CALIBRATION OF PLIENSBACHIAN CALCAREOUS NANNOFOSSIL EVENTS IN TWO AMMONITE-CONTROLLED SECTIONS FROM NORTHERN SPAIN (BASQUE-CANTABRIAN AREA)

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Received March 22, 2001; accepted January 18, 2002

Key-words: Biostratigraphy; Pliensbachian; Jurassic; Calcareous Nannofossils; Ammonites; Semiquantitative analysis; Cantabria; Iberian Plate.

Riassunto. Due sezioni continue ed espanse del Pliensbachiano, affioranti nell'area Basco-Cantabrica e già datate in base alle ammoniti, sono state campionate per lo studio dei nannofossili calcarei. Entrambe hanno fornito nannoflore calcaree ricche e diversificate che hanno permesso di descrivere, per questo settore sud-orientale del Dominio Boreale, i cambiamenti principali delle associazioni e di calibrare, rispetto alle zone ad ammoniti, gli eventi riconosciuti.

Il primo significativo cambio è rappresentato dalla comparsa e dall'incremento in abbondanza del genere Similiscutum che, insieme ai generi Crepidolithus e Parhabdolithus, è un costituente comune delle associazioni a nannofossili calcarei fino al Domeriano inferiore. Sebbene al passaggio Carixiano/Domeriano si registri la comparsa dei generi Biscutum e Bussonius, è solo nel Domeriano inferiore che si verifica l'altro significativo cambio della composizione delle associazioni a nannofossili calcarei. Questo cambio è legato all'aumento repentino in abbondanza del genere Calcivascularis ed alla comparsa del genere Lotharingius, che subito diventa un costituente dominante nelle associazioni del Domeriano superiore, caratterizzate anche dalla significativa presenza del genere Biscutum.

Questi cambiamenti forniscono una successione di bioorizzonti facilmente riconoscibili ed attendibili, che comprendono la comparsa di Similiscutum avitum e Similiscutum cruciulus (Zona a Jamesoni), di Lotharingius barozii e Lotharingius hauffii (limite tra le Zone Stokesi/Margaritatus) e il netto incremento in abbondanza di Lotharingius hauffii (limite tra le Zone Margaritatus/Spinatum). Anche l'aumento in abbondanza di Calcivascularis jansae (limite tra le Zone Stokesi/Margaritatus) sembra essere un evento utile ed attendibile, almeno alla scala regionale. Al contrario la comparsa di Biscutum dubium, Bussonius prinsii (Zona a Davoei), Biscutum novum, Biscutum grande e Biscutum finchii (Stokesi Zone) risulta difficile da calibrare con precisione rispetto alle zone ad ammoniti, in quanto queste specie sono generalmente rare e caratterizzate da presenza discontinua, soprattutto all'inizio della loro distribuzione.

Abstract. Common and diverse calcareous nannofossil assemblages were found in two continuous and expanded successions, sedimented on hemipelagic carbonate ramp. Based on refined ammonite biostratigraphy, closely spaced sampling and semiquantitative analysis, the main purpose of this paper is to calibrate against ammonite zones and subzones, the nannofossil composition changes and the identified biohorizons.

In the study area, the first notable composition change is in the lower Carixian, with the appearance and abundance increase of the genus Similiscutum, that represents a large amount of the assemblages up to the lower Domerian. Although, the appearance of the genera Biscutum and Bussonius is easily detectable around the Carixian/Domerian Zone boundary, the other relevant Pliensbachian composition changes took place in the lower Domerian. It includes the sharp abundance increase of Calcivascularis and the abundance appearance of the genus Lotharingius, that dominate the upper Domerian assemblages, also characterized by the significant presence of the genus Biscutum.

The set of easily recognizable and reliable events includes the First Occurrences (FOs) of Similiscutum avitum and Similiscutum cruciulus (Jamesoni Zone), the FOs of Lotharingius barozii and Lotharingius bauffii (Stokesi/Margaritatus Zone boundary), the First Common Occurrence (FCO) of Lotharingius hauffii (Margaritatus/Spinatum Zone boundary) and, probably, the FCO of Calcivascularis jansae (Stokesi/Margaritatus Zone boundary). Instead, the FOs of Biscutum dubium, Bussonius prinsii (Davoei Zone), Biscutum novum, Biscutum grande and Biscutum finchii (Stokesi Zone) are slightly difficult to calibrate against ammonite zones.

Introduction

After first appearing in the Late Triassic, the calcareous nannoplankton became a significant component of phytoplankton in the Early Jurassic and their skeletal remains are one of the main constituents of Mesozoic and Cenozoic marine carbonate sediments (Bown et al. 1992). In the Hettangian-Sinemurian, the appearance of the genera Schizosphaerella, Parhabdolithus, Crepidolithus Mitrolithus took place. During the Pliensbachian, the genera Similiscutum, Bussonius, Biscutum and Lotharingius first appeared and became important assemblage components. These evolutionary events provides a succession of age-diagnostic nannobiohorizons, that includes, amongst others, the first occurrences of Similiscutum cruciulus, Biscutum novum, Bussonius prinsii, Biscutum dubium, Biscutum finchii, Lotharingius hauffii and Lotharingius sigillatus and the last occurrences of Crepidolithus pliensbachiensis, Parhabdolithus robustus and Parhabdolithus liasicus liasicus (de Kaenel et al.

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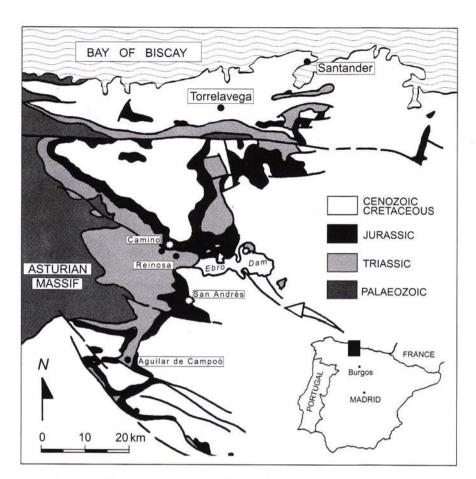


Fig. 1 - Geological sketch of Basque-Cantabrian area and location (white asterisks) of the Camino and San Andrés sections (simplified from Robles et al. 1988).

1996; Bown & Cooper 1998; Mattioli & Erba 1999).

Unfortunately, some of these events are not yet well calibrated to the ammonite biostratigraphy because of either the miscalibration of the collected samples with respect to the ammonite zones or the absence of a refined ammonite biostratigraphy. The different placements of nannobiohorizons by various authors, when they are not related to diachroneity or to an incomplete palaeontological and/or lithostratigraphic record, could be also due to sample spacing or reworking. Nevertheless, many authors agree to place both the appearance of the radiate two-shield placoliths in the lower Carixian and the major radiation of the placolith coccoliths in the lower Domerian. Furthermore, the first occurrences of Similiscutum cruciulus, Biscutum novum, Biscutum finchii and Lotharingius hauffii seem to be the main relevant Pliensbachian nannobiohorizons utilized in both Boreal and Tethyan sections. On the other hand, the precise order and the calibration of other proposed events remain problematic since they are utilized only in some areas or have been recognized only by some authors (see tab. III of de Kaenel et al. 1996; fig. 4 of Bown & Cooper 1998, and figs. 6-10 of Mattioli & Erba 1999). It is not excluded that some discrepancies could be related to paleoprovinciality.

Up to now Early Jurassic calcareous nannofossils have been investigated in Great Britain (Prins 1969; Barnard & Hay 1974; Hamilton 1982; Crux 1987; Bown 1987; Bown et al. 1988), Germany (Prins 1969; Crux 1984; Bown 1987; Bown et al. 1988), Northern France (Prins 1969; Barnard & Hay 1974; Bown 1987; Bown et al. 1988), Southern France (Bown 1987; Erba 1990; Lozar 1995; Mattioli & Erba 1999), Switzerland (de Kaenel in de Kaenel et al. 1996), Italy (Cobianchi 1992; Reale et al. 1992; Lozar 1995; Mattioli & Erba 1999), Portugal (Hamilton 1977, 1979; Bown 1987; de Kaenel & Bergen 1993; Bergen in de Kaenel et al. 1996) and Morocco (de Kaenel, in de Kaenel et al. 1996). In addition, Early Jurassic calcareous nannofossils from sediments drilled at Site 547B of DSDP Leg 79 on the northwest African margin of Morocco have been also studied (Wiegand 1984; Bown 1987; de Kaenel & Bergen 1993).

In Spain, calcareous nannofossils have been recently investigated in some Toarcian-Aalenian successions cropping out in the Iberian Range (Central Spain) and Basque-Cantabrian area (Northern Spain). In the Iberian Range, the studied sections are Almonacid de la Cuba (Comas-Rengifo et al. 1999), La Amunia de Doña Godina and Rambla del Salto (Perilli 2000a), and Fuentelsaz (Perilli 1999). In the Basque-Cantabrian area, the sampled sections are Tudanca and Santotis (Perilli & Comas-Rengifo in progress), Camino and San Andrés. The lower and middle Toarcian calcareous nannofossils of Camino and San Andrés have been already studied and the results have been recently published (Perilli 2000b). This paper is a result of the detailed investigation on calcareous nannofossils of the Pliensbachian succession cropping out at Camino and San Andrés, in

order to calibrate the main assemblage composition changes and the succession of the calcareous nannofossil events against ammonite zones.

Since in the majority of quoted papers the use of Carixian (= Lower Pliensbachian) and Domerian (= Upper Pliensbachian) is common, also in this work they are still preferred.

Geological setting

Post-Hercynian evolution of the Basque-Cantabrian area is linked to the geodynamic evolution of the North Atlantic domain (Ziegler 1989 for a concise summary). The first extensional Permo-Triassic rift pulse involved the western margin of the European and Iberian Plates (Masson & Miles 1986; Rat 1988; Hiscott et al. 1990). As recorded in other basins on both sides of the proto-Atlantic region, this episode was followed by a slowly progressive and essentially thermal subsidence that, without significant tectonic activity, gave rise to the Early Jurassic transgressive sedimentation (Wilson 1975). At that time, the Basque-Cantabrian area was part of an extensive epireic sea, which covered large parts of Western Europe and the Iberian margins (Quesada & Robles 1995). As supported by paleontological data (Braga et al. 1988; Comas-Rengifo et al. 1988; Fernández-López et al. 1988) and figured in paleogeographic maps (Yilmaz et al. 1996, Olivet 1990), during the Early Jurassic the Basque-Cantabrian area was a sector of the southern part of Boreal realm, temporarily connected with the Tethys.

Broken by a series of discontinuities that bound different tectono-sedimentary units (Braga et al. 1988), the Lower-Middle Jurassic marine sequence cropping out in the Basque-Cantabrian area is extensively exposed along the border of the Paleozoic Asturian Massif (Fig. 1). The Lower Jurassic portion comprises probably Rhaetian to lower Sinemurian shallow-marine carbonate ramp sediments, unfortunately without ammonites, and upper Sinemurian-Toarcian hemipelagic ramp deposits, with a good ammonite contents and the presence of euxinic facies, deposited in anoxic troughs (Braga et al. 1988; Comas-Rengifo et al. 1988; Robles et al. 1988; Quesada et al. 1995 and ref. therein).

Based on lithostratigraphic features, the upper Sinemurian-Toarcian succession can be divided into three units. The 10-90 m thick upper Sinemurian carbonate unit is made up of limestone (mudstone and packstone) with thin intercalations of marlstone and marly limestone. The overlying 30-100 m thick Pliensbachian unit, mainly consists of marly and marly limestone alternations, with lower Carixian and lower Domerian intercalations of both organic-rich marlstone and black shale, and a upper Domerian marly limestone bioclastic member. It grades into the 60-66 m thick

Toarcian unit, that is a regular marlstone and limestone alternation, characterized by a thin intercalation of organic-rich sediments in its lower portion and the progressive thickness reduction of the marlstone towards the Toarcian/Aalenian boundary.

Location and lithostratigraphy of the studied sections

The investigated composite Camino and San Andrés sections are located in the Reinosa area, 70 Km S of Santander (Perilli 2000b). Unfortunately, the lowest portion of Camino section (4° 10' 00" W and 43° 01' 25" N; sheet n° 83 "Reinosa" of the Mapa Geológico de España), discontinuously crops out westwards and within the Camino village, whereas the largest part of the section is well-exposed east of the village (3.5 Km NE of Reinosa). Both parts of the San Andrés section (4° 11' 50" W and 42° 54' 30" N; sheet n° 108 "Las Rozas" of the Mapa Geológico de España) lie along the Puerto de Pozazal-San Andrés road (1 Km W of San Andrés village, 10 Km SE of Reinosa).

Early references to the Jurassic sedimentary succession of the Reinosa area can be found in Dahm (1965), Ramírez del Pozo (1971a, 1971b), Meléndez Hevia (1976) and Carreras et al. (1978). Later, Braga et al. (1985) described the Pliensbachian deposits exposed at Camino and its ammonite content, and Braga et al. (1988) documented the stratigraphy and ammonite biostratigraphy of the Lower and Middle Lias succession, outlining the sedimentary evolution of the southwestern sector of the Basque-Cantabrian area. References to lithostratigraphy and organic-rich deposits of the "Marine Jurassic Succession" cropping out in the Basque-Cantabrian area can also be found in Robles et al. (1988), Quesada et al. (1991, 1993) and Quesada & Robles (1995).

