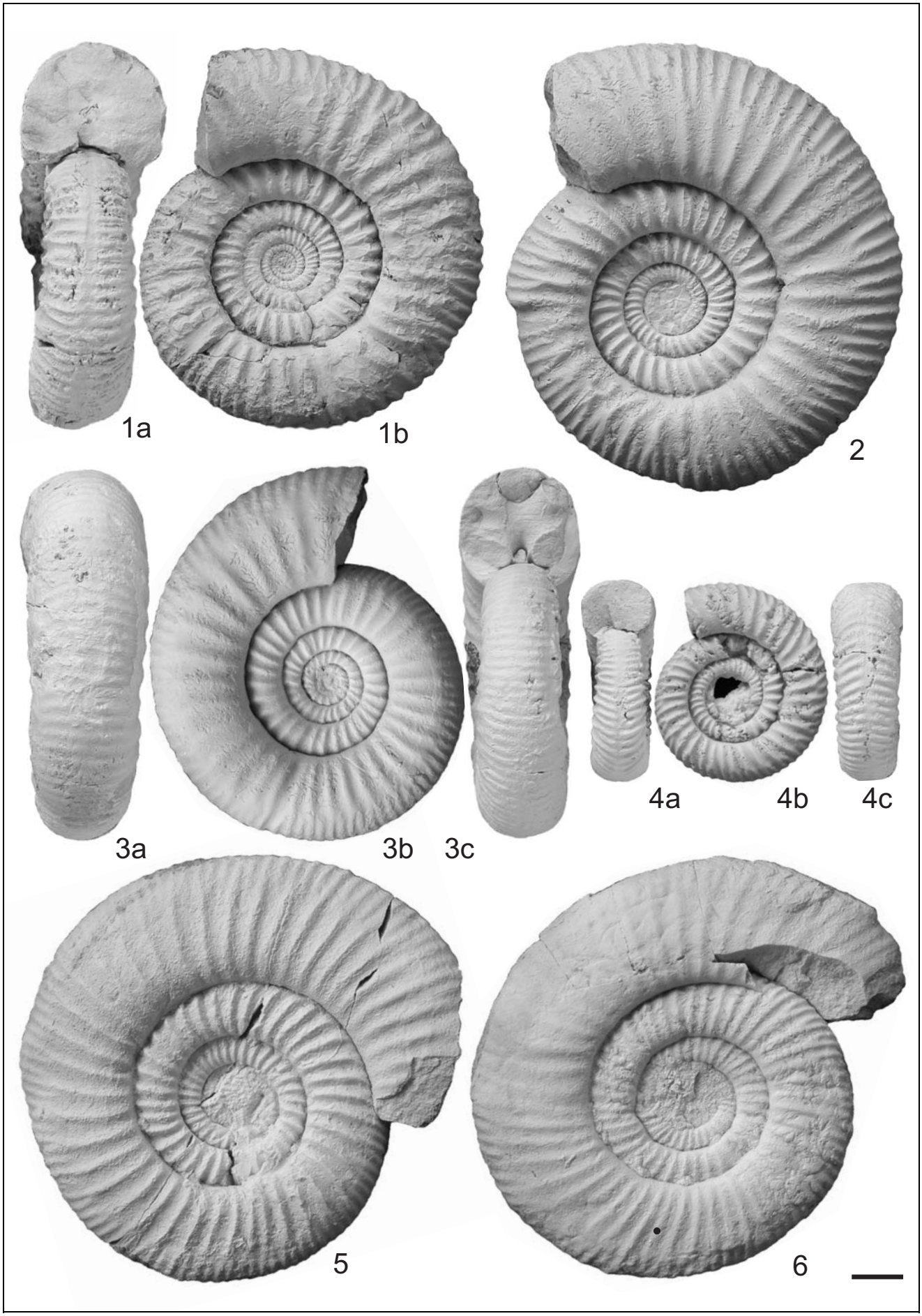
Discussion and comparisons with related species. *Bigotites petri* (Nicolesco), the type species of the genus, is the nearest looking Bajocian representative. *B. diniensis* Sturani, however, has a more quadrangular whorl section and is more evolute.

Distribution. *B. diniensis* Sturani occurs in the Bathonian Parvum Subzone of different localities of Digne-Castellane region: Chaudon, Bas Auran. La Blache, La Palud (Puma 1975, Innocenti et al. 1990). Specimens of this species have been found at the stratigraphic interval RA079 - RA049 (Fig. 2; levels 21 - 14 of Sturani 1967) in Ravin d'Auran Section. Two fragmentary specimens, comparable to this species, have been identified in Cabo Mondego in levels 02CM134 and 02CM172 from the Parvum Subzone (Fig. 3).

PLATE 1

Bathonian specimens of *Bigotites diniensis* Sturani from the Subalpine Basin (Parvum Subzone, Zigzag Zone). All specimens reproduced at natural size, except fig. 2 (x0,9). Scale bar 1 cm. Black spot marks the last septum of the phragmocone. The specimens figured here and in subsequent plates are whitened with magnesium oxide prior to photography.

Fig. 1 - Incomplete phragmocone of macroconch; oral (a) and lateral (b) views; specimen PU31606[M], holotype, Chaudon (Les Reichasses). Fig. 2 - Incomplete phragmocone of macroconch; specimen PU31611[M], topotype, Chaudon (Les Reichasses). Fig. 3 - Incomplete phragmocone of macroconch; ventral (a) lateral (b) and oral (c) views; specimen PU31610[M], topotype, Chaudon (Les Reichasses). Fig. 4 - Incomplete phragmocone of macroconch; oral (a) lateral (b) and ventral (c) views; specimen PU31607[M], paratype, Chaudon (Les Reichasses). Fig. 5 - Incomplete phragmocone of microconch; specimen PU111243[m], Bas Auran. Fig. 6 - Microconch with complete body chamber; black spot mark the last septum of the phragmocone; specimen PU111449[m], La Palud section (Innocenti et al. 1990).


1a
1b
2
3a
3b
3c
4a
4b
4c
5
6

Bigotites sturanii sp. nov. [M + m]

Pl. 2, figs 1-4

Material: 13 specimens from the Parvum Subzone of Bas Auran region have been studied: bed BA19 (PU111242[m], PU111253[M]), bed RA75 (PU111544[m]); interval BA19-20 (PU111252[M]); bed BA20 (PU111230[M?]; PU111231[m?], PU111232[M], PU111233[M], PU111234[m], PU111235[M?], PU111236[M?], PU111237[M], PU111238[M]).

Origin of the name: dedicated to Carlo Sturani, palaeontologist in "Dipartimento di Scienze della Terra", Torino University.

