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CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHIC EVENTS FROM THE EARLY-MIDDLE JURASSIC SEQUENCES OF THE UMBRIA-MARCHE AREA (CENTRAL ITALY)

CONTENTS

K e y w o r d s : *calcareous nannofossils, biostratigraphy, Early-Middle Jurassic, Central Italy.*

ABSTRACT

A detailed biostratigraphic study based on calcareous nannofossils has been carried out on several sections in the Umbria-Marche area. Semiquantitative analyses of calcareous nannofossil assemblages, performed by optical light microscope, has revealed numerous biostratigraphic events for the Pliensbachian-Early Bajocian interval. All the events have been correlated with the ammonite zones defined for each section.

The continuous succession of biostratigraphic events and the good coincidence of the appearance levels in the study area has made it possible to propose a biostratigraphic scheme for the Lower-Middle Jurassic interval that could be extended to the whole Mediterranean area.

All the important biostratigraphic events are described and discussed.

RIASSUNTO

Lo studio biostratigrafico di dettaglio basato sui nannofossili calcarei di otto sezioni del bacino Umbro-Marchigiano ha permesso l'identificazione di numerosi eventi biostratigrafici per l'intervallo Pliensbachiano-Bajociano inferiore.

La successione continua degli eventi, ben riconoscibile in tutte le sezioni dell'area Umbro-Marchigiana, ha permesso la definizione di uno schema biostratigrafico a nannofossili calcarei, utilizzabile nell'area Mediterranea, per l'intervallo compreso tra il Pliensbachiano e il limite Aaleniano-Bajociano.

INTRODUCTION

The Jurassic interval is still an open field, as biostratigraphy is concerned. Until now, only ammonites have provided a detailed zonation for

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both high and low latitudes, even if their occurrence is rare in some sediments. The calcareous nannofossils, with their rapid evolution, wide geographic distribution, and continuous and abundant occurrence, are one of the most useful fossil groups to provide a detailed biostratigraphic scheme.

In the last decade, a renewed interest has been devoted to Jurassic coccoliths from both the biostratigraphic point of view (CRUX, 1984, 1987; BOWN, 1987b, BOWN *et al.,* 1988) and the evolution and taxonomy (CRUX, 1987a, BOWN, 1987a, b); most of all the biostratigraphic studies, from the most recent to the oldest ones, are based on sections from high latitude areas or from Portugal, thus resulting in problems when applied to low latitudes.

The aim of this paper is to compile, through the study of several sections outcropping in the Umbria-Marchean Basin (Fig. 1), a succession of calcareous nannofossil events and to define a zonation for the Pliensbachian-Early Bajocian interval that could be extended to the whole Mediterranean area.

GEOLOGIC SETTING

The Umbria Marche basin is located between the Ancona-Anzio lineage and the Sillaro valley. The basin was formed by the breaking down of a wide carbonate platform (the Latium-Abruzzi carbonate platform) during the Early Lias (COLA-

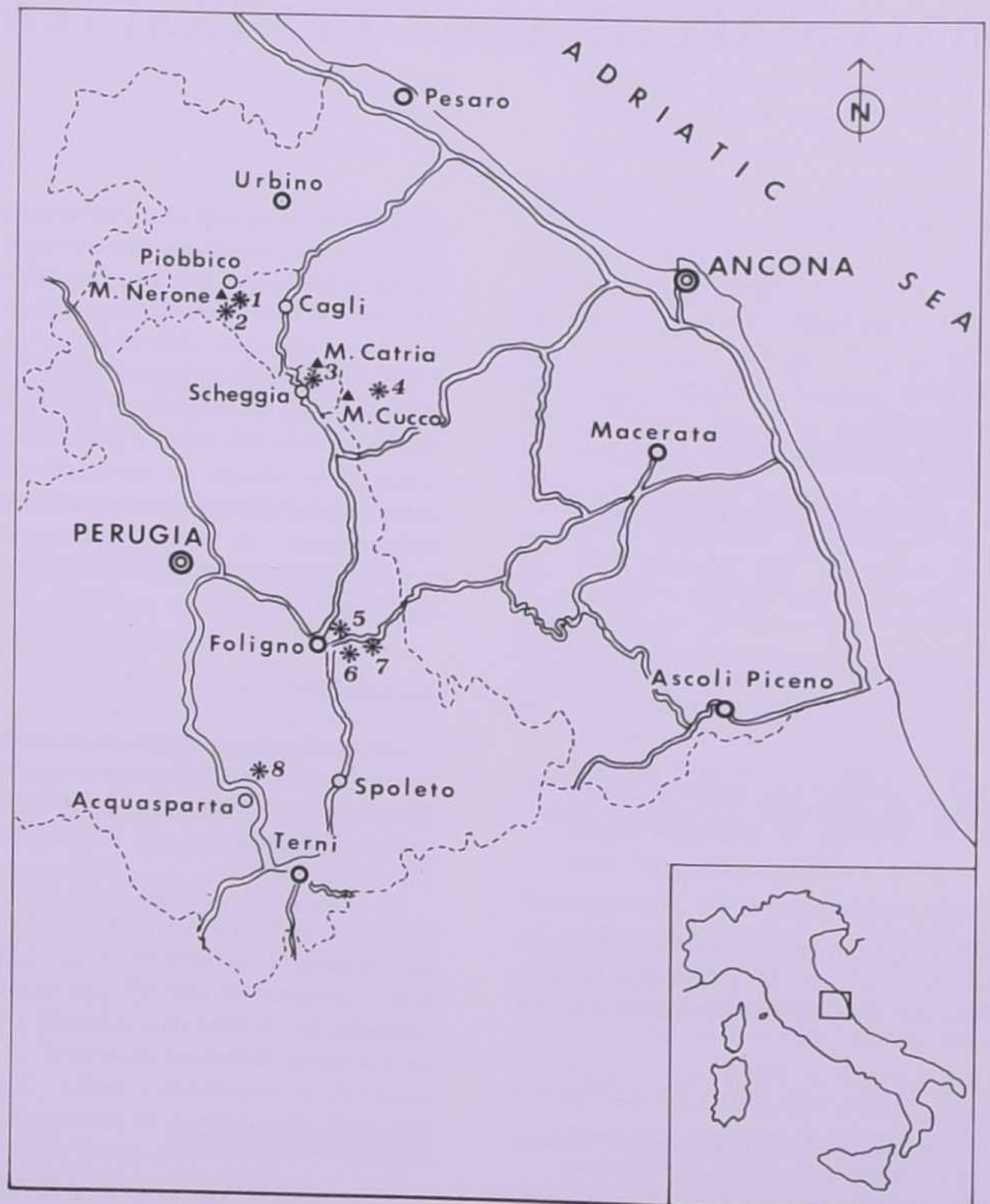

FIG. 1 - Location map of the studied sections: 1) Presale; 2) Infernaccio; 3) Valdorbia; 4) Fonte Avellana; 5) Pale; 6) M. Serrone; 7) M. Civitella; 8) Pozzale.

CICCHI *et al.*, 1970; FARINACCI *et al.*, 1981; COLACICCHI *et al.*, 1988). This break down can be related to the rifting phase during the opening of the western Tethys and the consequent intrusion of oceanic crust that led to the formation of the Ligurian ocean. This basin is related to the Adriatic subblock, a promontory of the African block, that moved together with Europe during the Mesozoic.

The extensional tectonics and subsidence created a heterogeneous situation, within the basin, with some isolated structural highs and depressed areas. The thicker basinal sequences were deposited in the latter areas. In the seamount sequences the reduction in thickness, compared to the basinal areas indicates either a slower sedimentation rate or hiatuses in deposition. This situation characterized by lateral facies and thickness variations extended up to the Tithonian, when, with the deposition of the Maiolica Formation, there was a trend of homogenization in the depositional environment across the whole area.

LITHOSTRATIGRAPHY

The Jurassic sediments analyzed in this paper come from different parts of the Umbria-Marche area: the basinal sequences, deposited in deeper regions of the sea, are characterized by thick and almost continuous sections such as Valdorbia and Monte Serrone; the Infernaccio and Pale sections were deposited in shallower water, on elevated blocks of structural highs; the Fonte Avellana, Presale, Pozzale and Monte Civitella sections show intermediate features between basinal and seamount sequences. The time interval ranges from the Pliensbachian to the lower Bajocian. The sedimentation rate in the seamount sections has been calculated by CECCA *et al.* (1990) in a study of the Monte Nerone area; they observed a decreasing trend from the Carixian to the Kimmeridgian with a change of the sedimentation rate from 2-4. 5 mm/1000 ys to 0.4 mm/1000 ys. This striking reduction of the sedimentation rate resulted in condensation of the fossiliferous horizons without faunal mixing except for rare cases. We can therefore find a complete succession of ammonite assemblages (Fig. 2) with different ages regularly superimposed.

The studied sequences are characterized, from oldest to youngest by the following formations:

Calcare Massiccio (Hettangian-Sinemurian). Poorly stratified massive carbonate sediments typical of carbonate platform consisting of two different facies: the first one is characterized by cyclothematic sequences deposited in a subtidal to supratidal environment with limestones with spatic matrix and abundant calcareous algae, oolite and stromatolitic mats; the second type is characterized by micritic sedimentation typical of subtidal facies. The thickness can reach 700 meters (COLACICCHI *et al.*, 1970; CENTAMORE *et al.*, 1971). The calcareous nannofossil assemblages are very rare.

AGE	AMMONITE ZONES	
	SUBMEDITERRANEAN PROVINCE	MEDITERRANEAN PROVINCE
BAJOCIAN EARLY	Humphriesianum	
	Sauzei	
	Sowerbyi	Laeviuscula
		Discites
AALENIAN	Concavum	
	Murchisonae	
	Opalinum	
TOARCIAN	Aalensis	Meneghinii
	Pseudoradiosa	
	Insigne	Erbaense
	Thouarsense	
	Variabilis	
	Bifrons	Mercati
	Serpentinus	Falcifer
	Tenuicostatum	
DOMERIAN	Spinatum	Emaciatum
	Margaritatus	Algovianum
	Stokesi	Lavinianum
CARIXIAN	Davoei	
	Ibex	
	Jamesoni	

FIG. 2 - Correlation ammonite zonation scheme of sub-Meditterranean and Mediterranean provinces, after PAVIA and SARTI 1987 and BRAGA *et al.* 1984.

Corniola (Lotharingian-lower Toarcian). Regularly bedded grey to nutty brown micritic limestones with radiolarians and sponge spicules. Cherty horizons and argillaceous interbeds are present in the lower and upper part of the formation respectively. Corniola Formation represents the transition from a platform to a basinal environment. The thickness varies from a few meters up to 200 meters. The calcareous nannofossil assemblages are rare, poorly preserved and not well diversified.

Marne del Monte Serrone (lower-middle Toarcian). Grey to brown marls, with few calcarenite levels in the lower part. The thickness of the formation varies from a few decimeters to 60 meters (PIALLI, 1969, 1970). In the Presale, Pozzale (CRESTA and GALACZ, 1990) and Valdorbia (JENKYNS and CLAYTON, 1986) sections, were recognized a three black shale levels (BARTOLINI *et al.*, 1990), interpreted by JENKYNS (1988) as a global anoxic event at the base of the Toarcian. The Toarcian black shale levels are also present in others Umbria-Marche sections under study. The abundance of calcareous nannofossil assemblages strongly increases and becomes well diversified and better preserved; this change can be related both to the explosive evolution of calcareous nannofossils at the base of the Toarcian and to the change in lithology.

Rosso Ammonitico (upper Toarcian). Grey to red nodular limestones and calcareous marls. The thickness varies from 7 to 20 meters. The calcareous nannofossil assemblages are consistently present, and are abundant and well preserved.

Calcari e Marne a Posidonia (upper Toarcian-Callovian). Well stratified and laminated nodular limestones, interbedded with nodular marly limestones in the lower part and cherty levels in the upper part. A very peculiar characteristic is the presence of "filaments", which are shells of very thin bivalves. The thickness varies from 40 to 70 meters. The calcareous nannofossil assemblages are not very abundant and well diversified, due to prevalent cherty limestone lithotype in the studied sections.

Bugarone (lower Pliensbachian-Tithonian) This formation has been defined following the definition of CRESTA *et al.* (1988) and CECCA *et al.* (1990); it consists of bioturbated, more or less dolomitized, sometimes nodular limestones and marly limestones. The thickness varies from a few up to 20 meters. In the type section (Fosso Bugarone section) an important stratigraphic gap has been recognized on the basis of ammonite biostratigraphy. The identification of this hiatus allowed the subdivision of this formation into two sections: a lower part of upper Toarcian-lower Bajocian age and an upper part of lower Kimmeridgian-upper Tithonian age. The calcareous nannofossil assemblages are usually rare and the preservation is poor.

Calcari Diasprigni (Callovian-upper Kimmeridgian). Radiolarian rich limestones with nodules, lenses and layers of chert. In the middle-upper part of this formation the cherty levels show a characteristic pinch and swell structure. The thickness varies from several tens to 120 meters. The calcareous nannofossil assemblages are not very abundant and well diversified because of the unfavorable lithology.

LOCATION OF THE SEQUENCES

The studied sequences (Fig. 1) are briefly described below. The lithologic description, the ammonite biostratigraphy and the calcareous nannofossil events are shown for each section in figures 3 to 9; the distribution charts of the calcareous nannofossil assemblages are given in tables 1 to 9.

The *Valdorbia* section is located along the Scheggia-Sassoferrato national route 360 on the left side of the Sentino river, between Ponte Calcara and Valdorbia. The studied sequence (Fig. 3) is 150 meters thick and spans the Domerian to lower Bajocian, from Corniola to the base of Calcari Diasprigni Formation. For a more detailed description we refer to CENTAMORE *et al.* (1971); for paleomagnetic data see CHANNEL *et al.* (1984); for ammonite biostratigraphy see VENTURI in CHANNEL *et al.* (1984); for ammonite biostratigraphy see VENTURI in CHANNEL *et al.* (1984) and CRESTA *et al.* (1989). Preliminary reports on the calcareous nannofossil assemblages have been provided by MONECHI and REALE (1987); REALE (1989). In tables 1 and 2 the abundance and the distribution of the calcareous nannofloras are shown.

The *Monte Serrone* section is the type section of the Monte Serrone Formation (PIALLI 1969). It crops out along the southern flank of the Monte Serrone following the road to Abbazia di Sassovivo. The section is 64 meters thick and spans the upper Domerian to Toarcian (Fig. 4). For a detailed stratigraphic description we refer to BALDANZA (1989), for ammonite biostratigraphy see VENTURI (1981). A preliminary report on the calcareous nannofloras has been provided by BALDANZA (1989); the nannofossil distribution chart is shown in table 3.

The *Monte Civitella* section is located on the right side of the Foligno-Colfiorito road at the Scopoli village, and outcrops on the NE flank of the anticline structure of the group Monte Civitella - M. Lagarella - M. Brunette and M. Serano. The sequence (Fig. 5) is 21 meters thick and spans the upper Domerian to upper Toarcian. For the stratigraphic description and the ammonite biostratigraphy see VENTURI (1975, 1981). The distribution chart of the calcareous nannofloras is given in table 4.

The *Pale* section outcrops on the right flank of the valley that comes down SE of the Belfiore village (NE of Foligno) from the top of Sasso di Pale. The thickness, from the top of the Calcare Massiccio Formation to the base of Calcare Diasprigni Formation, is about 30 meters and the section spans the Sinemurian to the lower Bajocian (Fig. 6). For a stratigraphic description and the ammonite biostratigraphy we refer to Bartolini (1989) and Venturi (personal communication 1989). This condensed sequence shows a discontinuous occurrence of calcareous nannofossils (table 5).

The *Fonte Avellana* section is located along the Scheggia to Mt. Catria road, along the Cesano river. The section is about 50 meters thick and spans the Pliensbachian to upper Bajocian-lowermost Bathonian (Fig. 7). For a more detailed stratigraphic description and paleomagnetic data see Channel *et al.* (1984). The distribution chart of calcareous nannofloras is shown in table 6. The Toarcian is very condensed and the FO's observed may not be true first appearances. In fact the thickness of the Monte Serrone marls is reduced by a fault which brings the basal part into contact with a reduced Rosso Ammonitico. A fault is present in the upper part of the section reducing the thickness of the Calcari Diasprigni.

The *Pozzale* section outcrops on the SE flank of the Martani Mountains (North of Terni); it is about 30 meters thick and spans the upper Domerian to upper Toarcian (Fig. 5). For more detailed stratigraphic description and for the ammonite biostratigraphy we refer to Venturi (unpublished data). The range chart of the calcareous nannofossil assemblage is given in table 7.

