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EOCENE LARGER FORAMINIFERAL BIOSTRATIGRAPHY IN THE SOUTHERNMOST DAUPHINOIS DOMAIN (MARITIME ALPS, FRANCE-ITALY BORDER)

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Abstract. The Trucco Formation and the Nummulitic Limestone (Dauphinois Domain, Maritime Alps) are characterized by abundant larger foraminifera, specifically nummulitids, orthophragminids and encrusting foraminifera. In the Maritime Alps, previous studies suggest a late Lutetian age for the Trucco Formation and a late Lutetian-Priabonian age for the Nummulitic Limestone.

Biostratigraphic analysis of the nummulitids, in 11 stratigraphic sections, allowed us to distinguish 3 biozones:

MALF1 Zone: defined by the presence of *Nummulites brongniarti* d'Archiac & Haime, *N. puschi* d'Archiac, *N. perforatus* de Montfort, *N. striatus* (Bruguière), *N.* cf. *dufrenoyi* d'Archiac & Haime, *N. variolarius/incrassatus* and *Operculina schwageri* Silvestri.

MALF2 Zone: defined by the presence of *Nummulites perforatus* de Montfort, *N. striatus* (Bruguière), *N.* cf. *dufrenoyi* d'Archiac & Haime, *N. variolarius/incrassatus* and *Operculina schwageri* Silvestri.

MALF3 Zone: defined by the presence of gr. *Nummulites variolarius/incrassatus*, *N. striatus* (Bruguière) and *Operculina schwageri* Silvestri.

According to current larger foraminiferal biozonal schemes, the age of these local biozones corresponds to the Bartonian *p.p.*

Moreover, the comparison with biostratigraphic schemes established for the Dauphinois Domain and for the Tethyan area evidences that several typical nummulitid species of the late Bartonian are lacking in the southern Dauphinois Domain, probably due to a paleogeographic control.

Riassunto. La Formazione di Trucco e i Calcari a Nummuliti del Dominio Delfinese (Alpi Marittime) sono costituiti da sedimenti molto ricchi in macroforaminiferi; si tratta principalmente di nummulitidi, orthophragminidi e foraminiferi incrostanti. Secondo i dati presenti in letteratura la Formazione di Trucco è riferibile al Luteziano superiore, mentre i Calcari a Nummuliti hanno un'età compresa tra il Luteziano superiore e il Priaboniano.

Un'analisi biostratigrafica basata sullo studio dei nummulitidi di 11 sezioni stratigrafiche ha permesso individuare 3 biozone:

Zona MALF1: definita dalla presenza di *Nummulites brongniarti* d'Archiac & Haime, *N. puschi* d'Archiac, *N. perforatus* de Montfort, *N. striatus* (Bruguière), *N.* cf. *dufrenoyi* d'Archiac & Haime, *N. variolarius/incrassatus* e *Operculina schwageri* Silvestri.

Zona MALF2: definita dalla presenza di *Nummulites perforatus* de Montfort, *N. striatus* (Bruguière), *N.* cf. *dufrenoyi* d'Archiac & Haime, *N. variolarius/incrassatus* e *Operculina schwageri* Silvestri.

Zona MALF3: definita dalla presenza di *Nummulites variolarius/incrassatus*, *Nummulites striatus* (Bruguière) e *Operculina schwageri* Silvestri.

Il confronto di queste biozone con quelle presenti in letteratura ha permesso di riferirle al Bartoniano *p.p.*; inoltre tale confronto ha messo in evidenza che nel Dominio Delfinese meridionale mancano le specie di nummulitidi caratteristiche dell'intervallo Bartoniano superiore, probabilmente a causa di un controllo paleogeografico.

Introduction

Larger foraminifera and in particular *Nummulites* are among the most useful shallow-water paleoecologic and paleogeographic index fossils, particularly in Alpine-Tethyan areas. Detailed evolutionary lineages of various groups of *Nummulites* have been established for the Tethyan area, especially by Boussac (1911), Hottinger et al. (1964), Blondeau (1972), Herb & Hekel (1973) and Schaub (1981). Biostratigraphic schemes based on these lineages have been proposed for the entire Tethyan area (i.e. Schaub 1981; Papazzoni & Sirotti 1995 and Serra-Kiel et al. 1998) and for the Dauphinois Domain (Boussac 1911; Blondeau et al. 1968; Campredon 1977; Sztrákos & du Fornel 2003).

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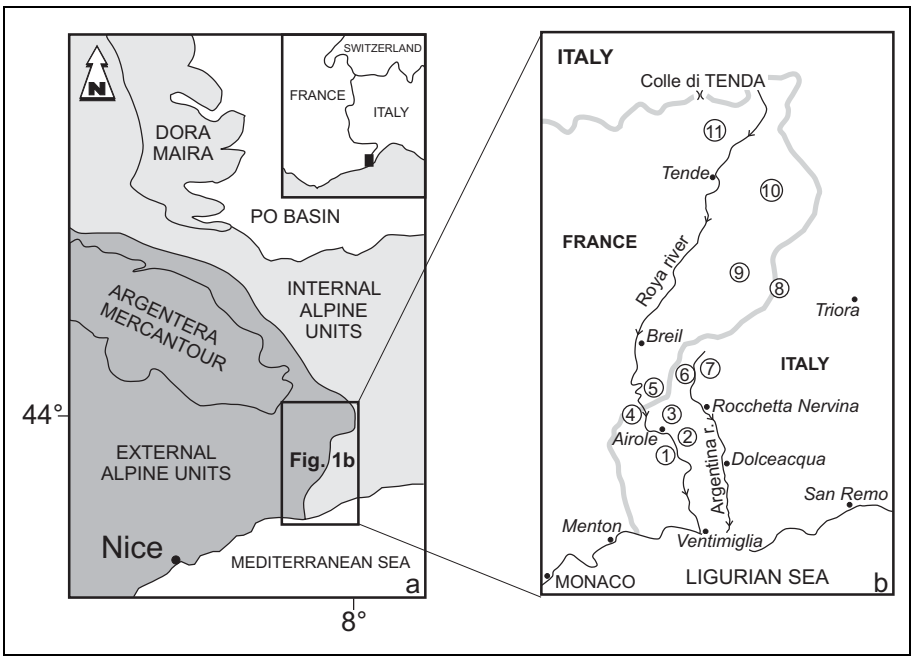


Fig. 1 - a) Sketch of the main structural domains of the Western Maritime Alps and position of the studied area (44° N-latitude and 8° E-longitude); b) Location of the measured stratigraphic sections.