Camino section

In the Camino area, the 283 m thick Hettangianlower Sinemurian shallow carbonate ramp deposits grade into 212 m of upper Sinemurian-Pliensbachian hemipelagic ramp deposits (Braga et al. 1988; Quesada et al. 1993).

The Pliensbachian portion (Fig. 2), corresponding to the L-R Units of Braga et al. (1988), is mainly composed of a regular alternation of grey to dark grey limestone (mudstone and skeletal wackestone) and marlstone, with a moderate percentage of organic matter (the TOC value ranges between 0.54 and 1.48% t.w.), strong bioturbation and abundant fossil contents, chiefly represented by benthic organisms, that suggest aerobic environment.

Part of Unit L (Jamesoni Zone), Unit M (from the upper part of the Ibex Zone to the lowermost part of the

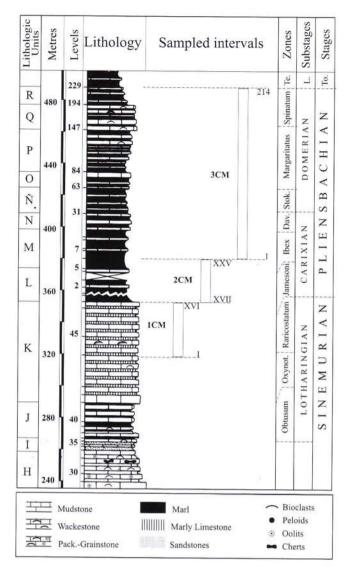


Fig. 2 - Lithostratigraphy of the upper Sinemurian-Pliensbachian succession cropping out at Camino section (slightly modified from Comas-Rengifo et al. 1988) and sampled intervals (1CM, 2CM, 3CM). The position of the samples 1CM I-XVI and 2CM XVII-XXIII is reported in Fig. 4, and the position of the samples 3CM 1-214 are reported in Fig. 6; due to the scale of the figure, the black shale are not reported. Abbreviations: Oxynot.=Oxynotum; Dav.=Davoei; Stok.=Stokesi; Te.=Tenuicostatum; L.=Lower; To.=Toarcian.

Davoei Zone) and the lower part of Unit P (lower part of the Margaritatus Zone) consist of laminated black shale and dark grey to black organic marlstone with thin intercalations of dark grey limestone (mudstone or skeletal wackestone). These lithologies are very rich in organic matter (TOC ranges from 1.62 and 4.8% t.w.) and are characterized by scarce fossil contents, represented by ammonites, belemnites and thin shell bivalves, with subordinated foraminifers and ostracods; these features indicate a benthic environment ranging from anaerobic to dysaerobic condition.

The upper part of the Domerian, corresponding to Units Q and R (Spinatum Zone), is chiefly made up of

bioclastic limestone (skeletal wackestone) intercalated with grey to dark grey marlstone with a low organic matter contents (TOC value ranges between 0.47 and 0.80 % t.w.), moderate to strong bioturbation, and rich benthic and nektonic assemblages, that support aerobic conditions through the water column.

San Andrés section

Never described before, the Pliensbachian succession of the San Andrés composite section is very similar to the coeval portion cropping out at Camino and is characterized by the occurrence of the same three lithological units previously described. Divided into 7 lithologic units (from A to G), the 90 m thick San Andrés succession comprises two portions: the lower portion ranges from Davoei Zone to the Margaritatus/Spinatum Zone boundary whilst the upper portion is entirely within the Spinatum Zone (Comas-Rengifo & Perilli in progress).

As recognized in the Camino sections, the Pliensbachian mainly consists of a regular alternation of grey to dark grey limestone and grey to dark grey marlstone with a low percentage of organic matter (TOC value ranges between 0.45 and 1.12% t.w.). The laminated black shale and dark grey to black organic-rich marlstone with an high organic matter content (TOC value ranges between 1.54 and 3.65% t.w.) characterize the upper part of the Unit C and the overlying lowermost portion of Unit D (Margaritatus Zone). Also at San Andrés, the upper part of the Domerian succession is represented by a bioclastic limestone member, chiefly consisting of limestone (mudstone and skeletal wackstone) and grey to dark grey marlstone with a low organic matter content (TOC value below 0.80% t.w.).

Materials and methods

In the investigated sections, 312 samples have been collected usually every 50-100 cm; 138 samples at Camino and 174 at San Andrés. The sampled lithologies are mainly marlstone and marly limestone. At Camino, 26 samples were discontinuously collected from the upper part of Raricostatum (cropping out westwards of the village) and the Jamesoni Zone (outcropping in the village), whilst the other closely-spaced and continuous sampling belong to the Ibex, Davoei, Stokesi, Margaritatus and Spinatum Zones. At San Andrés, the lower set of 93 samples belong to the Davoei, Stokesi and Margaritatus Zones, whilst the upper set of 48 samples have been collected from the uppermost part of the Margaritatus and Spinatum Zones. According to Braga et al. (1983) the adopted ammonite zones are well calibrated to Tethyan ammonite zones of the Betic Ranges (Fig. 3)

Simple smear slides were prepared as homogeneously as possible to get comparable sediment density on different slides. Neither centrifugation nor ultra-

It	periar	Range	Betic Ra	inges	
Sub- stage	Zones	Subzones	Subzones	Zones	Sub- stage
ian	Spinatum	Hawskerense	Elisa	Ema- ciatum	ian
ach	Spin	Solare	Solare Levidorsatum	5	achi
Jpper Pliensbachian	ga- us	Gibbosus	Meneghinii Accuratum	Algovianum	Pliensbachian
Pli	Marga- ritatus	Subnodosus	Bertrandi	Algov	Plie
20			Ragazzonii	-	
bbe	iesi	Celebratum	Cornacaldense	Lavinia- num	Upper
D C	Stokesi	Monestieri	Portisi	Lavin	5 -? -
J		Figulinum		е .	120
Pliensbachian	Davoei	Capricornus		Dilectum	Pliensbachian
bac		Maculatum			sac
sus		Luridum			sus
P1i(lbex	Valdani		-?-	Plie
		Masseanum		Demonense	
Lower	, E	Jamesoni			ower
Γ	Jamesoni	Brevispina	=	Aenigma-	Γ
	J.	Taylori		Aenign	

Fig. 3 - Correlation between ammonite zones and subzones utilized in the Iberian Range (central Spain) and Betic Ranges (southern Spain) as proposed by Braga et al. (1983).

sound was applied, in order to retain the original ratio between calcareous nannofossils and other components (e.g., micarbs, large carbonate fragments, quartz, micas, etc.). In order to obtain a uniform rippled distribution, a small amount of sediment was scraped and then smeared on a cover glass, dried on a hot plate, and permanently mounted on a microscope slide with Permount.

Semiquantitative analysis was performed using a Leitz light microscope at 1250 magnification. For each smear slide at least 10 complete longitudinal random transverses were analyzed (1 transverse = 170 fields of view). In order to check for the presence of rare or very rare taxa, in some smear slides more than 2000 fields of view have been observed.

Calcareous nannofossil assemblages

The majority of the samples, including those collected from the organic-rich intervals, yield common,

moderately preserved and relatively diverse assemblages, whereas the limestones usually provide rare and poorly preserved assemblages. Totally, 11 genera and 23 species have been recognized (see Appendix 1).

In the Camino section, the first fossiliferous samples, from the uppermost part of the Raricostatum Zone and the lowermost part of the Jamesoni Zone, are characterized by the exclusive presence of Schizosphaerella spp. The assemblages from the middle part of the Jamesoni Zone are still scarce but include, along with Schizosphaerella spp., extremely rare specimens of S. avitum, S. cruciulus, C. crassus, C. jansae, P. liasicus distinctus and P. liasicus liasicus. However, the samples from the upper part of the Jamesoni and the overlying Ibex Zones provide nicely preserved and diverse assemblages, characterized by the frequent occurrence of Schizosphaerella spp., C. crassus, P. liasicus distinctus, P. liasicus liasicus, S. avitum and S. cruciulus, along with extremely rare specimens of C. jansae, C. cavus, C. granulatus, Crepidolithus aff. C. crassus, C. primulus, M. lenticularis and T. patulus. Doubtless, the appearance and the sharp increase in abundance of the genus Similiscutum spp. represent the first significant composition change in Pliensbachian assemblages.

Always dominated by Similiscutum, Crepidolithus and Parhabdolithus, the nannofloras of the Davoei Zone also include extremely rare specimens of B. dubium, M. lenticularis and M. elegans. From the upper part of this zone, the size of Similiscutum slightly increases and Bussonius aff. B. prinsii and B. prinsii first appear, whilst the first specimens of B. novum, B. grande and B. finchii are observed in the overlying Stokesi Zone. Unfortunately, due to the low abundance and discontinuous occurrence of B. dubium, B. prinsii, B. novum, B. grande and B. finchii the precise order of their appearances is not yet precisely dated with respect to the ammonite zones.

At the Stokesi/Margaritatus Zone boundary, another significant assemblage composition change took place. It is related to the sharp increase in abundance of C. jansae, the first appearance of rare specimens of L. barozii and L. bauffii, and the notable abundance decrease of the genera Similiscutum and Crepidolithus in the lower part of the Margaritatus Zone. Although the abundance of genera Lotharingius and Biscutum increases in this zone, Schizosphaerella spp. and C. jansae frequently represent the bulk of the assemblages. With a sharp abundance increase of L. hauffii across the Margaritatus/Spinatum Zone boundary, and the further increase of B. novum in the lower part of the Spinatum Zone, the assemblage composition changes significantly again. Hence, the main constituents of the upper Domerian assemblages are Schizosphaerella spp., C. jansae, L. hauffii and B. novum, whilst the genera Crepidolithus, Parhabdolithus and Similiscutum are reduced. The genus Bussonius is rare to extremely rare and dis-

SUBSTAGE	ZONES	SAMPLES	Abundance	Preservation	Schizosphaerella spp.	C. jansae	M. lenticularis	P. liasicus distinctus	P. liasicus liasicus	C. primulus	T. patulus	Crepidolithus spp.	C. crassus	Crepidolithus aff. C. crassus	C. cavus	C. granulatus	S. avitum	S. cruciulus	Calyculus spp.	B. dubium	M. elegans	Bussonius aff. B. prinsii	B. prinsii	B. novum	B. grande	B. finchii
		3CM 65	R	В	R								VR				R					VR				VR
		3CM 64	С	М	С	F	VR		F		VR	F	F	R	R		F	F			VR	VR	VR	VR		VR
		3CM 62T	F	В	F	VR		VR	F						VR		F	F				R	VR	VR		1
-		3CM 62B	С	М	R	VR		R	R			R	R		VR	VR	С	С			_	VR		VR	R	VR
		3CM 60T	С	М		VR		R	F		R				VR	VR	С	F		VR		R	VR	R	R	VR
		3CM 60	С	М	С	R			R			R	F	R	VR		С	F	VR			R	VR		-	
		3CM 60B	С	М		VR		R	R		R	С	F				С	С		R		VR	VR		R	_
		3CM 58T	С	М	R							F	F				С	F		VR					F	_
z		3CM 58	С	М								С	F				Α	F	VR						F	
		3CM 58B	С	М	F	VR			R			С	F	R		VR	A	С	VR			VR	VR			
A	-	3CM 56T	F	М	F	R		VR	R	VR	VR	R	F	VR	VR	VR	С	С				R	VR		R	
_	S	3CM 56B	С	М	R			VR	R			F	F		VR	VR	С	R				VR				
œ	ш	3CM 54P	F	М	R	VR		VR	R	VR	R	F	F	R		VR	С	F		VR		R		VR	VR	
-	¥	3CM 52T	С	М	R	VR		R	R			F	С	R	VR	VR	C	С		VR					VR	_
ш	0	3CM 52B	F	В	R		VR						С	R			F	R				_				
Σ		3CM 50B	С	М	С	VR		R	R	VR		8	F			R	С	F		VR		R	VR			-
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۵		3CM 46	F	В	-		_			-		F	С		-		F	R			-					-
		3CM 44	C	М	F	VR	-	VR	VR			С	С	VR	-	VR	С	C	VR	VR		VR	VK	VR		-
		3CM 40	C	M	С	VR			F			С	F C	R		VR	C	F							-	-
		3CM 38N 3CM 38	F	B M	F	VR VR	200	VR	R		VR	С	С	R	VR	VR	C	C	VR	VR		VR	VR			
		3CM 36P	F	M	R	VIX	-	VIX	R		VIX	С	F	R	VR	VIX	F	R	VR	***		VR	VR	_	-	-
		3CM 36B	C	M	F		-		- 1			С	C	R	***	-	R	R		1		•	***			-
		3CM 35	R	В	R					-			VR				R								-	
		3CM 34	С	М	F	R	VR	R	F			F	С	F	R	VR	F	R	VR	VR	VR	VR	VR			T
		3CM 34B	С	М	F		342365	VR	18-1			F	С	R			F						•		-	Т
		3CM 32	F	М	F			VR	R		VR	R	F	100		VR	F	F	-	VR		VR	VR	3.6	1000	T
		3CM 30	С	М	F		-		F				С		VR		С	R				VR	VR	1 (2)		Г
		3CM 29	R	В	F			F	F			R	VR			VR										
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	ш	3CM 28	С	М	F	VR		VR	F	VR	VR	С	С	R	VR	VR	F	R	VR	VR	VR					
	o	3CM 28B	C	М	R			R	F			С	С	R	VR	VR	С	F		VR	VR					
Tires.	>	3CM 26P	F	В		VR		VR	F	VR		F	F	R		VR	F	R		VR						
z	-24	3CM 24	С	М	F			VR	F				F				С	R								
×	4	3CM 20	F	В	R			R	F				С									1				
_	۵	3CM 18	С	М				VR	F			С	С	R		VR	Α	R								
		3CM 16P	С	М				R	F			F	F		VR	VR	Α	R								
×		3CM 12P	С	М	R		-	R	F	VR		VR			VR		С	R	VR							L
-		3CM 10	С	М				VR	F	VR		С	С	R	VR		Α	F			_			_	_	_
œ		3CM 8T	С	М	F	VR		F	F	VR		С	F		VR		С	R	VR					_	_	L
-		3CM 8TP	C	M	F	VR		F	F	VR	VR	С	R	F	VR	VR	С	F								1
4		3CM 8B	С	М	С	VR	+	F	F				R			VR	-					_		-	L	-
O	×	3CM 7P	F	М	F	VR		F	F		VR	-	1	VR	-	VR	-	F			-	_		-	-	
	ш	3CM 6P	F	В	F		-	VR	11.50			R	R		VR		F	R	VR					-	-	-
		3CM 4T	F	В			1	R	R	VR			VR				С	F	-				-		-	
	00	3CM 4P	R	В	VR			R	F			R						-				1			-	
	-	3CM 4B	F	M	C		1		R				VR		1		C	R			1	1	1			
	-	Service Control		101	-	-	+	-	+	-	-				-	-		-	-	+	+-	+	+-	-	+	
		3CM 3 3CM 2	F	M	C	VR			C		VR	F	F	R		VR	F	R	VR		Ľ			F		