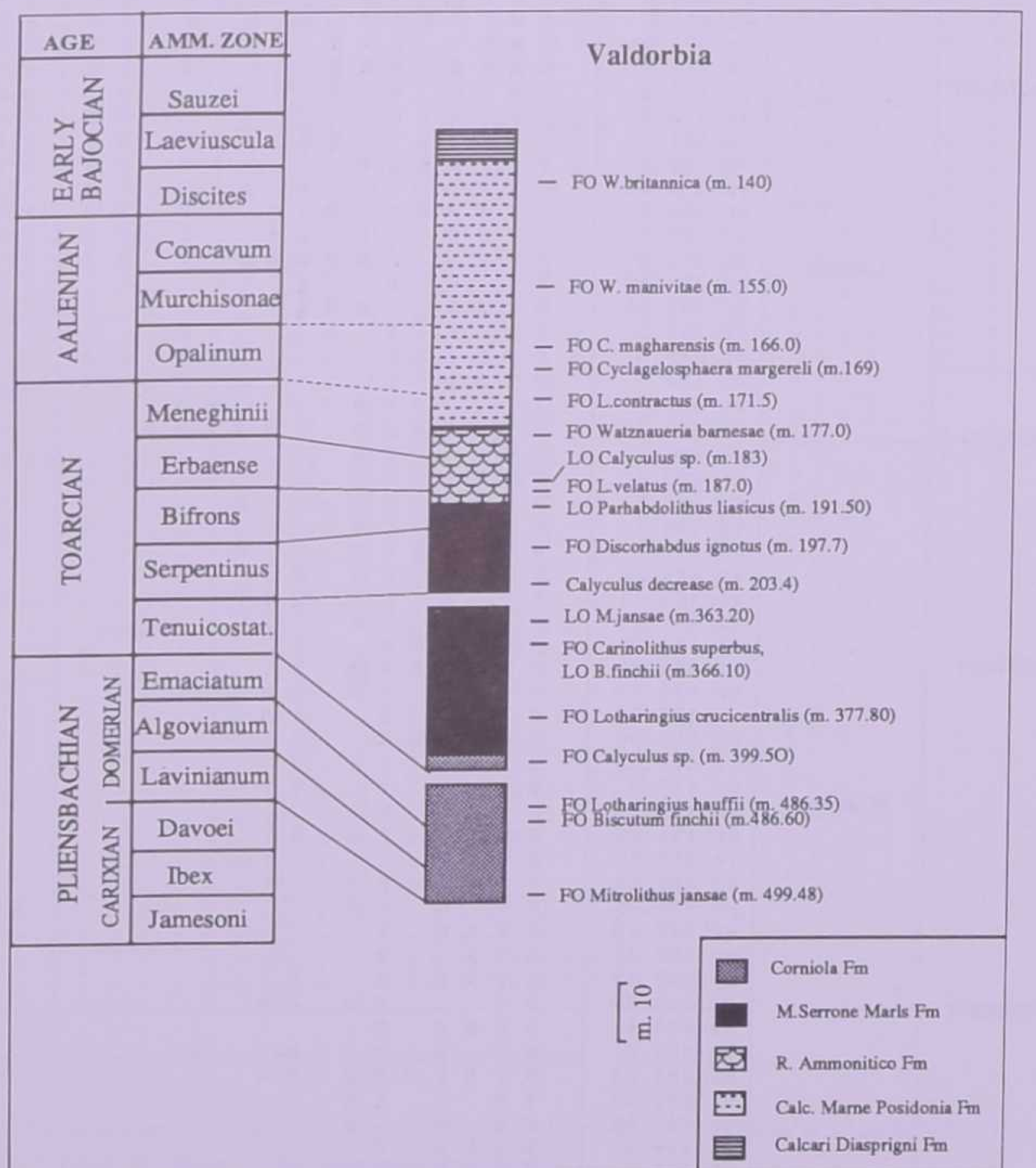

Fig. 3 - Schematic log showing the lithology, the ammonite zones and the main nannofossil events of Valdorbia section.

TABLE 1 - Distribution chart of calcareous nannofossil species from the Valdorbia section. For explanation of the symbols see caption for Table 2

VALDORBIA — SPECIES

AGE	AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Biscutum sp.	Crepidolithus crassus	Parhabdolithus liasicus	Schizosphaerella sp.	Mitrolithus jansae	Crepidolithus cavus	Mitrolithus elegans	Tetralithus cassianus	Tetralithus sp.	Biscutum finchii	Lotharingius hauffii	Mitrolithus lenticularis	Calyculus sp.	Lotharingius barozii	Crepidolithus sp.1	Sollasites sp.	Biscutum novum	Tubirhabdus patulus	Sollasites cfr. lowei	Lotharingius crucicentralis	Axopodorhabdus cfr. cylindratus	Biscutum dubium	Carinolithus superbus
TOARCIAN	Tenuicostatum	L.crucicentralis	vr 362.8	C	M	R	C	R	C	.	.	.	.	.	.	.	.	C	A	.	F	C	.	R	F	.	.	R
			vr 363.2	C	M	.	C	.	F	R	.	.	.	.	.	R	.	.	C	.	R	F	.	.	R	.	.	.
			vr 365.9	C	M	R	.	.	C	F	F	.	.	.	.	.	.	R	C	.	F	F	.	.	F	.	.	.
			vr 366.1	C	M	C	.	R	C	C	F	R	.	.	R	.	.	C	C	.	.	F	R	R	F	1	R	R
			vr 367.9	C	M	F	F	R	C	C	.	R	.	.	.	F	.	F	C	.	F	.	.	.	F	.	.	.
			vr 368.2	F	P	R	R	.	C	R	.	.	.	.	.	F	.	R	C	.	.	R	.	.	.	.	.	.
			vr 369.8	C	M	F	C	.	C	A	.	.	.	.	R	F	.	C	C	.	F	F	.	.	F	.	.	.
			vr 372.0	C	M	F	C	R	A	C	.	R	.	.	.	F	.	F	C	.	F	R	R	R	F	.	.	.
			vr 373.95	C	M	F	.	.	A	A	R	.	.	.	R	C	.	F	F	.	R	C	.	.	F	.	.	.
			vr 376.0	A	M	F	F	.	A	A	R	.	.	.	.	C	.	F	C	.	C	C	.	.	.	.	.	.
			vr 377.8	C	M	F	C	.	A	C	.	.	.	.	.	.	.	F	C	.	C	F	.	.	F	.	.	.
		L.hauffii	vr 379.4	C	P	C	C	R	C	C	.	.	.	.	.	C	.	C	C	.	C	C	R	.	.	.	.	.
			vr 381.1	C	P	F	C	R	.	C	R	R	.	R	R	C	.	R	F	.	F	R	R	.	.	.	.	.
			vr 382.8	F	P	F	R	R	C	F	.	.	.	.	R	F	.	R	F	.	R	R	.	.	.	.	.	.
			vr 383.45	C	P	F	.	.	C	.	.	R	.	R	.	C	.	C	F	.	.	R	.	R	.	.	.	.
			vr 383.8	C	P	F	R	R	C	.	R	.	R	.	.	C	.	F	C	.	F	R	R	.	.	.	.	.
			vr 389.7	C	P	F	F	.	C	R	.	R	R	.	.	C	.	F	C	R	F	R	R	.	.	.	.	.
			vr 391.0	F	P	F	R	.	C	R	R	R	R	R	.	C	.	R	F	R	F	.	.	.	.	.	.	.
			vr 393.95	R	V	.	R	.	R	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 395.95	R	P	R	R	.	C	R	R	R	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
			vr 397.0	R	P	.	R	.	F	.	R	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.
			vr 399.5	F	P	R	F	R	C	.	.	.	.	.	R	F	.	R	F	.	.	.	.	.	.	.	.	.
PLIENSBACHIAN	Emaciatum		vr 400	R	V	R	R	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 482.7	R	V	.	.	.	F	R	.	.	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.
			vr 486.35	F	V	F	R	R	C	R	.	R	R	R	R	R	R	.	.	.	.	.	.	.	.	.	.	.
		M.jansae	vr 486.60	R	V	R	.	.	F	R	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 486.75	F	V	R	F	.	C	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 487.1	R	V	R	.	.	R	R	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Algovianum		vr 488.2	F	V	R	F	.	C	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 489.1	R	V	.	.	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 489.25	R	V	.	R	.	C	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 490.35	F	V	.	R	.	C	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 490.91	F	V	R	R	.	C	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 491.34	R	V	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 491.74	R	V	.	R	R	R	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 492.73	R	V	.	R	.	R	R	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 493.40	R	V	R	R	.	R	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 493.90	R	V	R	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 494.22	R	V	.	R	.	C	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 495.0	R	V	.	R	.	F	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 495.20	R	V	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Lavinianum		vr 495.48	R	V	.	.	.	F	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 495.70	F	V	.	F	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 496.25	F	V	.	R	.	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 496.35	R	V	.	R	.	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 497.18	R	V	R	R	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 497.35	R	V	R	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 497.75	R	V	R	R	.	R	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 497.85	R	V	.	.	.	F	R	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 497.9	R	V	R	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 498.0	F	V	.	R	.	F	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 498.25	R	V	R	F	R	F	R	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 498.85	R	V	.	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 499.48	R	V	.	F	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 499.5	R	V	R	R	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 499.6	F	V	R	F	R	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

TABLE 2 - Distribution chart of calcareous nannofossil species from the Valdorbia section

VALDORBIA — SPECIES

AGE	AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Biscutum dubium	Biscutum novum	Calyculus sp.	Crepidolithus crassus	Lotharingius barozii	Lotharingius crucicentralis	Parhabdolithus liasicus	Schizosphaerella sp.	Biscutum sp.	Crepidolithus cavus	Lotharingius hauffii	Sollasites sp.	Tubirhabdus patulus	Carinolithus superbus	Discorhabdus ignotus	Discorhabdus striatus	Lotharingius velatus	Axopodorhabdus cfr. cylindratus	Carinolithus magharensis	Parhabdolithus sp.1	Mitrolithus elegans	Watznaueria barnesae	Lotharingius contractus	Crepidolithus sp.1	Cyclagelosphaera margerelii	Bussonius lefeuensis	Watznaueria sp.1	Watznaueria manivitae	Watznaueria sp.	Watznaueria britannica
EARLY BAJOC	?		cv 136.4	R	V	.	.	.	.	.	.	.	R	.	.	.	.	.	.	R	.	.	.	R	.	.	R	.	.	.	.	R	R	R	R
			cv 140.0	R	V	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	R	R	.	R	.	.	R	R	R
- ? -	- ? -	W.manivitae	cv 141.5	R	V	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	R	R	R	.
AALENIAN	Murchisonae		cv 144.0	R	V	.	.	.	R	1	R	.	R	.	.	.	.	.	.	R	.	R	.	.	.	.	R	.	.	.	.	R	R	R	.
			cv 150.0	R	V	.	.	.	R	.	.	.	R	.	.	.	.	.	.	.	.	.	.	R	.	.	R	R	.	.	.	.	R	R	.
			cv 152.4	R	V	.	.	.	R	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	R	R	.
			cv 152.8	R	V	.	.	.	R	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	R	R	.
			cv 155.0	R	V	.	.	.	R	.	.	.	R	.	.	.	.	.	.	R	.	.	.	R	.	.	R	R	.	.	.	R	R	R	.
		W.barnesae	cv 160.7	F	P	R	R	.	.	.	R	.	F	.	.	.	.	.	R	F	R	.	R	R	.	.	R	.	.	.	.	R	.	.	.
			cv 161.3	R	V	.	.	.	.	.	.	.	R	.	.	.	.	.	.	R	.	R	.	R	R	.	R	.	.	.	.	R	.	.	.
			cv 162.1	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 163.0	R	V	.	.	.	.	.	R	.	R	.	.	.	.	.	R	R	.	R	.	R	.	.	R	R	.	.	.	R	.	.	.
			cv 164.0	R	V	.	R	.	.	.	R	.	R	.	.	.	.	.	R	.	.	R	.	R	.	.	R	.	.	.	.	R	.	.	.
			cv 164.85	R	V	.	.	.	R	.	.	.	R	.	.	.	.	.	.	R	.	.	.	R	.	.	R	.	.	.	.	.	.	.	.
			cv 166.0	R	V	.	.	.	.	.	R	.	R	.	.	.	.	.	.	R	.	R	.	R	R	.	R	.	.	.	.	.	.	.	.
			cv 166.8	R	V	.	.	.	.	.	R	.	R	.	.	.	.	.	R	R	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
			cv 167.5	R	V	.	.	.	.	R	.	.	R	.	.	.	.	.	.	R	.	R	.	.	R	.	R	R	.	R	1	.	.	.	.
			cv 168.5	R	V	.	R	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	R	.	.	.	.	.
			cv 169.0	R	V	.	.	.	.	.	.	.	R	R	.	.	.	.	R	R	.	.	.	.	R	.	R	.	.	R	.	.	.	.	.
			cv 169.7	F	P	.	.	.	.	R	.	.	C	.	.	.	.	.	.	R	.	.	.	.	.	.	R	R	R	.	.	.	.	.	.
			cv 170.0	C	P	.	R	.	R	R	R	.	C	R	.	.	.	.	R	C	R	R	.	.	.	.	R	.	.	.	.	.	.	.	.
	Opalinum		cv 170.3	R	P	.	R	.	.	.	.	.	R	.	.	R	.	.	.	R	.	.	.	.	R	.	R	.	.	.	.	.	.	.	.
			cv 171.0	F	P	.	R	.	.	R	.	.	F	R	.	R	.	.	.	C	.	R	.	.	R	.	R	R	.	.	.	.	.	.	.
			cv 171.5	R	P	.	R	.	R	.	.	.	R	.	.	R	.	.	R	.	.	.	.	1	R	.	R	R	.	.	.	.	.	.	.
			cv 172.0	R	P	.	.	.	R	.	.	.	R	.	.	R	.	.	R	F	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
			cv 172.1	F	P	.	.	.	R	R	.	.	C	R	.	F	.	.	.	C	R	1	.	.	R	.	F	.	.	.	.	.	.	.	.
			cv 173.35	F	P	R	R	.	.	R	.	.	R	.	.	.	.	.	.	F	.	.	.	1	R	.	R	.	.	.	.	.	.	.	.
			cv 174.0	R	P	.	.	.	.	R	.	.	R	.	.	R	.	.	.	R	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
			cv 175.4	F	P	.	R	.	.	.	.	.	F	.	.	R	.	.	.	C	R	.	.	.	R	.	R	.	.	.	.	.	.	.	.
TOARCIAN	Meneghinii		cv 175.8	R	P	.	R	.	.	R	.	.	R	R	.	.	.	.	R	R	.	.	.	.	R	.	R	.	.	.	.	.	.	.	.
			cv 176.3	F	P	.	R	.	.	R	.	.	F	.	.	R	.	.	R	C	R	1	.	1	R	.	F	.	.	.	.	.	.	.	.
			cv 177.0	C	M	.	R	.	.	F	.	.	F	R	.	.	.	.	.	A	.	1	.	.	R	.	F	.	.	.	.	.	.	.	.
		D.ignotus	cv 177.6	F	M	.	R	.	R	R	R	.	R	R	.	.	.	.	R	C	R	1	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 178.5	R	P	.	R	.	.	R	.	.	R	.	.	.	.	.	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 14	C	M	.	R	.	C	.	R	.	F	.	.	R	.	.	F	C	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 13	R	P	.	R	.	F	R	.	.	R	.	.	.	.	.	R	F	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.
	Erbaense		vr O 12	R	P	.	.	.	F	.	.	.	F	.	.	.	.	.	.	R	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.
			vr O 11c	C	M	R	C	R	C	.	.	.	F	R	.	F	.	.	C	A	R	R	R	1	R	.	.	.	.	.	.	.	.	.	.
			vr O 11b	F	M	.	F	.	C	.	R	.	F	R	.	R	.	.	R	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 11	F	M	.	.	.	R	.	R	.	F	.	.	F	.	.	R	F	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 9	F	M	.	.	.	R	.	R	.	F	.	.	R	.	.	F	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 8	C	M	.	.	.	R	.	R	.	C	.	.	F	.	.	F	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 7a	C	M	.	.	.	F	.	F	.	F	R	.	F	.	.	C	C	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bifrons		vr O 6	C	M	.	R	R	F	.	F	.	C	.	.	C	.	.	C	C	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 186.5	F	M	.	R	.	R	R	.	.	F	.	.	R	.	.	F	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 5	C	M	.	R	R	R	.	R	.	C	R	.	F	.	.	F	C	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O.4	F	M	.	.	.	R	.	.	.	C	R	.	F	.	.	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 3b	C	M	.	R	R	R	.	R	R	C	.	.	.	.	.	F	C	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 3a	R	V	.	.	.	.	R	.	R	R	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 2b	F	P	.	.	R	.	.	.	.	F	.	F	R	.	.	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 2a	F	M	R	R	R	F	.	R	R	C	.	.	F	.	.	F	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr O 2a	C	M	R	C	R	F	.	R	R	A	.	.	F	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Serpentinus		cv 193.7	C	M	.	F	R	R	C	F	R	C	.	.	.	.	.	.	C	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 195.0	C	M	.	.	.	.	R	.	R	C	.	.	C	.	.	.	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 196.2	C	M	F	F	R	.	C	R	R	C	.	.	F	.	.	R	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 197.6	R	P	.	1	.	.	.	.	.	R	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 197.7	F	P	.	.	.	.	.	R	.	C	.	.	R	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		L.crucicentralis	cv 199.0	C	M	.	F	.	.	C	R	R	C	R	.	C	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 200.0	C	M	R	C	.	R	.	F	R	C	.	.	C	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 201.6	F	M	R	R	.	R	F	.	R	C	.	.	R	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			cv 203.4	A	M	R	C	F	R	A	F	F	C	C	R	F	R	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			vr 204.0	A	M	R	C	C	C	A	F	R	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

The total and relative abundance have been calculated as follow:

TOTAL ABUNDANCE A: Abundant, more than 10 specimens in 1 field; C: Common, 10 - 1 specimens in 1 field; F: Few, 1 - 0.1 specimen in 1 field; R: Rare, < 0.1 specimen in 1 field.

SPECIES ABUNDANCE A: Abundant, more than 1 specimen in 1 field; C: Common, 1 specimen in 1 - 10 fields; F: Few, 1 specimen in 10 - 30 fields; R: Rare, 1 specimen in more than 30 fields.

The *Presale* section outcrops along the NW flank of Monte Nerone. The section is about 47 meters thick but the studied intervals is 25 meters and spans the upper Domerian to the lower Bajocian (Fig. 8). For a more detailed stratigraphic description and for the ammonite stratigraphy we refer to CECCA *et al.* (1990) and CRESTA *et al.* (1988). The calcareous nannofossil distribution chart is given in table 8.

The *Infernaccio* section outcrops on the NE flank of the Monte Nerone (Campo al Bello); it is 15 meters thick and spans the Domerian to lower Toarcian (Fig. 9). For a more detailed stratigraphic description and for the ammonite biostratigraphy see CECCA *et al.* (1990). The calcareous nannofossil distribution chart is given in table 9.

For a more detailed stratigraphical and sedimentological description of the Aalenian-Bajocian interval in the Presale and Infernaccio sections, see BALDANZA *et al.* (1990) and CRESTA *et al.* (1988).

The calcareous nannofossil study of the Monte Civitella, Pale, Fonte Avellana, Pozzale, Presale and Infernaccio sections was carried out by BALDANZA and MATTIOLI; Valdorbia and Monte Serrone was studied by REALE and MONECHI.