Type specimens: specimen PU111233 figured in Plate 2, figs, 1ab is the holotype. Three paratypes have been figured in Plate 2, figs. 2-4, respectively PU111312, PU11242, PU111253.

Type horizon: Bed 075 of Ravin d'Auran Section, Parvum Subzone, in Fig. 2. Bed BA20 of the "Marno-calcaires à *Cancellophycus",* in Bas Auran region (after Sturani 1967).

Type locality: Bas Auran, Alpes de Haute Provence, South-East France.

Repository: Museo di Geologia e Paleontologia of the Torino University (Italy).

Diagnosis: Largely evolute *Bigotites* (U/D= 45-58 % in post-juvenile stages up to 115 mm in size) macro- and microconchs, with moderately acute ribbing and well marked constrictions.

Measurements:

Description. Adult shells of medium or large size. No adult conchs are known possessing the complete body chamber. Evolute coiling, with values of umbilical ratio ranging from 45 to 56%, decreasing in the successive stages of the ontogenic development (Fig. 7; Pl. 2, fig. 1). Whorls vary in section from low-oval to subcircular contour, with convex flanks (Figs. 8a-b). The ribbing is moderately acute and moderately prominent, with a low proportion of simple ribs in the phragmocone. There are about 17-21 primaries per half whorl, most of which biplicate, a very few simple. The secondaries are less sharp; up to at least 30 mm diameter they are interrupted and displaced on both sides of a median smooth line. The whorls increase by segments between well marked constrictions, one every half a whorl. Suture line relatively simple, with suspensive lobe not strongly retracted.

Discussion and comparisons with related species. *Bigotites petri* (Nicolesco) shows a more acute and prominent ribbing. *B. diniensis* Sturani has a more quadrangular whorl section and is less evolute.

Distribution. All syntypes of *B. sturanii* sp. nov.

Specimen	M - m	D (mm)	H (mm)	h	W (mm)	w	U (mm)	u	W/H	Ni/2	Ne/2	Ne/Ni
PU111233	M	70.7	22.6	0.32	19.2	0.27	31.7	0.45	0.85	21	43	2.0
		56.0	16.5	0.29	16.7	0.30	28.9	0.52	1.01	21	– – –	– – –
PU111234	m	53.4	15.3	0.29	13.7	0.26	27.8	0.52	0.90	21	– – –	– – –
PU111232	M	53.0	17.1	0.32	17.5	0.33	25.7	0.48	1.02	19	– – –	– – –
		38.0	10.6	0.28	11.1	0.29	18.7	0.49	1.05	– – –	– – –	– – –
PU111252	M	53.0	14.6	0.28	15.5	0.29	27.4	0.52	1.06	24	– – –	– – –
PU111230	M?	39.0	10.0	0.26	12.0	0.31	22.5	0.58	1.20	17	34	2.0
PU111236	M?	38.0	10.3	0.27	11.7	0.31	19.4	0.51	1.14	18	– – –	– – –
PU111544	m	37.0	10.5	0.28	11.5	0.31	18.0	0.49	1.10	16	35	2.2
		30.0	9.3	0.31	9.5	0.32	15.0	0.50	1.02	14	31	2.2
PU111238	M	34.0	8.7	0.26	11.2	0.33	18.6	0.55	1.29	– – –	– – –	– – –

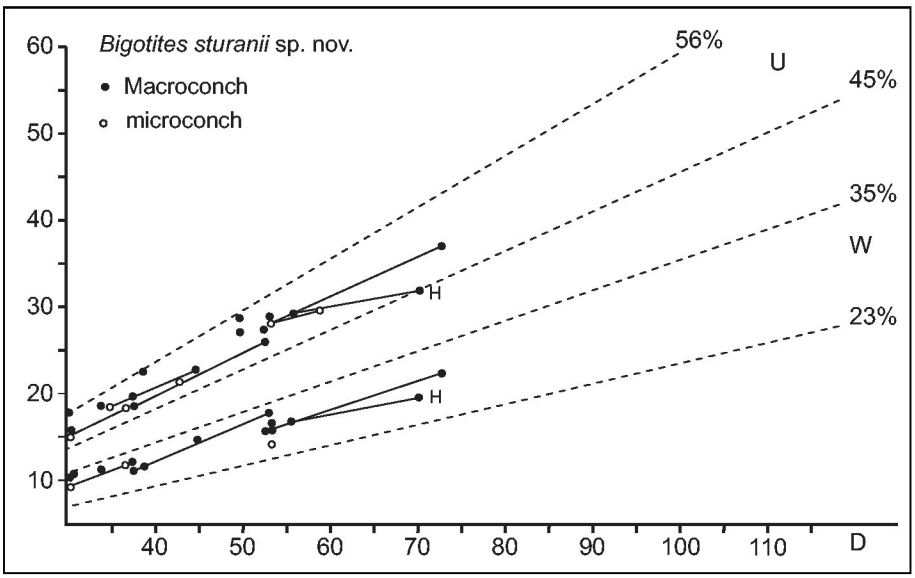


Fig. 7 - Bivariate scatter for *Bigotites sturanii* sp. nov. Plot of umbilical width (U) and whorl width (W) against shell diameter (D). H = holotype.

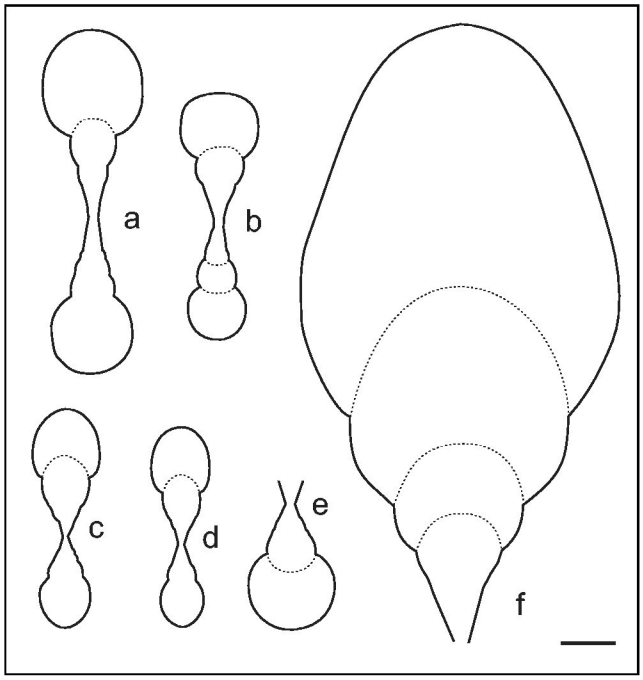


Fig. 8 - Cross sections through the phragmocones of *Bigotites sturanii* sp. nov. (a-b) and *B. mondegoensis* sp. nov. (c - f): a) specimen PU111233[M], holotype, Pl. 2, fig. 1; b) specimen PU111253[M], paratype, Pl. 2, fig. 4; c) specimen 02CM172/115[m], paratype, Pl. 3, fig. 7; d) specimen 02CM172/6[m], paratype, Pl. 3, fig. 5; d) specimen 02CM172/9[M], paratype, Pl. 3, fig. 2; f) specimen 02CM146/2[M],holotype,Pl.3,fig.1. Scale bar 1cm.

have been found at the stratigraphic interval RA075 - RA071 (Fig. 2; levels 20 - 19 of Sturani 1967), pertaining to the lower part of the Parvum Subzone, in Ravin d'Auran Section. So far, at Cabo Mondego no specimens have been found of *B. sturanii* sp. nov., which characterize lowermost Bathonian strata in Bas Auran.

