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BIOSTRATIGRAPHY OF UPPER TRIASSIC-LOWER JURASSIC CARBONATE PLATFORM SEDIMENTS OF THE CENTRAL-SOUTHERN APENNINES (ITALY)

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Abstract. The results of a biostratigraphic study on the Upper Triassic-Lower Jurassic carbonate platform sediments are outlined. Three stratigraphic successions cropping out in different areas were analysed: Monte Cefalo, (Aurunci Mts., southern Latium), Costa dei Frascari (Matese, northern Campania) and Monte Meta (Gran Sasso d'Italia, Abruzzi). The study of microfossil assemblages composed of benthic foraminifers and calcareous algae allowed identification of four biozones and one subzone. From the bottom upwards, the biostratigraphic units are: the *Triasina hantkeni* and *Griphoporella curvata* Zone; the *Thaumatoporella parvovesiculifera* Zone; the *Palaeodasycladus mediterraneus* Zone; the *Valvulinidae* and *Rivulariaceae* Zone; and the *Orbitopsella* Subzone. Besides, the lower part of the Costa dei Frascari section was referred to the portion of the Norian below the first occurrence of the *Triasina hantkeni* and *Griphoporella curvata.* These sediments are characterized by a rich assemblages mostly composed of pseudoudoteaceans algae, echinoderm remains, chaetetids and large gastropods. Microbiostratigraphic study of the Upper Triassic-Lower Jurassic sediments highlighted a similar succession of bioevents in all the sections analysed allowing precise bio- and chronostratigraphic correlations to be made. In contrast, the paleoecological data obtained from biofacies analysis combined with lithological features observed in coeval units point to different depositional environments, reflecting time and space variation within the context of a single, large carbonate platform. In fact, both sedimentation, and the observed associations of organisms, were controlled by chemical-physical factors connected to variations in water energy and water circulation. Instead, in other cases tectonics and subsidence seem to have played an essential role.

Riassunto. Vengono esposti i risultati di uno studio biostratigrafico condotto sui sedimenti carbonatici del Triassico superiore-Giurassico inferiore dell'Appennino centro-meridionale. Sono state analizzate tre successioni stratigrafiche affioranti in differenti aree: Monte Cefalo (Monti Aurunci, Lazio meridionale), Costa dei Frascari (Matese, Campania settentrionale) e Monte Meta (Gran Sasso d'Italia, Abruzzo). In base al contenuto paleontologico nell'intervallo Triassico superiore-Liassico sono state riconosciute quattro biozone e una subzona che, dal basso verso l'alto sono: Zona a *Triasina hantkeni* e *Griphoporella curvata*, Zona a *Thaumatoporella parvovesiculifera*, Zona a *Palaeodasycladus mediterraneus*, Zona a *Valvulinidae* and *Rivulariaceae* e Subzona a *Orbitopsella*. Inoltre, alla base della successione Costa dei Frascari (Matese) è presente un intervallo di circa 170 m caratterizzato dalla presenza di foraminiferi e alghe Pseudoudoteaceae di età norica, riferito alla porzione di Norico che precede la comparsa di *Triasina hantkeni* e *Griphoporella curvata*. Lo studio delle ricche associazioni fossili, costituite da foraminiferi bentonici e alghe calcaree ha evidenziato che la successione dei bioeventi è simile in tutte le sezioni analizzate, consentendo precise correlazioni bio- e cronostratigrafiche tra le sezioni stratigrafiche analizzate. I dati paleoecologici ottenuti dallo studio delle associazioni fossili, oltre alle differenze litologiche osservate tra le unità coeve, indicano che l'ambiente di deposizione, se pur riferibile ad una vasta piattaforma carbonatica, mostra variazioni nello spazio e nel tempo; infatti la sedimentazione, così come le associazioni di organismi, risultano condizionate in alcuni casi dai fattori chimico-fisici legati alle variazioni dell'energia delle acque e agli scambi con il mare aperto; in altri casi, invece, la tettonica e la subsidenza differenziata sembrano avere avuto un ruolo predominante.

