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MIRIAM COBIANCHI *, ELISABETTA ERBA ** and CAMILLA PIRINI RADRIZZANI °

EVOLUTIONARY TRENDS OF CALCAREOUS NANNOFOSSIL GENERA *LOTHARINGIUS* AND *WATZNAUERIA* DURING THE EARLY AND MIDDLE JURASSIC

CONTENTS

Key words: calcareous nannofossils, evolutionary trends, Upper Domerian-Lower Bajocian, Lombardy Basin, Digne area.

ABSTRACT

Semiquantitative studies of nannofloras from several sections outcropping in the Lombardy Basin of Italy and Digne area of Southeastern France reveal significant changes in the Early and Middle Jurassic.

We document:

1 - evolution of *Lotharingius* (Upper Domerian-Aalenian) and *Watznaueria* (Lower Toarcian-Bathonian);

2 - an evolutionary trend of the genus *Lotharingius* to the genus *Watznaueria* in the Domerian-Bathonian interval.

The moderate to poor preservation prevents analysis with the Scanning Electron Microscope because ultrastructure is partially modified by dissolution and/or overgrowth. Therefore, the study is performed with the Light Microscope and consequently taxonomy is simplified, mainly based on morphological characteristics and optical properties. For the same reason, statistical studies are not applied on assemblages.

The evolutionary trends observed within the genus *Lotharingius* are: 1) an increase of size from 3 µm to some 6 µm (maximum diameter); 2) the shield develops from monocyclic to bicyclic; 3) the inner cycle decreases in size, being much smaller than the outer cycle in the younger forms; 4) the central area changes from subcircular to subelliptical and elliptical, and simultaneously increases in size; 5) the central structure becomes more and more complex but no clear trends were observed possibly due to diagenetic modifications.

The genus *Watznaueria* appears to evolve from bicyclic *Lotharingius* taxa characterized by a small and open central area. Its evolution is marked by two different trends: a) an increase in size leading to *W. manivitae*; and b) the reduction of the central process leading to *W. barnesae*.

* Dipartimento di Scienze della Terra, Corso Strada Nuova 65, I - 27100 PAVIA (Italy).
** Dipartimento di Scienze della Terra, Via Mangiagalli 34, I - 20133 MILANO (Italy).
° Dipartimento di Scienze della Terra, Corso Europa 26, I - 16132 GENOVA (Italy).

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RIASSUNTO

Analisi semiquantitative sono state condotte sulle associazioni a Nannofossili di successioni del Giurassico inferiore e medio affioranti nel Bacino Lombardo (Italia settentrionale) e in Francia sud-orientale (area di Digne).

Tale studio ha permesso di osservare importanti cambiamenti nelle associazioni e di ricostruire possibili linee evolutive di alcuni generi e relative specie.

In particolare si è documentata l'evoluzione dei generi *Lotharingius* e *Watznaueria* durante l'intervallo cronostratigrafico Domeriano-Batoniano.

Poiché lo stato di conservazione delle nannoflore è moderato o scarso, le analisi al microscopio elettronico a scansione sono state effettuate solo sui campioni meglio conservati; lo studio è stato condotto essenzialmente al microscopio ottico al fine di ottenere una tassonomia più semplice e riproducibile ai fini biostratigrafici.

Le linee evolutive osservate nel genere *Lotharingius* sono: 1) un aumento di dimensioni del diametro massimo da 3µm nei *Lotharingius* primitivi a circa 6 µm in quelli evoluti; 2) l'area marginale da uniciclica diventa biciclica; 3) il ciclo interno diminuisce in dimensioni essendo più piccolo del ciclo esterno nelle forme più recenti; 4) l'area centrale da subcircolare diventa subellittica ed ellittica e contemporaneamente aumenta di dimensioni; 5) la struttura centrale diventa sempre più complessa, ma non è stato possibile osservare alcuna linea evolutiva probabilmente a causa di modificazioni diagenetiche.

Il genere *Watznaueria* si sviluppa probabilmente dai *Lotharingius* biciclici ed è caratterizzato da un'area centrale piccola e semplice.

La sua evoluzione si compie secondo due diverse direzioni: a) un aumento di dimensioni culminante in *W. manivitae*; b) la riduzione del processo centrale culminante in *W. barnesae*.