BIOSTRATIGRAPHY

AMMONITE ZONATIONS

The Jurassic interval can be dated by using a very detailed standard Ammonite Zonation

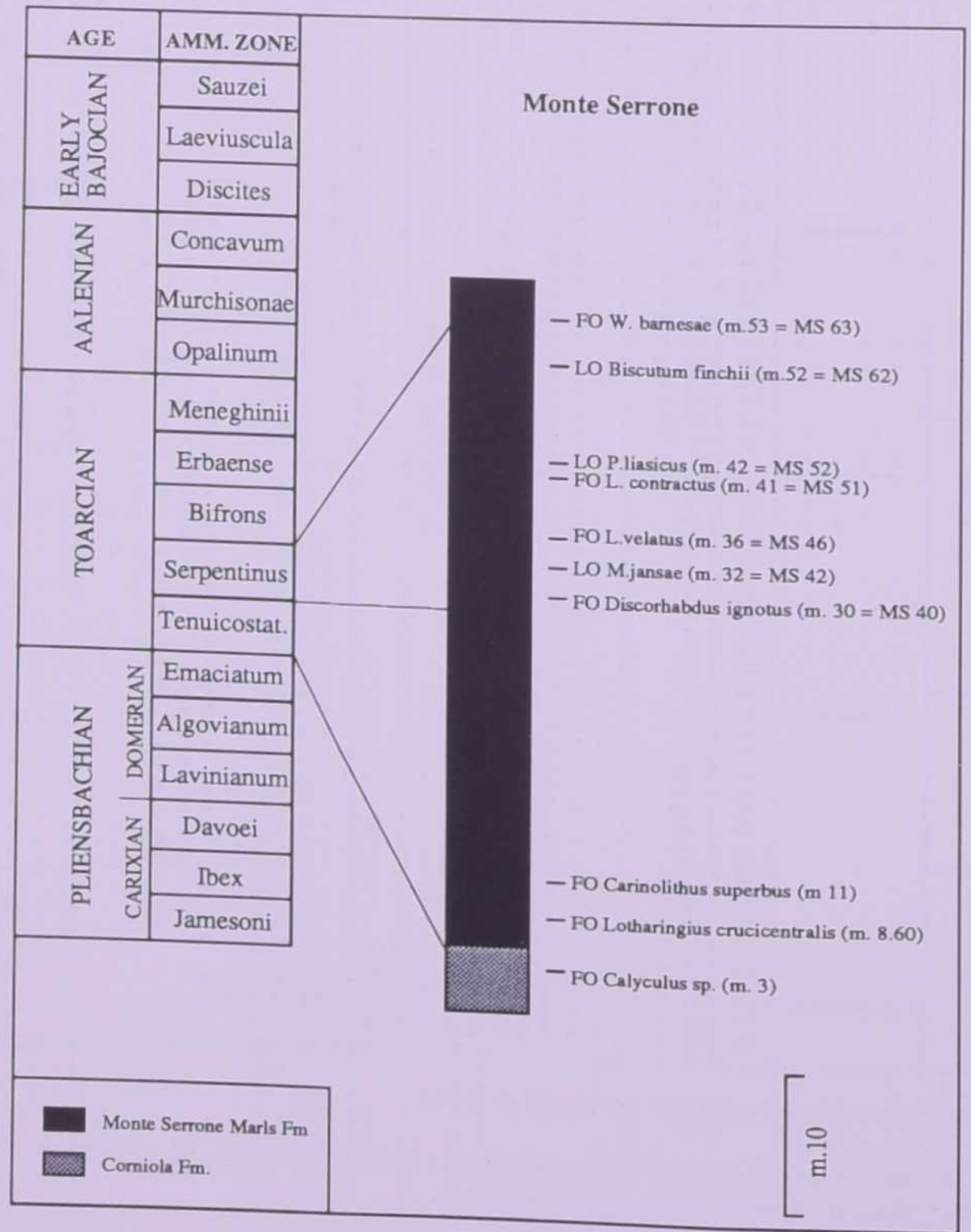

FIG. 4 - Schematic log showing the lithology, the ammonite zones and the main nannofossil events of M. Serrone section.

Scheme (Arkell, 1946; Dean *et al.*, 1961), based on studies performed on Northern European sequences. This zonation scheme cannot be easily applied to the study area, because of the differences existing between the Boreal and the Mediterranean bioprovinces, very likely related to different evolution rates, migration patterns (Enay 1980) and provincialism (Cariou *et al.*, 1985) of ammonite faunas induced by the different paleoecological condition (Tintant *et al.*, 1982). These discrepancies are well known in the Upper Jurassic where well correlated zonations have been defined in the Boreal, sub-Mediterranean and Mediterranean bioprovinces; unfortunately no well correlated zonations have been yet produced for the Lower-Middle Jurassic, where the same problem of provincialism exists.

The Mediterranean and sub-Mediterranean provinces belong to the Tethyan realm; however, the first is of "european" affinity (the northern edge of the Tethys), the second one is of "african" affinity (the southern edge of Tethys). Pavia e Sarti, 1987 include the Apennine region in the Mediterranean province; we refer to the same authors for the zonal scheme adopted here, except for the Domerian interval where the zonal scheme of Braga *et al.* (1984), more suitable for the Umbria-Marche basin, has been used (Fig. 2).

Table 3 - Distribution chart of calcareous nannofossil species from the M. Serrone section. For explanation of the symbols see caption for Table 2

MONTE SERRONE — SPECIES

AGE	AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Lotharingius hauffii	Mitrolithus jansae	Schizosphaerella sp.	Parhabdolithus liasicus	Biscutum finchii	Crepidolithus crassus	Crepidolithus granulatus	Calyculus sp.	Biscutum dubium	Biscutum novum	Crepidolithus cavus	Lotharingius barozii	Lotharingius sigillatus	Sollasites cfr. lowei	Lotharingius crucicentralis	Carinolithus superbus	Crepidolithus pliensbachensis	Discorhabdus ignotus	Lotharingius velatus	Lotharingius contractus	Axopodorhabdus cfr. cylindratus	Biscutum sp.	Watznaueria barnesae
TOARCIAN	Bifrons	W.barnesae	MS 64.00	R	P	R	.	F	.	.	.	.	.	.	R	.	R	1	.	1	R	.	.	.	.	.	.	.
			MS 63.00	R	P	R	.	F	.	.	.	.	.	.	R	.	R	.	.	.	.	1	.	.	.	.	.	R
	Serpentinus	D.ignotus	MS 62.00	F	M	R	.	F	.	R	R	.	.	R	R	.	R	R	.	R	F	.	C	.	.	.	.	.
			MS 61.00	C	P	F	.	C	.	R	R	.	1	R	C	R	R	.	.	.	R	.	C	.	.	R	R	.
			MS 60.00	F	P	A	.	C	.	1	.	.	.	.	R	.	1	.	.	.	R	1	R	.	1	.	.	.
			MS 59.00	R	P	R	.	F	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R	.	.	.	.	.
			MS 58.00	R	P	R	.	R	.	.	.	.	R	R	R	.	.	.	.	.	.	.	R	.	.	.	.	.
			MS 56.00	R	P	R	.	R	.	R	.	.	R	R	R	.	R	R	.	R	R	.	R	R	R	.	.	.
			MS 55.00	F	M	F	.	C	.	R	R	.	.	.	C	.	.	.	.	F	C	.	R	R	R	.	.	.
			MS 54.00	F	M	F	.	C	.	R	R	.	F	R	F	.	R	.	.	R	F	.	.	.	.	R	.	.
			MS 52.00	F	M	C	.	R	R	R	R	.	R	R	C	R	R	R	.	R	C	.	.	.	.	.	.	.
			MS 51.00	F	M	F	.	C	.	R	.	.	.	.	C	.	.	.	.	C	C	.	R	R	R	.	.	.
			MS 50.00	F	M	F	.	R	R	R	R	.	R	R	C	.	R	1	.	1	R	.	.	.	.	.	.	.
			MS 49.00	C	M	C	.	C	R	R	R	R	F	R	C	R	F	R	.	R	C	.	R	.	.	.	.	.
			MS 47.00	F	M	F	.	R	R	R	R	.	C	.	C	.	R	1	.	R	F	.	.	.	.	.	.	.
			MS 46.00	F	M	C	.	A	.	.	R	.	.	R	A	.	F	.	.	F	F	.	.	R	.	.	.	.
			MS 45.00	C	M	C	.	C	.	F	R	.	F	.	F	.	R	R	1	R	F	R	1	.	.	.	.	.
			MS 43.00	C	M	C	.	A	.	.	R	.	.	.	C	.	.	.	.	R	C	.	.	.	.	.	.	.
			MS 42.00	C	M	A	R	C	R	F	R	.	C	R	C	R	F	.	R	A	C	R	R	.	.	.	.	.
			MS 41.00	C	M	C	.	C	1	R	F	.	R	.	F	.	.	.	.	F	C	.	1	.	.	.	.	.
			MS 40.00	F	M	C	F	C	R	R	R	.	F	R	1	.	F	R	.	R	R	R	R	.	.	.	.	.
	Tenuicostatum	L.crucicentralis	MS 27.00	F	M	F	R	R	R	R	R	R	R	R	F	R	F	R	.	R	R	R	.	.	.	.	.	.
			MS 13.50	C	M	A	.	C	.	R	R	.	R	R	.	.	F	.	1	.	.	.	.	.	.	.	.	.
			MS 13.00	R	P	F	F	R	R	R	R	.	R	R	.	R	R	.	.	.	.	.	.	.	.	.	.	.
			MS 12.00	F	P	C	.	C	.	.	R	.	F	.	R	R	1	.	.	R	.	R	.	.	.	.	.	.
			MS 11.00	F	M	C	F	C	R	R	F	R	F	R	R	.	R	R	.	.	1	.	.	.	.	.	.	.
			MS 9.60	F	M	R	C	C	1	.	R	.	R	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
			MS 8.85	F	M	R	F	C	R	.	.	.	R	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
			MS 8.60	C	M	A	F	A	R	R	F	R	F	R	F	R	F	R	.	R	.	.	.	.	.	.	.	.
		L.hauffii	MS 6.00	F	P	R	F	C	R	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
			MS 5.90	C	M	C	F	A	R	F	F	R	F	R	R	R	F	R	R	.	.	.	.	.	.	.	.	.
PLIENS.	Emaciatum		MS 3.00	F	P	.	F	C	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			MS 2.00	F	P	R	F	A	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			MS 1.00	F	P	R	C	A	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			MS 0.50	F	P	R	F	A	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			MS 0.00	F	P	R	F	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

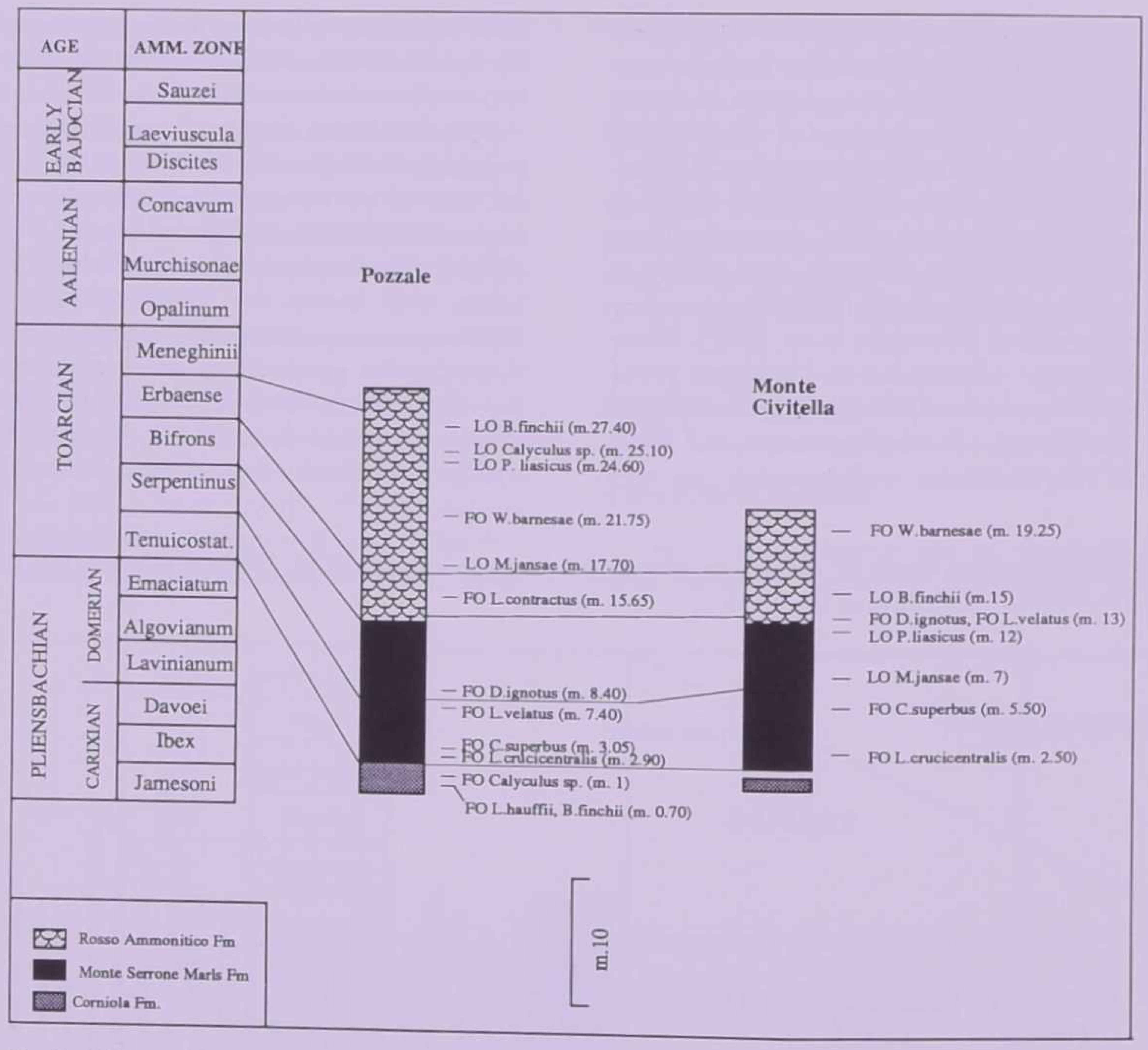

FIG. 5 - Schematic log showing the lithology, the ammonite zones and the main nannofossil events of Pozzale and M. Civitella sections.

The ammonite biostratigraphy shown in the different sections has been defined by several authors: VENTURI (1986); CHANNEL *et al.* (1984); CRESTA *et al* (1989) for the Valdorbia section; VENTURI (unpublished data) for the Pozzale section; BALDANZA *et al.* (1990), CECCA *et al.* (1990) and CRESTA *et al.* (1988) for the Presale and Infernaccio sections; PIALLI (1969) and VENTURI (1981) for the Monte Serrone section; VENTURI (1975, 1981) for the Monte Civitella section; and VENTURI (unpublished data) for the Pale section.

CALCAREOUS NANNOFOSSILS

Previous studies

In the last twenty five years several calcareous nannofossil biostratigraphic schemes have been proposed for the Jurassic time interval. Most of the schemes proposed were based on sequences belonging to the Boreal realm (NW Europe) or sub-Mediterranean province (Portugal) and cannot be satisfactorily applied to the studied area due to the problem connected with provincialism. In fact the Mediterranean province shows the

TABLE 4 - Distribution chart of calcareous nannofossil species from the M. Civitella section. Explanation of the symbols see caption for Table 2

MONTE CIVITELLA — SPECIES

AGE	AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Biscutum finchii	Calyculus sp.	Crepidolithus cavus	Crepidolithus crassus	Lotharingius barozii	Lotharingius hauffii	Parhabdolithus liasicus	Schizosphaerella sp.	Sollasites cfr. lowei	Biscutum dubium	Biscutum novum	Crepidolithus pliensbachensis	Lotharingius sigillatus	Mitrolithus jansae	Lotharingius crucicentralis	Crepidolithus granulatus	Bimorhabdus gallicus	Carinolithus superbus	Lotharingius contractus	Discorhabdus ignotus	Lotharingius velatus	Watznaueria barnesae
TOARCIAN	Erbaense	W.barnesae	MC3 18.00	F	P	.	.	.	.	.	.	.	F	.	.	A	.	.	.	.	.	.	F	.	R	.	R
			MC3 17.30	C	P	.	.	.	.	R	F	.	C	.	.	A	R	.	.	R	R	.	F	.	R	.	R
		D.ignotus	MC3 16.80	R	P	.	.	.	F	.	R	.	F	.	.	.	.	.	.	R	.	.	F	.	.	.	.
			MC3 15.00	F	P	R	R	.	F	.	R	.	F	.	R	C	.	.	.	.	.	.	F	.	.	.	.
			MC3 14.60	C	P	.	.	.	.	.	F	.	C	.	.	C	.	.	.	R	.	.	C	.	R	.	.
			MC3 14.20	C	P	F	.	.	R	.	F	.	C	.	.	A	.	.	.	.	.	.	C	.	R	R	.
	Bifrons		MC3 13.40	C	P	F	.	R	R	R	F	.	F	R	R	C	.	.	.	.	R	.	C	.	R	.	.
			MC3 12.00	F	P	R	.	.	.	.	F	.	A	.	.	F	.	.	.	.	R	.	C	F	R	R	.
			MC3 11.00	F	P	R	.	R	R	R	R	.	F	.	R	C	R	.	.	R	.	.	F	R	F	R	.
	Serpentinus	L.crucicentralis	MC3 10.20	F	P	R	R	R	F	R	F	R	C	.	.	.	.	.	.	R	.	.	C	.	.	.	.
			MC3 9.30	F	P	.	R	.	F	R	C	R	F	.	.	.	.	.	.	R	.	.	.	.	.	.	.
			MC3 8.60	F	P	.	R	R	F	R	C	R	C	.	R	.	.	R	.	R	.	.	.	.	.	.	.
			MC3 8.40	F	P	.	R	R	F	F	C	R	C	.	.	.	.	.	.	R	.	.	.	.	.	.	.
			MC3 5.80	F	P	R	F	.	.	R	F	.	C	R	R	F	.	.	.	.	.	.	.	.	.	.	.
			MC3 5.60	R	P	.	.	.	.	.	R	.	A	.	.	.	.	.	.	R	.	.	R	R	.	.	.
			MC3 5.30	R	P	R	R	.	.	R	F	.	F	.	R	.	.	R	.	R	.	.	R	R	.	.	.
			MC3 5.00	F	P	R	.	.	.	R	F	.	C	.	.	.	.	.	.	.	.	.	R	R	.	.	.
			MC3F 7.00	R	P	F	.	.	.	R	F	.	F	.	R	R	.	.	R	R	.	.	.	.	.	.	.
			MC3F 6.80	F	P	R	.	.	R	R	R	.	F	.	.	R	.	.	.	F	.	R	F	.	.	.	.
			MC3F 6.50	R	V	R	.	.	.	.	R	.	R	.	.	R	.	.	.	.	.	.	R	.	.	.	.
			MC3F 6.00	F	P	R	R	.	R	R	F	.	F	.	.	.	.	.	.	R	.	.	F	.	.	.	.
	Tenuicostatum		MC3F 5.50	R	P	.	.	.	.	R	R	.	F	.	R	.	.	.	.	R	.	.	R	.	.	.	.
			MC3F 5.10	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			MC3F 4.80	F	M	.	.	F	F	F	F	.	A	.	.	.	F	.	R	R	F	R	.	.	.	.	.
			MC3F 4.10	F	M	.	R	.	R	R	R	.	A	.	.	R	R	.	R	R	.	.	.	.	.	.	.
			MC3F 3.75	F	M	.	R	.	R	R	F	.	A	.	.	R	R	.	R	R	.	.	.	.	.	.	.
			MC3F 3.50	F	M	F	F	.	R	.	F	.	C	1	.	F	R	.	R	.	R	.	.	.	.	.	.
			MC3F 2.90	C	M	F	C	F	F	C	C	.	C	.	F	.	F	.	F	F	F	.	.	.	.	.	.
			MC3F 2.60	C	M	F	C	F	F	C	C	.	C	.	F	.	F	.	F	F	F	.	.	.	.	.	.
			MC3F 2.50	R	P	R	R	.	.	.	F	.	C	R	R	R	.	.	.	R	.	.	.	.	.	.	.
		L.hauffii	MC3F 2.10	F	P	R	F	R	.	R	C	.	C	.	R	.	R	R	.	.	.	.	.	.	.	.	.
			MC3F 2.00	R	P	R	R	R	.	R	C	.	C	.	R	.	R	.	.	.	.	.	.	.	.	.	.
			MC3F 1.60	F	P	R	C	R	R	R	C	R	A	R	R	F	R	R	R	.	.	.	.	.	.	.	.
			MC3F 0.25	F	P	R	C	R	R	R	C	R	A	R	R	F	R	R	R	.	.	.	.	.	.	.	.
DOM.	Emaciatum		MC3 1.00	R	P	F	R	R	R	R	R	R	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.