Introduction

Mesozoic carbonate sediments widely crop out in the central-southern Apennines; several studies carried out in the last few years have allowed reconstruction of the stratigraphical succession (ca 2700 m thick) deposited on the Apennine platform, during Late Triassic-Late Cretaceous times (Chiocchini & Mancinelli 1977, 1978; Chiocchini et al. 1994, Mancinelli & Coccia 2002). In particular, during the Late Triassic-Early Jurassic times, the investigated area belonged to a vast "paleo-

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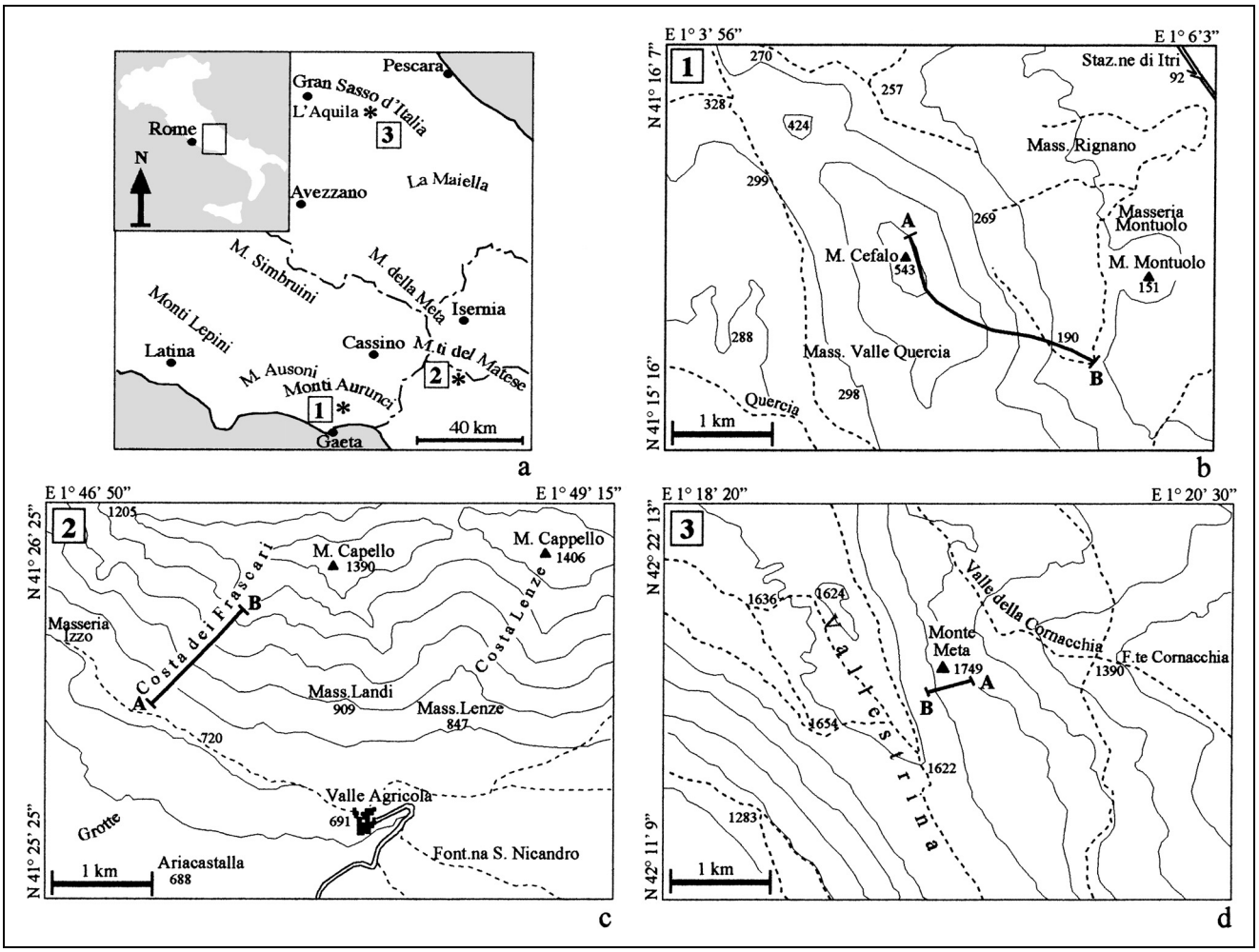