INTRODUCTION

In recent years Jurassic calcareous nannofossils have been investigated in detail. Numerous studies have been conducted on nannofloras from Lower Jurassic sections in Britain and in North-western Europe. Certain early coccolith evolutionary schemes have been proposed (*e.g.* PRINS 1969; BOWN 1987a, 1987b) and some new taxa have been described (*e.g.* BOWN 1987b; BOWN and COOPER, 1989).

The aim of this paper is to interpret the results obtained from detailed biostratigraphic studies of Jurassic calcareous nannofossils from several sections from the Lombardy Basin of Italy and South-eastern France (Tab. 1).

Semiquantitative analysis of nannofloras reveals significant changes during the Early and Middle Jurassic. The morphological modifications of the distinct morphotypes permit us to recognize some phyletic relationships between the taxa.

In particular, an evolutionary trend of the genus *Lotharingius* to the genus *Watznaueria* is documented in the Domerian-Bathonian interval.

MATERIAL AND METHODS

Thirteen measured sections spanning the Middle Carixian to Berriasian (Early Cretaceous) interval were investigated. Nine sections outcrop in the Lombardy Basin and four sections in the Digne area.

Although preservation is moderate to poor, calcareous nannofossils are always abundant and a complete sequence of nannofossil-biohorizons is recognized. The nannofossil events are calibrated to ammonite, radiolarian and calpionellid biozonations and in a few cases to magnetostratigraphy (Tab. 1). A total of 692 samples were collected from marly and marly limestone layers.

Semiquantitative estimates of total and relative species abundances, morphological and morphometric measurements were made in the light microscope (1250 X). Standard smear slide preparation techniques were employed, with no decanting in order to retain the original nannofossil assemblage composition.

Scanning Electron Microscope investigation was limited to the best preserved samples.

The morphological features and optical properties employed in this study for taxonomic division are as follows:

GENUS:

— shape and detailed features of the rim;
— extinction pattern;
— birefringence colors;
— shape of the central area;

SPECIES:

— coccolith size;
— shape and size of the central area;
— detailed structure of the central area.

Figure 1 illustrates the parameters taken into account for the definition of the species within genera *Lotharingius* and *Watznaueria*. They were adopted during investigations with light polarizing microscope and therefore consists of simple morphological and morphometric parameters such as general shape, structure and size of the central area, maximum diameter, and colors in crossed nicols. Quantitative studies are in

TAB. 1 - Summary of the studied sections

SECTION	SETTING	AGE	LM SAMPLES	SEM SAMPLES	AMMONITE BIOSTRATIGRAPHY	CALPIONELLID BIOSTRATIGRAPHY	MAGNETOSTRATIGRAPHY
CLIVIO	basin	Late Domerian Early Toarcian	27	—	X		
ARZO	slope	Late Carixian Early Domerian	17	—	X		
BREGGIA	basin	Late Carixian Early Bajocian	57	20	X		X
ALPE TURATI	basin	Carixian Late Tithonian	58	20	X	X	X
VAL CEPELLINE	slope	Late Carixian Late Tithonian	50	20	X	X	
VAL VAREA	slope	Domerian Late Toarcian	52	—	X		
COLMA	structural high	Late Domerian Late Tithonian	46	—		X	
CORNI DI CANZO	structural high	Late Domerian Late Tithonian	50	—		X	
COLLE DI SOGNO	basin	Late Carixian Early Bajocian	186	—	X pro parte		X
SOGNO	basin	Late Bathonian Late Tithonian	11	—		X	
CARICATORE	basin	Late Domerian Early Toarcian	34	20	X		
MOLVINA	basin	Late Domerian Late Toarcian	21	—	X		
DIGNE	basin	Late Aalenian Bathonian	114	10	X		

progress to better define the characteristics of *Lotharingius* and *Watznaueria* populations on the basis of statistics.

THE EVOLUTIONARY TRENDS OF THE GENERA *LOTHARINGIUS* AND *WATZNAUERIA*

This study allows the recognition of some morphological trends of the genera *Lotharingius* and *Watznaueria* through time (Fig. 2).

The genus *Lotharingius* appeared in the Upper Domerian (base of the Spinatum Zone) and dominates the Lower and Middle Toarcian assemblages with fluctuations in the relative abundance of the various species. The genus *Watznaueria*, probably evolved from the genus *Lotharingius*, appeared in the middle portion of the stratigraphic interval corresponding to the Serpentinus Zone (Lower Toarcian), but it is extremely rare below the Aalenian/Bajocian boundary.