presence of distinct nannofossil assemblages and different distributions of taxa. The first biostratigraphic schemes were proposed by STRADNER (1963), PRINS (1969), and AMEZIEUX (1972). BARNARD and HAY (1974) suggested a quite detailed zonation scheme (well correlated with the ammonite zones) for the Boreal realm; 22 zones were established and based on species well described in the electron microscope, but quite difficult to recognize in the light microscope. THIERSTEIN (1976) correlated several biostratigraphic schemes (STRADNER, 1963; PRINS, 1969; AMEZIEUX, 1972) with the results of his own work on the Jurassic of England, Poland, Germany, France, Switzerland and on DSDP Sites of the NW Atlantic and Indian Oceans; he defined a stratigraphic scheme based on ten biostratigraphic events, for the whole Jurassic, well identifiable in the optical light microscope. MEDD (1979, 1982) suggested a biostratigraphic scheme of 15 zones based on English sequences, well defined by ammonites for the Bajocian - Portlandian interval.

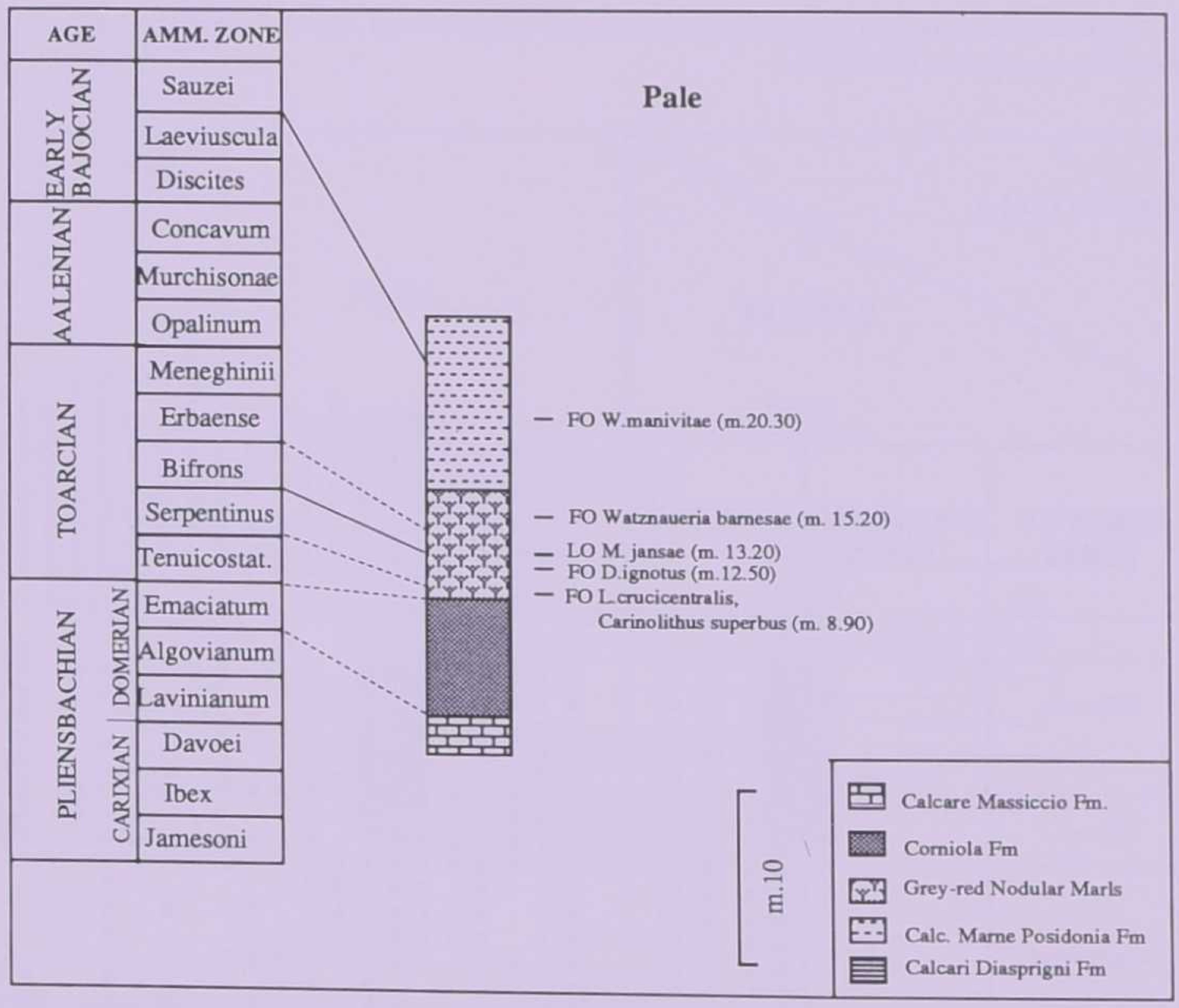

FIG. 6 - Schematic log showing the lithology, the ammonite zones and the main nannofossil events of the Pale section.

Subsequently, HAMILTON (1982) proposed a biostratigraphic scheme for the whole Jurassic summarizing previous works, and including data from Portuguese sections (HAMILTON 1977, 1979) and the results of her work at University College, London. The drilling of the Jurassic interval in the NW Atlantic Ocean (DSDP Site 534) allowed ROTH *et al.* (1983) to define a detailed biostratigraphic scheme for the Middle-Upper Jurassic. CRUX (1984, 1987b) in his studies of SW Germany and Great Britain defined 22 events for the Rhaetian - Toarcian interval. Recently BOWN (1987b), in a paper of taxonomic revision and biostratigraphy for the Upper Trias to Toarcian, suggested a zonal scheme for NW Europe comprising 8 zones and 6 subzones. BOWN *et al.* (1988) extended the previous zonation to the whole Jurassic interval. ERBA (1990), in a biostratigraphic study of the Digne area (SW France), recognized several events in the late Aalenian-Bathonian interval.

Biostratigraphic studies for the Early-Middle Jurassic in the Mediterranean area are quite few and a suggested biostratigraphic scheme does not exist yet. MOSHKOVITZ and EHRLICH (1976a) recognized quite abundant calcareous nannofossil assemblages in three boreholes from Israel and northern Sinai, and defined three biozones for the Bajocian-Oxfordian interval. NICOSIA and PALLINI (1977) studied the Rosso Ammonitico Formation (Toarcian) of the Monte La Pelosa (Central Italy) and showed the stratigraphic distribution of nannofossil correlated with the ammonite zones. FANTINI SESTINI *et al.* (1981) in a paper on the *Margaritatus* zone (Domerian) of the Rosso Ammonitico of the Turati Alps, correlate nannofossils with the ammonite zonation and define two assemblage zones. YOUNG *et al.* (1986), in a stratigraphic revision of the Longobucco Group (Calabria, S. Italy), found a distinct calcareous nannofossil assemblage but the data was not sufficient to propose a biostratigraphic scheme. MANIVIT (1987) in Central Arabia defined three zones for the Toarcian-Oxfordian interval. BALDANZA *et al.* (1990), in a paper on the Aalenian-Bajocian boundary, found several nannofossil

TABLE 5 - Distribution chart of calcareous nannofossil species from the Pale section. For explanation of the symbols see caption for Table 2

PALE — SPECIES

AGE	AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Mitrolithus jansae	Schizosphaerella sp.	Tetralithus cassianus	Biscutum dubium	Carinolithus superbus	Lotharingius barozii	Lotharingius crucicentralis	Calyculus sp.	Crepidolithus crassus	Lotharingius hauffii	Biscutum finchii	Biscutum novum	Biscutum sp.	Discorhabdus ignotus	Watznaueria barnesae	Mitrolithus elegans	Watznaueria manivitae	Cyclagelosphaera margerelii	Watznaueria britannica
EAR. BAJO.	Sauzei		PLV 26.20	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	.	R	R	.
			PLV 25.70	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	C	R	R
AALENIAN ?	?	W.manivitae	PLV 25.25	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 24.90	R	V	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R	.	.
			PLV 24.20	R	V	.	.	.	.	.	.	.	.	.	.	.	R	.	R	R	.	.	.	.
			PLV 23.50	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 22.90	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 22.40	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 21.40	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 20.30	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	.	.
		W.barnesae	PLV 19.20	R	P	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
			PLV 18.60	R	P	.	.	.	.	.	.	.	.	1	.	.	R	.	.	.	R	.	.	.
			PLV 17.60	R	P	.	R	.	.	.	.	.	.	R	.	.	1	.	.	.	.	.	.	.
			PLV 17.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN ?	?		PLV 16.00	R	P	.	R	.	.	.	.	.	.	R	.	1	R	.	.	.	.	.	.	.
			PLV 15.20	R	P	.	F	.	.	.	.	.	.	.	.	.	1	.	.	R	.	.	.	.
			PLV 14.80	F	P	.	R	.	.	R	R	R	R	R	.	R	C	.	R	.	.	.	.	.
		D.ignotus	PLV 14.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 13.70	F	P	.	C	.	R	F	R	1	.	.	.	R	C	R	.	.	.	.	.	.
	Bifrons		PLV 13.20	F	P	R	C	.	.	F	.	.	R	.	R	.	.	.	R	.	.	.	.	.
			PLV 12.50	F	P	.	F	.	.	R	R	.	R	R	R	F	F	R	1	.	.	.	.	.
		L.crucicentralis	PLV 12.00	R	P	.	.	.	.	R	.	.	.	.	.	.	F	R	.	.	.	.	.	.
	Serpentinus		PLV 11.50	R	P	R	A	.	.	1	R	.	R	R	R	.	.	.	.	.	.	.	.	.
			PLV 11.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 10.50	F	P	R	A	.	R	R	R	.	R	F	R	R	R	.	.	.	.	.	.	.
			PLV 10.00	F	P	R	A	.	R	.	.	.	R	F	R	R	R	.	.	.	.	.	.	.
	Tenuicostatum		PLV 9.50	F	P	R	A	.	R	.	R	.	R	R	F	R	R	1	.	.	.	.	.	.
			PLV 9.00	F	P	R	R	.	R	.	R	.	R	R	R	.	.	.	.	.	.	.	.	.
			PLV 8.90	R	P	1	F	.	R	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.
		L.hauffii ?	PLV 8.60	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 8.55	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
PLIENSB.	Emaciatum		PLV 8.50	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 7.00	R	P	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 6.00	R	P	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 5.20	R	P	1	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 3.80	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 2.40	R	V	1	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	?		PLV 2.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PLV 0.60	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

events that approximately define the boundary in the Umbria-Marche area. ERBA & COBIANCHI (1989) defined several important biostratigraphic events from a detailed study of the Lombardy basin for the lower Pliensbachian-lower Bajocian interval.

Methods

Samples were usually taken at intervals of one meter. Due to differences in the sedimentation rate and the presence of numerous fossilifereous ammonite horizons, some samples were taken every 20-30 cm. The calcareous nannofossil analy-

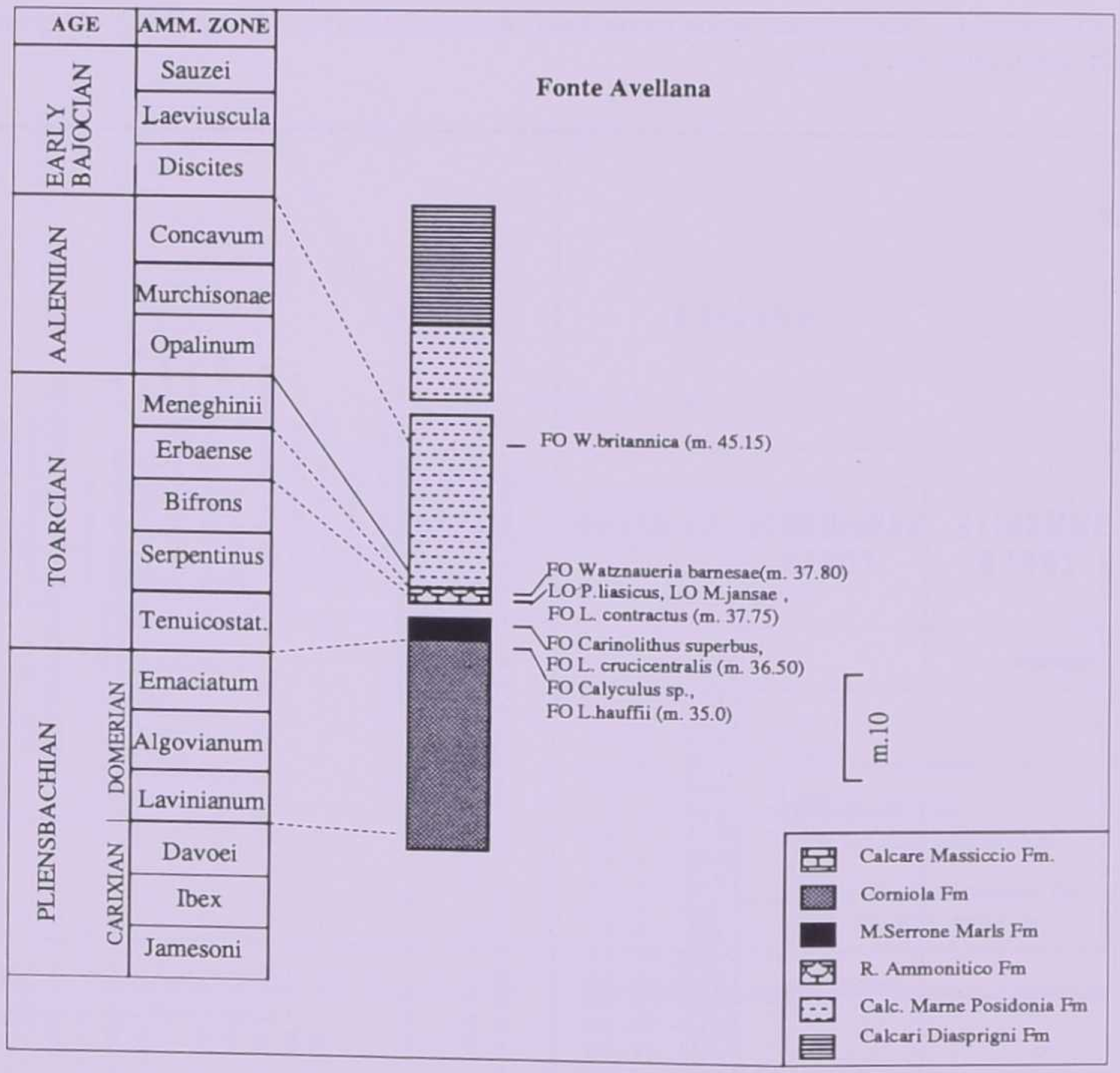

FIG. 7 - Schematic log showing the lithology, the ammonite zones and the main nannofossil events of Fonte Avellana section.

sis was performed mainly by optical light microscopy at a magnification of 1000 and 1500x. Standard techniques for smear slides preparation (HAY, 1965; MONECHI and THIERSTEIN, 1985) were employed. Some specimens, whose identification was unclear in the light microscope (l.m.), were observed both in the scanning electron microscope (SEM) and in the light microscope using the MOSHKOVITZ's (1974) same specimen technique. Unfortunately the poorly preserved material did not provide satisfactory results. The total and relative nannofossil abundances are given in table 1; the counting is based on light microscope observations of at least 360 fields of view.

Events

From the detailed biostratigraphic study of eight sequences of the Umbria-Marche basin it has been possible to define a continuous succession of biostratigraphic events for the Pliensbachian-Aalenian/Bajocian boundary interval, well correlated with the ammonite zones. The events recognized are listed below from oldest to youngest and compared with previously published data.