◀ Tab. I

Range chart of the samples 3CM 1P-8T (Ibex Zone), 3CM 10-32 (Davoei Zone) and 3CM 34B-65 (Stokesi Zone) collected from the lower/middle portion of the Camino section. Assemblage abundance classes. A = abundant (10-15 specimens in each field of view); C = common (1-10 specimen/s in 1 field of view); F = few (1 specimen in 1-10 field/s of view); R = rare (1 specimen in 11-100 fields of view); VR = very rare (1 specimen >101 fields of view). Species abundance classes. A = abundant (1-5 specimens in each field of view); C = common (1 specimen/s in 2-10 fields of view); F = few (1 specimen in 11-30 fields of view); R = rare (1 specimen in 31-100 fields of view); VR = very rare (1 specimen >101 fields of view). Preservation classes. G = good (the majority of the specimens show their diagnostic characteristic and only some of them are slightly etched and/or overgrown); M = moderate (the majority of the specimens are recognizable, even if part of them are etched and/or overgrown and or fragmented); B = bad (the majority of the specimens are heavily etched and/or overgrown and/or fragmented and the identification of the species is sometimes difficult); VB = very bad (only few specimens are recognizable).

Tab. II ▶

Range chart of the samples 3CM 70-151 (Margaritatus Zone), 3CM 154-214P (Spinatum Zone) collected from the middle/upper portion of the Camino section (for simbols see Tab. I).

SUBSTAGE	ZONES	SAMPLES	Abundance	Preservation	Schizosphaerella spp.	C. jansae	M. lenticularis	P. liasicus distinctus	P. liasicus liasicus	T. patulus	Crepidolithus spp.	C. crassus	Crepidolithus aff. C. crassus	C. cavus	C. granulatus	S. avitum	S. cruciulus	Calyculus spp.	M. elegans	Bussonius aff. B. prinsii	B. prinsii	B. novum	B. grande	B. finchii	L. barozii	L. hauffii	L. sigillatus	L. umbriensis	B. intermedium
		3CM 214P	F	М	R	С			R	F				VR		VR	F	VR				F	VR	VR	R	F		VR	R
		3CM 210P	F	М	R	С			R	F				VR			VR	VR			R	F	VR		F	С		VR	VF
		3CM 208	С	М	F	С			R	R						VR						F			R	F	VR	VR	
		3CM 204	С	М	F	F			R			VR					VR			VR	VR	F	VR		F	С	VR	R	
		3CM 202P	R	В	_			_				_							_			R	_		VR	R			
		3CM 198	R	В	C	R	-		-	-	_	_	-	VR							_	_	_	VR	_		_		_
	Σ	3CM 196	C	В	C	C				F	-	R	-			-	VR	VR		VR	R	F	R	R	F	С		R	-
	-	3CM 194	C	м	c	F	-	R	F	- 1	1	R	-					VIX			VR	R	VR	R	F	С			-
	>	3CM 194P 3CM 190P	С	М	С	c	-		*:	-		- 1.									VIC	- 1	VIV	15	R	R		-	-
	-	3CM 186	С	М	A	С			R			R				VR		VR				R	VR	R	F	С		R	VF
	-	3CM 184	С	М	Α	A			R			R				VR	VR			VR		R	VR	R	R	F	-	VR	
	4	3CM 182	С	М	F	F		R	VR	F		VR										R	VR	R	R	С		VR	
	z	3CM 182P	F	М	R	F						R				VR	R	VR			VR	F		F	R	F			
	-	3CM 179	F	В	F		- 200						Carrier of									100							
	۵.	3CM 178	С	В	С	VR			R			VR		VR											R				
	11111	3CM 176P	С	М	С				F	F		R												R	F	С			
	S	3CM 174	С	G	A	F	-		F	F	F	F	VR	VR		-203	lone.			R	VR	F	VR	F	F	С		VR	
		3CM 172	C F	M	С	C		-	F	F	_	F			_	-		VR		VR		F		F	F	F			-
z		3CM 170	C	M	C F	F C	-	R	R VR	C			-	-	-	-	VR	VR	_	VR	VP	F	VD	R	F	R		VR	-
-		3CM 168 3CM 166P	F	M	F	C	-	R	R	F			-	VR	_		VK	VR		VR	VR VR	F	VR	R	F	C	-	VK	-
		3CM 161	F	В	C	_			R	Ė				***				VIX		VIX	VIV	-/:-		VIX	18	- IX		-	-
⋖		3CM 160	С	М	С	С			F	F	R	F		VR						VR	VR	VR	VR	VR	R	С	VR	-	
71		3CM 154	С	М	С	F			F	F		R		VR				VR		1000	R	VR	VR	F	F	С	VR		
_		3CM 151	С	В	С				VR	VR							I (5,500			
_		3CM 150	F	В	С	F			R	VR	F	F	R												VR	VR			
		3CM 148	С	М	С	F		С	F	F	R	F	R	VR		R	R					R	F	VR	R	F			
œ		3CM 146T	С	М	С	F			С	F		R	R	R		R				VR	VR	R	F	VR	F	F			
		3CM 144	С	М	С	С		R	С	R	R	R		VR	VR				COL			VR	F	VR	R	R			
ш		3CM 142	С	М	С	F		F	R	F	F	F	_	VR	VR	VR	R				1		VR	R	VR	F			
-		3CM 140	С	M	A	F					_										-				VR	VR			_
		3CM 139	F C	B M	C	F	-	D	_	-	R			VD	VO	VR	-	VD	_		-			_	VR			-	
Σ	s	3CM 138	С	М	C	C	-	R	F C	F	R	R	_	VR VR	VR	R	V/D	VR VR				VR VR	-	F	F	VR	-		-
		3CM 136 3CM 134	С	В	C	c		,,	F	VIX	F	R		¥.15		ix	VIX	VIX				VIC		R	R	VR			
0	>	3CM 132	С	М	C	C	VR		F			VR		***		-	R	-	VR			-		R	R	VR			
<u> </u>	-	3CM 129	F	В	F	F			VR		VR	VR	VR			-							VR				-	-	
	4	3CM 128P	С	М	F	С		-	R														VR	VR	VR				
٥		3CM 126	С	М		С	R		F		R	F		VR			R	VR			VR		VR	R	F				
	۰	3CM 126	С	М	С	С	F	F	F	F	С	F	R	R	VR	VR	VR	-77	R	VR		VR	R	VR	VR	VR			
	-	3CM 122	С	М	F	F		1		F	F	F	С						VR				R						
	œ	3CM 117	F	В	F	F	VR		R		F	F	R									VR		VR					
	4	3CM 116	С	M	С	R	VR	R	F	F	Α	F		R	R		R			VR		VR		R		VR			-
	1	3CM 111	F	В	C	-	VID	-	-			1/5	1/15	VR		-		100	- 4	1/5		1.5	VR	_	_				
	9	3CM 110	С	M	A	C	VR	F	C F	R	R	VR F	VR VR	VR	VR	R	R	VR		VR	100	-	VR	F VP	R	VR			-
	~	3CM 104 3CM 100P	F	M	R	R	-		-	K	VR	R	VR		VK	R	R	VR				VR		VR	VR	VR	-		-
		3CM 100P	c	M	C	R	VR		R	VR	C	C	VR	VR		C	F	-	VR	VR	VR	VR	VR			2007		110,000	
	4	3CM 95	R	В					2321	12.75		R			- 8	F	R	200		4.0	2.1								-
	Σ	3CM 93	F	В		R	1.00		R		С	С						1 7	VR			VR							-
		3CM 92	С	М	С	F		R	F	R	С	F		R	VR	С	С		R	VR		R		VR					100
		3CM 83	F	В	F	R			VR																				
		3CM 82	С	М	С	F	R		R			R				F	R		VR			VR			R	VR			
		3CM 77	С	В	С	R	R	VR	F	R	R					R	F		VR			R		VR	VR	VR			
		3CM 76P	С	М	_	VR			R	R	R	F	VR	100000		С	С		77.7	VR	[]								
- 1		3CM 76	F	М	С	R	VR		R		R			VR		F	R		VR	VR		VR			VR				
- 1			~	M	F	R	1	1	F	1 1	Α	C		VR	VR	C	C	VR	VR			VR		VR					
		3CM 72 3CM 71	C	В	C	F	-	VR	F	R	Α	С	F		VR	-	1000	-				-		VR	-	-	-	-	

STAGES	ZONES	LITHOILOGIC UNIT	SAMPLES	Lithology	Abundance	Preservation	Schizosphaerella spp.	Crepidolithus crassus	Calcivascularis jansae	Similiscutum avitum	Similiscutum cruciulus	Parhabdolithus I. distincus	Parhabdolithus I. liassicus
Z	<u>0</u>	Μ	XXVI		С	М	F	VR	VR	F	F	VR	
Ī			XXV		C	M	F	VR	VR	F	R	R	
Ö			XXIV		С	Μ	F	R		F	F	R	R
PLIENSBACHIAN	Jamesoni	L	XXIII		CR	M B	C F	F VR		R VR	VR	VR	VR
PLIE	Jan	,L	XXI XX XIX	~~~	R F R	B M B	VR C F	VR	VR	VR			
			XVIII		R	B B	VR VR						
z			XVI XV		В	arre	en						
SINEMURIAN	Raricostatum	K	XIV XIII XII XI XI X IX VIII		VR VR VR VR VR	B B B B	VR VR VR VR						
SINE	Raric		VII V V III II I		В	arre	en						

Fig. 4 - Lithostratigraphy of the Sinemurian-Pliensbachian boundary cropping out at Camino section (enlarged from Fig. 2); position of the samples 1CM I-XVI (collected westward of the village) and 2CM XVII-XXVI (collected in the village); abundance and preservation degree of the nannofossil assemblages and relative abundance of the species recognized (for assemblages abundance, preservation and relative abundance classes see Tab. I).