In the last decade, the Dauphinois Domain has been object of detailed sedimentologic and tectonostratigraphic studies in Champsaur area (Gupta 1997, 1999), in Annot-Entrevaux area (Sinclair 1997; Sinclair et al. 1998) and in the Maritime Alps (Ford et al. 1999; Ford & Lickorish 2004) but the dating of the successions is still based on old data that need careful revision.

This work provides new biostratigraphic data on a stratigraphic interval of great significance to recognize the worldwide demise of large-sized *Nummulites* and the Middle-Upper Eocene boundary.

The individuation of biostratigraphic events, in the southernmost part of the Dauphinois Domain (Maritime Alps), allows us a comparison with other biostratigraphic schemes for the Tethyan area, with general implications related to the stratigraphic distribution of larger foraminifera and to the extinction events occurred in this time span.

The Nummulitic Limestone represents the fully first marine deposit of the Alpine foreland basin; consequently it holds a key role in the understanding of the geodynamic evolution of this domain. For this reason a more precise dating of the Nummulitic Limestone in this sector may provide a strong constrain for tectonostratigraphic models.

Geological setting

The studied area is localized in the Maritime Alps, near the French-Italian border, at the southernmost edge of the Dauphinois Domain (Fig. 1a). In this area, the Eocene succession records the initial transgression and the subsidence of the southernmost Alpine foreland basin. This basin-fill succession (Sinclair 1997) rests through an erosional surface upon a Cretaceous substrate that represents the passive-margin wedge developed at the paleoeuropean margin of the Ligurian Tethys Ocean (Ford & Lickorish 2004).

The Eocene succession of the Dauphinois Domain in the Western Alpine foreland basin consists of four main lithostratigraphic units (Fig. 2).

The first unit is represented by the Trucco Formation (TF) consisting of thin lenticular bodies of continental and estuarine deposits. This as yet informal formation has been proposed by Varrone (2004) to indicate

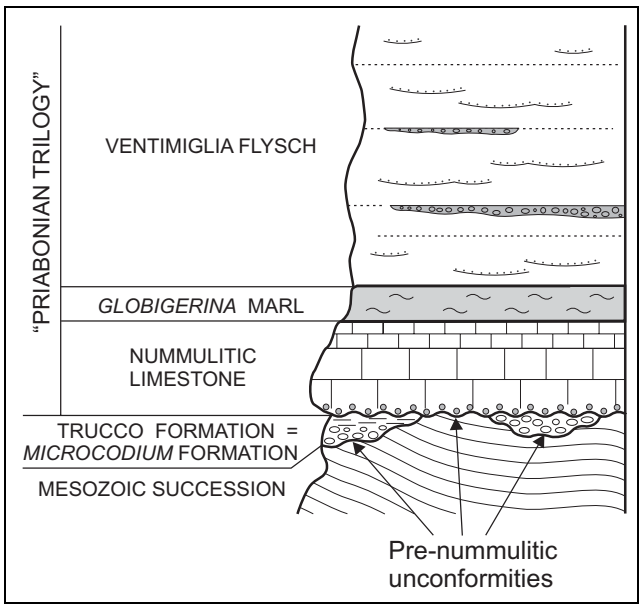


Fig. 2 - Schematic lithostratigraphy, not to scale, of the Eocene Dauphinois Domain succession in the Maritime Alps.

all the sediments sandwiched between the Upper Cretaceous substratum and the transgressive shallow marine Nummulitic Limestone. This definition has been preferred to the original one of *Microcodium* Formation given by Faure Muret & Fallot (1954), because quite often the upper portion of this unit does not contain *Microcodium* remains but instead brackish mollusc assemblages characterized by abundant gastropods. These layers were known as Couches à *Cerithium* (Bodelle 1968) and were not included in the original description of the *Microcodium* Formation given by Faure Muret & Fallot (1954). The well-known locality of Trucco (Sturani 1969; Campredon 1977) has been chosen as the type locality, where all the facies recognized in the formation are well exposed. The TF coincides with the "Infra Nummulitic conglomerate" (Ravenne et al. 1987; Apps et al. 2004) and the "Infranummulitic Formation" by Sinclair et al. (1998) defined in Haute Savoie and French Maritimes Alps immediately to the west of the studied area. These authors however did not propose any type section.

The TF is characterized, in its lower part, by *Microcodium* and paleosols indicating subaerial conditions followed by continental deposits, while in the upper part estuarine-lagoonal deposits prevail. The age of these deposits has been strongly debated; at present the TF is dubitatively referred to the Lutetian (Sturani 1969; Lanteaume 1968).

The following three units (Nummulitic Limestone, *Globigerina* Marls and Ventimiglia Flysch) are known in the Alpine literature as "Priabonian trilogy" (Boussac 1911).

The Nummulitic Limestone (NL) consists of a 30 to 100 m thick time-transgressive succession of shallow-marine limestone that unconformably overlies the TF or directly the Upper Cretaceous substrate. This formation consists of arenaceous limestones, limestones and bioclastic quartzarenites rich in larger foraminifera, deposited on a mixed siliciclastic-carbonate ramp characterized by moderate to high energy (Sinclair et al. 1998; Varrone & Clari 2003). The NL has been usually referred to the upper Lutetian-Bartonian (Campredon 1977; Lanteaume 1990).