First Occurrence of *Mitrolithus jansae*

The FO of *M. jansae* occurs in the upper Carixian in the *Davoei* Zone of the Infernaccio section; and in the lower Domerian *Lavinianum* Zone of the Valdorbia section. In the Valdorbia section the FO di *M. jansae* may not be its true first occurrence and it could be absent in the lower levels due to preservation. It seems to be an important and well recognizable event in the Umbria-Marche basin. PRINS (1969) found the FO of *M. irregularis* (= *jansae*) in the lower Pliensbachian (*Davoei Zone*) in France, England and Germany. WIEGAND (1984) at Site 547 found *Calcivascularis* (=*Mitrolithus*) *jansae* from the upper Sinemurian. YOUNG *et al.* (1986) found this species already present in the lowermost part of

TABLE 6 - Distribution chart of calcareous nannofossil species from the Fonte Avellana section. For explanation of the symbols see caption for Table 2

FONTE AVELLANA — SPECIES

AGE	AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Mitrolithus elegans	Mitrolithus jansae	Schizosphaerella sp.	Crepidolithus crassus	Calyculus sp.	Lotharingius hauffii	Biscutum dubium	Biscutum finchii	Biscutum novum	Carinolithus superbus	Crepidolithus pliensbachensis	Lotharingius barozii	Lotharingius crucicentralis	Parhabdolithus liasicus	Lotharingius contractus	Crepidolithus cavus	Discorhabdus ignotus	Sollasites cfr. lowei	Watznaueria barnesae	Watznaueria sp.1	Watznaueria britannica	Cyclagelosphaera margerelii	Watznaueria manivitae	Retacapsa incompta	Carinolithus magharensis
EARLY BAJOCIAN ?			CS 74.60	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	R	R	.	.
			CS 74.00	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	R	R	.	R	.	.
			CS 73.00	C	P	.	.	R	.	.	.	.	.	R	.	.	.	.	.	R	.	.	.	C	.	.	F	A	R	.
			CS 72.00	R	P	.	.	R	.	.	.	.	.	R	R	.	.	.	.	R	.	.	.	F	.	R	R	F	R	.
			CS 71.20	C	P	.	.	R	.	.	.	.	.	.	R	.	.	.	.	F	.	.	.	R	.	R	F	A	R	.
			CS 69.50	C	P	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	A	R	F	.	C	.	.
			CS 68.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 67.10	F	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	F	R	F	R	F	.	.
			CS 65.30	R	P	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	R
			CS 64.50	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	R	.	.	.	.	.	.
			CS 62.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 61.50	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 60.50	R	P	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 59.80	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 59.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 58.00	R	P	.	.	R	.	.	.	.	.	R	.	.	.	.	.	R	.	R	.	F	R	F	R	R	.	.
			CS 57.00	F	P	.	.	R	.	.	.	.	.	R	.	.	.	.	.	R	.	C	.	R	R	F	R	R	R	.
			CS 56.00	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R	R	R	.	.
			CS 54.90	C	P	.	.	.	.	.	.	.	.	A	R	.	.	.	.	R	.	R	.	A	R	A	C	C	.	.
			CS 53.70	F	P	.	.	F	.	.	.	.	.	F	.	.	.	.	.	.	.	C	.	F	R	F	F	F	.	.
			CS 52.50	R	P	.	.	R	.	.	.	.	.	R	R	.	.	.	.	.	.	R	.	R	R	R	R	R	.	.
			CS 51.00	F	P	.	.	R	.	.	.	.	.	F	R	.	.	.	.	.	.	.	.	F	R	F	F	F	.	.
			CS 48.90	R	P	.	.	.	R	.	.	.	.	R	F	.	.	R	.	.	.	R	.	R	.	R	R	R	.	.
			CS 48.40	R	P	.	.	R	R	.	.	.	.	R	.	.	.	R	.	R	.	R	.	R	.	R	R	F	.	.
			CS 47.50	R	P	.	.	.	.	.	.	.	.	R	R	.	.	.	.	R	.	.	.	R	.	R	.	R	.	.
			CS 46.70	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	R	R	R	R	.	.
			CS 45.70	R	P	.	.	F	R	.	.	.	.	.	F	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.
?	?		CS 45.15	R	P	.	.	A	R	.	.	.	.	R	.	.	.	R	.	.	.	.	.	R	R	R	.	.	.	.
AALENIAN	Opalinum	W.barnesae / W.manivitae	CS 44.50	R	P	.	.	.	R	.	.	.	.	F	F	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
			CS 44.20	R	P	.	.	.	R	.	.	.	.	F	F	R	.	R	.	.	.	R	.	R	R	.	.	.	.	.
			CS 43.50	R	P	.	.	R	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	R	.	.	.	.	.	.
			CS 42.00	R	P	.	.	.	R	R	.	.	.	R	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.
			CS 40.30	R	P	.	.	A	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 39.65	R	P	.	.	A	R	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Meneghinii		CS 38.75	F	P	.	.	R	R	R	R	R	.	A	R	.	R	R	.	R	.	.	.	R	.	.	.	.	.	.
			CS 38.50	F	P	.	.	A	R	.	R	R	.	A	F	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.
			CS 38.35	R	P	.	.	.	R	R	R	R	.	R	R	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.
			CS 38.00	R	P	.	.	R	.	.	R	.	R	R	R	.	R	.	.	R	.	.	.	.	.	.	.	.	.	.
			CS 37.80	C	P	.	.	A	C	F	F	R	.	A	F	.	R	R	.	.	R	R	R	R	.	.	.	.	.	.
	?	L.crucicentralis	CS 37.75	A	P	.	R	A	R	R	F	R	F	A	R	R	R	R	R	R	.	.	.	.	.	.	.	.	.	.
			CS 36.60	R	P	.	R	F	R	R	R	R	R	R	R	R	.	.	R	.	.	.	.	.	.	.	.	.	.	.
			CS 36.50	C	P	.	R	C	R	R	.	F	F	F	R	R	F	R	R	.	.	.	.	.	.	.	.	.	.	.
		L.hauffii	CS 36.20	R	P	R	R	R	.	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 36.05	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
PLIENSBACHIAN	Emaciatum		CS 35.00	R	P	.	R	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		M.jansae	CS 34.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 33.00	R	P	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 32.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 30.50	R	P	.	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	?		CS 30.00	R	P	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 28.65	R	P	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 28.00	R	P	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Lavinianum		CS 26.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 23.90	R	P	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	?		CS 21.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			CS 20.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

TABLE 7 - Distribution chart of calcareous nannofossil species from Pozzale section. For explanation of the symbols see caption for Table 2

POZZALE — SPECIES

AGE	AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Biscutum dubium	Crepidolithus crassus	Lotharingius barozii	Mitrolithus jansae	Schizosphaerella sp.	Biscutum finchii	Crepidolithus granulatus	Lotharingius hauffii	Lotharingius sigillatus	Biscutum novum	Calyculus sp.	Parhabdolithus liasicus	Sollasites cfr. lowei	Crepidolithus pliensbachensis	Lotharingius crucicentralis	Carinolithus superbus	Crepidolithus cavus	Mitrolithus elegans	Eimorhabdus gallicus	Lotharingius velatus	Discorhabdus ignotus	Lotharingius contractus	Watznaueria barnesae
TOARCIAN	Meneghinii	W.barnesae	PO 28.90	R	P	R	.	.	.	A	.	.	.	.	R	.	.	.	.	R	R	.	.	.	.	R	.	.
TOARCIAN	Meneghinii	W.barnesae	PO 28.30	F	P	.	C	.	.	C	.	.	.	.	F	.	.	.	R	.	.	.	.	.	R	R	R	R
TOARCIAN	Erbaense	W.barnesae	PO 27.40	R	P	.	.	R	.	C	R	.	.	.	C	.	.	.	.	R	R	.	.	.	.	R	.	R
TOARCIAN	Erbaense	W.barnesae	PO 27.30	F	P	.	R	R	.	.	R	.	.	.	C	.	.	.	.	R	R	.	.	.	R	R	.	C
TOARCIAN	Erbaense	W.barnesae	PO 26.50	R	P	.	.	.	.	C	.	.	.	.	R	.	.	.	.	.	R	.	.	.	.	.	.	R
TOARCIAN	Erbaense	W.barnesae	PO 25.10	F	P	.	.	.	.	A	.	.	.	.	F	R	.	.	R	.	R	R	.	.	.	R	R	R
TOARCIAN	Erbaense	W.barnesae	PO 24.60	R	P	R	R	.	.	C	R	.	.	.	R	.	R	.	.	.	R	.	.	.	.	.	.	R
TOARCIAN	Erbaense	W.barnesae	PO 23.75	R	P	R	R	.	.	C	R	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.
TOARCIAN	Erbaense	W.barnesae	PO 21.75	F	P	R	R	.	.	A	R	.	R	.	R	.	R	.	.	R	A	.	.	.	R	R	R	R
TOARCIAN	Erbaense	D.ignotus	PO 21.20	R	P	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Erbaense	D.ignotus	PO 20.50	F	M	R	.	.	.	F	R	.	.	.	C	.	R	.	R	R	R	.	.	.	.	R	.	.
TOARCIAN	Erbaense	D.ignotus	PO 19.60	R	P	.	.	R	.	.	R	.	.	.	R	.	.	.	.	R	R	.	.	.	.	.	.	.
TOARCIAN	Erbaense	D.ignotus	PO 18.20	R	P	R	.	.	.	R	.	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	R	.
TOARCIAN	Erbaense	D.ignotus	PO 17.70	F	P	R	R	R	R	C	R	R	C	.	R	R	R	.	.	.	R	.	.	.	.	R	.	.
TOARCIAN	Bifrons	D.ignotus	PO 16.45	F	P	R	.	R	R	C	R	.	C	.	R	R	R	.	.	R	A	R	.	.	R	R	.	.
TOARCIAN	Bifrons	D.ignotus	PO 15.65	F	P	R	R	R	R	A	R	.	C	.	R	R	.	.	R	R	C	.	.	.	.	.	R	.
TOARCIAN	Bifrons	D.ignotus	PO 15.15	C	P	R	R	R	.	A	R	.	A	R	A	.	R	.	R	R	A	.	.	.	.	.	.	.
TOARCIAN	Bifrons	D.ignotus	PO 13.80	R	P	.	R	R	R	F	R	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Bifrons	D.ignotus	PO 13.00	C	P	R	R	R	R	A	R	.	A	.	R	F	R	.	.	R	A	.	.	R	.	.	.	.
TOARCIAN	Bifrons	D.ignotus	PO 12.45	C	P	R	R	R	R	A	F	.	A	R	R	A	R	.	R	.	A	.	R	.	R	R	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 12.20	F	P	.	.	R	.	A	.	.	A	.	R	R	.	R	R	R	R	.	.	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 11.80	F	P	.	.	R	.	A	R	.	F	.	R	R	.	.	R	R	R	R	.	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 11.05	R	P	.	R	R	R	R	R	.	R	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 10.90	R	P	.	.	R	.	R	.	.	F	.	R	R	.	.	.	R	R	.	.	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 10.70	C	P	R	R	R	.	A	.	R	A	.	A	.	.	R	R	R	A	R	.	.	R	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 10.05	C	P	.	R	R	.	C	.	.	A	.	A	R	.	.	R	F	R	R	.	.	.	R	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 10.00	F	M	.	.	.	.	C	.	R	F	.	R	R	.	.	.	F	F	.	.	.	.	R	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 9.80	F	P	.	R	.	.	A	.	.	C	.	R	R	.	R	.	R	F	.	.	.	.	R	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 9.65	C	M	.	R	F	.	A	.	R	A	.	R	C	.	.	R	A	A	R	R	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 9.40	C	M	.	R	R	.	C	R	.	F	.	F	A	.	.	.	F	A	R	R	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 8.70	C	M	.	R	R	.	A	R	.	F	.	F	A	.	.	.	F	A	R	R	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 8.50	F	P	.	.	.	.	A	R	.	A	.	R	.	.	R	.	F	.	R	R	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 8.45	R	P	.	R	R	.	A	R	.	R	.	.	R	.	.	.	R	.	.	.	.	.	.	.	.
TOARCIAN	Serpentinus	D.ignotus	PO 8.40	F	P	R	R	R	R	A	R	.	R	.	R	R	.	R	R	.	R	.	R	.	.	R	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 8.00	R	P	.	.	.	.	A	.	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 7.80	C	P	.	R	F	.	A	A	.	A	.	R	R	.	.	.	R	.	.	.	.	R	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 7.60	R	P	.	.	.	.	R	.	.	R	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 7.55	R	P	.	.	R	.	A	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 7.50	R	P	.	.	.	.	A	.	.	R	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 7.40	C	M	R	R	A	R	A	R	C	A	.	F	R	.	R	A	R	.	.	R	.	R	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 7.00	C	M	.	.	F	R	A	R	C	A	.	R	F	.	.	A	R	.	R	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 6.90	F	P	.	R	F	R	A	F	F	A	.	.	R	R	R	F	R	.	R	R	R	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 6.50	F	P	.	R	R	R	A	R	.	A	.	R	.	.	.	R	R	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 6.40	C	P	R	R	C	R	R	A	R	A	.	R	R	.	R	R	F	.	R	R	R	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 6.00	R	P	.	R	R	R	.	.	.	C	.	R	.	.	R	R	R	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 5.85	F	P	R	R	R	F	A	R	R	A	.	R	R	.	R	R	R	.	R	R	R	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 5.50	C	M	.	.	R	A	A	R	.	A	.	R	R	.	R	.	R	R	.	R	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 5.30	C	P	.	R	R	A	A	R	.	A	.	R	R	.	R	R	R	R	.	R	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 5.00	C	M	R	.	.	A	A	R	R	A	.	R	R	.	R	.	.	R	R	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 4.60	C	M	R	A	R	.	A	R	R	A	R	R	R	.	R	R	R	.	C	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 4.50	C	P	R	R	R	A	A	R	.	A	R	R	R	.	.	.	R	R	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 4.40	F	P	R	.	R	R	C	R	R	A	.	R	R	.	R	.	.	R	R	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 4.00	C	P	.	R	.	F	A	.	.	A	.	R	R	.	R	R	.	R	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 3.90	A	M	R	R	F	A	A	R	.	A	.	A	R	.	F	R	R	R	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 3.50	A	M	R	C	R	A	A	R	.	A	.	A	F	.	R	.	.	.	R	R	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 3.40	F	M	.	R	R	A	C	R	R	C	.	F	R	.	.	.	R	R	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 3.20	A	M	R	R	R	A	A	R	R	A	R	R	R	.	R	R	.	R	R	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 3.05	C	M	R	R	R	A	A	R	R	A	R	R	.	R	R	.	R	C	R	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.crucicentralis	PO 2.90	F	M	R	.	R	F	A	R	.	R	.	R	R	.	.	R	R	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.hauffii	PO 2.50	R	P	.	.	R	F	A	R	.	F	.	.	.	R	R	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.hauffii	PO 1.80	C	P	R	.	R	F	A	.	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.hauffii	PO 1.30	R	P	.	.	R	R	F	.	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.hauffii	PO 1.25	R	P	.	R	R	R	C	R	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.hauffii	PO 1.00	R	P	.	.	.	R	C	.	.	R	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.
TOARCIAN	Tenuicostatum	L.hauffii	PO 0.90	R	P	.	R	.	R	F	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
PLIEN.	Emaciatum	L.hauffii	PO 0.80	R	P	.	R	R	R	C	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.
PLIEN.	Emaciatum	L.hauffii	PO 0.70	R	P	.	R	R	.	C	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
PLIEN.	Emaciatum	M.jansae	PO 0.10	R	P	R	R	.	R	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

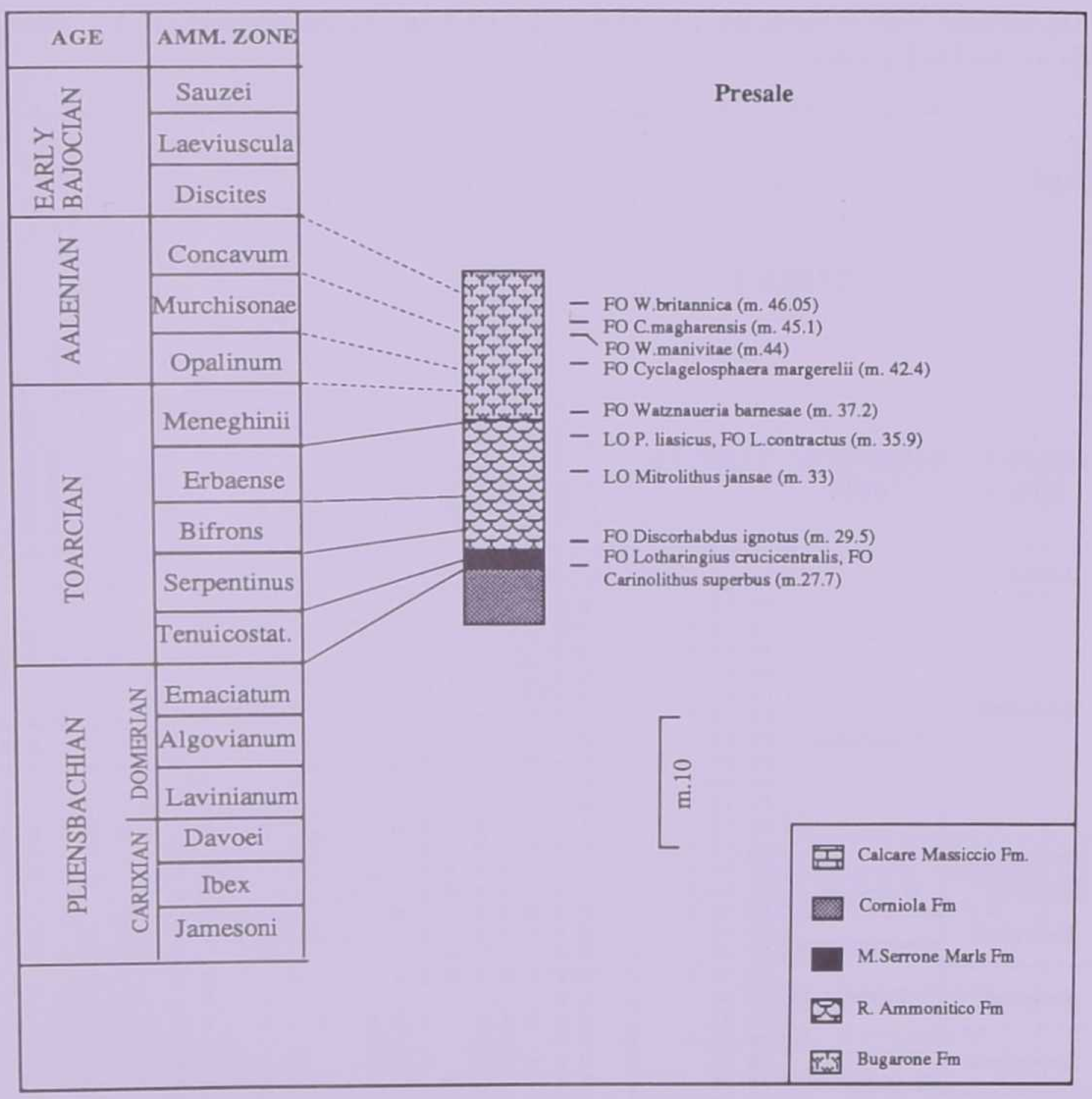

FIG. 8 - Schematic log showing the lithology, the ammonite zones and the main nannofossil events of Presale section.

the Carixian of the Longobucco Group (S. Italy). *M. jansae* is absent or rare and discontinuously present in high latitudes (CRUX 1987b; BOWN 1987b; BOWN *et al.*, 1988), while in the studied area it is continuously present and one of the major components of Pliensbachian-lower Toarcian nannofossil assemblages. ERBA & COBIANCHI (1989) found the FO of *M. jansae* in the upper Carixian (*Davoei Zone*) of the Lombardy basin (N. Italy).