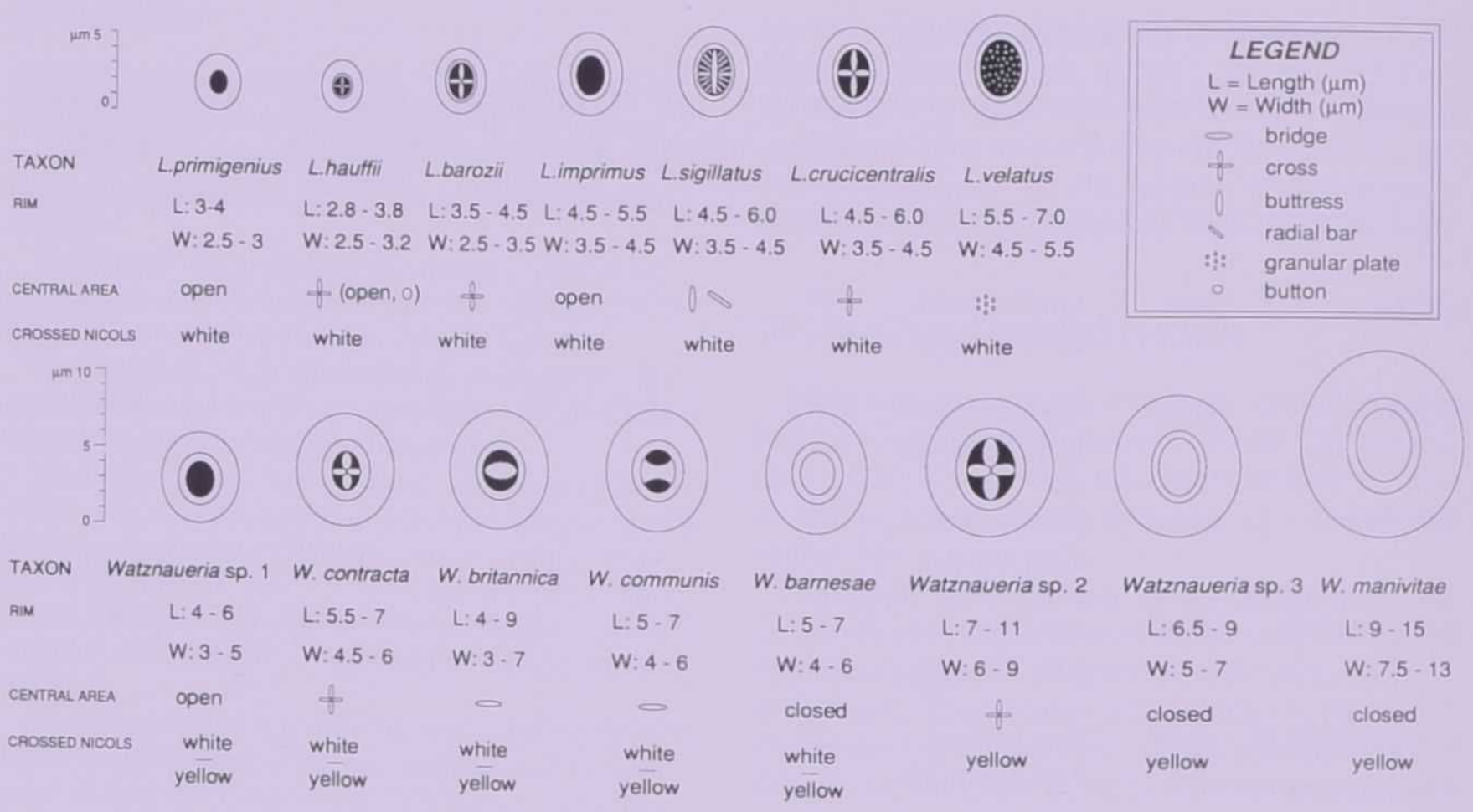

FIG. 1 - Morphology, rim size, central area feature, and color in crossed nicols of the species defined in this paper.

The genus *Watznaueria* evolved during the Early Bajocian and rapidly became the most abundant Jurassic coccolith, dominating assemblages right up to the Jurassic/Cretaceous boundary. The increase in abundance of *Watznaueria* corresponded to the decrease of the genus *Lotharingius*.