Fig. 1 - a: Geographic location of the study areas; b: location of the sampled Monte Cefalo section; c: location of the sampled Costa dei Frascari section; d: location of the sampled Monte Meta section.

platform" domain (sensu Chiocchini & Mancinelli 1978). A phase of extensional tectonism occurred at the end of lower Sinemurian and led to fragmentation of the paleoplatform, changing this paleogeographic picture and creating new sedimentary environments as a result: a tectonically depressed area corresponding to the Umbro-Marchean Basin (Centamore et al. 1971) and the Apennine Platform (sensu Mostardini & Merlini 1986). Pelagic sedimentation took place north-westwards, while shallow-water sedimentation continued south-eastwards. In such a paleogeographical picture, the Gran Sasso d'Italia area was the link zone between the Apennine Platform and the Umbro-Marchean Basin (Adamoli et al. 1978, 1981-82).

In order to enhance the litho- and biostratigraphic knowledge of the Upper Triassic-Lower Jurassic carbonate sediments and to provide a basis for facies interpretation and lateral correlations, the following stratigraphical sections, cropping out in different areas of the central-southern Apennines, were studied (Fig. 1):

1. Monte Cefalo section, cropping out on the Tyrrhenian side of the Aurunci Mountains, southern Latium. In Sheet 171 (Gaeta) of the 1: 100.000 Geological Map of Italy, the Triassic-Liassic sediments are described as "G^{1}-T^{6} (Lias inf. p.p.-Trias sup. p.p.)" and "G^{5-1} (Lias sup. p.p.-Lias inf. p.p.)".

2. Costa dei Frascari section, cropping out on the south-western side of the Matese Mountains, Campania. In Sheet 161 (Isernia) of the 1:100.000 Geological Map of Italy the analysed sediments are described as "$G^{2}T^{6}$ (Lias inf. p.p.-Trias sup.)" and as "G^{5-1} (Lias sup. p.p.-Lias inf. p.p.)".

3. Monte Meta section, cropping out in the south-eastern side of the Gran Sasso d'Italia Ridge, Abruzzi. In Sheet 140 (Teramo) of the 1:100.000 Geological Map of Italy the analysed sediments are described as "t_s (Trias sup.-?Lias inf.)" and "l_2 (Pliensbachiano-Sinemuriano)".

Each succession has been illustrated in detail (Figs. 2-4), including the fossil distribution. More than 60 species of microfossils were recognized. The study of these rich biofacies assemblages prevalently composed of benthic foraminifers and calcareous algae, allowed the biostratigraphic units to be described in detail and