Bigotites mondegoensis sp. nov. [M + m]

Pl. 3, figs 1-10

1987 *Planisphinctes acurvatus* (Wetzel). Torrens, pl. 4, figs. 1,5,6.

2006 *Bigotites* gr. *diniensis* Sturani [M]. Fernández-López et al. 2006a, figs. 7a-b.

2006 *"Bigotites" acurvatus* (Wetzel) in Torrens [m]. Fernández-López et al. 2006a, figs. 8a-c.

Material: 18 specimens from the Parvum Subzone of Cabo Mondego area have been studied. 8 specimens from Cabo Mondego Section 02: 02CM146/2[M], 02CM156/9[m], 02CM168/2[m], 02CM172/6[m], 02CM172/9[M], 02CM172/115[m], 02CM176/10[m], 02CM176/10[m], 02CM180/5[m]. 10 specimens from Serra de Boa Viagem Section, around 4 km east of Cabo Mondego: 07BV174/l[m], 07BV174/2[m], 07BV174/3[m], 07BV174/4[m], 07BV174/5[m], 07BV174/6[m], 07BV174/7[m], 07BV174/8[m], 07BV174/9[m], 07BV174/10[M].

Origin of the name: after the Cabo Mondego region, between Figueira da Foz and Murtinheira (Portugal) which has yielded the syntypes of the taxon described.

Type specimens: The holotype is the specimen 02CM146/2 figured in Plate 3, fig. 1. Several paratypes have been figured in Plate 3, figs. 2-10.

Type horizon: Bed 146 of Section 02, Parvum Subzone, indicated in Fig. 3.

Type locality: Section 02 of Cabo Mondego, Portugal (Fernández-López et al. 2006a).

Repository: Fernández-López & Henriques Collection in "Departamento de Ciências da Terra e Centro de Geociências", Coimbra University (Portugal).

Diagnosis: Moderately evolute *Bigotites* (U/D= 40-45% in post-juvenile stages up to 110 mm in size) macro- and microconchs, with moderately prominent ribbing and weak constrictions.

Measurements:

Specimen	M - m	D (mm)	H (mm)	h	W (mm)	w	U (mm)	u	W/H	Ni/2	Ne/2	Ne/Ni
02CM146/2	M	110.0	41.0	0.37	38.0	0.35	47.0	0.43	0.93	17	- - -	- - -
		86.0	23.0	0.27	26.0	0.30	35.4	0.41	1.13	18	- - -	- - -
07BV174/1	m	64.0	20.0	0.31	16.4	0.26	25.5	0.40	0.82	20	34	1.7
07BV174/8	m	58.0	16.2	0.28	- - -	- - -	25.2	0.43	- - -	17	34	2.0
02CM172/115	m	49.0	16.0	0.33	13.0	0.27	21.5	0.44	0.81	18	- - -	- - -
02CM172/9	M	45.0	14.3	0.32	16.0	0.36	19.5	0.43	1.12	18	- - -	- - -
02CM172/6	m	43.0	15.0	0.35	14.0	0.33	17.5	0.41	0.93	19	- - -	- - -
07BV174/4	m	41.0	15.0	0.37	12.0	0.29	16.5	0.40	0.80	17	32	1.9
07BV174/3	m	40.0	14.0	0.35	12.0	0.30	17.8	0.45	0.86	18	34	1.9
02CM180/5	m	40.0	14.0	0.35	12.0	0.30	17.0	0.43	0.86	18	- - -	- - -
07BV174/10	M	37.0	13.2	0.36	12.6	0.34	16.0	0.43	0.95	18	34	1.9
07BV174/2	m	37.0	13.5	0.36	11.0	0.30	15.9	0.43	0.81	17	33	1.9
07BV174/5	m	33.0	11.5	0.35	11.0	0.33	14.5	0.44	0.96	16	29	1.8
07BV174/6	m	33.0	10.6	0.32	10.0	0.30	14.8	0.45	0.94	21	32	1.5
07BV174/7	m	30.0	11.3	0.38	8.0	0.27	13.0	0.43	0.71	19	30	1.6