A general evolutionary trend observed in the two genera throughout the Domerian-Bathonian interval is an increase of coccolith size both in successive new taxa (*e.g.* from *L. primigenius* to *L. velatus*; from *Watznaueria* sp. 1 to *W. manivitae*) and within individual species.

The first occurrence of the genus *Lotharingius* is recorded in the Upper Domerian with *Lotharingius primigenius*, the most simple form. This is a small subcircular coccolith (2-3 µm in diameter) with a monocyclic shield and subcircular structurless central area.

During the Late Domerian diversity and abundance increase. The evolution within the genus *Lotharingius* is marked by many morphological modifications ending in the well-developed *Lotharingius* species of the Early Toarcian. The evolutionary trends observed are: a size increase from 3µm to some 6µm in diameter; the shield develops from monocyclic in *L. primigenius* to bicyclic (*e.g. L. hauffii*· and following younger forms); the inner cycle decreases in size being much smaller than the outer cycle in younger forms; the central area develops from subcircular to subelliptical and elliptical and simultaneously increases in size; the central structure becomes more and more complex but no clear trends are observed. Structures such as bars and crosses appear commonly and repeatedly in many coccoliths.

The genus *Watznaueria*, probably developed from bicyclic *Lotharingius* (*e.g. L. hauffii*), appears in the Lower Toarcian (Serpentinus Zone), and is characterized by forms with a small, open central area (*Watznaueria* sp. 1). During the Toarcian the assemblages are dominated by the genus *Lotharingius* while the genus *Watznaueria* is rare and only represented by *Watznaueria* sp. 1. The interval spanning the Aalenian/Bajocian boundary is characterized by several extinctions of *Lotharingius* species.

In the Upper Aalenian the diversity of the genus *Watznaueria* increases and reaches a maxi-