PLATE 1

All micrographs crossed nicols, approximately X4500 magnification

Fig. 1	- Lotharingius barozii (sample 174 3CM, Spinatum Zone, Camino section)
Fig. 2	- Lotharingius barozii (sample 76 3CM, Stokesi Zone, Camino section)
Fig. 3	- Lotharingius hauffii (sample 77 3CM, Stokesi Zone, Camino section)
Fig. 4	- Lotharingius hauffii (sample 77 3CM, Margaritatus Zone, Camino section)
Fig. 5	- Calcivascularis jansae (sample 64 3CM, Margaritatus Zone, Camino section)
Fig. 6	- Calcivascularis jansae (sample 64 3CM, Stokesi Zone, Camino section)
Fig. 7	- Calcivascularis jansae (sample 53 ISAD, Margaritatus Zone, San Andrés section)
Fig. 8	- Lotharingius hauffii (sample 53 ISAD, Margaritatus Zone, San Andrés section)
Fig. 9	- Bussonius prinsii (sample 154 3CM, Spinatum Zone, Camino section)
Fig. 10	- Bussonius prinsii (sample 28 1SAD, Stokesi Zone, San Andrés section)
Fig. 11	- Biscutum grande (sample 148 3CM, Margaritatus Zone, Camino section)
Fig. 12	- Biscutum finchii (sample 142 3CM, Margaritatus Zone, Camino section)
Fig. 13	- Tubirhabdus patulus (sample 154 3CM, Spinatum Zone, Camino section)
Fig. 14	- Parhabdolithus liasicus distinctus (sample 70 3CM, Margaritatus Zone, Camino section)
Fig. 15	- Parhabdolithus liasicus distinctus (sample 56 3CM, Stokesi Zone, Camino section)
Fig. 16	- Calyculus spp. (sample 82 3CM, Margaritatus Zone, Camino section)
Fig. 17	- Crepidolitus crassus (sample 110 3CM, Margaritatus Zone, Camino section)
Fig. 18	- Crepidolithus granulatus (sample 22 1SAD, Davoei Zone, San Andrés section)
Fig. 19	- Crepidolithus granulatus (sample 60 3CM, Stokesi Zone, Camino section)
Fig. 20	- Mitrolitus lenticularis (sample 64.2 1SAD, Margaritatus Zone, San Andrés section)
Fig. 21	- Similiscutum avitum (sample 4 3CM, Jamesoni Zone, Camino section)
Fig. 22	- Similiscutum avitum (sample 4 3CM, Jamesoni Zone, Camino section)
Fig. 23	- Similiscutum cruciulus (sample 4 3CM, Jamesoni Zone, Camino section)
Fig. 24	- Similiscutum cruciulus (sample 4 3CM, Jamesoni Zone, Camino section)



SUBSTAGES	ZONES	SAMPLES	Abundance	Preservation	Schizosphaerella spp.	C. jansae	M. lenticularis	P. liasicus distinctus	P. liasicus liasicus	C. primulus	T. patulus	Crepidolithus spp.	C. crassus	Crepidolithus aff. C. crassus	C. cavus	C. granulatus	S. avitum	S. cruciulus	Calyculus spp.	M. elegans	Bussonius aff. B. prinsii	B. prinsii	B. dubium	B. novum	B. grande	B. finchii	L. barozii	L. hauffi
		1SAD 52.3	С	М	F	F	VR	VR	F		R	С	С	VR	VR		F	F	VR		R	VR		VR		VR	VR	VR
1		1SAD 52.2	A	М	С	С	R	F	R		F	С	С		R		С	R	-	VR	VR	VR		VR			VR	-
		1SAD 52.1	С	М	F	VR		VR	R			F	R	_	VR	R		VR	R		R	VR			R			-
		1SAD 52B	С	М				F	R			F	R	R	-	VR	С	С	-	-	VR	VR	200	VR	R	1/15		-
i		1SAD 50	С	М	С	VR		VR	F	_	-	F	R	R	R	-	С	R	-	-	R	VR VR	-		R	VR		
1		1SAD 50B	С	М	F	_	_	F	F	-	R	-	F	-	-	-	С	С		-	-	VK	-	-	rs.	-	-	
		1SAD 49	F	В	R	-		VR	VR	-	-	С	R F	-	+	-	R	R	-	+	VR			VR	R	-		-
		1SAD 48T	C	М	С	R	VR	-	R F		-	F	F		R	VR	C	F	VR	-+	R	VR	-	VR	VR		-	1
		1SAD 48	C F	В	С	R	VI	R	R			F	F	-	_	VR	F	F	-		VR	VR	VR		VR	VR		-
	- 6	1SAD 48B	c	м		R		F	F		F	F	C	-		VR	С	F	VR		R	VR	R	R	R	VR		
z	1	1SAD 46	С	м	F	- 11	-	VR	F		Ť			-		-	С	R				VR			VR			
4	1	1SAD 46B 1SAD 44.2	С	В	F		VR		R		\neg	С	С	\neg	VR	VR	С	F	T						VR	VR		
	1	1SAD 44.1	С	м	С							F	R				С	R	\neg									
-	-	1SAD 44C	F	м	F	R		VR	F		R		С		VR	VR	С	F	VR		VR		VR	VR	VR			
	S	1SAD 42N	С	В	С				F			C	С				C	С	VR				2					
œ	ш	1SAD 42	С	м	F	VR	VR	R	VR			F	F			VR	¢	F	VR			VR			VR		1	
		1SAD 40.3	F	В	F							R	R					1										
w	¥	1SAD 40.2	С	М	R	R		F	F		R	F	F		VR	VR	С	F	VR		VR	VR	VR		VR			
5/1	0	1SAD 40.1	С	М	F			VR	R				F		VR		C	F	-		VR				VR	-	-	-
ار	25.0	1SAD 38	С	М	F				R			R	F				С	R	VR		VR	VR	1:5	-	_	-		
Σ	-	1SAD 38B	C	М	F	-		R	12			F	C	_	1.00	100	C	C	1/15		VR R	VR	VR VR	-		-	-	\vdash
	S	1SAD 36	C	М	F			VR	R	_	VR	F	F	F	VR	VR	C	R	VR	-	ĸ	VR	VH			-	-	-
0	3	1SAD 36B	F	В	F	-		- 1	R	-	-	-	F	-	VR	-	c	F	VR			VR	R	VR	-	-	-	+
		1SAD 34	F C	M	F	VR	711-2	R	R	VR	-	С	C	R	VK		c	С	VIC			VR	VR	VIX		-	-	1
٥	3	1SAD 32	c	В	c	VI			F	414		С	C	F			c	C	-		-	VR	***	-			-	+
	1	1SAD 32B	F	м	-	VR	-		-		F	F	F	R	R		F	F			R					-	-	1
		1SAD 30	c	м	-	***		R	R		-	c	c	,,			C	F	VR	·	R	R	R	-				+
		1SAD 28T	c	M	С	VR	R	VR	R			С	C	VR	VR	VR	C	F			R	VR	-			1		+
		1SAD 28 1SAD 28B	c	В	C		R			-	R	F	C	1000	- 1		F	R		VR	VR					_		+
		1SAD 26.1	С	М				R	R			С	С		VR		С	C			VR	VR	VR					
		1SAD 26.1	С	М	С	VR	VR	R	R		R	A	A	R	VR	VR	С	F	VR		R	VR	R					T
		1SAD 26B	С	М	C			R	F			С	С	F	VR	VR	F		VR									
		1SAD 24T	С	М			VR	VR				С	F	R	VR		C	F				R	VR					
	1	1SAD 24B	С	F	F							R	A	A	R	VR	C	С				R	VR					
		1SAD 24	С	м								С	F			VR	A	С			F	VR						╙
		1SAD 22T	С	М	С					VR		С	С	R		VR	F	F	VR		VR	VR		_	_	_	_	\perp
		1SAD 22	С	F	F							F	С	F			VR	-	С		_	_		-	ļ.,.	-	Ļ.,	+
		1SAD 22B	C	М	F				R	VR	VR	С	С	R	R	VR	F	VR	VR		_	-		-	-	-	-	+
	11 3	1SAD 20.3	С	М	С	-			R			С	-	С	VR	-	С	F		_	-	-	-	-	-	-	-	+
		1SAD 20.2	С	М	F	-	-	R	F		VR	C	C	R	R	VR	F	F		\/D	-	-	⊢	+	-	+	+	+-
		1SAD 20.1	С	М	F	VR	1	-	F	VR	VR	F	C	R	R	VR	-	C	VR	VR	-	-	-	1-	-	+	-	+
		1SAD 20B	C	M	F	VR	-	VR	-	-	-	C	C	R	VR	-	F	F	-	VK	-	-	+	-	-	+	+	+
Ų		1SAD 18T	C	M	+			R	F	\vdash	R VR	C	C	R	VR	-	C	VR		-		+	+	+-	-	+	+-	+
z		1SAD 16	R	В	F	-	-	VR		-	VK	-	VR	-	VIC	-	F	F		-	-	1	1	1	-	+	1	+
55		1SAD 15	C	M	-	-	-	VR	-		-	С	C	F	VR		C	c	VR			+	+	1	1	1		1
4		1SAD 14	c	В	+		1	1	F			F	c	R	1		F	F	1	-		1		1	-	1	1	T
	-	1SAD 14B 1SAD 12T	c	M	-	-	1	R	F			C	C	R	VR		C	-						1		T	T	T
-	-	1SAD 121	С	М	-	VR	VR	-	F		VR	-	С	С	R		C	-										
	ш	1\$AD 12B	С	В	-	-			F			C	С	R	VR		С	F										I
×	0	1SAD 10T	c	м	+			R	F			С	С	F			С	R										
	88	1SAD 10	С	М	F			VR	R	VR	1	С	С	С		VR	С	С								-		1
-	>	1SAD 10B	F	В	R				R			F	С		VR	VR	F	VR					L		1		1	
	<	1SAD 8T	С	М					R	1	VR	С	C	+			С	-			-	-	-	-	-	-	-	1
œ	۵	1SAD 8	С	М	-	-	1	R	F	VR	1	A	С	F	VR	VR	+	100	VR		1	-	-		+	1	+	+
	1	1SAD 8B	C	100	100	+		R	R		F	C	C				C	+			-	-	-	-	-	-	-	+
V		1SAD 6.2	C	-	-	-	1	F	F	1	R	C	C	-	VR	-	C	-	-	-	-	-	1	+	-	-	+-	+
-	1	1SAD 6.1	C	-	-	+	-	VR	+	VR	R	R	F	F	R	+	A	-		-	-	+	-	+	+	-	+	+
3270		1SAD 6B	F	В	-	+	-	-	C	-	-	R	1	VR	-	+	C	-	VID	-	-		+	+ 100	+	+		+
٥	1	1SAD 4	C	+	-	-	-	-	F	-	-	C	C	-	VR	+	A	-	VR	-	+	+	+	+	+	+-	+	+
		1SAD 4B	C	+	-	-	+	F	R	+-	R	С	C	+		-	F	F	-	-	+	+	-	+	+	+	+-	+
1		1SAD 3	R	-	-	+	+	-	R	-	-	-	R	-	-	-	C	C	-	-	-	+-	+	+	1	+	+	+
1	11	1 SAD 2 T	F	-	-	-	+	F	VF	+-	R	F	C F	+	-	+	+	+	-	-	+	+	1	+	+	+-	+	+
				B	R		4	R	VF	1		1	F			1			1	-		-	1		1	1	+	-
		1SAD 2M	-	-	-	-	+	-		1				D		VE	E	0										
		1SAD 2B	C	М	+	-	-	R	-	-	╀	F	F	-	+	VR	-	-	-	-	-	+		+	+	+	+	-
			-	M	F			R	F			C R	F	VR	R	-	-	R		VF						+		-

◀ Tab. III

Range chart of the samples 1SAD 1-22T (Davoei Zone), 1SAD 24-52.3 (Stokesi Zone) collected from the lower part of the San Andrés section (for simbols see Tab.I).

Tab. IV ▶

Range chart of the samples 15AD 54-106T (Margaritatus Zone) collected from the middle/upper part of the San Andrés section (for simbols see Tab. I).