First Occurrence of *Biscutum finchii*

The FO of *B. finchii* occurs in the upper Domerian (*Emaciatum Zone*) and generally just precedes the FO of *L. hauffii* in the Valdorbia, Infernaccio and Pozzale sections. It has also been reported at this level by ERBA & COBIANCHI (1989) in the Lombardy basin, and by CRUX (1984) in West Germany. In the NW European sequences BOWN (1987b) and BOWN *et al.* (1988) found it in the *Margaritatus* Zone. *B. finchii* is continuously present in the studied sequences although not very abundant from its appearance to extinction level.

First Occurrence of *Lotharingius hauffii*

The FO of *L. hauffii* occurs in the *Emaciatum* Zone and is an important and recognizable event in the upper Domerian interval because of its abundance and distinctive appearance. In the Lombardy basin ERBA & COBIANCHI (1989) found this event in the same interval, in the *Spinatum* Zone. CRUX (1984; 1987b) uses the "*Lotharingius* group" to include *L. hauffii, L. crucicentralis*, and *Noellithina prinsii*, so the FO of *L. hauffii* is quite difficult to define, however he reported a few specimens of *L. hauffii* in the *Margaritatus* Zone as did BOWN (1987b).

TABLE 8 - Distribution chart of calcareous nannofossil species from the Presale section. For explanation of the symbols see caption for Table 2

PRESALE — SPECIES

AGE	AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Biscutum dubium	Biscutum finchii	Biscutum novum	Calyculus sp.	Crepidolithus crassus	Lotharingius barozii	Lotharingius hauffii	Lotharingius sigillatus	Mitrolithus jansae	Parhabdolithus liasicus	Schizosphaerella sp.	Sollasites cfr. lowei	Carinolithus superbus	Lotharingius crucicentralis	Crepidolithus pliensbachensis	Discorhabdus ignotus	Lotharingius contractus	Carinolithus magharensis	Watznaueria barnesae	Cyclagelosphaera margerelii	Mitrolithus elegans	Watznaueria manivitae	Watznaueria britannica
EARLY BAJOC.	Discites		PR 47	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R	.	.	.	.	R
AALENIAN	Concavum		PR 46.15	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PR 46.05	R	P	.	.	.	.	.	.	.	.	.	.	R	.	R	.	.	.	.	.	R	.	.	.	R
		W.manivitae	PR 45.6	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R	R	R	.	R	.
			PR 45.5	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.
			PR 45.4	R	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.
			PR 45.1	C	P	R	R	R	.	.	.	.	.	.	.	.	.	F	.	.	A	R	R	A	R	F	.	.
			PR 45	F	P	.	.	F	.	R	.	.	.	.	.	.	.	F	.	.	C	.	.	R	R	.	R	.
			PR 44.8	R	P	R	.	R	.	R	R	.	.	.	.	.	.	.	R	.	F	R	.	R	R	.	.	.
			PR 44.7	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PR 44.4	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
			PR 44	R	P	.	.	R	.	R	R	.	.	.	.	R	.	R	.	.	R	R	.	R	R	.	R	.
	Murchisonae	W.barnesae	PR 42.4	R	P	R	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	R	.	R	R	R	.	.
			PR 41.3	C	P	.	C	A	R	R	.	.	.	.	.	.	.	F	R	.	.	.	.	R	.	.	.	.
	Opalinum		PR 40.6	C	P	.	C	A	R	R	.	.	.	.	.	.	.	F	R	.	.	.	.	.	.	.	.	.
TOARCIAN	Meneghinii		PR 38.4	R	P	R	R	F	.	.	R	.	.	.	.	.	.	F	.	.	R	.	.	.	.	.	.	.
			PR 37.2	F	P	R	F	R	.	R	.	.	.	.	.	C	R	R	R	.	R	R	.	R	.	.	.	.
		D.ignotus	PR 37	R	P	.	.	.	R	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.
	Erbaense		PR 35.9	R	P	R	R	R	R	R	F	.	.	.	R	.	.	F	R	.	.	R	.	.	.	.	.	.
			PR 34	R	P	.	.	.	.	.	.	.	.	.	.	R	.	R	.	.	R	.	.	.	.	.	.	.
			PR 33	R	P	R	R	R	.	R	R	R	.	R	.	R	.	F	R	.	.	.	.	.	.	.	.	.
	Serpentinus		PR 29.5	C	P	.	C	F	.	.	C	R	.	.	.	.	.	A	.	R	R	.	.	.	.	.	.	.
		L.crucicentralis	PR 29	C	P	R	R	R	.	R	R	R	.	.	.	A	.	C	R	.	.	.	.	.	.	.	.	.
			PR 28	R	P	.	.	.	R	.	.	.	.	.	.	R	.	R	R	.	.	.	.	.	.	.	.	.
	Tenuicostatum		PR 27.7	R	P	R	R	R	F	R	1	R	.	R	.	R	.	R	R	.	.	.	.	.	.	.	.	.
		L.hauffii	PR 27.5	R	P	.	.	.	R	R	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
PLIEN.	Emaciatum		PR 25	F	P	R	F	R	A	R	R	R	R	R	R	R	R	.	.	.	.	.	.	.	.	.	.	.

First Occurrence of *Calyculus* sp.

In this study the FO of *Calyculus* sp. has been used due to the difficulty in the identification of the different species of *Calyculus* in the light microscope. The FO of *Calyculus* sp. in all the studied sections occurs between the upper part of the *Emaciatum* Zone and the lower part of the *Tenuicostatum* Zone and it occurs around the Domerian-Toarcian boundary; in the Lombardy basin ERBA & COBIANCHI (1989) recognized this event in the *Spinatum* Zone. The lowest occurrence of this group was found in Portugal in the Sinemurian by HAMILTON (1977; 1979). In SW Germany and in England CRUX (1984; 1987b), found rare and discontinuous *Calyculus* sp. from the *Margaritatus* Zone. In Portugal and in NW Europe BOWN (1987b) found the FO of *Calyculus* in the *Davoei* Zone and in the *Spinatum* Zone respectively.

First Occurrence of *Lotharingius crucicentralis*

In all the studied sequences the FO of *L. crucicentralis* occurs in the lower part of the Toarcian in the *Tenuicostatum* Zone; in the Lombardy basin ERBA & COBIANCHI (1989) found this event in the same ammonite zone. CRUX (1984; 1987b) found the FO of *Lotharingius crucicentralis* group either at the top of the *Margaritatus* Zone or at the base of the *Spinatum* Zone.

Last Occurrence of *Biscutum finchii*

The LO of *B. finchii* is not synchronous in the Umbrian sequences; in fact it occurs in the *Tenuicostatum* Zone in the Valdorbia section, at the boundary between the *Serpentinus* and the *Bifrons* Zone in the Monte Serrone section, in the *Bifrons* Zone in the Monte Civitella section, and in the *Erbaense* Zone in the Pozzale section. In the Lombardy basin ERBA & COBIANCHI (1989)

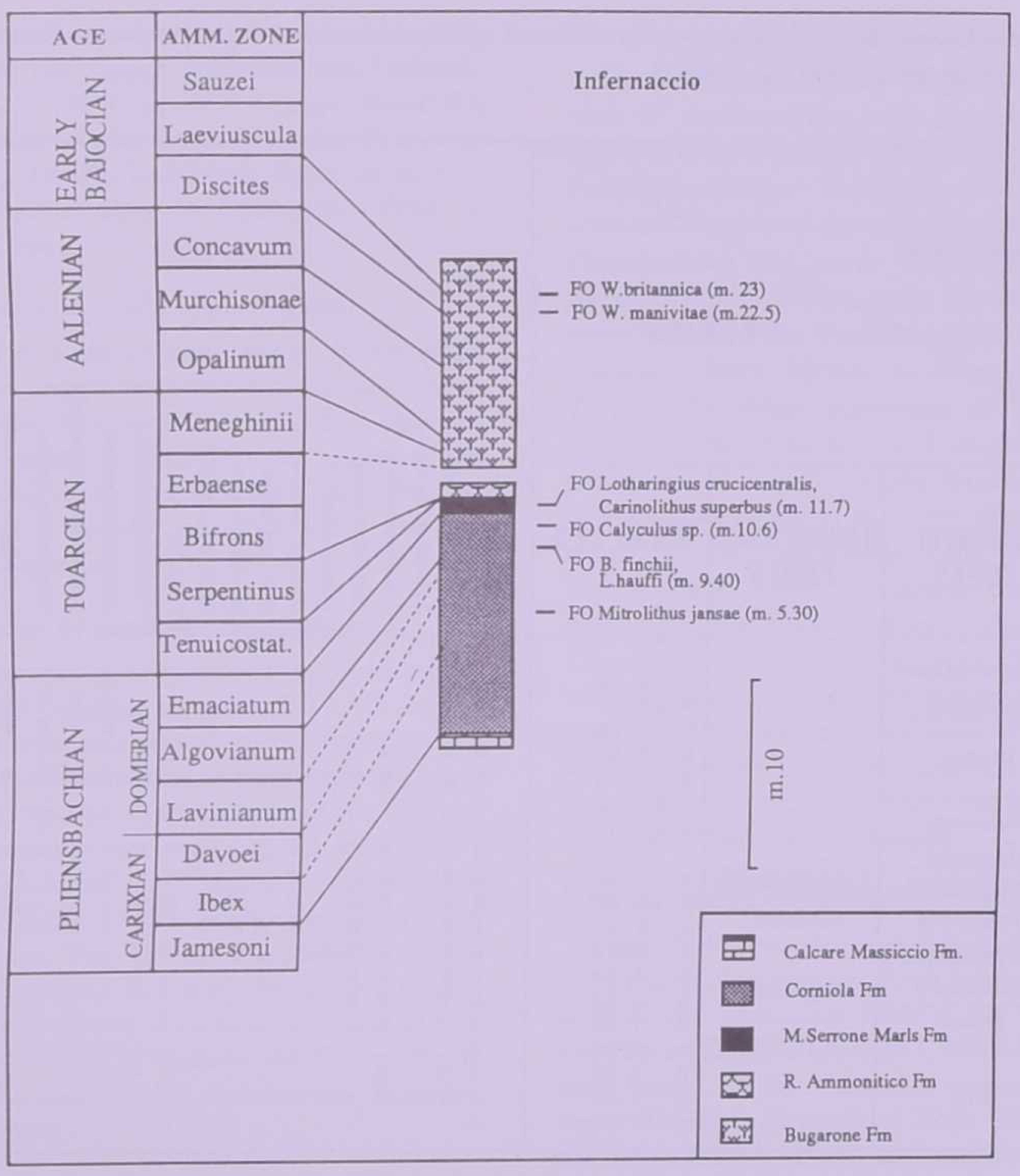

FIG. 9 - Schematic log showing the lithology, the ammonite zones and the main nannofossil events of the Infernaccio section.

recognized the LO of *B. aff. B. finchii* in the *Discites* Zone (lower Bajocian). CRUX (1987b) found this event in the *Tenuicostatum* Zone of SW Germany, but observed it in the *Falciferum* Zone in the Sentino (= Valdorbia) section. This discrepancy with our results could be due to a revision of the ammonite zonation in this section.

First Occurrence of *Carinolithus superbus*

This event has been recognized in all the studied sequences in the *Tenuicostatum* Zone, just above the FO of *L. crucicentralis*; both events are important for the identification of the *Tenuicostatum* Zone. In the Portuguese sections HAMILTON (1979) found this event in the same ammonite zone: in England MEDD (1982) found this event in the *Levesquei* Zone of the upper Toarcian. In NW Europe the FO of *C. superbus* was found in the *Falciferum* Zone of the lower Toarcian by CRUX (1984; 1987b) and BOWN *et al.* (1988). ERBA & COBIANCHI (1989) recorded this event from the *Serpentinus* Zone.

Last Occurrence of *Mitrolithus jansae*

The LO of *M. jansae* is not synchronous in the Umbria-Marche area, but is observed from the *Tenuicostatum* Zone in the Valdorbia section to the *Erbaense* Zone in the Fonte Avellana section. However in all the studied sections at the *Tenuicostatum/Serpentinus* boundary Zones the *M. jansae* abundance decreases and higher up only few sporadic occurrences have been observed. PRINS (1969) recognizes the LO of *M. irregularis* in the *Spinatum* Zone (Upper Pliensbachian) of England, France and Germany. In Leg. 79, Site 547, WIEGAND (1984) finds the LO of *M. jansae* in the lower Pliensbachian, while YOUNG *et al.* (1986), in the Longobucco section, found this event in the *Tenuicostatum* Zone, as in Valdorbia section. In the Lombardy basin this event occurs in the *Serpentinus* Zone (ERBA & COBIANCHI 1989).

TABLE 9 - Distribution chart of calcareous nannofossil species from the Infernaccio section. For explanation of the symbols see caption for Table 2

INFERNACCIO — SPECIES

AGE		AMMONITE ZONES	NANNOFOSSIL ZONES	SAMPLES	ABUNDANCE	PRESERVATION	Parhabdolithus liasicus	Schizosphaerella sp.	Mitrolithus jansae	Biscutum sp.	Biscutum dubium	Biscutum finchii	Biscutum novum	Lotharingius hauffii	Calyculus sp.	Tetralithus cassianus	Carinolithus superbus	Lotharingius crucicentralis	Discorhabdus ignotus	Lotharingius contractus	Lotharingius velatus	Watznaueria barnesae	Cyclagelosphaera margerelii	Watznaueria manivitae	Watznaueria britannica
EARLY	BAJOCIAN	Humphriesianum	?	R 27.20	F	P	.	.	.	.	.	.	.	.	.	.	R	.	F	R	.	F	F	F	F
		Laeviuscula		R 23.00	R	P	.	.	.	.	.	.	.	.	.	.	R	R	R	R	.	R	R	R	R
		Discites		R 22.70	R	P	.	.	.	.	.	.	.	.	.	.	R	R	R	R	.	R	R	R	.
				R 22.50	R	P	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	R	R	R	.
				R 22.00	R	P	.	R	R	.	.	.	.	.	.	.	R	R	R	R	R	R	.	.	.
AALEN.		Concavum		R 21.80	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
				R 21.50	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TOAR.		Meneghinii		R 15.20	R	P	.	R	.	.	R	R	R	R	R	R	R	1	R	R	R	.	.	.	.
		Tenuicostatum	L.crucicentralis	R 11.70	R	P	.	R	R	.	R	.	.	R	R	.	R	R	.	.	.	.	.	.	.
PLIENSBACHIAN	DOMERIAN	Emaciatum	L.hauffii	R 10.60	R	P	.	F	R	.	R	.	R	R	R	R	.	.	.	.	.	.	.	.	.
				R 9.40	R	P	.	R	R	.	R	R	R	R	.	.	.	.	.	.	.	.	.	.	.
		Algovianum	M.jansae	R 8.90	R	P	.	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Lavinianum		R 7.40	R	P	.	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
				R 6.80	R	P	.	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Davoei		R 5.30	R	P	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	CARIXIAN	Ibex		R 4.00	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
				R 3.00	R	P	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
				R 1.00	R	P	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
				R 0.50	B	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

First Occurrence of *Discorhabdus ignotus*

The first small, circular, non imbricating placoliths occurring in the Umbria-Marche area have been recognized as *D. ignotus*, because of the smaller size and for the larger central area, compared to *D. striatus* (see taxonomic remarks). The FO of *D. ignotus* was found in the *Serpentinus* Zone in most of the studied sequences. The only exception is Monte Civitella section where this event has been found in the middle part of the *Bifrons* Zone: however the unusually high abundance of this species at its appearance level, where it is usually rare and increasing afterwards, could suggest an older occurrence and possibly a hiatus in the sequence corresponding to the *Serpentinus* Zone. In Portugal, the FO of *D. ignotus* occurs in the upper Sinemurian (HAMILTON, 1979). BOWN *et al.* (1988) found, in the NW Europe, the FO of *D. striatus* (= *D. ignotus* in BOWN 1987b) in the *Falciferum* Zone. ERBA & COBIANCHI (1989), in the Lombardy basin, found the first discorhabdid as *D. aff. D. striatus* in the *Serpentinus* Zone.

Last Occurrence of *Parhabdolithus liasicus*

The LO of *P. liasicus* is not consistent in the studied sections: in the M. Serrone and M. Civitella sections it occurs in the *Serpentinus* Zone; in the Valdorbia section in the *Bifrons* Zone; in the Pozzale and Fonte Avellana section in the *Erbaense* Zone. Similar disagreement is found in previous studies. AMEZIEUX (1972), in the Paris basin, found this event in the lower Pliensbachian, while BARNARD and HAY (1974), in England and Southern France, found it in the upper Pliensbachian (*Margaritatus* Zone). THIERSTEIN (1976) reported a continuous stratigraphic distribution up to the upper Pliensbachian and a discontinuous presence up to the Bajocian. In Portugal (HAMILTON 1977; 1979) the extinction of this species has been recognized in the upper Pliensbachian (*Davoei-Margaritatus* zonal boundary). MEDD (1982) found *P. liasicus* up to the Toarcian

(*Tenuicostatum* Zone) and reported few sporadic occurrences in the upper Callovian and Oxfordian. BOWN *et al.* (1988), in NW Europe, found the LO of *P. liasicus* in the lower Toarcian (*Tenuicostatum* Zone). In the Lombardy Basin its extinction is reported by ERBA & COBIANCHI (1989) in the *Bifrons* Zone.