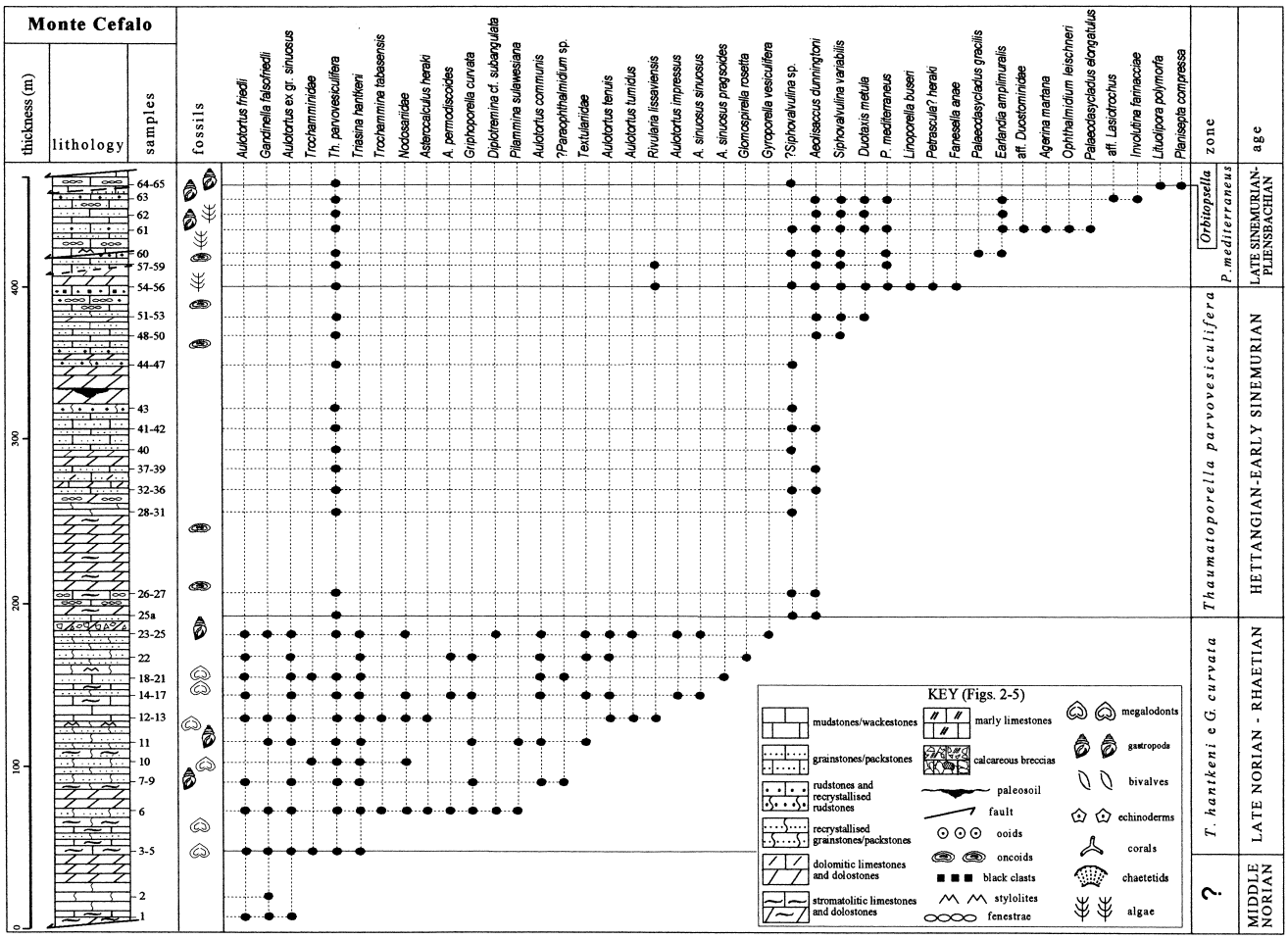


Fig. 2 - Monte Cefalo section: lithological log and fossil distribution. (biozones after Chiocchini et al. 1994).

reliable bio- and chronostratigraphic correlations among the study sections to be made. The lithological features of the successions are also illustrated.

Biostratigraphy

In the studied sequences, four biozones and one subzone have been identified according to the schemes proposed by Chiocchini & Mancinelli (1978) and Chiocchini et al. (1994). From Late Norian to Pliensbachian the biostratigraphic units are: the *Triasina hantkeni* and *Griphoporella curvata* Zone, the *Thaumatoporella parvovesiculifera* Zone, the Valvulinidae and Rivulariaceae Zone, the *Palaeodasycladus mediterraneus* Zone, and the *Orbitopsella* Subzone.

Besides, it is worth noticing the presence, in the lower portion of the Triassic-Liassic succession, of sediments containing Norian foraminifers and calcareous algae but characterized by the lack of *Triasina hantkeni* (see Appendix) and *Griphoporella curvata*.