The *Globigerina* Marl (GM) consists of bioturbated hemipelagic marls, 10 to 80 m thick deposited in a deep-water setting (Allen et al. 1991). Various bathymetric indicators demonstrate that the top of the GM was deposited at the time of maximum water depth in the Eocene succession (Sinclair et al. 1998). The GM is referred to the Priabonian *l.s.* (Lanteaume 1990; Varrone & d'Atri in press).

The last unit is represented by the Ventimiglia Flysch, a thick unit laterally equivalent to the Annot Sandstone (Stanley 1961; Vanossi 1990) consisting of siliciclastic turbidites supplied by the Maures Esterel Massif (Ravenne et al. 1987). These turbidites are referred to the Priabonian – Oligocene? (Vanossi 1990).

Methods

A total of 11 stratigraphic sections were measured (Fig. 1b, Fig. 3) and 226 samples were collected for investigating their larger foraminiferal content.

The samples consist of arenaceous, strongly lithified limestones. After a preliminary examination they were processed for acetate peels (222), thin-sections (52) and cut into random thin-slabs (85 slabs and 995 polished surfaces). The slabs proved the most successful way to obtain equatorial and axial sections of *Nummulites* and to observe the complete fossil assemblages in lithified rocks.

Only 4 less lithified samples were crushed, disaggregated by hydrogen peroxide solution, boiled in a sodium hydroxide solution and then washed through a 63 μm sieve obtaining 56 isolated larger foraminiferal specimens. After observations on external morphology the specimens were polished with increasingly fine grades of carborundum until the required equatorial section was reached.

Of the 226 samples analysed only 97 contain biostratigraphically-relevant larger foraminiferal assemblages (Tab. 1).

The biostratigraphic analysis focussed on the nummulitids, whereas the orthophragminids have been omitted. Previous works (i.e. Campredon 1977; Carbone et al. 1980) indicate that orthophragminids are very abundant in this area, but represented by very few species characterized by a wide biostratigraphic range, unsuitable for biostratigraphic purposes.

Age-diagnostic larger foraminifera are present in the topmost layers of the TF and are especially abundant in the lower part of the NL (Fig. 3), whereas the upper part of the NL is characterized by scarce fossils content represented by nummulitids, gypsinids and rotaliids.

The Trucco Formation

The Trucco Formation consists of continental and estuarine deposits filling a paleo-valleys system. The top of this formation usually is characterized by lenticular bodies of quartzarenites with cross bedding and locally hummocky cross stratification. This facies represents submerged discontinuous sand bars embaying a lagoon, while distally inner ramp sediments (NL) were deposited (Varrone & Clari 2003). The depositional environments of the TF and the NL were contiguous and during storm events bioclasts of the inner ramp (especially nummulitids) were transported and deposited in the external part of the lagoon. For this reason the larger foraminifera are confined to the top of the TF and consist of nummulitids, encrusting and attached foraminifera, bivalves and rarely echinoid spines. Lithology and sedimentary structures suggest a high-energy environment and locally the fossil assemblage may consist of both in place and displaced specimens. The displacement and mixing of sediments and faunas, locally, may hamper paleoenvironmental reconstruction but not biostratigraphic analysis because usually the displacement occurs between neighbouring environments.