SUBSTAGE	ZONES	SAMPLES	O Abundance	Z Preservation	O Schizosphaerella spp.	C. jansae	M. Ienticularis	α P. liasicus distinctus	O P. liasicus liasicus	T. patulus	Crepidolithus spp.	C. crassus	Crepidolithus aff. C. crassi	C. cavus	C. granulatus	S. avitum	S. cruciulus	Calyculus spp.	M. elegans	Bussonius aff. B. prinsii	B. prinsii	B. dubium	B. novum	B. grande	B. finchii	n L. barozii	L. hauffii
		1SAD 106T	С	M	A	R		100	F	F		R		R		-		-	-			VR	R	VR R	C	F	VR
		1SAD 106	C	M	c	F	1	VR	-	C		- EX	H	IX.	VR		-		-	-	-	VIC	K	K	VR	VR	-
		1SAD 106B 1SAD 105	С	M	F	F	-	VR		F	-				***	VR				7763	VR			VR	VR	-	-
		1SAD 103	С		A	R		1								***		-		-	VIX			VIX	VIC	VIX	VI
		1SAD 103	С	M	С	F		VR		-		R					VR							VR			
		1SAD 102	С	М	A	R			R	R		VR		VR			155.77.50										H
		1SAD 101C	С	М	F	F		R	-	R		F					VR		-		VR			VR	VR	R	VR
		1SAD 100B	С	М	Α	Α			R					VR						-				_	VR	R	VR
		1SAD 99	F	В	С	R			VR																		
		1SAD 98C	C	М	С	С		R	F	R		F	R	VR			VR			VR				R	R	F	VR
		1SAD 98	С	М	С	С	VR	R	F	R	FC	F		R	VR	R	F						R	R	F	R	VR
		1SAD 98B	С	М	С	F				F		F							R					VR			
		1SAD 97	C	В	F	С		VR	VR			R						_						VR	VR		
		1SAD 96	A	M	A	A	-	R	F	-	F	F	_	VR	-	VR			VR					F	F	F	
		1SAD 94T	C	M	C	C	F	R	F	R	F	F	R		-		VR	-	R	VR		VR	-	-	R		
		1SAD 94B 1SAD 93	F	В	F	R	14	1		R	-	R	K	- 77		-	VK	-	-				-	-	-		
	S	1SAD 93 1SAD 92T	F	М	C	F	R	R	R	F		R		VR	VR								-		R	R	VR
		1SAD 921	С	В	С	F	F	F	-11	R	С	C		110	VR						VR			VR		1,	***
		1SAD 91	Α	М	A	R	VR	-	R	F	F	F	VR	VR	7.00	R	VR	VR		VR	VR		VR	VR	VR	R	R
z	>	1SAD 90	F	М	F	F		R	F	R	F	С	R				F	VR		VR			VR	VR		R	VR
		1SAD 88	FC	М	F	F		R	VR	R	С	F	R	VR		R	R	VR		R			VR	VR	R	VR	VR
		1SAD 88B	С	В	С	F	R	F		R	С	С			VR										VR		
	-	1SAD 86	С	М	С	С	R	R	F	F	F	F	F			F	R								F	VR	VR
4		1SAD 86B	С	М	С	С	F	F	R		С	С	R				VR	VR	R		VR					VR	
		1SAD 85	F	В	F	VR	1.00	_	R	-	F	F		_	_		VR				VR		70.025	VR			
ı	4	1SAD 84	C	M	С	F C	VR	R	F	F	С	С	VR	VR		VR	VR		VR				VR	VR	R	VR	VR
		1SAD 82	F	M	F	F	R	VR VR	F	R	C	C R	R	VR				-	VR	1/0	VR		VR	R	F	VR	VR
-	-	1SAD 80	F	В	R	R		R	VR	R		VR	-	VA			R		-	VR		VR		VR	F VR	VR	-
	100	1SAD 79 1SAD 78T	A	М	C	A		- 15	R	F	F	F	-	R		VR			-	VR		_	-	VK	R	VR	-
		1SAD 78	С	М	С	С		VR	VR	F	-	F		- 1		*15		-	-	VIX				-	VR	VI	73-
œ		1SAD 78B	С	М	С	F	VR	F	R	R	F	F					VR							F	R		
	-	1SAD 76B	С	М	F	F		R	F		С	С	VR		-	VR	VR							R	VR	VR	VR
3		1SAD 75	С	М	С	С		R		R	F	F					VR						- 10		VR		
3525	œ	1SAD 74C	F	М	F	С			R	R	R	R				R	R							VR	VR		
ш	-	1SAD 74T	С	М	С	F	VR				С	С	R									- 1		VR	VR		
		1SAD 74	С	М	С	С	VR	VR	R	R	С	С	R	VR	VR	R	R		VR				VR	R	R	VR	
	4	1SAD 74B	С	В	С	F	-	VR	_	R	С	С	VR				VR							VR	F		
2		1SAD 73	C	M	C	C		R		R	С	_													VR		
700		1SAD 72T 1SAD 72	C	M	С	С		- K	-	, r	C	C R		-		VR	VD	_	_		_	-	_	-	-	-	VR
	O	1SAD 72	С	М	С	F	VR	-	-		VR	VR				R	R						-73	-	VR	-7-	-
		1SAD 70M	С	М	С	-	VR				C	С	R	-			15	-						VR	VR	-	-
0		1SAD 70B	С	М	C	С	R	R	F		F	F	VR	VR		R	R			VR					R	-	
	2	1SAD 69	Α	М	Α	Α	VR		R	R	С	F	R	VR		R	R						VR	_	F	VR	VR
		1SAD 68C	С	В	С	С					R	R		VR				R		VR							
۵	4	1SAD 68M	R	В	R	R						VR									VR						
		1SAD 68	С	В	С	R					R	R		VR		F	F								R		
		1SAD 67	С	В	С	С	-	1000			F	R															
	Σ	1SAD 66T	C	М	A	F	R	VR	F		F	F		VR		С	R	VR	VR		R				VR		
		1SAD 66M	F	В	F	R	-				_	F	_	VR		R	R						-	772		1.7-	
i		1SAD 66B	С	M	С	F	R	R	R	F	C	F	R	VR VR	VD	C F	F	VR	VD		VR		R	VR	F	VR	11-
		1SAD 64.2 1SAD 64.1	F	M	F	R	15	rx	R	R	VR	VR		VIK	VK	F	F	VR	VR	R	VR R		VR VR		F	VR	VR
		1SAD 64.1 1SAD 62B	F	M	F	R		R			211	VR				R	R	***		K	-0		VIV.		VIT	VIC	
		1SAD 62T	C	М	С	С	VR	1		R		C			VR	(4,900)	VR							VR			-
		1SAD 62	С	М	Α	С	VR	VR	F		С	С				F						-			VR		
		1SAD 60T	С	М	С	R	VR	VR	R		R	R		VR		F	VR		-0		12			VR	12.77	VR	
		1SAD 60B	С	М	С	F	F				R	R	1 2 2			- 1					VR					VR	VR
		1SAD 60	С	М	F	F	VR	R	F	R	F	F	VR	R		R	R	VR	VR	R	VR	VR			VR	R	VR
		1SAD 59	С	М	С	F		R	F							R	F						R	SITE OF		R	R
		1SAD 58B	C	М	С	F	F			- 200	R	R					F	VR			VR			VR		R	
		1SAD 58	С	M	A	R	F	R	F	R						R	R	VR		VR	VR				VR	-	R
		1SAD 56	C	M	C	R	R		R	_		-				C	F		VR	R	VR				VR	F	R
		1SAD 54T	F	M	F	VR	D	R	R	VE	-	R	-	VE		R	F			VR	VR				R	VR	-
			C	M	Α	R	R	VR	F	VR	С	С	_	VR		R	R	-	VR	VR		_				VR	R
		1SAD 54.2 1SAD 54.1	С	M	C	C	F	R	R	VR		F	R	VR							VR		VR		VR	F	

SUBSTAGE	ZONE	SAMPLES	Abundance	Preservation	Schizosphaerella spp.	M. jansae	M. lenticularis	P. liasicus distinctus	P. liasicus liasicus	C. cavus	T. patulus	Crepidolithus spp.	C. crassus	Crepidolithus aff. C. crassus	C. granulatus	S. cruciulus	Calyculus spp.	Bussonius aff. B. prinsii	B. prinsii	B. grande	B. finchii	B. novum	L. barozii	L. hauffii	L. sigillatus	L. umbriensis	B. intermedium
		2SAD 56	С	М	C	F		VR	-			R	R		-500	VR			-	VR	VR	F	F	F	-	R	
		2SAD 56	С	В	С	F			R													F	F	F			
		2SAD 54	F	М	F	F					- 711		R								VR			F			VR
		2SAD 52.	С	М	С	С															R	С	R	С			
		2SAD 52.	F	В	F	F				R	R		R									R	F	R			
		2SAD 50	С	М	С	С				VR	R		R							VR		F	F	С			V.
		2SAD 48	С	М	С	С															R		R	С			VR
z	Σ	2SAD 46	F	М	С	F			F				R			VR						R		С			
		2SAD 44	A	М	Α	A										R					R		R	Α			
		2SAD 42	С	М	С	С					R										F	R	R	С		VR	
4	ם	2SAD 42	С	М	С	F	VR		R				R		VR			VR	VR		R	F	VR	С			
		2SAD 40	С	М	С	С		R	1		F		R								R		R	R			
_		2SAD 40	С	М	F	С				R	F		F		R						R	С	С	Α			
	-	2SAD 38T	С	М	С	С			F									VR	VR		R	R	F	F			
		2SAD 36T	C	М	С	С			F		R		R	VR			VR					F	R	F			
œ	4	2SAD 34	C	М	С	F				F	F		F			R		(,,,)			RF	VR	F	F			
		2SAD 32	С	М	С	С			F	VR			R		18					VR	R	С	R	С			
		2SAD 28	С	М	С	С			С	VR	С	С	F						VR	VR		F	R	С			
ш	z	2SAD 26	С	С	С	С			F		F		F				VR				R	С	R	С			
		2SAD 24	С	М	F	С			F		F		R						VR		VR	FR	1	F			
Σ		2SAD 20	Α	М	С	С			F	VR	F		R							VR		R	VR	F	VR		
-	0.7	2SAD 18	С	М	С	С			F	VR	F						VR				VR	F	F	С	VR		
	1	2SAD16	С	М	F	С			F	VR	F		С							VR	VR		F	С			
0	۵	2SAD 14	С	М	С	C					С	С	F							VR			R				
		2SAD 14	Α	М	Α	С		u.e.	С		R									F	R	VR	F	F			
		2SAD 12	С	М	С	R		R			R										VR	VR					
٥	S	2SAD 12	F	М	С	F			F								VR		VR	VR	F	R		R	VR		
		2SAD 10	Α	М	С	С			F	R	С	F	F		VR		VR			F	F	VR	F	F			
		2SAD 8T	С	М	С	F						2000	F		R								F	F			
		2SAD 6T	С	M	С	R					F		С								VR	VR		1			
		2SAD 4T	С	М		С	F	R	R		F		R	R					VR		F		С	F			
		2SAD 4	Α	М	С	С			F	VR	R	R							VR	VR	VR	VR	F	F			
		2SAD 4B	С	М	С	F			F											VR	R	VR	R	R	VR		
		2SAD 1A	С	М	C	С		The state of	F											VR	VR	VR	VR	VR			

Tab. V - Range chart of the samples 2SAD 1A-56 (Spinatum Zone) collected from the upper part of the San Andrés section (for simbols see Tab. I).

continuous in all the investigated samples. In the samples belonging to the Spinatum Zone of both sections, scattered specimens of *L. umbriensis* and *L. sigillatus* have also been recognized.

Abundance and preservation degree of the assemblages, and relative abundance of the species are reported in Fig. 4, Tabs. I-II (Camino section) and Tabs. III-V (San Andrés Section). Besides, the distribution pattern of some selected taxa is outlined in Fig. 5, and the events recognized in both Camino and San Andrés sections are reported in Fig. 6.

Calcareous nannofossil events

Distinguished as "main" and "others" events, the biohorizons recognized in the Camino and San Andrés sections (Fig. 7) are discussed below. According to Perilli (2000a, 2000b), the "main" events are quite easily recognizable and consistent in both sections, whilst the "other" events must be carefully checked because they are based on taxa with low abundance and discontinuous occurrence, in particular in their initial range.

Main events

FOs of *S. avitum* and *S. cruciulus*. In the Camino section, *S. avitum* appears in the Brevispina Subzone, slightly below the first occurrence of *S. cruciulus*. The relative abundance of both species remarkably increases around the Jamesoni/Ibex Zone boundary and, up to the lower part of the Margaritatus Zone (i.e. Subnodosus Subzone of the Camino section), they represent a large amount of the assemblages.

FO of *L. barozii*. Although the species is rare and scattered in its initial range, the FO of *L. barozii* is nice-

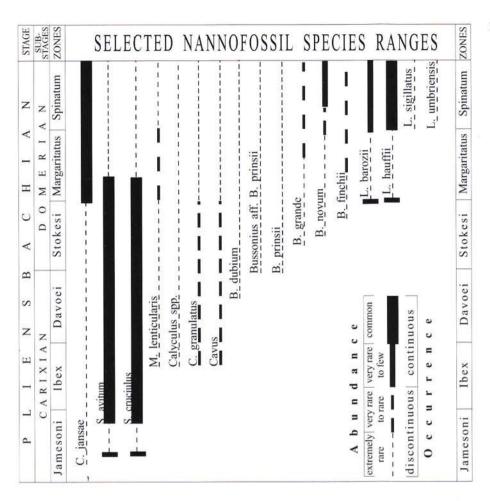


Fig. 5 - Abundance and range of some selected taxa.

ly recognizable slightly below the Stokesi/Margaritatus Zone boundary at San Andrés section and slightly above this boundary (i.e. Subnodosus Subzone) at Camino. In both sections, it nearly coincides with FO of *L. hauffii*. From the upper part of the Margaritatus Zone, *L. barozii* becomes a significant constituent of the upper Domerian assemblages.

FO and FCO of *L. hauffii*. At San Andrés, the FO of *L. hauffii* takes place slightly below the Stokesi/Margaritatus Zone boundary, whilst at Camino it lies slightly above this boundary (i.e. Subnodosus Subzones). Due to the sharp increase in abundance of this taxon, slightly below the Margaritatus/Spinatum Zone boundary (i.e. Gibbosus Subzone) at Camino section and slightly above it at San Andrés, the FCO of *L. hauffii* is a useful and easily recognizable event. It is placed in the lowermost part of the continuous range of *L. hauffii*, in correspondence to the relative abundance increase of the nominate species from very rare to rare/few.

Other events

FO of *B. prinsii*. First occurring around the Davoei/Stokesi Zone boundary in the Camino (i.e. Celebratum Subzone) and San Andrés sections, *B. prinsii* is very rare and discontinuously present in both sections.

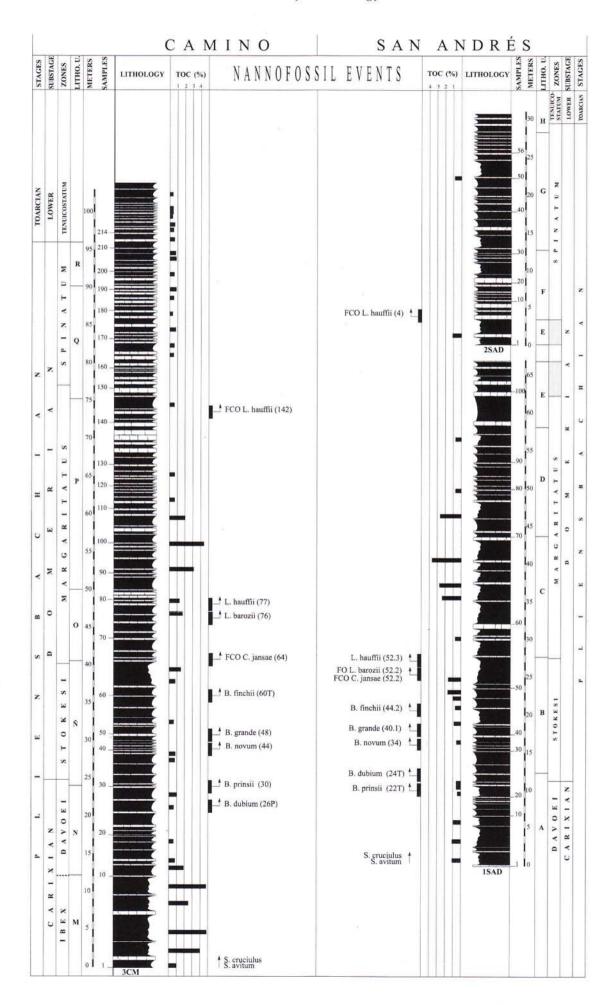
Hence, the precise placement of this biohorizon is difficult and its biostratigraphic value doubtful.