These sediments widely crop out at Costa dei Frascari (ca 170 m thick) and they are characterized by the presence of benthic foraminifers among which *Agathammina austroalpina* (Pl. 1s, t), *Auloconus permodiscoides* (Pl. 1a), *Aulotortus friedli*, *Aulotortus sinuosus sinuosus, Aulotortus tumidus*, *Duotaxis birmanica* (Pl. 1h, i), *Earlandia amplimuralis*, *Gandinella falsofriedli* (Pl. 1p, q), ?*Paraophthalmidium* sp. (Pl. 1u, v, w) prob. *Triasina oberhauseri*, *Trochammina tabasensis*, Nodosariidae and Textulariidae. Calcareous red algae, such as *Asterocalculus heraki* and green algae such as *Heteroporella zankli* and *Probolocuspis espahkensis* (Pl. 1x), recently attributed by Senowbari-Daryan & Majidifard (2003) to the Dasycladales (family ?Acetabulariaceae) are also present. In addition, a flora consisting of green siphoneous Pseudoudoteaceae algae is dominant in this unit; the taxa with large sized strongly calcified thalli, such as *Pseudoudotea magna*, together with the ancestral pseudoudoteacean *Garwoodia maxima* (Pl. 2f) and *Garwoodia toomeji*, sometimes compose the whole biofacies; *Jabrianella* sp. *Ortonella* sp. and *Hedstroemia* sp. (Pl. 2g) are also present. Megalodonts, echinoderm remains, large sized gastropods and chaetetids are frequent.

These sediments were referred by Mancinelli et al. (2004) to the portion of the Norian below the *Triasina*