First Occurrence of *Lotharingius velatus*

The FO of *L. velatus*, reported by BOWN *et al.* (1988) in the upper Aalenian (*Concavum Zone*) in NW Europe, has been recognized in the studied sections in the Toarcian, in the upper part of the *Serpentinus* Zone and *Bifrons* Zone. Sporadic occurrences of *L. velatus* are observed in the *Tenuicostatum* Zone in the Pozzale section.

First Occurrence of *Lotharingius contractus*

L. contractus is quite rare and discontinuously present in the studied sections. The FO in the Valdorbia section was found in the lower Aalenian. Few sporadic occurrences have been found in the Toarcian in the *Serpentinus* Zone in the Monte Serrone and Monte Civitella sections; in the *Bifrons* Zone in the Pozzale section and in the *Erbaense* Zone in the Presale section. In the Lombardy basin, the FO of *Watznaueria* (=*Lotharingius*) *contracta* has been recognized in the *Opalinum* Zone (lower Aalenian) by ERBA & COBIANCHI (1989). In NW Europe the FO has been reported at the base of the *Murchisonae* Zone by BOWN *et al.* (1988).

Last Occurrence of *Calyculus* sp.

This event is well defined in all the studied sequences; the extinction level is just below the FO of *W. barnesae* (*Meneghinii* Zone, upper Toarcian). It has to be noted also that in the lower Toarcian of the *Serpentinus* Zone a strong decrease was found in the abundance of the *Calyculus* sp.; from this level only rare specimens were observed up to the LO of *Calyculus* sp. In the Lombardy basin the extinction is at the same level. The data available from the literature does not agree: BOWN *et al.,* (1988) found, in NW Europe, the last occurrence in the *Murchisonae* Zone (middle Aalenian); but *Calyculus* sp. appears again in the lower Bajocian, *Laeviuscula* and *Sauzei* Zones, and becomes extinct at the top of the latter zone. In Portugal, HAMILTON (1977) found the LO in the middle Toarcian (*Bifrons* Zone), the same author in 1979 found the LO, in the Brenha and Peniche sections at the base of the Toarcian (*Falciferum* Zone). CRUX (1987b), in England (Dorset), found the LO in the *Levesquei* Zone (upper Toarcian).

First Occurrence of *Watznaueria barnesae*

The first appearance of the genus *Watznaueria* with *W. barnesae* is a very important event. It marks a drastic change in the calcareous nannofossil assemblages: the genus *Lotharingius*, the main constituent of the assemblages in the upper Pliensbachian and lower Toarcian, is partly replaced by genus *Watznaueria*. The FO of *W. barnesae* occurs, in the studied sections, in the upper Toarcian (from *Bifrons* to *Meneghinii* Zone). This is the oldest occurrence of *W. barnesae* found in the Jurassic: in Portugal HAMILTON (1979) found the FO in the Bajocian, while in NW Europe, BOWN *et al.* (1988) found the same event in the *Laeviuscula* Zone. In Southern France, ERBA (1990) recognized the FO of *W. barnesae* in the lower Bathonian (*Zig zag* Zone). The oldest appearance of the genus *Watznaueria*, with *W. aperta*, has been found by ERBA & COBIANCHI (1989) in the *Serpentinus* Zone (lower Toarcian) of the Lombardy basin. The discrepancies in the FO's of *W. barnease* may be the result of differing taxonomic concepts.

First Occurrence of *Carinolithus magharensis*

The FO of *C. magharensis* falls in the Aalenian (*Opalinum*/*Murchisonae* Zone in the Valdorbia section, and *Concavum* Zone in the Presale section. Sporadic occurrences of *C. magharensis* have been found, in the Valdorbia section, from the upper Toarcian *Meneghinii* Zone. The FO level has been chosen where the distribution of the marker is continuous. In Israel, MOSHKOVITZ and EHRLICH (1976a) found *Hexalithus* = *C. magharensis* in the middle/upper Bajocian. BOWN (1987b) found the FO at the Toarcian-Bajocian boundary in the Brenha section (Portugal). In Central Arabia MANIVIT (1987) found the FO of *C. magharensis* in the middle Bajocian (*Humphriesianum* Zone). In Southern France this event has been reported by ERBA (1990) in the upper Aalenian (*Concavum* Zone), while, in the Lombardy basin, by ERBA & COBIANCHI (1989) in the lower Aalenian (*Opalinum* Zone).

First Occurrence of *Watznaueria manivitae*

Due to the great confusion existing in the literature on the taxonomy of this species, it is quite difficult to asses its true stratigraphical distribution. In this study the systematic revision made by MOSHKOVITZ and EHRLICH (1987) has been followed. The first occurrence of *W. manivitae* has been correlated with the ammonites zones in the Presale section; it occurs at the base of *Concavum* Zone (upper Aalenian). In the Valdorbia section this event could not be calibrated, because of the absence of ammonites in the upper part of the Calcari e Marne a Posidonia Formation. In Southern France this event has been found by REALE (unpublished thesis, 1988) in the *Discites* Zone (lower Bajocian), one ammonite zone below the finding of ERBA (1990) who studied the same section. In Central Arabia MANIVIT (1987) found the FO of *W. manivitae* at the base of the Callovian. In NW Europe BOWN *et al.* (1988) found the FO of *W. deflandrei* in the lower Bajocian (*Macrocephalus* Zone). In the Lombardy basin, this event has been found in the *Laeviuscula* Zone (lower Bajocian) by ERBA & COBIANCHI (1989).

First Occurrence of *Cyclagelosphaera margerelii*

In the studied sequences the FO of *C. margerelii* has been recognized in the middle Aalenian (*Murchisonae* Zone). The rarity and discontinuous presence of this species at its appearance level makes this event unrealiable. In the Valdorbia section, the FO of *C. margerelii* is found just below the FO *W. manivitae*. In the Paris basin AMEZIEUX (1972) found this event in the Domerian; in Southern England and Northern France BARNARD and HAY (1974) found it in the lower Bathonian (*Zig zag* Zone). HAMILTON (1979) recognized this event in Portugal at the Toarcian/Bajocian boundary. In Great Britain this event was found by HAMILTON (1982) and MEDD (1982) in the lower Bathonian. BOWN *et al.* (1988) showed a very peculiar distribution of this species. In NW Europe *C. margerelii* appears in the upper Bajocian, disappears in lower-middle Bathonian and appears again in the upper Bathonian. In the Lombardy basin, the appearance level is in the *Murchisonae* Zone (middle Aalenian) (ERBA & COBIANCHI, 1989).

First Occurrence of *Watznaueria britannica*

The FO of *W. britannica* has been recognized, in the upper part of the *Concavum* Zone just below the Aalenian/Bajocian boundary in the Presale section. Remarkable differences exist in the stratigraphic range of *W. britannica* reported in the literature; this may be related to major problems existing in its systematic definition. The range varies from the lower Toarcian (HAMILTON 1977) to Oxfordian (THIERSTEIN 1976). In NW Europe BOWN *et al.* (1988) reported this event in the *Laeviuscula* Zone (lower Bajocian). The FO of *W. britannica* has been found by ERBA & COBIANCHI (1989) and by ERBA (1990) in the *Concavum* Zone (upper Aalenian), in the Lombardy basin and S. France respectively.

The lack of coincidence of the above mentioned events inside the Umbria - Marchea Area can probably be ascribed to the problem related to the precise definition, in the studied sequences, of the boundaries among the ammonite zones. The ammonite fauna is found discontinuosly and is concentrated in fossiliferous biohorizons often separated by several meters; consequently it is impossible to accurately define the position of the zonal boundaries.

The differences existing among the events recognized in the Northern part of Europe and Portugal with respect to the Umbria-Marche Area could be due to provincialism.

Nevertheless, the succession of the events, recognized in the studied sequences, has allowed us to propose a nannofossil biozonation scheme for the Lower-Middle Jurassic which is reliable and well applicable in Central Italy.

EARLY-MIDDLE JURASSIC BIOZONATION SCHEME

As previously reported, the calcareous nannofossil biozonation schemes existing in the literature for the Jurassic interval could not be satisfactorily applied to the studied area; for this reason a detailed biostratigraphic scheme, that can be used in the Tethyan Realm and in particular for the Mediterranean Province, has been proposed (Fig. 10). This biozonation scheme is based on index taxa which are distinctive in the light microscope and not solution susceptible. The zones are defined by first occurrences and correlated with the Standard Ammonite Zonation Scheme.

Mitrolithus jansae Zone

AUTHOR: defined here.
DEFINITION: First occurrence of *Mitrolithus jansae* to the first occurrence of *Lotharingius hauffii*.
RANGE: *Davoei* Zone (upper Carixian) to *Emaciatum* Zone (upper Domerian).
REFERENCE SECTION: Infernaccio section.
COMMENTS: At the top of the zone the FO of *Biscutum finchii* occurs, slightly earlier than the FO of *L. hauffii*. Assemblages are not abundant and diverse due to the unfavorable lithology.
ASSOCIATED SPECIES: *B. finchii, B. dubium, B. novum, Crepidolithus crassus Parhabdolithus liasicus, Mitrolithus elegans* and *Schizosphaerella* spp.

Lotharingius hauffii Zone

AUTHOR: BOWN (1987b) emended.

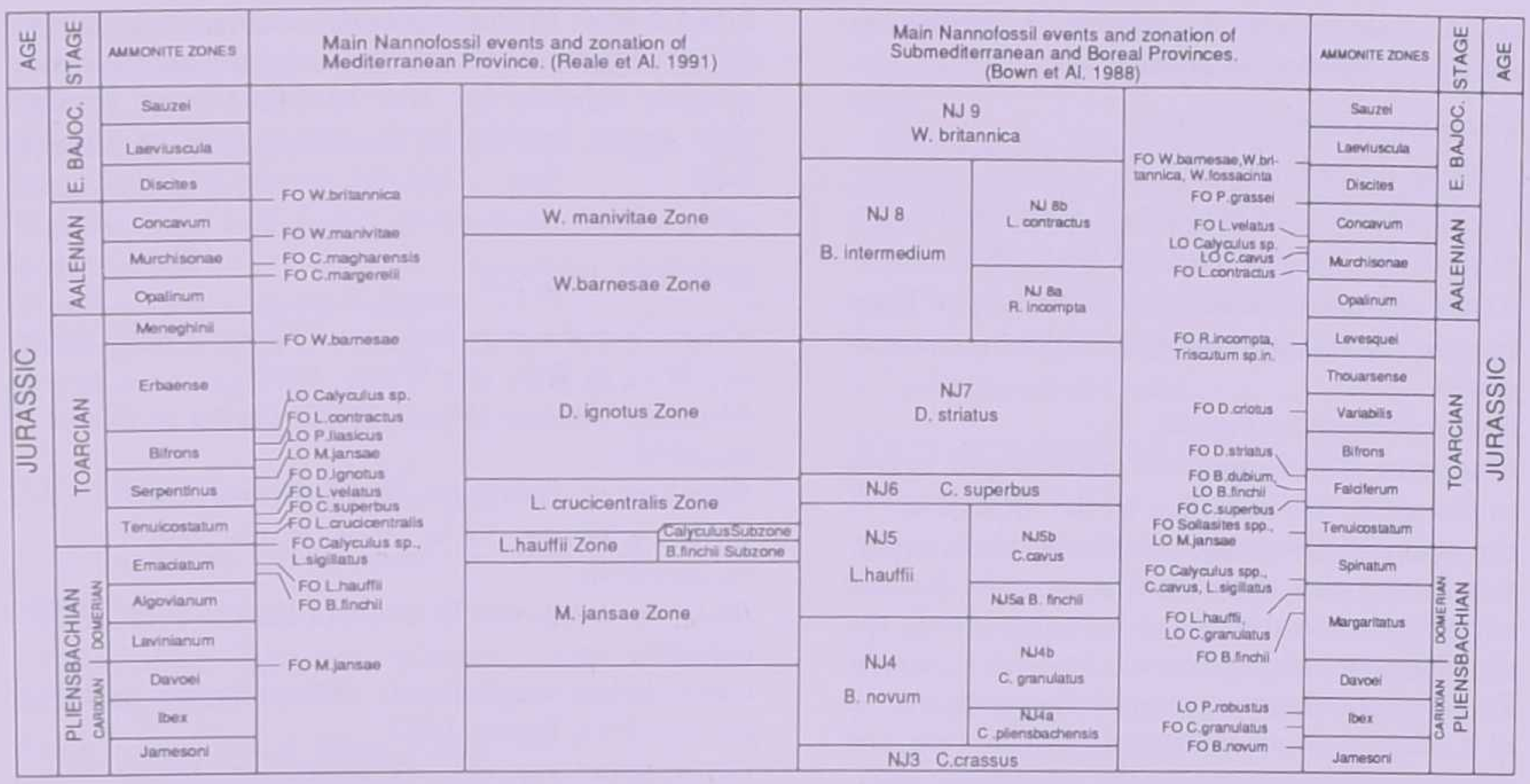

FIG. 10 - Correlation scheme between the nannofossil zonation proposed in this paper and the nannofossil zonation after BOWN *et al.* 1988.

DEFINITION: First occurrence of *Lotharingius hauffii* to the first occurrence of *Lotharingius crucicentralis*.
RANGE: *Emaciatum* Zone (upper Domerian) to *Tenuicostatum* Zone (lower Toarcian).
COMMENTS: This zone includes the FO of *L. barozii* and *L. sigillatus*.
REFERENCE SECTION: Valdorbia section.

Biscutum finchii Subzone

AUTHOR: BOWN (1987b) emended.
DEFINITION: First occurrence of *Lotharingius hauffii* to the first occurrence of *Calyculus* sp.
RANGE: *Emaciatum* Zone (upper Domerian) to the base of *Tenuicostatum* Zone (lower Toarcian).
COMMENTS: *C. cavus* occurs in this subzone but it is rare and discontinuosly present.
ASSOCIATED SPECIES: *L. barozii, M. jansae, B. novum, B. finchii, B. dubium, C. crassus, C. cavus*.

Calyculus Subzone

AUTHOR: defined here.
DEFINITION: First occurrence of *Calyculus* sp. to the first occurrence of *Lotharingius crucicentralis*.
RANGE: *Tenuicostatum* Zone (lower Toarcian).
ASSOCIATED SPECIES: the same assemblage as the above Subzone plus *L. sigillatus, Sollasites cf. S. lowei* and *Sollasites* sp.

Lotharingius crucicentralis Zone

AUTHOR: defined here.
DEFINITION: First occurrence of *Lotharingius crucicentralis* to the first occurrence of *Discorhabdus ignotus*.
RANGE: *Tenuicostatum* Zone to *Serpentinus* Zone (lower Toarcian).
REFERENCE SECTION: Valdorbia section.
COMMENTS: This zone includes the FO of *Carinolithus superbus*, the extinctions of *M. jansae* and *B. finchii*, and a strong reduction in the abundance of *Calyculus* sp.. Few sporadic *Lotharingius velatus* have been observed at the top of this zone in the Pozzale and M. Civitella sections.
ASSOCIATED SPECIES: *L. hauffii, L. barozii, B. finchii, B. novum, C. crassus, C. cavus, Calyculus* sp., *Sollasites* sp.

Discorhabdus ignotus Zone

AUTHOR: BOWN (1987b) emended.
DEFINITION: First occurrence of *Discorhabdus ignotus* to the first occurrence of *Watznaueria barnesae*.
RANGE: *Serpentinus* Zone (lower Toarcian) to *Erbaense / Meneghinii* Zone (upper Toarcian).
REFERENCE SECTION: Valdorbia section.
COMMENTS: Several events occur in this zone; the extinctions of *P. liasicus* and *Calyculus* sp., and the rare occurrence of *L. contractus*. *D. ignotus* (see the taxonomic remarks) is the first discorhabdid occurring in the Umbria-Marche Basin. The assemblages are not very abundant or diverse.
ASSOCIATED SPECIES: *L. hauffii, L. barozii, L. vela-*

tus, L. crucicentralis, B. dubium, B. novum, C. crassus, C. superbus, D. ignotus.

Watznaueria barnesae Zone

AUTHOR: defined here.

DEFINITION: First occurrence of *Watznaueria barnesae* to the first occurrence of *W. manivitae.*

RANGE: *Erbaense/Meneghinii* Zone (upper Toarcian) to the base of *Concavum* Zone (upper Aalenian).

REFERENCE SECTION: Presale.

COMMENTS: The nannofossil assemblages begins to change in this zone due to the appearance of the genus *Watznaueria*, one of the most important components of the middle to upper Jurassic nannofossil assemblages; and the decrease in the abundance of *Schizosphaerella* sp. and *L. hauffii.* Two first occurrences appear in this zone; the FO of Cyclagelosphaera margerelii (quite rare and discontinuously present in the Valdorbia, Infernaccio and Presale sections), and the FO of *Carinolithus magharensis* (in the *Opalinum/Murchisonae* Zone in Valdorbia section, although very rare and discontinuous specimens of *C. magharensis* have been observed in few samples of the upper Toarcian).

ASSOCIATED SPECIES: *B. novum, C. superbus, D. ignotus, L. contractus, L. velatus, Watznaueria* sp. 1, *C. margerelii.*

Watznaueria manivitae Zone

AUTHOR: defined here.

DEFINITION: First occurrence of *Watznaueria manivitae* to the first occurrence of *Watznaueria britannica.*

RANGE: *Concavum* Zone (upper Aalenian).

REFERENCE SECTION: Presale.

COMMENTS: The assemblages in this zone are less diverse compared to the *W. barnesae* Zone because of the unfavorable lithology. *Biscutum* and *Lotharingius* become very rare and discontinuously present.

ASSOCIATED SPECIES: *Discorhabdus ignotus, Carinolithus magharensis, Lotharingius contractus,* and *Cyclagelosphaera margerelii.*

CONCLUSIONS

The detailed calcareous nannofossil analyses performed on eight sequences of the Umbria-Marche Area allowed the recognition of a continuous succession of events, correlated with the ammonite zones, for the Pliensbachian-Early Bajocian interval.

The relatively good coincidence of the recognized events in the sequences studied has allowed us to suggest a calcareous nannofossil biostratigraphic scheme for the Middle-Lower Jurassic that seems applicable in the whole of Central Italy.