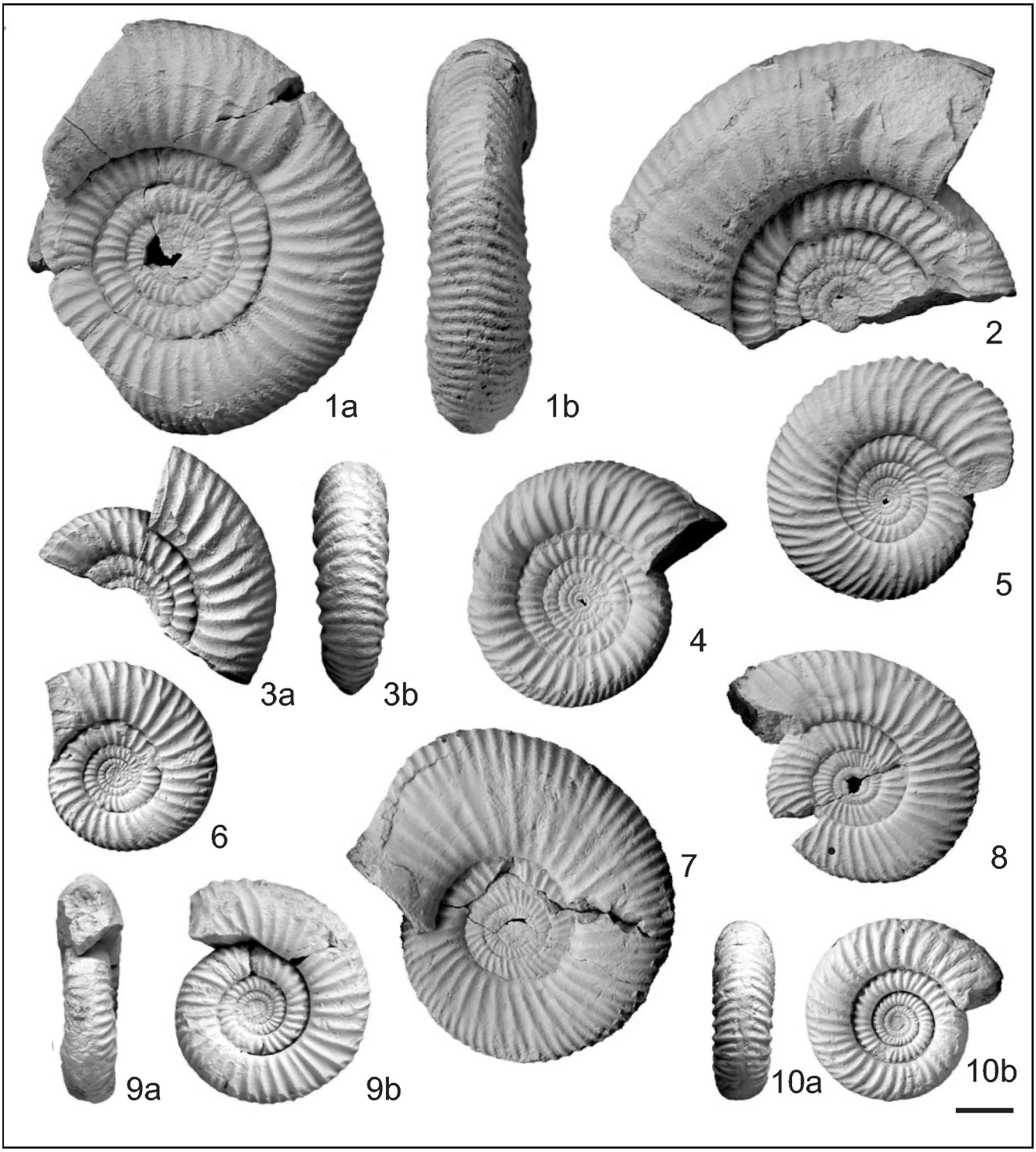


PLATE 2

Bathonian specimens of *Bigotites sturanii* nov. sp. (figs. 1-4) and *Bigotites mondegoensis* sp. nov. (figs. 5-10) from Bas Auran sections (Alpine Basin, Parvum Subzone, Zigzag Zone). Natural size. Scale bar 1 cm.

Fig. 1 - Incomplete phragmocone of macroconch; lateral (a) and ventral (b) views; specimen PU111233[M], holotype. Fig. 2 - Incomplete phragmocone of macroconch; specimen PU111252[M], paratype. Fig. 3 - Incomplete microconch; specimen PU111242[m], paratype. Fig. 4 - Incomplete phragmocone of microconch; specimen PU111253[m], paratype. Fig. 5 - Incomplete phragmocone of macroconch; specimen PU111312[M]. Fig. 6 - Incomplete phragmocone of microconch; specimen PU111271[m]. Fig. 7 - Incomplete phragmocone of macroconch; specimen PU111317[M]. Fig. 8 - Microconch with complete body chamber; specimen PU111314[m]. Fig. 9 - Incomplete phragmocone of microconch; oral (a) and lateral (b) views; specimen PU111311[m]. Fig. 10 - Incomplete phragmocone of microconch; ventral (a) and lateral (b) views; specimen PU111308[m].

Description. Adult shells of medium to large size, from microconchs reaching 50 mm of maximal diameter (Pl. 3, fig. 4) to macroconchs exceeding 500 mm in diameter (Pl. 3, fig. 1). No macroconchs are known displaying the complete body chamber. Moderately evolute coiling, with values of umbilical ratio ranging from 40 to 45%, decreasing in the successive stages of the ontogenic development (Fig. 9), except by egression of the umbilical seam in the adult body chamber. Whorls vary in section from low-oval to high oval contour, with convex flanks (Figs. 8c-f). The ribbing is moderately acute and moderately prominent. There are about 16-21 primaries per half whorl, most of which biplicate, a very few simple. The secondaries are less sharp; up to at least 40 mm diameter they are interrupted and displaced on both sides of a median smooth line. The whorls increase by segments between weak constrictions. Suture line relatively simple, with suspensive lobe not strongly retracted (Fig. 6b).

Discussion and comparisons with related species. Nineteen specimens of this species have been found at the stratigraphic interval RA061 - RA039 (Fig. 2; levels 17-13 pars of Sturani 1967) of Ravin d'Auran section (Pl. 2, figs. 5-10): bed BA14 (PU111308[m], PU111309[m], PU111310[m], PU111311[m], PU111312[M], PU111313[m], PU111314[m], PU111315[m?], PU111316[m?], PU111317[M], PU111318[M], PU111319[m]), bed RA39 (PU111567[m]), bed BA17 (PU111269[m], PU111270[m?], PU111271[m]), bed RA47 (PU111550[m], PU111560[m], PU111561[m]). They show the following mensurational values:

Specimen	M - m	D (mm)	H (mm)	h	W (mm)	w	U (mm)	u	W/H	Ni/2	Ne/2	Ne/Ni
PU111317	M	60.0	24.0	0.40	– – –	– – –	21.5	0.36	– – –	17	36	2.1
		48.0	17.1	0.36	– – –	– – –	19.0	0.40	– – –	16	34	2.1
PU111269	m	50.0	16.5	0.33	– – –	– – –	23.0		– – –	19	34	1.8
PU111319	m	48.0	15.0	0.31	– – –	– – –	22.0	0.46	– – –	20	33	1.7
PU111316	m?	44.0	15.0	0.34	– – –	– – –	18.0	0.46	– – –	20	38	1.9
PU111312	M	43.0	13.5	0.31	– – –	– – –	18.5	0.43	– – –	16	29	1.8
PU111314	m	41.0	14.0	0.34	– – –	– – –	18.0	0.44	– – –	18	29	1.6
PU111311	m	37.0	11.8	0.32	10.8	0.29	17.4	0.47	0.92	16	– – –	– – –
		30.0	9.1	0.30	10.1	0.34	14.4	0.48	1.11	15	25	1.7
PU111318	M	35.0	10.9	0.31	– – –	– – –	17.0	0.49	– – –	16	33	2.1
PU111560	m	35.0	10.5	0.30	10.0	0.29	17.4	0.50	0.95	15	26	1.7
PU111308	m	35.0	10.0	0.29	10.5	0.30	17.0	0.49	1.05	18	32	1.8
		30.0	8.1	0.27	10.0	0.33	15.1	0.50	1.23	16	– – –	– – –
PU111271	m	33.0	10.2	0.31	– – –	– – –	15.9	0.48	– – –	13	25	1.9
PU111313	m	32.0	10.5	0.33	– – –	– – –	14.0	0.44	– – –	17	27	1.6
PU111310	m	31.0	9.8	0.32	11.2	0.36	14.5	0.47	1.14	16	25	1.6