FO of *B. dubium*. This event lies in the upper part of the Davoei Zone at Camino and in the lower part of the Stokesi Zone at San Andrés section. Unfortunately, due to its small size, low abundance and scattered occurrence, *B. dubium* can be overlooked in routine work. Consequently, its first occurrence is difficult to precisely locate and its reliability poor.

FO of *B. novum*. The first extremely rare specimens of *B. novum* have been identified in the Stokesi Zone of both Camino and San Andrés sections, below the FOs of *B. grande* and *B. finchii*. Discontinuously present up to the Margaritatus/Spinatum Zone boundary, the occurrence of *B. novum* is easily detectable in the Spinatum Zone of both sections.

FO of *B. grande*. In the studied sections, the first occurrence of this very easily recognizable large species lies within the Stokesi Zone and below the FOs of *L. barozii* and *L. hauffii*. Though *B. grande* is very rare in its initial range, the presence of this taxon is well documented from the upper Domerian of both sections.

FO of *B. finchii*. First appearing in the Stokesi Zone of Camino and San Andrés sections, the placement of this biohorizon should be carefully checked because only extremely rare specimens of *B. finchii* have been



identified below the FOs of *L. barozii* and *L. hauffii*. The relative abundance of the species slightly increases in the overlying Margaritatus and Spinatum Zones.

FCO of *C. jansae*. Recognized from the Jamesoni Zone of Camino section, *C. jansae* is extremely rare and discontinuous up to the Stokesi Zone, whilst its relative abundance sharply increases slightly below the Stokesi/Margaritatus Zone boundary of the Camino and San Andrés sections. Based on the distribution pattern of this species, the easily recognizable FCO of *C. jansae* is placed when the relative abundance of the species rises from very rare to few/common in the lower part of its continuous range.

Discussion

In this section, the reproducibility and reliability of the nannofossil events recognized in the Camino and San Andrés sections will be discussed, along with the consistencies and discrepancies with previous findings from other Boreal and Tethyan sections (Tab. VI-VII). However, comparison between sections from different faunal/floral realms and which often utilized different ammonite zonation is clearly problematic. In this study only the papers published in the last two decades will be considered, because they significantly improve the knowledge on Jurassic calcareous nannofossil biostratigraphy (for earlier findings see Bown 1987 and Mattioli & Erba 1999).

In the Basque-Cantabrian area, the FO of S. cruciulus is a reliable lower Carixian event lying in the Jamesoni Zone, as previously recognized in other Boreal and Tethyan sections by de Kaenel & Bergen (1993), de Kaenel et al. (1996), Bown & Young (1997), Bown & Cooper (1998) and Mattioli & Erba (1999) that locate this biohorizon in the Jamesoni Zone. Also the FO of S. avitum (including S. orbiculus) is a proven and useful biohorizon, which lies in the Jamesoni Zone according to Bown & Young (1997), de Kaenel & Bergen (1993, Morocco), de Kaenel et al. (1996, Morocco) and Mattioli & Erba (1999). Instead, de Kaenel & Bergen (1993, Portugal) placed the FO of S. orbiculus above the Jamesoni/Ibex Zone boundary. On the basis of the achieved results, the appearance of the genus Similiscutum, including the FOs of S. cruciulus and S. avitum, could be a more practical and useful event, reliable for inter-regional correlations.

Present from the Ibex Zone of the Camino section, a Carixian occurrence of C. granulatus is here con-

Fig. 6 - Lithology, TOC value and calcareous nannofossil events recognized in the Camino and San Andrés sections, and position of the samples (3CM 1-214, 1SAD 1-106 and 2SAD 1-56); the grey areas within the lithozone E of San Andrés section, correspond to a possible overlap between the top of the 1SAD and the bottom of the 2SAD.

firmed. This record is consistent with Bown (1987) and Bown et al. (1988) that locate the FO of *C. granulatus* in the Ibex Zone, and de Kaenel et al. (1996, Morocco) that place this event at Ibex/Davoei Zone boundary. However, due to its low and scattered occurrence, a Sinemurian FO of *C. granulatus* is not excluded, as reported by Bown & Young (1997) and de Kaenel et al. (1996, Portugal and Switzerland) that place this event in the Oxynotum and Raricostatum Zone respectively.

In the Camino section, a Carixian occurrence of *C. cavus* is also proved, because the species is present from the Ibex Zone. On the contrary, Bown (1987), Bown & Young (1997) and Bown & Cooper (1988) locate the FO of *C. cavus* (i.e. *C. impontus*) in the Domerian Spinatum Zone.

The FO of Calyculus spp. is not utilized herein, being the genus rare and discontinuous in both sections; however, it is present from the Ibex Zone of the Camino section. A Carixian occurrence of the genus Calyculus spp., from the underlying Jamesoni Zone, is documented also by Bown & Young (1997) and Bown & Cooper (1998). Instead, the FO of Calyculus spp. is considered a Domerian event and placed in the Spinatum Zone by Bown (1987), Bown et al. (1988), Cobianchi (1992) and Mattioli & Erba (1999), or at Emaciatum/Tenuicostatum Zone boundary by Reale et al. (1992). Actually, Bown (1987) identified specimens of Calyculus spp. in the Ibex (Mochras borehole) or Davoei (Brenha section, Portugal) Zone.

Although the entry of the imbricating three-shield placoliths genus *Bussonius* is not yet precisely located, a Carixian FO of *B. prinsii* is proved in both sections below the FO of *L. hauffii*. Nevertheless, a lower occurrence of this taxon is not excluded, according to de Kaenel & Bergen (1993, Portugal), de Kaenel et al. (1996, Portugal) and Bown & Cooper (1998) that locate this event in the Jamesoni Zone. Conversely, the FO of *B. prinsii* is placed higher, in the Domerian Spinatum Zone and above the FO of *L. hauffii* by Bown (1987), Bown et al. (1988) and Mattioli & Erba (1999).

In this work, the scarce biostratigraphic value of the FO of *B. dubium* is inferred, and its distribution pattern could partly explain the inconsistent previous findings. De Kaenel & Bergen (1993) and de Kaenel et al. (1996, Portugal and Morocco) place the FO of *Palaeopontosphaera dubia* (i.e. *B. dubium*) in the Margaritatus or Lavinianum Zone. Instead, the presence of *B. dubium* is documented from the lower Toarcian Falciferum Zone by Bown (1987), Bown et al. (1988) and Bown & Cooper (1998), though Bown (1987) recognized specimens of this species from the Davoei Zone (Brenha section, Portugal).

In the Basque-Cantabrian area, the FO of *B. novum* lies in the Stokesi Zone, although a Carixian first appearance is not excluded, as reported by Mattioli & Erba (1999) that locate this biohorizon in the Jamesoni

Bown & Young (1997)

Down a roung (1997)	lower part	Jamesom
Bown & Cooper (1998)	lower part	Jamesoni
de Kaenel & Bergen (1993, Portugal)	middle part	Jamesoni
de Kaenel et al. (1996, Portugal)	middle part	
de Kaenel et al. (1996, Switzerland)	upper part	
de Kaenel & Bergen (1993, Morocco)	boundary	Jamesoni-Ibex
de Kaenel et al. (1996, Morocco)	A STATE OF S	Jamesoni
Mattioli & Erba (1999)		Jamesoni
This paper	ALCOHOLOGICA MARCONA	Jamesoni
57653	SECTION SECTION	
FO Similiscutum avitum Bown & Young (1997)°	lower part	
de Kaenel & Bergen (1993, Portugal)°	lower part	Ibex
de Kaenel et al. (1993, Morocco)	boundary	Jamesoni/Ibex
de Kaenel & Bergen (1993, Morocco)°	boundary	Oxynotum/Jamesoni
de Kaenel et al. (1996, Morocco)°	boundary	Oxynotum/Jamesoni
	March 2000 191	THE STATE OF THE PARTY OF THE PARTY.
Mattioli & Erba (1999)°	lower part	Jamesoni
This paper	middle part	Jamesoni
FO Crepidol	ithus granulat	
Bown (1987)	lower part	Ibex
Bown et al. (1988)	lower part	Ibex
Bown & Young (1997)	upper part	Oxynotum
de Kaenel (1996, Portugal)	upper part	
de Kaenel (1996, Switzerland)	lower part	Raricostatum
de Kaenel (1996, Morocco)	boundary	Ibex/Davoei
- I I I I I I I I I I I I I I I I I I I		
FO Crepidolithus cavus		
Bown (1987)		Spinatum
Bown & Young (1997)°	lower part	Spinatum
Bown & Cooper (1998)*	lower part	Spinatum
Bown (1987, Mochras borehole)	yculus spp.	Ibex
Bown (1987, Brenha section)		Davoei
Bown (1987, Brenha section) Bown (1987)	lower part	
	lower part	Davoei
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988)	lower part	Davoei Spinatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997)	lower part	Davoei Spinatum Spinatum Jamesoni
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998)	lower part lower part lower part	Davoei Spinatum Spinatum Jamesoni Jamesoni
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992)	lower part lower part lower part boundary	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992)	lower part lower part lower part boundary upper part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992)	lower part lower part lower part boundary	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999)	lower part lower part lower part boundary upper part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999)	lower part lower part lower part boundary upper part upper part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987)	lower part lower part lower part boundary upper part upper part onius prinsii lower part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988)	lower part lower part lower part boundary upper part upper part onius prinsii lower part lower part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998)	lower part lower part lower part boundary upper part upper part onius prinsii lower part lower part lower part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal)	lower part lower part lower part boundary upper part upper part onius prinsii lower part lower part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal)	lower part lower part lower part boundary upper part upper part onius prinsii lower part lower part lower part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Spinatum Jamesoni
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Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999)	lower part lower part lower part boundary upper part upper part lower part lower part upper part upper part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel et al. (1996, Portugal) Mattioli & Erba (1999) This paper	lower part lower part lower part boundary upper part upper part lower part lower part upper part upper part upper part upper part upper part boundary	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Spinatum Davoei/Stokesi
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Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel et al. (1996, Portugal) Mattioli & Erba (1999) This paper FO Biscutum dubium (**) Bown (1987, Brehna section Portugal)	lower part lower part lower part boundary upper part upper part lower part lower part lower part upper part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Spinatum Davoei/Stokesi
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Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel & Bergen (1996, Portugal) Mattioli & Erba (1999) This paper FO Biscutum dubium (** Bown (1987) Bown (1987) Bown (1987) Bown et al. (1988)	lower part lower part lower part lower part upper part upper part lower part lower part lower part upper part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Davoei/Stokesi Chaera dubia) Davoei Falciferum Falciferum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel et al. (1996, Portugal) Mattioli & Erba (1999) This paper FO Biscutum dubium (** Bown (1987, Brehna section Portugal) Bown (1987, Brehna section Portugal) Bown (1987, Brehna section Portugal) Bown (1987) Bown 4 (1988) Bown 8 Young (1997)	lower part lower part lower part boundary upper part upper part lower part lower part lower part upper part boundary "Paleopontos; middle part middle part boundary	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Davoei/Stokesi Dhaera dubia) Davoei Falciferum Tenuicostatum/Falciferum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel & Bergen (1993, Portugal) de Kaenel et al. (1996, Portugal) Mattioli & Erba (1999) This paper FO Biscutum dubium (** Bown (1987, Brehna section Portugal) Bown (1987, Brehna section Portugal) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998)	lower part lower part lower part lower part upper part upper part lower part lower part lower part upper part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Spinatum Davoei/Stokesi Davoei Falciferum Falciferum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel et al. (1996, Portugal) Mattioli & Erba (1999) This paper FO Biscutum dubium (1987) Bown (1987) Bown (1987) Bown et al. (1988) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal)*	lower part lower part lower part boundary upper part upper part lower part lower part lower part upper part boundary "Paleopontos; middle part middle part boundary	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Davoei/Stokesi Davoei Falciferum Tenuicostatum/Falciferum Falciferum
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Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel & I. (1996, Portugal) Mattioli & Erba (1999) This paper FO Biscutum dubium (** Bown (1987, Brehna section Portugal) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal)* de Kaenel & Bergen (1993, Portugal)* de Kaenel & Bergen (1996, Portugal)*	lower part lower part lower part lower part poundary upper part upper part lower part lower part lower part upper part middle part middle part lower part lower part lower part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Davoei/Stokesi Davoei Falciferum Falciferum Falciferum Falciferum Lavinianum Lavinianum
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel & Inspection (1998) de Kaenel & Bergen (1998) This paper FO Biscutum dubium (1987) Bown (1987) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel & Bergen (1993, Portugal) de Kaenel & Bergen (1993, Portugal) de Kaenel & Bergen (1993, Morocco) de Kaenel & Bergen (1993, Morocco)	lower part lower part lower part boundary upper part upper part lower part lower part lower part upper part lower part lo	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Spinatum Davoei/Stokesi Chaera dubia) Davoei Falciferum Falciferum Tenuicostatum/Falciferum Falciferum Lavinianum Lavinianum Margaritatus
Bown (1987, Brenha section) Bown (1987) Bown et al. (1988) Bown & Young (1997) Bown & Cooper (1998) Reale et al. (1992) Cobianchi (1992) Mattioli & Erba (1999) FO Buss Bown (1987) Bown et al. (1988) Bown & Cooper (1998) de Kaenel & Bergen (1993, Portugal) de Kaenel & Bergen (1996, Portugal) Mattioli & Erba (1999) This paper	lower part lower part lower part lower part poundary upper part upper part lower part lower part lower part upper part middle part middle part lower part lower part lower part	Davoei Spinatum Spinatum Jamesoni Jamesoni Emaciatum/Tenuicostatum Spinatum Spinatum Spinatum Spinatum Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Jamesoni Falciferum Falciferum Falciferum Falciferum Lavinianum Lavinianum Margaritatus Lavinianum