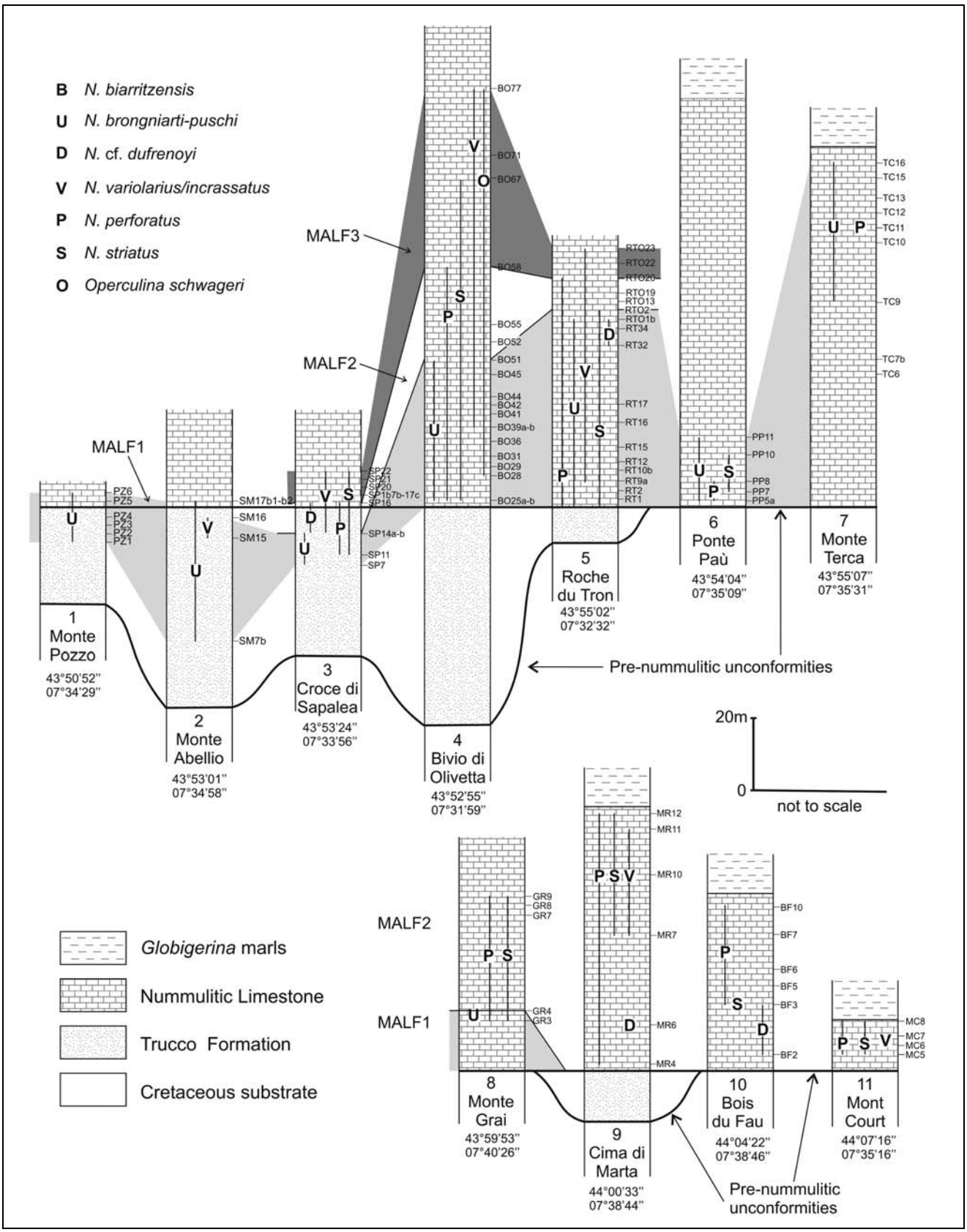


Fig. 3 - Logs of the 11 stratigraphic sections. Coordinates in latitude-longitude degrees (according to WGS84) of the stratigraphic sections, sample localisation, lithostratigraphy, main stratigraphic surfaces (pre-nummulitic unconformities), ranges of selected species and biozones have been evidenced. *Nummulites brongniarti* and *N. puschi* are characterized by the same biostratigraphic range and consequently they are represented with a single symbol (U).

Samples \ Species	*Nummulites* sp.	*N. brongniarti*	*N. cf. dufrenoyi*	*N. variolarius/incrassatus*	*N. perforatus*	*N. puschi*	*N. gr. puschi/brongniarti**	*N. striatus*	*Operculina* sp.	*Operculina schwageri*	*Fabiania cassis*	*Gyroidinella* cf. *magna*	*Orbitolites* sp.	*Sphaerogypsina globulus*	*Victoriella* sp.	*Asterocyclina* sp.	*Discocyclina* sp.	Rotaliidae indet.
(1) Monte Pozzo																		
PZ6		▪				▪												
PZ5		▪				▪							▪					
PZ4		▪	▪			▪	▪											
PZ3		▪				▪												
PZ2		▪				▪	▪											
PZ1		▪				▪	▪											
(2) Monte Abellio																		
SM17b2		▪				▪												
SM17b1		▪																
SM16	▪	▪		▪		▪												
SM15	▪	▪		▪		▪	▪											
SM7b		▪				▪												
(3) Croce di Sapalea																		
SP22				▪			▪	▪									▪	
SP21				▪			▪	▪									▪	
SP20				▪			▪	▪									▪	
SP17c				▪				▪								▪	▪	▪
SP17b	▪			▪			▪											
SP16		▪	▪	▪	▪		▪											
SP14b	▪			▪	▪		▪	▪			▪		▪				▪	▪
SP14a	▪	▪	▪		▪		▪	▪			▪		▪				▪	▪
SP11	▪				▪		▪	▪										
SP7							▪											
(4) Bivio di Olivetta																		
BO77	▪			▪					▪	▪							▪	
BO71	▪			▪					▪	▪							▪	
BO67	▪			▪				▪									▪	
BO58	▪			▪	▪			▪	▪								▪	
BO55					▪			▪										
BO52			▪					▪										
BO51	▪	▪	▪	▪	▪		▪	▪										▪
BO45		▪			▪													
BO44		▪						▪										
BO42	▪	▪			▪		▪	▪										
BO41	▪	▪			▪	▪		▪	▪									
BO39b	▪			▪	▪		▪	▪	▪					▪				▪
BO39a			▪	▪	▪												▪	
BO36	▪		▪					▪										
BO31	▪				▪		▪										▪	
BO29		▪			▪					▪								
BO28					▪					▪								
BO25b	▪	▪				▪												
BO25a	▪				▪		▪										▪	
(5) Roche du Tron																		
RTO23				▪					▪								▪	▪
RTO22									▪							▪	▪	
RTO20			▪	▪	▪				▪								▪	
RTO19	▪																	
RTO13	▪			▪														
RTO2	▪			▪	▪			▪	▪								▪	▪
RTO1b			▪		▪	▪	▪		▪									

Samples \ Species	*Nummulites* sp.	*N. brongniarti*	*N. cf. dufrenoyi*	*N. variolarius/incrassatus*	*N. perforatus*	*N. puschi*	*N. gr. puschi/brongniarti**	*N. striatus*	*Operculina* sp.	*Operculina schwageri*	*Fabiania cassis*	*Gyroidinella* cf. *magna*	*Orbitolites* sp.	*Sphaerogypsina globulus*	*Victoriella* sp.	*Asterocyclina* sp.	*Discocyclina* sp.	Rotaliidae indet.
(5) Roche du Tron																		
RT34		▪			▪	▪	▪		▪									
RT32		▪	▪			▪			▪									
RT17			▪			▪			▪								▪	
RT16	▪	▪			▪	▪			▪									
RT15						▪			▪	▪							▪	
RT12	▪	▪		▪		▪							▪	▪				▪
RT10b					▪				▪									
RT9a	▪	▪		▪		▪			▪			▪		▪				▪
RT2						▪												
RT1	▪		▪		▪	▪	▪		▪								▪	▪
(6) Ponte Paù																		
PP11	▪			▪			▪										▪	▪
PP10	▪			▪				▪									▪	
PP8	▪				▪	▪			▪								▪	
PP7	▪	▪			▪	▪		▪										
PP5a	▪	▪			▪		▪										▪	
(7) Monte Terca																		
TC16	▪					▪											▪	
TC15	▪						▪		▪									
TC13	▪	▪																
TC12	▪		▪						▪								▪	
TC11	▪		▪		▪				▪								▪	
TC9	▪					▪												
TC7b	▪															▪	▪	▪
TC6	▪											▪						
(8) Monte Grai																		
GR9	▪				▪			▪									▪	▪
GR8	▪			▪	▪			▪										▪
GR7			▪		▪			▪									▪	▪
GR4		▪	▪		▪	▪	▪											
GR3		▪	▪		▪	▪	▪				▪							
(9) Cima di Marta																		
MR12					▪			▪										
MR11				▪	▪			▪										▪
MR10					▪			▪										
MR7				▪	▪			▪										
MR6	▪		▪		▪													
MR4					▪													
(10) Bois du Fau																		
BF10					▪				▪								▪	
BF7				▪	▪													
BF6					▪													
BF5					▪													
BF3	▪		▪		▪			▪										
BF2	▪		▪														▪	
(11) Mont Court																		
MC8					▪			▪										▪
MC7				▪	▪			▪										
MC6	▪			▪	▪			▪										▪
MC5	▪				▪			▪										