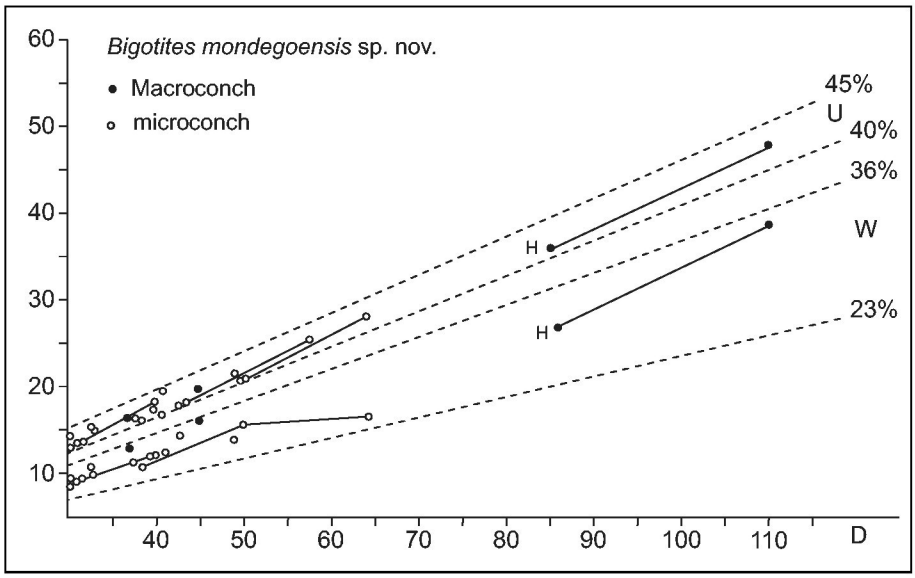


Fig. 9 - Bivariate scatter for *Bigotites mondegoensis* sp. nov. Plot of umbilical width (U) and whorl width (W) against shell diameter (D). H = holotype.

As showed in Plate 2, figs. 6, 9, 10, the umbilicus variability of Bas Auran specimens spans 35 to 50 (vs. 40-45) and surpasses the relative umbilical values of syntypes of *B. mondegoensis* sp. nov. However, we could refer these French specimens to the new species as, associated with such a more evolute morphotype, some shells (Pl. 2, figs. 7, 8) show geometric shape, weak ribbing and constrictions characteristic of *B. mondegoensis* sp. nov.

Bigotites petri (Nicolesco), *B. diniensis* Sturani, *B. sturanii* sp. nov. and *Bigotites acurvatus* (Wetzel 1937, p. 96, pl. 10, fig. 12) show more evolute coiling, more prominent and rod-like ribs and stronger constrictions. In contrast, microconchs of *B. mondegoensis* sp. nov. are more strongly ribbed than *Planisphinctes planilobus* Buckman (1922 in 1909-30, pl. 327); they may show nodes in the bifurcation of the primary ribs and display a suspensive lobe not strongly retracted.

Distribution. Syntypes of *B. mondegoensis* sp. nov. have been found at the stratigraphic interval 02CM146 - 02CM180, at the middle part of the Parvum Subzone, in Cabo Mondego region (Fig. 3). Specimens of this moderately evolute species are relatively common in Bas Auran and have been identified at the stratigraphic interval RA061 - RA044, at the middle part of the Parvum Subzone. A microconch specimen, possibly referable to this new species, has been figured by Dietze & Dietl (2006, pl. 7, fig. 4) as *Planisphinctes acurvatus* from the Convergens Subzone of the Swabian Alb region.

Evolution and biochronostratigraphy

Bigotites seems to be an endemic genus of West Tethyan perisphinctids during early Bathonian. First representatives of the genus occur in the Bajocian Garantiana Biochron of Mediterranean and Submediterranean provinces, displaying a high diversity. In contrast, Bathonian ammonite fossil assemblages from Western Tethys include scarce specimens of *Bigotites*. At the Digne-Castellane region, a chronocline from evolute, with acute and prominent ribbing, and well constricted forms (including *B. sturanii* sp. nov. and *B. diniensis* Sturani) to involute forms with blunt, moderately prominent ribbing and weak constrictions (including *B. mondegoensis* sp. nov.) can be recognized. This chronocline can be interpreted as a peramorphic result of a palingenetic evolutionary process. Consequently, the species *B. sturanii* sp. nov., *B. diniensis* Sturani and *B. mondegoensis* sp. nov. make up a Bathonian peramorphocline (cf. Dommergues et al. 1986, 1989, Guex et al. 2003, Guex 2007). This specialized lineage includes the last known representatives of the genus and subfamily, which became extinct during the latest Bathonian Zigzag Biochron (Macrescens Subzone).