FO Similiscutum cruciulus

lower part Jamesoni

Tab. VIa

Bown & Young (1997)

Reale et al. (1992) Mattioli & Erba (1999)

This paper

Tab. VI b

FO Biscutum novum	(*Discorhab	dus novus)	_
Bown & Young (1997) Bown & Cooper (1998)	lower part	Margaritatus Margaritatus	
de Kaenel & Bergen (1993, Portugal)* de Kaenel & Bergen (1996, Portugal)* de Kaenel & Bergen (1993, Morocco)* de Kaenel (1996, Morocco)*	middle part upper part upper part lower part	Margaritatus Lavinianum Lavinianum Algovianum	
Mattioli & Erba (1999)	lower part	Jamesoni	
This paper	lower part	Stokesi	
FO Biscutum grand	de (°Biscutum	The state of the s	
Bown (1987, Brenha section Portugal) Bown (1987)° Bown et al. (1988)°	lower part	Jamesoni Spinatum	

lower part	Spinatum
boundary	Stokesi/Margaritatus
lower part	Stokesi
ii (°Similiscutu	ım finchii)
upper part	Margaritatus
upper part	Margaritatus
boundary	Margaritatus/Spinatum
lower part	Margaritatus
middle part	Davoei
lower part	Lavinianum
boundary	Davoei-Lavinianum
upper part	Spinatum
	boundary lower part upper part boundary lower part middle part lower part boundary boundary

lower part

lower part

upper part

Spinatum

Emaciatum

Spinatum

Stokesi

FO Calcivascularis	jansae (*Mitroli	ithus jansae)
Bown (1987)°	upper part	Raricostatum
Bown et al. (1988)°	upper part	Raricostatum
Cobianchi (1992)°	upper part	Davoei
Reale et al. (1992)°	upper part	Davoei
Lozar (1995)*	lower part	Bucklandi
Mattioli & Erba (1999)°	lower part	Bucklandi
FCO Calo	ivascularis jans	880
This paper	boundary	Stokesi/Margaritatus

FO Lotharingius barozi			
Cobianchi (1992)	lower part	Spinatum	
Mattioli & Erba (1999)	upper part	Spinatum	
This paper	boundary	Stokesi/Margaritatus	

FO Lott	aringius hauffii	
Bown (1987)	upper part	Margaritatus
Bown et al. (1988)	upper part	Margaritatus
Bown & Young (1997)	upper part	Margaritatus
Bown & Cooper (1998)	upper part	Margaritatus
de Kaenel (1996, Portugal)	lower part	Algovianum
de Kaenel (1996, Morocco)	lower part	Algovianum
de Kaenel (1996, Switzerland)	lower part	Algovianum
Cobianchi (1992)	lower part	Spinatum
Reale et al. (1992)	middle part	Emaciatum
Mattioli & Erba (1999)	middle part	Spinatum
This paper	boundary	Stokesi/Margaritatus
FCO Los	haringius hauff	II .
This paper	boundary	Margaritatus/Spinatum

Tab. VI - Previous findings of S. cruciulus, S. avitum, C. granulatus, C. cavus, Calyculus spp., B. prinsii and B. dubium in Tab. VIa, and of B. novum, B. grande, B. finchii, C. jansae, L. barozii and L. hauffiii in Tab. VIb (as reported by Bown 1987, Bown et al. 1988, de Kaenel & Bergen 1993, Cobianchi 1992, Reale et al. 1992, Bown & Young 1997, Bown & Cooper 1998 and Mattioli & Erba 1999). Note: because of in the original papers are utilized only ammonite zone, the reported lower, middle and upper part, or boundary, is a geometric approximation (see scaling in de Kaenel et al. 1996).

Zone. However, the FO of B. novus (i.e. D. novum) is considered a Domerian event and placed in the Lavinianum or Margaritatus by de Kaenel & Bergen (1993), de Kaenel et al. (1996, Portugal), Bown & Young (1997), Bown & Cooper (1998), or in the Algovianum Zone by de Kaenel et al. (1996, Morocco). Certainly, some of these discrepancies could be related to the documented initial rare and discontinuous occurrence of B. novum, but also taxonomic biases should be taken in account (see discussion in de Kaenel et al. 1996, Bown & Cooper 1998 and Mattioli & Erba 1999).

In the studied sections, the FO of B. grande lies in the lower Domerian Stokesi Zone, below the FO of L. hauffii. Also Mattioli & Erba (1999) placed this event below the FO of L. hauffii, but around the Stokesi/Margaritatus Zone boundary. Bown (1987), Bown et al.

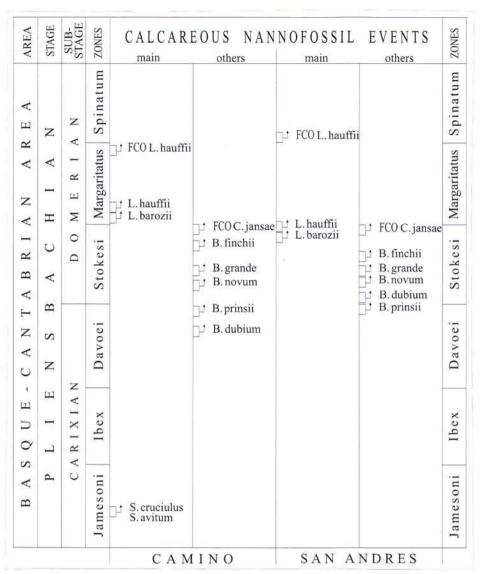


Fig. 7 - Calcareous nannofossil events recognized in the Camino and San Andrés sections.

(1988), Bown & Young (1997) and Bown & Cooper (1998) locate the appearance of *B. grande* in the overlying Spinatum Zone and above the FO of *L. hauffii*, though Bown (1987) found specimens of this taxon in the Jamesoni Zone (Brenha section, Portugal).

Certainly present from the Stokesi Zone, the FO of *B. finchii* is difficult to pinpoint. However, as recognized in the present work, this biohorizon is placed (as *Similiscutum finchii*) below the FO of *L. hauffii*, but around the Davoei/Lavinianum Zone boundary by de Kaenel et al. (1996, Morocco) and de Kaenel & Bergen (1993, Morocco). In de Kaenel & Bergen (1993, Portugal) this event even lies in the underlying Davoei Zone. On the contrary, the FO of *B. finchii* is located higher and above the FO of *L. hauffii*, that is in the Margaritatus Zone by Bown (1987), Bown et al. (1988), Bown & Young (1997) and Bown & Cooper (1998) or in the overlying Spinatum or Emaciatum Zone by Cobianchi (1992), Mattioli & Erba (1999) and Reale et al. (1992).

In the Basque-Cantabrian area, C. jansae is rare and discontinuous up to Stokesi/Margaritatus Zone

boundary. This distribution pattern could partly explain the below reported previous findings, and does not exclude a Sinemurian FO of *C. jansae* (i.e. *M. jansae*), according to Bown (1987) and Bown et al. (1988) who place this event in the Raricostatum Zone and Mattioli & Erba (1999) that locate the FO of *C. jansae* in the Bucklandi Zone. Instead, Cobianchi (1992) and Reale et al. (1992) place this biohorizon in the Davoei Zone. Hence, the FO of *C. jansae* is unreliable, whilst the proposed FCO of *C. jansae* seems to be a significant biohorizon, at least for regional correlations.

In both studied sections, the FO of *L. barozii* is a useful event that, together with the FO of *L. hauffii*, roughly coincides with the Stokesi/Margaritatus Zone boundary. Utilized by Cobianchi (1992) and Mattioli & Erba (1999) this biohorizon is located higher, above the FO of *L. hauffii* and within the Spinatum Zone.

Along with the FOs of *S. avitum* and *S. cruciulus*, the FO of *L. hauffii* is the other relevant and reliable Pliensbachian event recognized in the Basque-Cantabrian area. Although the species is rare in its lowest range,

its occurrence is well-documented from the Margaritatus Zone as recognized in other Boreal and Tethyan sections. Bown (1987), Bown et al. (1988), Bown & Young (1997) and Bown & Cooper (1998) place the FO of *L. hauffii* in the Margaritatus Zone, whilst de Kaenel et al. (1996) located this biohorizon in the Algovianum Zone. The FO of *L. hauffii*, instead, is located in the overlying Spinatum or Emaciatum Zone by Cobianchi (1992), Reale et al. (1992) and Mattioli & Erba (1999). In addition, in the Basque-Cantabrian area, also the FCO of *L. hauffii* is a useful biohorizon, which could be correlated with the sharp increase in abundance of *L. haffii* reported by Bown & Cooper (1998) within the Spinatum Zone.

Conclusions

As part of a multidisciplinary study focused on the Lower Jurassic "Marine Succession" of the Basque-Cantabrian area (Northern Spain), two continuous and expanded Pliensbachian sections have been sampled in the south-western sector of this area in order to investigate the nannofossil contents.

The composition changes of nannofossil assemblages during the Pliensbachian are characterized by first occurrences (mainly within the Jamesoni, Stokesi and Margaritatus Zones) and abundance variation (within the Jamesoni, Margaritatus and Spinatum Zones) of both genera and species. Undoubtedly, the first appearance and the abundance increase of the genera Similiscutum (lower Carixian) and Lotharingius (lower Domerian) are the main identified composition changes. Between them, the appearance of the genera Biscutum and Bussonius (upper Carixian) and the sharp increase in abundance of the genus Calcivascularis (lower Domerian) took place. The Domerian is also characterized by the significant decrease in abundance of the genera Similiscutum, Parhabdolithus and Crepidolithus, and the abundance increase of the genus Biscutum.

On the basis of both reproducibility and reliability, the recognized biohorizons are distinguished into two groups. Including the FOs of *S. avitum, S. cruciulus, L. barozii, L. bauffii* and the FCO of *L. bauffii*, the "main" events are quite easily recognizable, nicely calibrated with respect to the ammonite zones, consistent in both sections, and based on solution-resistant taxa. Certainly, the FOs of *S. cruciulus* and *L. bauffii* are the most proven and reliable biohorizons and, according to the literature, they are key-events for long-distance correlations. Proposed for the first time in this paper, also the FO of *L. barozii* and the FCO of *L. bauffii* are reliable biohorizons or at least useful for regional correlations.

In contrast, the FOs of B. dubium, B. prinsii, B.

novum, B. grande, and B. finchii, here labelled as "other" events, are not yet well calibrated against ammonite zones, probably because they are dissolution-susceptible taxa, rare or very rare and discontinuous, particularly in their initial ranges. Nevertheless, their reciprocal position as well as their placement with respect to main events are quite consistent in both Camino and San Andrés sections. The FOs of B. dubium, B. novum and B. prinsii lie above the FOs of S. avitum and S. cruciulus and below the FOs of B. grande and B. finchii. These latter events certainly precede the FOs of L. barozii and L. hauffii. Hence, the pre-Domerian FOs of B. dubium and B. prinsii and the lower Domerian FOs of B. novum, B. finchii and B. grande are in this paper documented.

The "other events" also include the FCO of *C. jansae*, that nearly coincides with the Stokesi/Margaritatus Zone boundary and precedes the FOs of *L. barozii* and *L. hauffii*. Although its reliability should be further proved, this event seems to be useful at least for regional correlations. Instead, a pre-Pliensbachian FO of *C. jansae* and its questionable biostratigraphic value is here hinted. The gathered data also point out the poor biostratigraphic value of the FOs of *C. granulatus*, *C. cavus* and *Calyculus* spp.; nevertheless, in the Basque-Cantabrian area, *C. granulatus*, *C. cavus* and *Calyculus* spp. occur from the early Carixian.