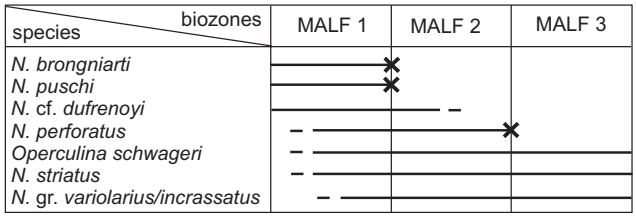
Tab. 1 - Distribution of the larger foraminifera in the studied sections. Only the samples containing age-diagnostic larger foraminifera are included. *The indication *N.* gr. *puschi/brongniarti* has been utilized when the specific determination was uncertain.

The TF passes with a ravinement surface to the NL, indicating a sea level rise.

The Nummulitic Limestone

The NL consists of mixed carbonate-siliciclastic sediments characterized by lateral changes in thickness (30 to over 100 m) (Fig. 3). Changes in sedimentation indicate a deepening trend, from inner to outer ramp environments.

The NL is characterized, at the base, by a ubiquitous clast-supported polygenic conglomerate, 0.5 to 1 m thick. In this layer the fossil content (within the matrix) consists of nummulitids, orthophragminids, encrusting foraminifera and fragmented and/or abraded bivalves, gastropods, echinoids, red algae and scaphopod. Abrasion of skeletal remains and sediment texture point to a high environmental energy. This layer has been interpreted as a lag deposit covering the ravinement surface (Varrone & Clari 2003). Lag deposits are usually followed by middle-fine grained allochemic sandstones and sandy allochem limestones (*sensu* Mount 1985) in beds 0.5 to 2 m thick. The fossil content is represented by encrusting foraminifera, nummulitids, orthophragminids, rotaliids, gastropods, bivalves, solitary corals and echinoids. These sediments have been deposited in an inner ramp environment. In the upper part, the NL consists of alternating (decimetre to centimetre) middle-coarse allochemic sandstones (*sensu* Mount 1985) and



Tab. 2 - Distribution of the larger foraminifera with respect to the discussed biozones. (X) Disappearance; (dashed line) uncertain occurrence.

silty marls, characterized by an evident thinning and fining upward trend. In the allochemic sandstones the fossil assemblage is rich in orthophragminids, nummulitids, gastropods, bivalves, echinoderms, solitary corals and benthic foraminifera; in contrast, the silty marls are characterized by scarce fossil content consisting mainly in benthic foraminifera (gypsinids and rotaliids), gastropods and rarely nummulitids. The upper part of the NL has been deposited in a middle-outer ramp environment (Varrone & Clari 2003).

Distribution of larger foraminifera in the Trucco Formation and in the Nummulitic Limestone

The larger foraminiferal assemblages recognized in the TF and in the NL are characterized by a low number of species that nevertheless are enough to evidence regional and local biostratigraphic events (Pl. 1).

Three subsequent range biozones have been distinguished (Tab. 2) and indicated with the abbreviation MALF (Maritime Alps Larger Foraminifera).

MALF1 Zone

The lower zone is characterized by thick, large or small, *Nummulites* species and is defined by the presence of *Nummulites brongniarti* d'Archiac & Haime, *N. puschi* d'Archiac, *N. perforatus* de Montfort, *N. striatus* (Bruguière), *N.* cf. *dufrenoyi* d'Archiac & Haime, *N. variolarius/incrassatus* and *Operculina schwageri* Silvestri.

The fossil assemblage also comprises *Fabiania cassis* (Oppenheim), *Gyroidinella* cf. *magna* (Le Calvez), *Orbitolites* sp. and *Sphaerogypsina globulus* (Reuss).

Locally, the assemblage at the base of MALF1 is represented exclusively by large and flat forms of the *N. brongniarti-puschi* group, probably indicating an ecological control.

This zone has been recognized in 8 stratigraphic sections in the upper part of the Trucco Formation (where present) and the lower part of the NL (Fig. 3) and seems to be restricted to the southern part of the studied area.

MALF2 Zone

MALF2 is defined by the presence of *Nummulites perforatus* de Montfort, *N. striatus* (Bruguière), *N.* cf. *dufrenoyi* d'Archiac & Haime, *N. variolarius/incrassatus* and *Operculina schwageri* Silvestri (Tab. 2 and Fig. 3). The fossil assemblage also comprises *Gyroidinella* cf. *magna* (Le Calvez) and *Sphaerogypsina globulus* (Reuss).

The lower boundary coincides with the last occurrence of *Nummulites brongniarti* d'Archiac & Haime and *N. puschi* d'Archiac.

MALF2 has been recognized in 7 stratigraphic sections (Fig. 3) in the lower-middle part of the NL.

MALF3 Zone

The upper zone is characterized by the dominance of small *Nummulites* species and is defined by the presence of gr. *Nummulites variolarius/incrassatus*, *N. striatus* (Bruguière) and *Operculina schwageri* Silvestri.

The lower boundary coincides with the last occurrence of *Nummulites perforatus* de Montfort.

This zone has been recognized in 3 stratigraphic sections (Fig. 3) in the upper part of the NL.