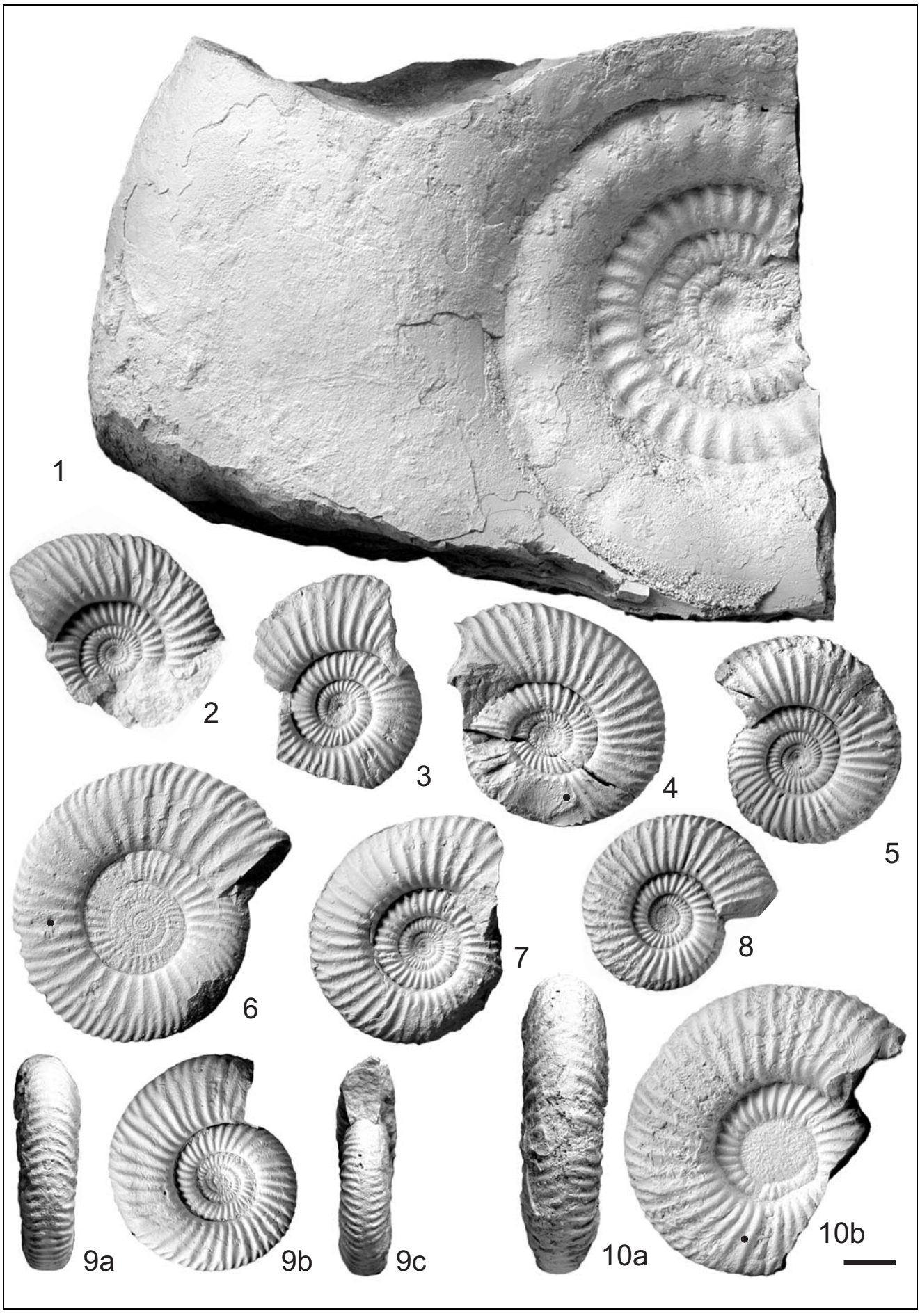
Several authors have suggested that near the Bajocian-Bathonian boundary, and shortly before its own extinction, *Bigotites* seems to have been at the origin of at least two main lineages of Bathonian perisphinctids, evolving in different directions: *Procerites* [M] - *Siemiradzkia* [m] through *Planisphinctes* [m] - *Lobosphictes* [M] and *Zigzagiceras* [m] - *Procerozigzag* [M] through *Franchia* [M+m] (cf. Arkell et al. 1957, Arkell 1958 in 1951-59, Sturani 1967, Hahn 1969, Mangold 1971a,b, Callomon *in* Donovan et al. 1981, Sandoval 1983). However, in accordance with the sutural complexity, ornamentation and biochronostratigraphic distribution, it seems more probably that the dimorphic group *Planisphinctes* [m] - *Lobosphictes* [M] represents a direct derivative of some Late Bajocian species of the group of *Vermisphinctes* [m] - *Prorsisphinctes* [M], as suggested by Stephanov (1972), and this dimorphic group may be included among the youngest Leptosphinctinae (Torrens 1987, Innocenti et al. 1990, Fernández-López et al. 2006a).

Further, the phylogenetic derivation of Zigzagiceratinae (Buckman, 1920), in particular *Zigzagiceras* [m] - *Procerozigzag* [M] and *Franchia* [M+m], from *Bigotites* [M+m], as supported by Sturani (1967) and Torrens (1987), or from *Phaulozigzag* [m] - *Lobosphinctes?* [M], as suggested by Fernández-López et al. (2006a), need to be assessed according to very accurate biochronological data. Rather than a Bathonian species of *Bigotites,* the immediate predecessor of *Franchia* [M+m], bearing simple suture line, and *Zigzagiceras* [m] - *Procerozigzag* [M], displaying complex suture, may be a more primitive species of Zigzagiceratinae

PLATE 3

Bathonian syntypes of *Bigotites mondegoensis* sp. nov. from the Cabo Mondego area (Lusitanian Basin, Parvum Subzone, Zigzag Zone). Natural size. Scale bar 1 cm. Black spot marks the last septum of the phragmocone.

Fig. 1 - Incomplete phragmocone of macroconch; specimen 02CM146/2[M], holotype. Fig. 2 - Incomplete phragmocone of macroconch; specimen 02CM172/9[M], paratype. Fig. 3 -Incomplete phragmocone of microconch; specimen 02CM180/5[m], paratype. Fig. 4 - Microconch with complete body chamber; specimen 07BV174/l[m], paratype. Fig. 5 - Incomplete phragmocone of microconch; specimen 02CM172/6[m], paratype. Fig. 6 - Incomplete microconch; specimen 07BV174/8[m], paratype. Fig. 7 - Incomplete phragmocone of microconch; specimen 02CM172/115[m], paratype. Fig. 8 - Incomplete phragmocone of microconch; specimen 07BV174/2[m], paratype. Fig. 9 - Incomplete phragmocone of microconch; ventral (a) lateral (b) and oral views; specimen 07BV174/3[m], paratype. Fig. 10 - Microconch with complete body chamber; ventral (a) and lateral (b) views; specimen 07BV174/l[m], paratype.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10a
10b

showing complex suture line and only a short zigzag stage, without smooth band on external region, developed during the earliest Bathonian (as proposed by Fernández-López et al. 2006a, fig. 9). Bearing such primitive morphological traits, however, only two incomplete specimens have been so far discovered in the upper part of the Parvum Subzone (Figs. 10-11) in Cabo Mondego and Bas Auran areas; these primitive morphological features are present also in *"Zigzagiceras torrensi"* Sturani (1967, p. 47, pl. 2, fig. 4, pl. 21, fig. 3) and *"Zigzagiceras torrensi variecostatum"* Sturani (1967, p. 48, pl. 2, fig. 5, pl. 13, fig. 4, pl. 19, fig. 5, pl. 20, fig. 2) from the Macrescens Subzone, as well as in two specimens taxonomically determined as *"Zigzagiceras* aff. *torrensi* Sturani [m]" by Dietze and Chandler (1997, pl. 1, figs. 3-4).