Based on the adopted boreal ammonite zones, the following correspondences are another achievement of this paper: the FOs of *S. avitum* and *S. cruciulus* lie above the Raricostatum/Jamesoni Zones boundary, and their abundance increase lies below the Jamesoni/Ibex Zone boundary, the FOs of *L. barozii* and *L. bauffii* roughly coincide with the Stokesi/Margaritatus Zone boundary, and the FCO of *L. bauffii* nearly corresponds to the overlying Margaritatus/Spinatum Zone boundary. Furthermore, the Davoei/Stokesi Zone boundary nearly coincides with the FO of *B. prinsii*, whilst the FCO of *C. jansae* roughly approaches the Stokesi/Margaritatus Zone boundary.

Acknowledgements. We are warmly grateful to Elisabetta Erba, Paul Bown and the Editor for the critical and careful revision of the manuscript, as well as for the useful suggestions that improved both the documentation of the paper and the readability of the text. Thanks also to Bianca for reviewing the original manuscript and for the careful check of the last misprints. This research was supported by the Proyecto PB97-0274 del Ministerio de Educación Español, M.U.R.S.T. (60%) and by the Centro di Studio per la Geologia Strutturale e Dinamica dell'Appenino, CNR.

REFERENCES

- Barnard T. & Hay W.W. (1974) On Jurassic coccoliths, a tentative zonation on the Jurassic of Southern England and Northern France. Ecl. Geol. Helv., 67: 563-586, Basel.
- Bown P.R. (1987) Taxonomy, evolution, and biostratigraphy of Late Triassic-Early Jurassic calcareous nannofossils. Paleont. Ass., Special Paper Paleont., 38: 118 pp., London.
- Bown P.R., Cooper M.K.E. & Lord A. R. (1988) A Calcareous Nannofossil Biozonation scheme for the early to mid Mesozoic. Newsl. Stratigr., 20: 91-114, Berlin.
- Bown P.R., Burnet J.A. & Gallagher L.T. (1992) Calcareous Nannoplankton evolution. Mem. Soc. Geol. Padova, 43: 1-17, Padova.
- Bown P.R. & Cooper M.K.E. (1998) Jurassic. In: Bown P.R. (ed.) Calcareous Nannofossil Biostratigraphy, 34-85, Cambridge.
- Bown P.R. & Young R.J. (1997) Mesozoic calcareous nannoplankton classification. *Journ. Nannopl. Res.*, 19: 21-47, Slavkov u Brna.
- Braga J.C., Comas-Rengifo M.J., Goy A. & Rivas P. (1985) -Le Pliensbachian dans la Chaîne Cantabrique orientale entre Castillo Pedroso et Reinosa (Santander, Espagne). Les Cahiers de l'Institut Catholique de Lyon, 14: 69-83, Lyon.
- Braga J.C., Comas-Rengifo M.J., Goy A., Rivas P. & Yébenes A. (1988) El Lías inferior y medio en la zona central del Cuenca Vasco-Cantábrica (Camino, Santander). Ciencias de la Tierra. Geología, 11: 18-45, Logroño.
- Braga J.C., Comas-Rengifo M.J., Goy A. & Rivas P. (1983) -Comparaciones faunísticas y correlaciones en el Pliensbachiense de la Zona Subbética y Cordillera Ibérica. *Bol.* R. Soc. Esp. Hist. Nat. (Sec. Geol.), 80: 219-227, Madrid.
- Carreras Suárez F., Porter García J.M., Olmo Zamora P., Ramírez Del Pozo J. & Aguilar Tomás M.J. (1978) -Mapa Geológico de España Escala 1:50.000. Explicación de la hoja nº83 (Reinosa). 83 pp., Madrid.
- Cobianchi M.A. (1992) Sinemurian-Early Bajocian Calcareous Nannofossil biostratigraphy of the Lombardy Basin, Southern Calcareous Alps (Northern Italy). *Atti Ticinensi Sc. Terra*, 35: 61-106, Pavia.
- Comas-Rengifo M.J., Gómez J.J., Goy A., Herrero C., Perilli N. & Rodrigo A. (1999) - El Jurásico Inferior en la sección de Almonacid de la Cuba (Sector Central de la Cordillera Ibérica, Zaragoza, España). Cuad. Geo. Ibén, 25: 27-57, Madrid.
- Comas-Rengifo M.J., Goy A., Rivas P.& Yébenes A. (1988) -El Toarciense en Castillo Pedroso (Santander). *Ciencias* de la Tierra. Geología, 11: 63-71, Logroño.
- Crux J.A. (1984) Biostratigraphy of early Jurassic calcareous nannofossils from Southwest Germany. N. Jb. Geol. Paläont. Abh., 169: 160-186, Stuttgart.
- Crux J.A. (1987) Early Jurassic calcareous nannofossil biostratigraphic events. *Newsl. Stratigr.*, 17: 79-100, Berlin.
- Dahm H. (1965) Stratigraphie und Paläogeographie im Kantabrischen Jura (Spanien). Beih. Geol. Jb., 44: 13-54, Hannover.
- de Kaenel E. & Bergen J. A. (1993) New Early and Middle Jurassic coccolith taxa and biostratigraphy from the

- eastern proto-Atlantic (Morocco, Portugal and DSDP Site 547B). Ecl. Geol. Helv, 86: 861-907, Basel.
- de Kaenel E., Bergen J.A. & von Salis Perch-Nielsen K. (1996)
 Jurassic calcareous nannofossil biostratigraphy of Western Europe. Compilation of recent studies and calibration of bioevents. *Bull. Soc. Géol. France*, 167: 15-28, Paris.
- Erba E. (1990) Calcareous nannofossil biostratigraphy of some Bajocian sections from the Digne area (SE France). Mem. Descr. Carta Geol. d'Italia, 40: 237-256, Roma.
- Fernández-López S., Goy A. & Ureta S. (1988) El Toarciense superior, Aaleniense y Bajociense en Camino (Santander). Precisiones bioestratigráficas. *Ciencias de la Tierra*, *Geología*, 11: 47-62, Logroño.
- Hamilton G.B. (1977) Early Jurassic calcareous nannofossils from Portugal and their biostratigraphic use. *Ecl. Geol. Helv.*, 70: 575-597, Basel.
- Hamilton G.B. (1979) Lower and Middle Jurassic calcareous nannofossils from Portugal. *Ecl. Geol. Helv.*, 72: 1-17, Basel.
- Hamilton G.B. (1982) Triassic and Jurassic calcareous nannofossils. In: Lord A. (ed.)- A stratigraphical index of calcareous nannofossils, 136-137, Chichester.
- Hiscott R., Wilson R.C.L., Gradstein F.M., Pujalte, V., García-Mondéjar J., Boudreau, R.R. & Wishart H.A. (1990) Comparative stratigraphy and subsidence history of Mesozoic rift Basins of North Atlantic. Amer. Ass. Petrol. Geol. Bull., 74: 1, 60-76, Tulsa.
- Lozar F. (1995) Calcareous nannofossil biostratigraphy of Lower Liassic from Western Tethys. *Paleontogr. Italica*, 82: 91-121, Pisa.
- Masson D.G. & Miles D.R. (1986) Development and hydrocarbon potential of Mesozoic sedimentary basins around margins of North Atlantic. *Amer. Ass. Petrol. Geol. Bull.*, 70: 721-729, Tulsa.
- Mattioli E. & Erba E. (1999) Synthesis of calcareous nannofossil events in the Tethyan Lower and Middle Jurassic successions. Riv. Ital. Paleont. Strat. 105: 43-376, Milano.
- Meléndez Hevia F. (1976) El interés petrolífero del Jurásico marino de la parte SW de la Cuenca Cantábrica. II Jornadas Nacionales del Petróleo y Gas Natural. Sindicato Nacional del Combustible, 117-137, Madrid.
- Olivet J.L. (1990) La cinématique de la Plaque Iberique. *Bull. Centre Res. Expl. Prod. Elf Aquitaine*, 20: 131-195, Pau.
- Perilli N. (1999) Calcareous nannofossil biostratigraphy of Toarcian-Aalenian transition at Funtelsaz section (Iberian Range, East Spain). Cuad. Geol. Ibér., 25: 189-212, Madrid.
- Perilli N. (2000a) Calibration of early-middle Toarcian nannofossil events based on high-resolution ammonite biostratigraphy in two expanded sections from the Iberian Range (East Spain). *Mar. Micropal.*, 39: 293-308, Amsterdam.
- Perilli N. (2000b) Calibration of early-middle Toarcian nannofossil events in two expanded and continuous sections from the Basque-Cantabrian area (Northern Spain). Rev. Esp. Micropal., 31: 393-401, Madrid.

- Prins B. (1969) Evolution and stratigraphy of Coccolithinids from the Lower and Middle Lias. *Proceedings First International Conference on Planktonic Microfossils*, 2: 547-558, Genève.
- Quesada S. & Robles S. (1995) Distribution of Organic Facies in the Liassic Carbonate Ramps of the Western Basque-Cantabrian Basin (Northern Spain). 17th Intern. Meeting on Organic Geochemistry, Field Trip Guidebook, 36 pp., San Sebastián.
- Quesada S., Robles S. & Pujalte V. (1991) Correlación secuencial y sedimentológica entre registros de sondeos y series de superficie del Jurásico Marino de la Cuenca de Santander (Cantabria, Palencia y Burgos). Geogaceta, 10: 3-6, Madrid.
- Quesada S., Robles S. & Pujalte V. (1993) El "Jurásico Marino" del margen suroccidental de la Cuenca Vascocantábrica y su relación con la exploración de hidrocarburos. Geogaceta, 13: 92-96, Madrid.
- Ramírez del Pozo J. (1971a) Bioestratigrafía y microfacies del Jurásico y Cretácico del Norte de España. Ediciones CEPSA, 357 pp., Madrid.
- Ramírez del Pozo J. (1971b) Algunas observaciones sobre el Jurásico de Álava, Burgos y Santander. *Cuad. Geo. Ibér.*, 2: 491-508, Madrid.
- Rat P. (1988) The Basque-Cantabrian Basin between the Iberian and European plates: Some facts but still many problems. Rev. Soc. Geo., Esp., 1: 327-348, Madrid.
- Reale V., Baldanza A., Monechi S. & Mattioli E. (1992) Calcareous nannofossil biostratigraphic events from the Early-Middle Jurassic of the Umbria-Marche area (Central Italy). Mem. Sc. Geol. Padova, 43: 41-75, Padova.
- Robles S., Pujalte V. & Vallés J.C. (1988) Sistemas sedimentarios del Jurásico de la parte occidental de la Cuenca Vasco-Cantábrica. *Ciencias de la Tierra*, *Geología*, 11: 1-15, Logroño.
- Wiegand G. E. (1984) Two New Genera of Calcareous Nannofossils from the Lower Jurassic. *J. Paleont.*, 58: 1151-1155, Tulsa
- Wilson R.C.L. (1975) Atlantic opening and Mesozoic continental margin basins of Iberia. *Earth and Planet. Sc. Lett.*, 25: 33-34, Amsterdam.
- Yilmaz P.O., Norton I.O., Leary & Chuchla R.J (1996) Tectonic evolution and paleogeography of Europe. In: Ziegler, P.A. and Horvàth, F. (eds.) Peri-Tehtys Memoir 2, Structure and Prospects of Alpine Basins ande Forelands. Mém. Muséum Nat. Hist. Nat, 170: 47-60, Paris.
- Ziegler P.A. (1989) Evolution of the Northern Atlantic, an

Overview. In: Tankard A.J.& Balkwill H.R. (eds.) - Extensional tectonic and stratigraphy of the Northern Atlantic Margins. *Amer. Ass. Petrol. Geol. Bull.*, 46: 11-129, Tulsa.

Appendix 1

Calcareous nannofossil species recognized or quoted in the text, bibliography reference for citeted taxa can be found in Bown & Young (1997) and Bown & Cooper (1998)

Biscutum dubium (Noel, 1965) Grün in Grün et al., 1974

Biscutum finchii (Crux, 1979) Bown, 1987

Biscutum grande Bown, 1987

Biscutum intermedium Bown; 1987

Biscutum novum (Goy, 1979) Bown, 1987

Bussonius prinsii (Noel, 1973) Goy, 1979

Bussonius aff. Bussonius prinsii (Noel, 1973) Goy, 1979

Calcivascularis jansae Wiegand, 1984

Calyculus spp. indet.

Crepidolithus spp.

Crepidolithus crassus (Deflandre, 1954) Noel, 1965

Crepidolithus aff. C. crassus (Deflandre, 1954) NOEL, 1965

Crepidolithus cavus Rood, Hay and Barnard, 1973

Crepidolithus granulatus Bown, 1987

Crepidolithus pliensbachiensis Crux, 1985

Crepidolithus primulus Prins 1969 ex Rood, Hay and Barnard, 1973

Lotharingius barozii Noel, 1973

Lotharingius hauffii Grün and Zweili, 1980 in Grün et al., 1974 Lotharingius sigillatus (Stradner, 1961) Prins in Grün et al., 1974

Lotharingius umbriensis Mattioli, 1996

Mitrolithus elegans Deflandre in Deflandre & Fert 1954

Mitrolithus lenticularis, Bown, 1987

Pararhabdolithos liasicus distinctus (Deflandre, 1952) Bown, 1987

Pararhabdolithos liasicus liasicus Deflandre, 1952

Pararhabdolithos robustus Noel, 1965

Schizosphaerella spp.

Similiscutum avitum De Kaenel and Berger, 1993

Similiscutum cruciulus De Kaenel and Berger, 1993

Tubirhabdus patulus Prins 1969 ex Rood, Hay and Barnard, 1973