Discussion

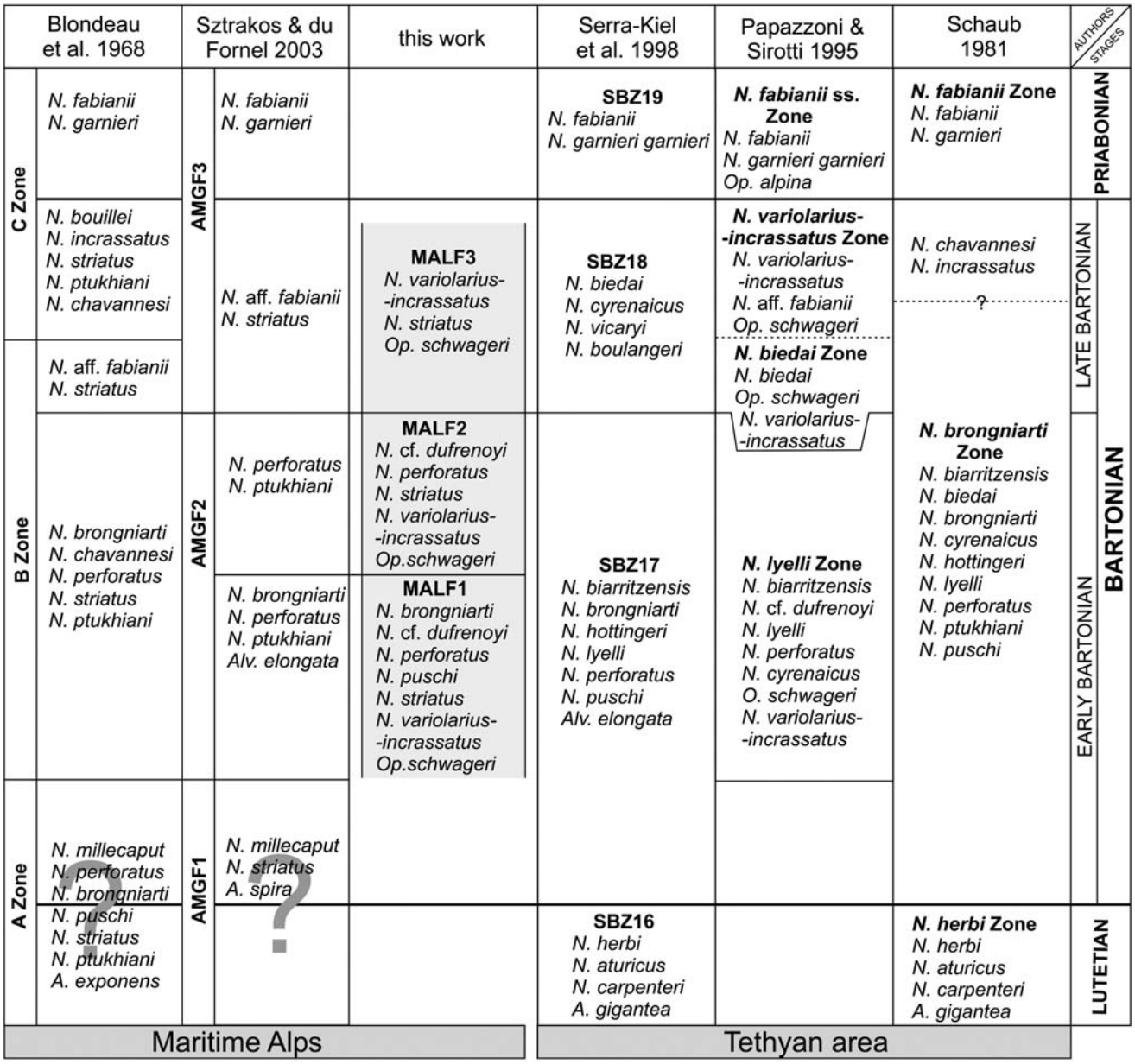
The three biozones identified (MALF1, MALF2 and MALF3) have been compared with biostratigraphic schemes established for the Dauphinois Domain and for the Tethyan area, with the aim to individuate common biostratigraphic events suitable for correlations (Tab. 3).

Dauphinois Domain

The more significant biostratigraphic schemes of the Dauphinois Domain are the ones established by Blondeau et al. (1968) and Sztrákos & du Fornel (2003).

The biostratigraphic events utilized to distinguish MALF1, MALF2 and MALF3 (Tab. 3) well correspond with those of Blondeau et al. (1968) and Sztrákos & du Fornel (2003), nevertheless an important incongruence has been evidenced in their schemes.

The incongruence concerns the occurrence/absence of *Nummulites millecaput*. In fact, on the base of the occurrence of *N. millecaput*, the authors individuate a late Lutetian (?)-early Bartonian biozone (biozone A of Blondeau et al. 1968 and biozone 1 *p.p.* of Sztrákos & du Fornel 2003) (Tab. 3). This biozone is defined by the presence of *N. millecaput* (a Lutetian species) associated with typical Bartonian species (*N. perforatus*, *N. brongniarti*, *N. striatus*). Detailed stratigraphic analyses (Varrone & Clari 2003) exclude reworking processes that should be invoked to explain this unusual assemblage.



Tab. 3 - Comparison between Maritime Alps Larger Foraminiferal biozones (MALF) and different biostratigraphic schemes established for the Dauphinois Domain and for the Tethyan area. A late Bartonian age is tentatively (?) inferred for MALF3 zone.

In our opinion, the specimens characterized by very large test and spiral-doubling indicated as *N. millecaput* are referable to *Nummulites* cf. *dufrenoyi* (a late Lutetian-early Bartonian species). In comparison to *N. millecaput*, *N.* cf. *dufrenoyi* shows a minor thickness of the test, the absence of a bulging in the central part, a more irregular coiling and septa that are long, thin and undulated.

Considering these observations, biozone A of Blondeau et al. (1968) and biozone 1 *p.p.* of Sztrákos & du Fornel (2003) can be included in the MALF1 zone of the present work, early Bartonian *p.p.* in age.

Tethyan area

The more significant biostratigraphic schemes of the Tethyan area are the ones established by Schaub (1981), Papazzoni & Sirotti (1995) and Serra-Kiel et al. (1998) (Tab. 3).