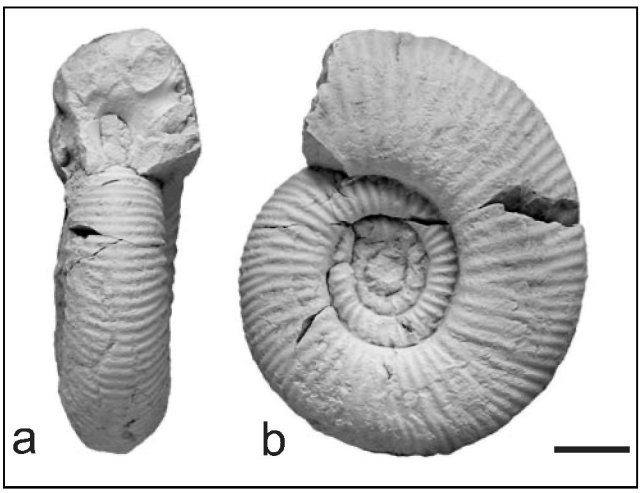

Fig. 10 - *Protozigzagiceras* g. nov. sp. aff. *P. torrensi* (Sturani). Oral (a) and lateral (b) views. Incomplete phragmocone of macroconch; specimen PU31694[M]. D = 35.0. H = 11.0 (0.31). W = 12.5 (0.36). U = 12.6 (0.36). W/H = 1.14. Ni/2 = 24. Ne/2 = 42. Ne/Ni = 1.8. Scale bar 1 cm. Parvum Subzone (Zigzag Zone, Bathonian). Bas Auran (France).

In order to encompass these species of Zigzagiceratinae, recorded at least in the Bathonian Parvum, Convergens and Macrescens subzones and bearing primitive morphological traits such as nuclei or early whorls with an incipient and short zigzag stage, and primaries relatively dense, we propose a separate genus, the new name *Protozigzagiceras* g. nov. (type species, *"Zigzagiceras torrensi"* Sturani, 1967; Fig. 12) and the following diagnosis: Macro- and microconchs of small or medium size, with planulate and evolute coiling, subcircular to subrectangular whorl section, nuclei with primaries relatively dense and a short zigzag stage restricted to the early whorls, without parabolae, parabolic nodes or smooth band on external region, and showing relatively complex suture line with a slender first lateral lobe. *Franchia* [M+m], showing a simple suture line, constitutes an apomorphic group derived from *Protozigzagiceras* [M+m]. In this phyletic scheme, also the couple *Zigzagiceras* [m] - *Procerozigzag* [M] represents a group derived from *Protozigzagiceras* g. nov. [M+m] (Fig. 13). This new genus, consequently, should be considered the immediate predecessor of both mentioned taxa and the oldest Zigzagiceratinae so far known in the Bas Auran area.

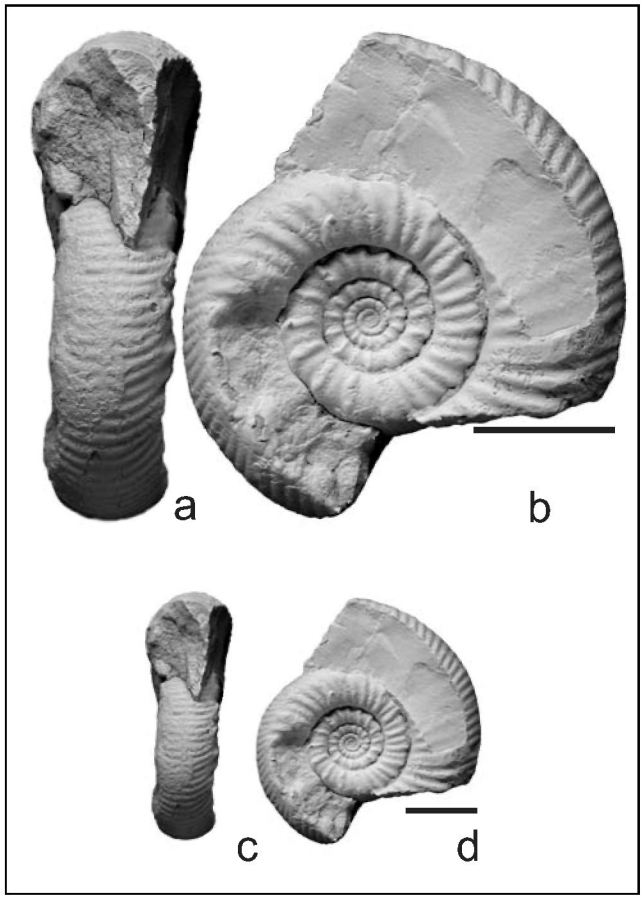

Fig. 11 - *Protozigzagiceras* g. nov. sp. aff. *P. torrensi* (Sturani).). Oral (a) and lateral (b) views x2. Oral (c) and lateral (d) views x1. Incomplete phragmocone of microconch; specimen 04CM183/l[m]. D = 24.0. H = 7.4 (0.31). W = 8.9 (0.37). U = 10.9 (0.45). W/H = 1.20. Ni/2 = 19. Scale bar 1 cm. Parvum Subzone (Zigzag Zone, Bathonian). Cabo Mondego (Portugal).

These new palaeontological data about the youngest members of Bigotitinae and oldest members of Zigzagiceratinae are of biochronostratigraphic significance for the subdivision and correlation of the basal Bathonian Zigzag Zone. The lowest occurrences of *Bigotites mondegoensis* sp. nov. and *Protozigzagiceras* g. nov. correspond to two successive biostratigraphic events allowing to distinguish three successive biohorizons at the Parvum Subzone in Bas Auran (Alpine Basin) and Cabo Mondego (Lusitanian Basin). Consequently, three biostratigraphic units may be named: Diniensis, Mondegoensis and Protozigzagiceras biohorizons.

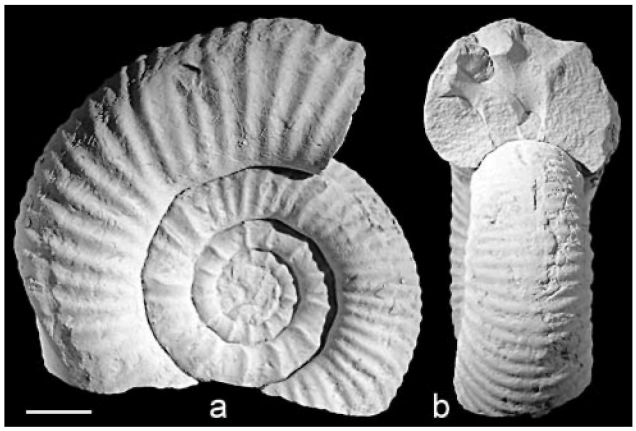

Fig. 12 - *Protozigzagiceras* g. nov. *torrensi* (Sturani). Holotype. Lateral (a) and oral (b) views. Incomplete phragmocone of macroconch; specimen PU31676[M]. At D = 43.0: H = 15.1 (0.35), W = 17.7 (0.41), U = 19.4 (0.45), W/H = 1.17, Ne/Ni = 1.7. Scale bar 1 cm. Macrescens Subzone (Zigzag Zone, Bathonian). Bas Auran (France).