SPECIES INDEX

Axopodorhabdus cylindratus (NOEL, 1965) WIND and WISE in WISE and WIND, 1977
Biscutum dubium (NOEL, 1965) GRÜN in GRÜN *et al.*, 1974
Biscutum finchii (CRUX, 1984) BOWN, 1987
Biscutum novum (GOY, 1979) BOWN, 1987
Biscutum sp.
Biscutum leufuensis BOWN and KIELBOWICZ, 1987
Calyculus sp.
Carinolithus magharensis (MOSHKOVITZ and EHRLICH, 1976), BOWN, 1987
Carinolithus superbus (DEFLANDRE, 1954) PRINS in GRÜN *et al.*, 1974
Crepidolithus cavus PRINS *ex* ROOD, HAY and BARNARD, 1973 emend.
Crepidolithus crassus (DEFLANDRE, 1954) NOEL, 1965
Crepidolithus granulatus BOWN, 1987
Crepidolithus pliensbachensis (CRUX, 1985) BOWN, 1987
Crepidolithus sp. 1
Crepidolithus sp.
Cyclagelosphaera margerelii NOEL, 1965
Discorhabdus ignotus (GORKA, 1957) PERCH-NIELSEN, 1968
Discorhabdus striatus MOSHKOVITZ and EHRLICH, 1976a
Etmorhabdus gallicus NOEL, 1965
Lotharingius barozii NOEL, 1973
Lotharingius contractus BOWN & COOPER, 1989
Lotharingius crucicentralis (MEDD 1971) GRÜN & ZWEILI, 1980
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Mitrolithus lenticularis BOWN, 1987
Parhabdolithus liasicus DEFLANDRE, 1952
Retecapsa incompta BOWN and COOPER, 1989
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Sollasites sp.
Schizosphaerella punctulata DEFLANDRE & DANGEARD, 1938
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Tetralithus cassianus JAFAR, 1983
Tubirhabdus patulus PRINS, 1969 *ex* ROOD *et al.*, 1973
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Watznaueria britannica (STRADNER, 1963) REINHARDT, 1964
Watznaueria manivitae BUKRY, 1973
Watznaueria sp. 1
Watznaueria sp.

APPENDIX: Taxonomic remarks

Few comments on some of the more problematic species.

Discorhabdus ignotus (GORKA, 1957) PERCH-NIELSEN, 1968

Plate 1, figs. 17-20, Plate 2, figs. 1-6

Remarks: The first small, circular, non imbricating placoliths have been recognized as *D. ignotus*. Circular radial coccolith composed of two monocyclic shields, the distal shield is wider than the proximal one. The central area is characterized by a small, conical central depression in which four crystals or calcite are present.

It differs from *D. striatus* for the smaller size (dimension 3.5-5.5 micron) and for the wider central depression (plate 2, fig. 1). At cross polarized light, the last feature is well recognizable by a distinctive black area as plate 2, in fig. 2.

We consider as *D. ignotus* the specimens shown by BOWN 1987b in Plate 7, fig. 1 and in Plate 14, figs. 7-8.

Discorhabdus striatus MOSHKOVITZ and EHRLICH, 1976

Plate 2, figs. 7-12

Remarks: Circular radial placolith composed of two unicyclic shields and a very small central depression. The distal shield is wider then the proximal one and its diameter is about 5-7 microns.

In light microscope it differs from *D. ignotus* by the lack of the dark central depression.

D. striatus has been differentiated by *D. ignotus* only in the Valdorbia section. This species is rare and appears few meters above the FO of *D. ignotus*.

Watznaueria barnesae (BLACK in BLACK and BARNES 1959) PERCH-NIELSEN 1968
Plate 3, figs. 1, 2

Remarks: Elliptical coccolith composed of two superimposed shields. The distal one is made of two cycles and the proximal one is unicyclic. In light microscope between crossed nicols it is well recognizable for the extinction cross with the cross arms curved and almost joined during rotation.

This species differs from *W. manivitae* for the smaller size and the weaker birigrangence colours; from *W. communis* for the extinction cross in which the arms do not divide during rotation; from *W. britannica*, for the lack of a bridge.

Size varies from 3.5-5 microns (minor axis) to 5-7 microns (major axis).

Watznaueria manivitae (BUKRY, 1973)

Plate 3, Figs. 13-16

Remarks: Large subelliptical to subcircular placoliths (9-16 microns) with a relatively small subelliptical to elliptical central area, sometimes obstructed by irregular coarse elements. Under cross polarized light this species is easely recognized by its high birefringence colours.

In our sections the specimens with the same structures and optical features but size smaller than 9 micron have been identified in the range charts as *Watznaueria* sp. 1.

Cyclagelosphaera deflandrei differs from *W. manivitae* for the circular shape and the circular central area.

Watznaueria britannica (STRADNER, 1963) REINHARDT 1964

Plate 3, Figs. 17-20

Remarks: Elliptical coccolith with two superimposed shields. The central area is characterized by a bridge along the minor axis of the ellipse. Between crossed nicols the bridge is bright and is optically discontinuous.

For the differences with respect to other species of *Watznaueria* see the remarks at *W. barnesae*.

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PLATES I - III

EXPLANATION OF PLATE I

(The abbrevations XN and OL denote cross-polarized and transmitted light, all magnifications x 3600).

FIGS. 1-4 - *Mitrolithus jansae* (WIEGAND, 1984) BOWN and YOUNG in YOUNG *et al.* 1986; 1: side view XN (103), vr 377.8 Valdorbia, *Tenuicostatum* Zone, Lower Toarcian; 2: OL as fig. 1; 3: side view XN (196), R 7.40 Infernaccio *Lavinianum* Zone, Domerian; 4: OL as fig. 3.

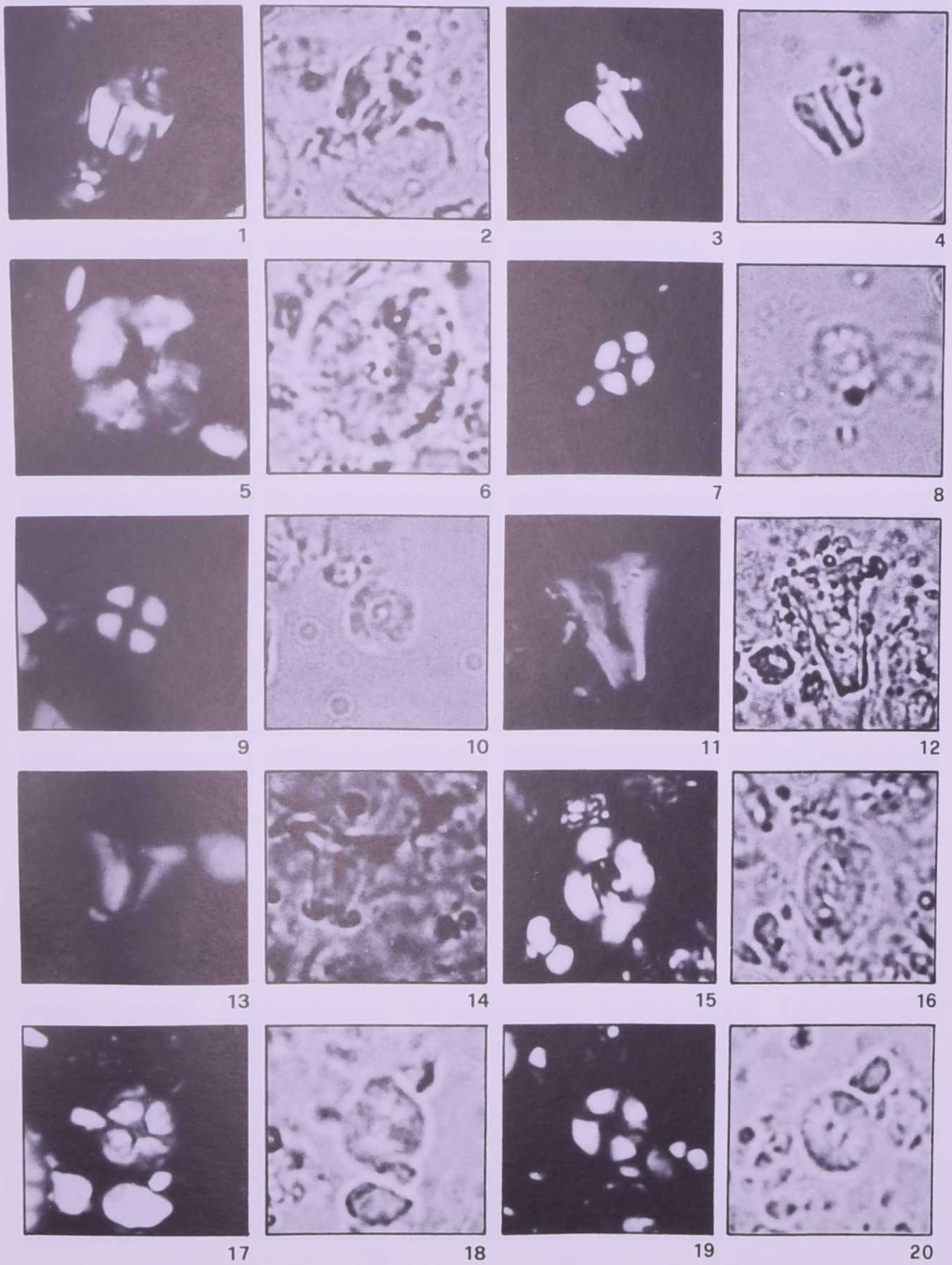
FIGS. 5, 6 - *Biscutum finchii* CRUX, 1984 emend. BOWN, 1987b; 5: distal view NX (97) vr 376 Valdorbia, *Tenuicostatum* Zone, Lower Toarcian; 6: OL as fig. 5.

FIGS. 7-10 - *Lotharingius hauffii* GRUN and ZWEILI in GRUN *et al.* 1974; 7: distal view XN (97), Valdorbia vr 373.95, *Tenuicostatum* Zone, Lower Toarcian; 8: OL as fig. 7; 9: distal view XN (92), cv 193.7 Valdorbia, *Serpentinus* Zone, Lower Toarcian; 10: OL as fig. 9.

FIGS. 11-14 - *Calyculus* spp.; 11: side view XN (157), vr 376 Valdorbia, *Tenuicostatum* Zone, Lower Toarcian; 12: OL as fig. 11; 13: side view XN (93), vr 382.80 Valdorbia, *Tenuicostatum* Zone, Lower Toarcian.

FIGS. 15, 16 - *Lotharingius crucicentralis* (MEDD, 1971) GRUN and ZWEILI 1980; 15: distal view XN (199), MS 27 Monte Serrone, *Tenuicostatum* Zone, Lower Toarcian; 16: OL as fig. 15.

FIGS. 17-20 - *Discorhabdus ignotus* (GORKA, 1957) PERCH-NIELSEN 1968; 17: proximal view XN (199), MS 40 Monte Serrone, *Serpentinus* Zone, Lower Toarcian; 18: OL as fig. 17; 19: distal view XN (199), MS 40 Monte Serrone, *Serpentinus* Zone, Lower Toarcian; 20: OL as fig. 19.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EXPLANATION OF PLATE II

(The abbrevations XN, OL and SEM denote cross-polarized light, transmitted light and scanning electron micrographs, all light micrographs x 3600).

Figs. 1-6 - *Discorhabdus ignotus* (Gorka 1957) Perch-Nielsen 1968, vr o 11c Valdorbia, *Erbaense* Zone, Upper Toarcian; 1: distal view SEM x 4800; 2: XN (120) same specimen as in fig. 1; 3: OL same specimen as in fig. 1; 4: proximal view SEM x 6750; 5: XN (120) same specimen as in fig. 4; 6: OL same specimen as in fig. 4.

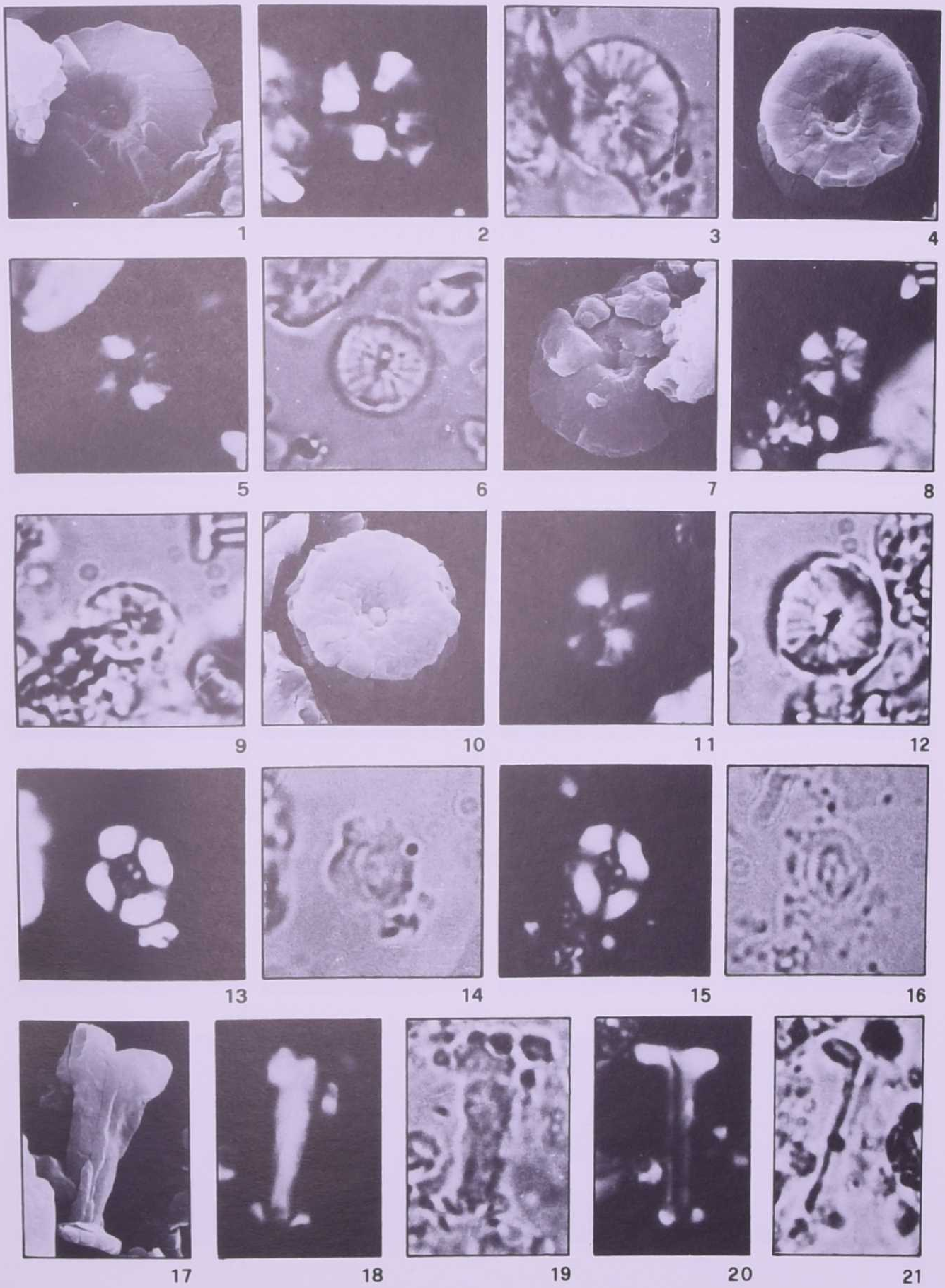
Figs. 7-12 - *Discorhabdus striatus* Moshkovitz and Ehrlich 1976a; 7: distal view SEM x 7500, cv 160.7 Valdorbia, *Opalinum-Murchisonae* Zone, Aalenian; 8: XN (120) as fig. 7; 9: OL as fig. 7; 10: proximal view SEM x 5000, vr 0 11c Valdorbia, *Erbaense* Zone, Upper Toarcian; 11: XN (120) same specimen as in fig. 10; 12: OL same specimen as in fig. 10.

Figs. 13, 14 - *Lotharingius velatus* Bown & Cooper 1989; 13: distal view XN (196), MS 65.5 *Bifrons* Zone, Lower Toarcian; 14: OL as fig. 13.

Figs. 15, 16 - *Lotharingius contractus* Bown & Cooper 1989; 15: distal view XN (196) MS 65. 5 *Bifrons* Zone, Lower Toarcian 16: OL as fig. 15.

Figs. 17-21 - *Carinolithus superbus* (Deflandre, 1954) Prins in Grun *et al.* 1974; 17: side view SEM x 4575, vr 0 11c Valdorbia, *Erbaense* Zone, Upper Toarcian; 18: side view XN (157); 19: OL as fig. 18; 20: side view XN (157), 21: OL as fig. 21, MS 42 Monte Serrone *Serpentinus* Zone, Lower Toarcian.

PLATE II



EXPLANATION OF PLATE III

(The abbrevations XN and OL denote cross-polarized and transmitted light, all magnifications x 3600).

FIGS. 1, 2 - *Watznaueria barnesae* (BLACK in BLACK and BARNES 1959) PERCH-NIELSEN 1968; 1: distal view XN (176), cv 177 Valdorbia, *Meneghini* Zone, Upper Toarcian; 2: OL as fig. 1.

FIGS. 3, 4 - *Cyclagelosphaera margerelii* Noël 1965, 3: distal view XN (173), cv 140 Valdorbia, Early Bajocian?; 4: OL as fig. 2.

FIGS. 5-8 - *Carinolithus magharensis* (MOSHKOVITZ and EHRLICH 1976a) BOWN 1987b; 5: isolated distal hexalith XN (184) cv 166 Valdorbia, *Opalinum/Murchisonae* Zone, Aalenian; 6: OL as fig. 4; 7: isolated distal hexalith XN (199), cv 140 Valdorbia, Early Bajocian?; 8: OL as fig. 7.

FIGS. 9, 10 - *Watznaueria sp.*; 9: distal view XN (199), cv 150 Valdorbia *Murchisonae* Zone, Middle Aalenian; 10: OL as fig. 9.

FIGS. 11, 12 - *Watznaueria sp. 1* 11: distal view XN (185), cv 158 Valdorbia *Opalinum/Murchisonae* Zone, Aalenian.

FIGS. 13-16 - *Watznaueria manivitae* BUKRY 1973; 13: distal view XN (185) cv 155 Valdorbia, *Murchisonae* Zone; 14: OL as fig. 13; 15: distal view XN (187), cv 140 Valdorbia Early Bajocian?; 16: OL as fig. 15.

FIGS. 17-20 - *Watznaueria britannica* (STRADNER 1963) REINHARDT 1964; 17: distal view XN (187); 18: OL as fig. 17; 19: distal view XN (199), cv 140 Valdorbia, Early Bajocian?; 20: OL as fig. 19.

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PLATE III