The MALF 1, MALF2 and MALF3 zones are all included in the *N. brongnarti* Zone of Schaub (1981) known in literature as Biarritzien (*sensu* Hottinger & Schaub 1960) (Tab. 3).

The comparison with the Shallow Benthic Zones (SBZ) of Serra-Kiel et al. (1998) is more articulated. MALF1 and MALF2 zones are both referable to SBZ17, early Bartonian in age (Tab. 3). The disappearance of *N. brongniarti* and *N. puschi* that represents the biostratigraphic event separating MALF1 to MALF2 is not considered as a regional event in the scheme of Serra-Kiel et al. (1998). Consequently, we suppose that this biostratigraphic event, recognized in the entire

southern Dauphinois Domain (Sztrákos & du Fornel 2003) can probably due to a paleoecological control.

MALF3 zone is dubitatively correlated to the SBZ18 of Serra-Kiel et al. (1998), late Bartonian in age. This correlation, based on the disappearance of *Nummulites perforatus* and *N.* cf. *dufrenoyi*, is uncertain because in the Maritime Alps the species characterizing SBZ18 are completely lacking. In fact, the early Bartonian assemblage (MALF1 and MALF2 coinciding with SBZ17) is followed by a biozone (MALF3) containing a low-diversity larger foraminifera fauna with few stratigraphically significant species.

The difference between the Maritime Alps and the Tethyan area associations is limited to this interval (MALF3 – SBZ18 zones). In fact, in the westernmost sectors (Arc de Nice, Campredon 1977) associations comparable to those of MALF3 zone are followed by typical Priabonian assemblages referable to SBZ19 of Serra-Kiel et al. (1998) (Tab. 3: Blondeau et al. 1968 and Sztrákos & du Fornel 2003).

The comparison with the scheme of Papazzoni & Sirotti (1995) evidences that MALF1 and MALF2 correspond both to the *Nummulites lyelli* Zone, early Bartonian in age (cf. SBZ17 of Serra-Kiel et al. 1998). Instead, MALF3 should partially correspond to the *N. variolarius/incrassatus* Zone (late Bartonian *p.p.*). In the southern Dauphinois Domain, the *N. biedai* Zone of Papazzoni & Sirotti (1995), late Bartonian *p.p.* in age (corresponding to the lower part of SBZ18 of Serra-Kiel et al. 1998), is lacking and the entire late Bartonian interval is represented by a larger foraminiferal assemblage dominated by *N. variolarius/incrassatus* and *N. striatus* (Tab. 3).

Moreover, according to Papazzoni & Sirotti (1995), the range of *N. striatus* is more extended than that indicated by Serra-Kiel et al. (1998).

The reason of the absence, in the southern Dauphinois Domain, of the more typical species of the late Bartonian is unclear. Detailed stratigraphic analyses (Varrone & Clari 2003) allow us to exclude the existence of a stratigraphic gap. Therefore, this fact can be explained supposing that a paleogeographic control has isolated during a short interval (late Bartonian) the southern Dauphinois Domain to the other Tethyan areas.

Conclusion

The present work, focused on the larger foraminiferal biostratigraphy of the Trucco Formation (TF) and the Nummulitic Limestone (NL), in the south-easternmost edge of the Dauphinois Domain (Maritime Alps), has evidenced:

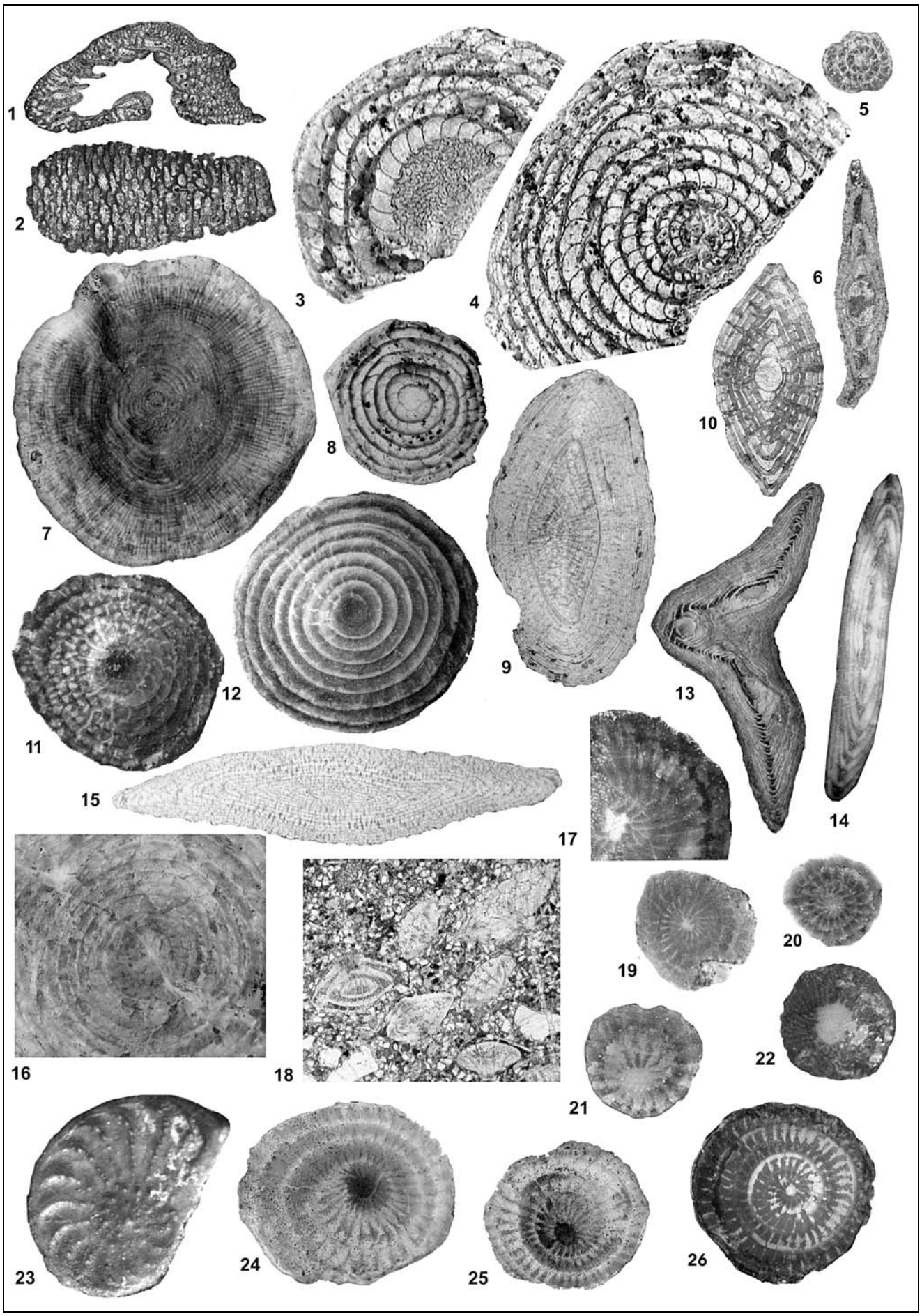
1) The top of the Trucco Formation is early Bartonian *p.p.* in age, while in previous works this stratigraphic interval was usually considered upper Lutetian (Lanteaume 1968).