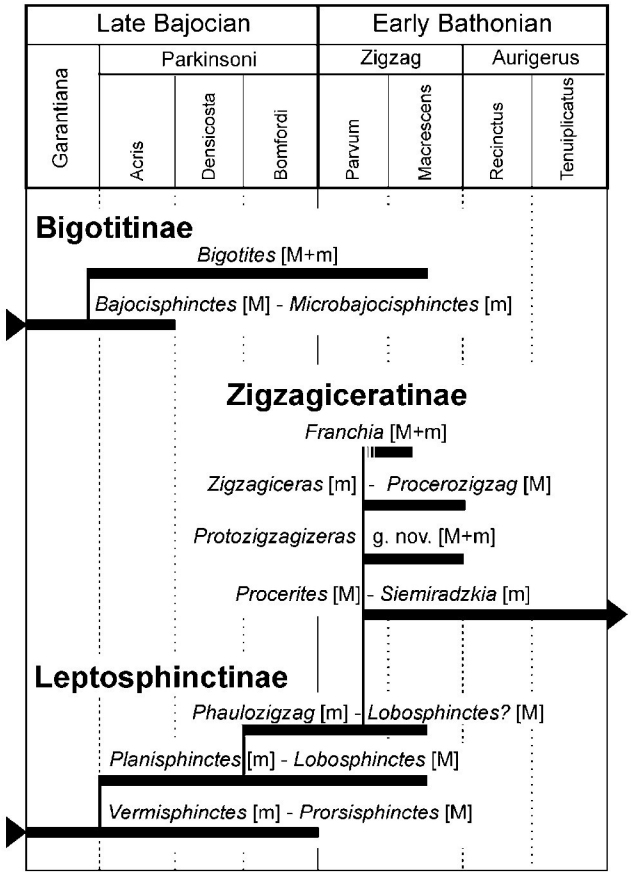

Fig. 13 - Phylogenetic scheme of the first genera of Zigzagiceratinae, originated and diversified from Leptosphinctinae during latest Parvum Subzone (Zigzag Zone, Early Bathonian), before the extinction of *Bigotites*.

The Diniensis Biohorizon is characterized by the occurrence of *Bigotites diniensis* representatives and it corresponds to the lowest part of the Bathonian Zigzag Zone. It encompasses the stratigraphic intervals RA085 - RA062 (Fig. 2, levels 23 - 18 of Sturani 1967) in Ravin d'Auran Section and RB071 - RB054 (Fig. 2, levels 23 - 18 of Sturani 1967) in Ravin du Bès Section. It is represented in Cabo Mondego by the stratigraphic intervals 02CM123 - 02CM145 in the Section 02 and FC1- FC17 in the Section 90 as illustrated in Fig. 3.

The Mondegoensis Biohorizon is defined by the lowest occurrence of *Bigotites mondegoensis* sp. nov. representatives. It encompass the stratigraphic intervals RA061 - RA044 (Fig. 2, levels 17 -14 of Sturani 1967) in Ravin d'Auran Section and RB053 - RB034 (Fig. 2, levels 17 - 14 of Sturani 1967) in Ravin du Bès Section, taking into account the occurrence of *B. mondegoensis* sp. nov. at the level RA061. It is represented in Cabo Mondego by the stratigraphic intervals 02CM146 - 02CM182 in the Section 02 and FC18 - FC43 in the Section 90, as illustrated in Fig. 3, taking into account the occurrence of *B. mondegoensis* sp. nov. at the level 02CM146.

The Protozigzagiceras Biohorizon is defined by the lowest occurrence of Zigzagiceratinae representatives, in particular *Franchia* [M+m] and *Protozigzagiceras* [M+m]. It encompasses the stratigraphic intervals RA043 - RA034 (Fig. 2, level 13 of Sturani 1967) in Ravin d'Auran Section and RB033 - RB026 (level 13 of Sturani 1967) in Ravin du Bès Section, taking into account the occurrence of *Franchia* from RA035 and *Protozigzagiceras* g. nov. from level 13. The Protozigzagiceras Biohorizon is represented in Cabo Mondego by the stratigraphic intervals 02CM183 - 02CM198 in the Section 02 and FC44 - FD11 in the Section 90 as illustrated in Fig. 3, taking into account the occurrence of *Protozigzagiceras* g. nov. at the level 04CM183.

Conclusions

Two new species of *Bigotites* are described and assigned to the subfamily Bigotitinae (Westermann 1956) and family Perisphinctidae (Steinmann 1890): *B. sturanii* sp. nov. and *B. mondegoensis* sp. nov. The species *B. sturanii* sp. nov., *B. diniensis* Sturani and *B. mondegoensis* sp. nov. make up a Bathonian peramorphocline. *Bigotites,* the last West Tethyan genus of the subfamily Bigotitinae, became extinct during the Zigzag Biochron (Macrescens Subzone) lacking of known descendent taxa. A separate genus of the subfamily Zigzagiceratinae (Buckman 1920), *Protozigzagiceras* g. nov., is proposed to encompass *P. torrensi* (Sturani) and similar species, bearing a short zigzag stage and primaries relatively dense in the early whorls, associated with relatively complex suture lines, recorded at least in the Parvum, Convergens and Macrescens subzones. The first genera of Zigzagiceratinae origi-

nated and diversified from Leptosphinctinae, during the Zigzag Biochron (Parvum Subzone) and before the extinction of *Bigotites*.

These new palaeontological data about the youngest members of Bigotitinae and oldest members of Zigzagiceratinae are relevant in understanding the evolution of the West Tethyan Perisphinctidae during earliest Bathonian. These new taxa of Perisphinctidae are of particular relevance for the biochronostratigraphic subdivision and correlation of the basal Bathonian Zigzag Zone. Three successive biohorizons can be recognized in the Parvum Subzone at Bas Auran (Alpine Basin) and Cabo Mondego (Lusitanian Basin): Diniensis, Mondegoensis and Protozigzagiceras biohorizons.

Such biochronostratigraphic results are of biochronostratigraphic importance for the subdivision and correlation of the base of the Zigzag Zone and will assume a basilar role in the construction of the proposal of the basal boundary stratotype of the Bathonian Stage. The G.S.S.P, formal proposal is in progress under the accordance of the International Subcommission of the Jurassic Stratigraphy.

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