THE GENERA *LOTHARINGIUS-WATZNAUERIA* EVOLUTIONARY TRENDS

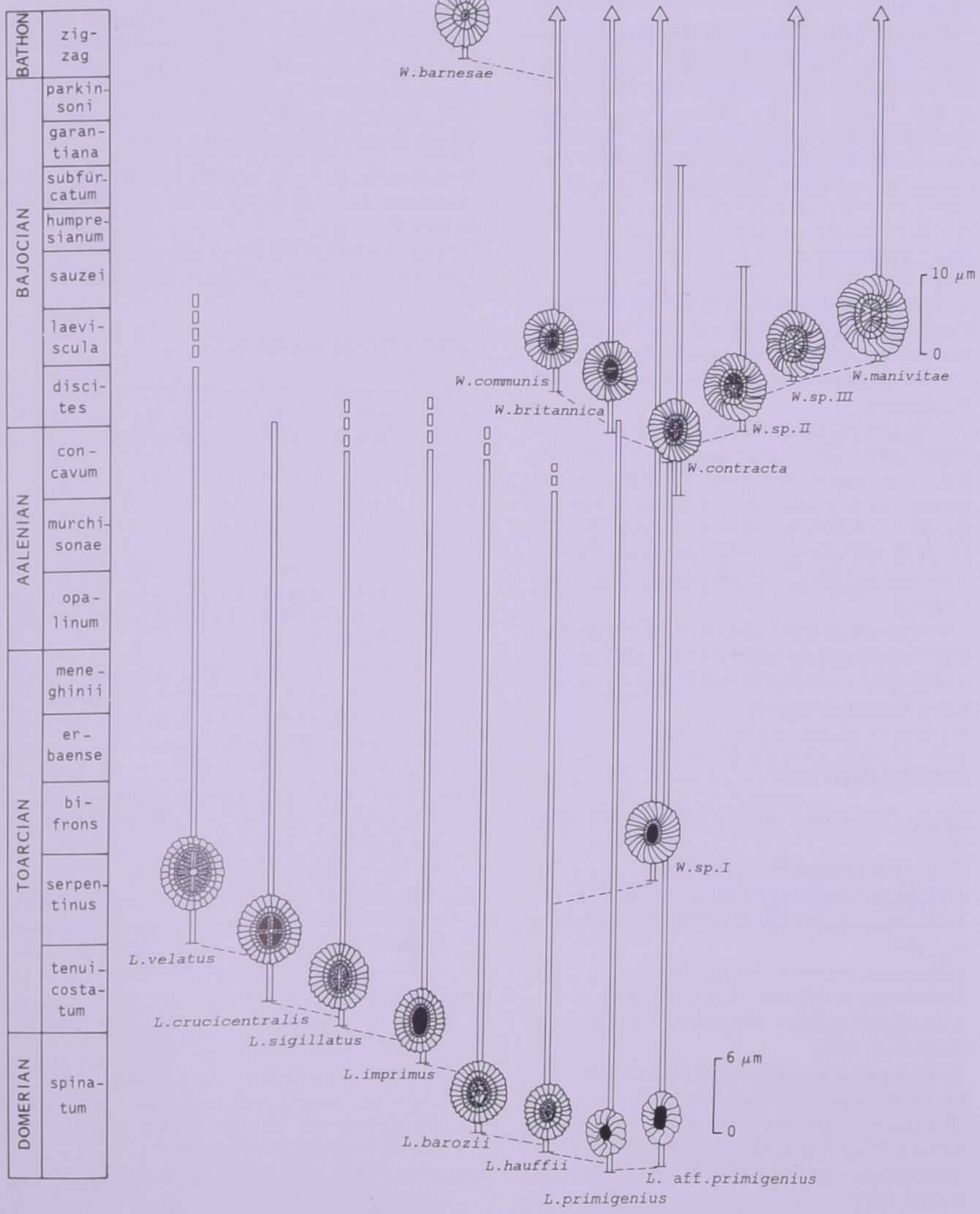

FIG. 2 - Evolutionary trends of the genera *Lotharingius* and *Watznaueria*.

mum in the Bajocian. This diversification is paralleled by an increase in abundance, *Watznaueria* became the dominant genus for the rest of the Jurassic.

From the first occurrence of *Watznaueria contracta* (Upper Aalenian) the evolution of this genus is marked by two different trends: an increase in size leading to *W. manivitae* through *Watznaueria* sp. 2 and *Watznaueria* sp. 3, and the reduction of the central process leading to *W. britannica, W. communis*, and finally *W. barnesae*.

CONCLUSIONS

1 - Semiquantitative studies of calcareous nannofloras from several Lower and Middle Jurassic sections have helped to determine the evolutionary trends of the genera *Lotharingius* and *Watznaueria*.

2 - In general, the evolutionary trends observed in both genera are: a) an increase in coccolith size both in successive new taxa and within single species, and b) gradual morphological changes of central area structures. Schemes proposed allow a better understanding of the evolution of calcareous nannofossils in the early stages of their occurrence.

3 - The sequence of successive *Lotharingius* and *Watznaueria* species improves the potential biostratigraphic resolution of the Upper Domerian-Lower Bathonian interval.

SPECIES INDEX

Genus *Lotharingius* NOËL, 1973 emend. GOY, 1979
Lotharingius barozii NOËL, 1973
Lotharingius crucicentralis MEDD, 1971
Lotharingius hauffii GRÜN and ZWEILI in GRÜN *et al.*, 1974
Lotharingius imprimus BOWN, 1987b
Lotharingius primigenius BOWN, 1987b
Lotharingius sigillatus (STRADNER, 1961) PRINS in GRÜN *et al.*, 1974
Lotharingius velatus BOWN and COOPER, 1989
Genus *Watznaueria* REINHARDT, 1964
Watznaueria barnesae (BLACK in BLACK and BARNES, 1959) PERCH-NIELSEN, 1968
Watznaueria britannica (STRADNER, 1963) REINHARDT, 1964
Watznaueria communis REINHARDT, 1964
Watznaueria contracta (BOWN and COOPER, 1989) n. comb.
Watznaueria manivitae BUKRY, 1973
Watznaueria sp. 1 - A species of *Watznaueria* characterized by a small and open central area.
Occurrence: Lombardy Basin.
Range: Serpentinus Zone to? Callovian.

Watznaueria sp. 2 - A normally elliptical species of *Watznaueria* with a large central area spanned by a cross aligned with the principal axes of the ellipse. High colors in crossed nicols.
Occurrence: Lombardy Basin and Digne area.
Range: Discites Zone to Sauzei Zone.

Watznaueria sp. 3 - A species very similar to *W. manivitae* but smaller than 9 µm (maximum diameter).
Occurrence: Lombardy Basin and Digne area.
Range: Discites Zone to Upper Tithonian.

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