2) The Nummulitic Limestone is early Bartonian *p.p.*-late Bartonian *p.p.* in age.

3) The larger foraminiferal assemblages recognized in the TF and in the NL allow us to distinguish three biozones (MALF, Maritime Alps Larger Foraminifera):

PLATE 1

Fig. 1 - *Fabiania cassis*: axial section (10x) (SP14b).
Fig. 2 - *Orbitolites* sp. (10x) (SP14b).
Fig. 3 - *Nummulites puschi*, B form: sub-equatorial section (2,5x) (PZ6).
Fig. 4 - *Nummulites puschi*, B form: equatorial section (2,5x) (PZ2).
Fig. 5 - *Nummulites puschi*, A form: equatorial section (2,5x) (PZ3).
Fig. 6 - *Nummulites puschi*, A form: axial section (5x) (PZ6)
Fig. 7 - *Nummulites perforatus*, B form: sub-equatorial section (2,5x) (BO28).
Fig. 8 - *Nummulites perforatus*, A form: equatorial section (7,5x) (BO28).
Fig. 9 - *Nummulites perforatus*, B form: axial section (2,5x) (BO31).
Fig. 10 - *Nummulites perforatus*, A form: axial section (10x) (MR10).
Fig. 11 - *Nummulites perforatus*, A form: sub-equatorial section (10x) (RTO2).
Fig. 12 - *Nummulites perforatus*, A form: equatorial section (10x) (RTO2).
Fig. 13 - *Nummulites* cf. *dufrenoyi*, B form: sub-axial section (2,5x) (GR3).
Fig. 14 - *Nummulites* cf. *dufrenoyi*, B form: sub-axial section (2,5x) (GR3).
Fig. 15 - *Nummulites brongniarti*, B form: sub-axial section (2,5x) (PZ2).
Fig. 16 - *Nummulites brongniarti*, B form: equatorial section (5x) (MR6).
Fig. 17 - *Nummulites variolarius/incrassatus*, sub-equatorial section (25x) (BO77).
Fig. 18 - *Nummulites variolarius/incrassatus*, detail of the assemblage (10x) (RTO23).
Fig. 19 - *Nummulites variolarius/incrassatus*, sub-equatorial section (25x) (MC6).
Fig. 20 - *Nummulites variolarius/incrassatus*, sub-equatorial section (25x) (MC7).
Fig. 21 - *Nummulites variolarius/incrassatus*, sub-equatorial section (25x) (SP21).
Fig. 22 - *Nummulites variolarius/incrassatus*, external view (25x) (RT16).
Fig. 23 - *Operculina schwageri*, external view (15x) (BO29).
Fig. 24 - *Nummulites striatus*, A form: sub-equatorial section (5x) (MC8).
Fig. 25 - *Nummulites striatus*, A form: sub-equatorial section (5x) (MR11).
Fig. 26 - *Nummulites striatus*, B form: equatorial section (7,5x) (GR8).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MALF1 Zone: defined by the presence of *Nummulites brongniarti* d'Archiac & Haime, *N. puschi* d'Archiac, *N. perforatus* de Montfort, *N. striatus* (Bruguière), *N.* cf. *dufrenoyi* d'Archiac & Haime, *N. variolarius/incrassatus* and *Operculina schwageri* Silvestri.

MALF2 Zone: defined by the presence of *Nummulites perforatus* de Montfort, *N. striatus* (Bruguière), *N.* cf. *dufrenoyi* d'Archiac & Haime, *N. variolarius/incrassatus* and *Operculina schwageri* Silvestri. The lower boundary of MALF2 corresponds to the last occurrence of *Nummulites brongniarti* d'Archiac & Haime and *N. puschi* d'Archiac.

MALF 3 Zone: defined by the presence of gr. *Nummulites variolarius/incrassatus*, *N. striatus* (Bruguière) and *Operculina schwageri* Silvestri. The lower boundary of MALF2 corresponds with the last occurrence of *Nummulites perforatus* de Montfort and *N.* cf. *dufrenoyi* d'Archiac & Haime.

4) The first two biozones (MALF1 and MALF2), both early Bartonian *p.p.* in age, have a local significance. In fact, the biostratigraphic event separating MALF1 and MALF2 (disappearance of *N. brongniarti* and *N. puschi*) is not recorded in other Tethyan areas.

5) In the southern Dauphinois Domain, the more typical nummulitid species of the late Bartonian are lacking, probably due to a paleogeographic control which affected the area until the Priabonian. Only a low-diversity larger foraminiferal assemblage is present. This assemblage has been assigned to a third biozone (MALF3), late Bartonian *p.p.* (?) in age, whose lower boundary is defined by the disappearance of *N. perforatus* and *N.* cf. *dufrenoyi* (biostratigraphic events recognized in the entire Tethyan area).

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