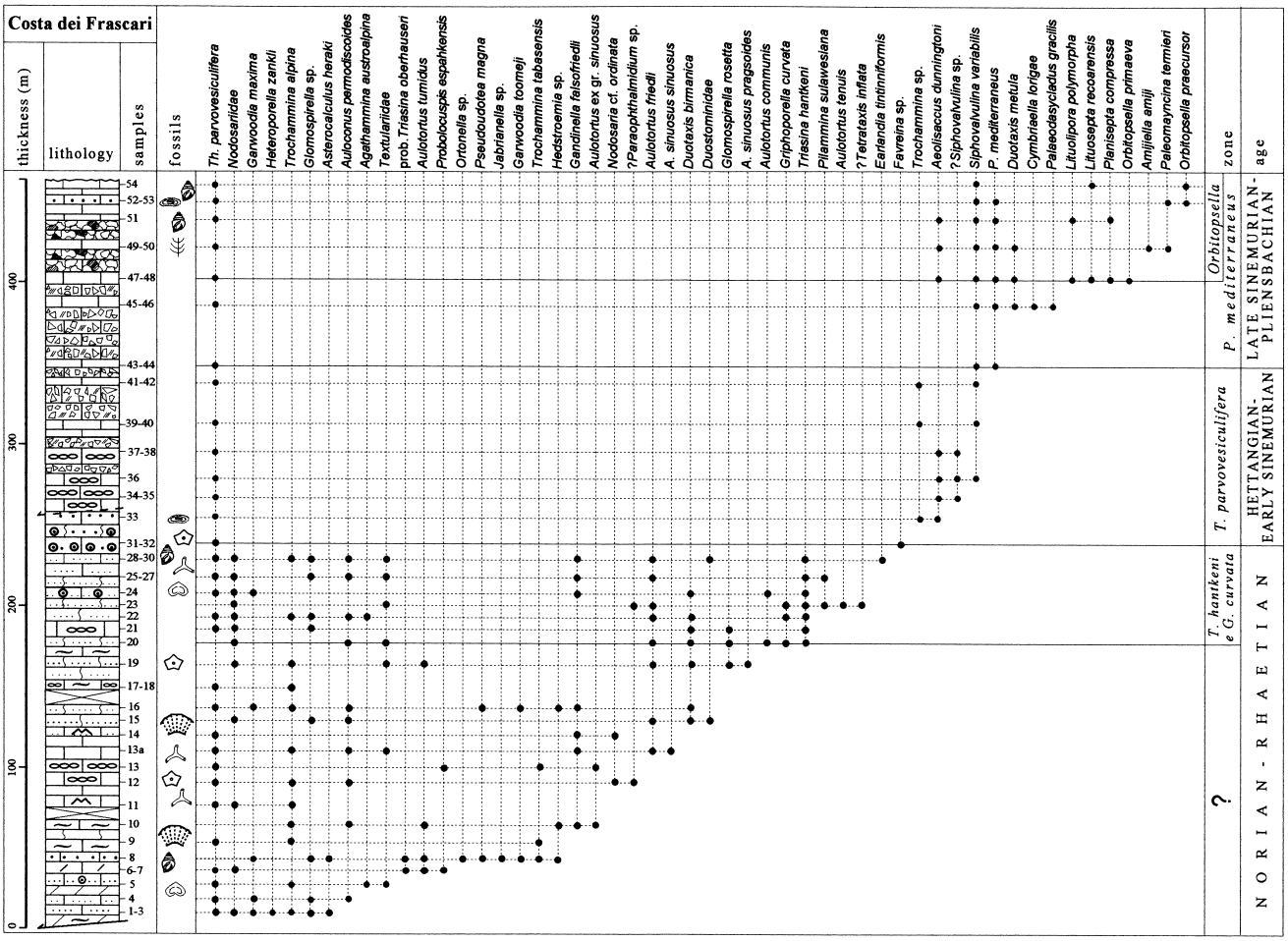


Fig. 3 - Costa dei Frascari section: lithological log and fossil distribution (biozones after Chiocchini et al. 1994).

hantkeni Zone (sensu Marcoux et al. 1993). The ca 50 m thick dolostones cropping out at the base of the Monte Cefalo section, were referred to this unit too, owing to their stratigraphic position below the *Triasina hantkeni* and *Griphoporella curvata* first occurrence.

Triasina hantkeni and *Griphoporella curvata* local taxon range Zone

Lower boundary: first occurrence of *Triasina hantkeni* and *Griphoporella curvata.*

Upper boundary: last occurrence of the two markers.

The unit crops out in all the analyzed sections; its thickness varies from 60 to 150 m.

The rich paleontological assemblage is composed of: *Agathammina austroalpina*, *Ammodiscus* cf. *multivolutus*, *Auloconus permodiscoides*, *Aulotortus communis*, *A. friedli* (Pl. 1c, r), *A. impressus* (Pl. 1e), *A. sinuous pragsoides*, *A. sinuosus sinuosus* (Pl. 1d, f), *A. tenuis* (Pl. 1b, n), *A. tumidus* (Pl. 1g), *Diplotremina* cf. *subangulata*, *Duotaxis birmanica*, *Earlandia tintinniformis*, *Endotriada* cf. *thyrrhenica*, *Gandinella falsofriedli*, *Glomospirella rosetta*, *Nodosaria* cf. *ordinata* (Pl. 1o), *?Paraophthalmidium* sp., *Pilammina sulawesiana*, *Tetrataxis inflata*, *Triasina hantkeni* (Pl. 1l, m), *Trochammina alpina*, *T. espahkensis*, *T. tabasensis* (Pl. 1j, k), Duostominidae, Nodosariidae, and Textulariidae. The microfloral assemblage is composed of *Asterocalculus heraki*, *Griphoporella curvata* (Pl. 2a, b, d), *Gyroporella vesiculifera* (Pl. 2c, e), and *Probolocuspis espahkensis*.

The unit is referred to the late Norian-Rhaetian.

Thaumatoporella parvovesiculifera interval Zone

Lower boundary: disappearance of *Triasina hantkeni* and *Griphoporella curvata.*

Upper boundary: first occurrence of *Palaeodasycladus mediterraneus.*

The unit crops out at Costa dei Frascari and Monte Cefalo sections; its thickness varies from 110 to 200 m, respectively.

The micropaleontological association is very poor, only composed of *Aeolisaccus dunningtoni*, *Siphovalvulina* sp., *Thaumatoporella parvovesiculifera* and Ostracoda. In the upper part of the unit *Duotaxis metula* and *Siphovalvulina variabilis* appear.

This unit was referred the to the Early Jurassic (Hettangian-early Sinemurian) owing to the disappearance of all the Upper Triassic microfossils characteriz-

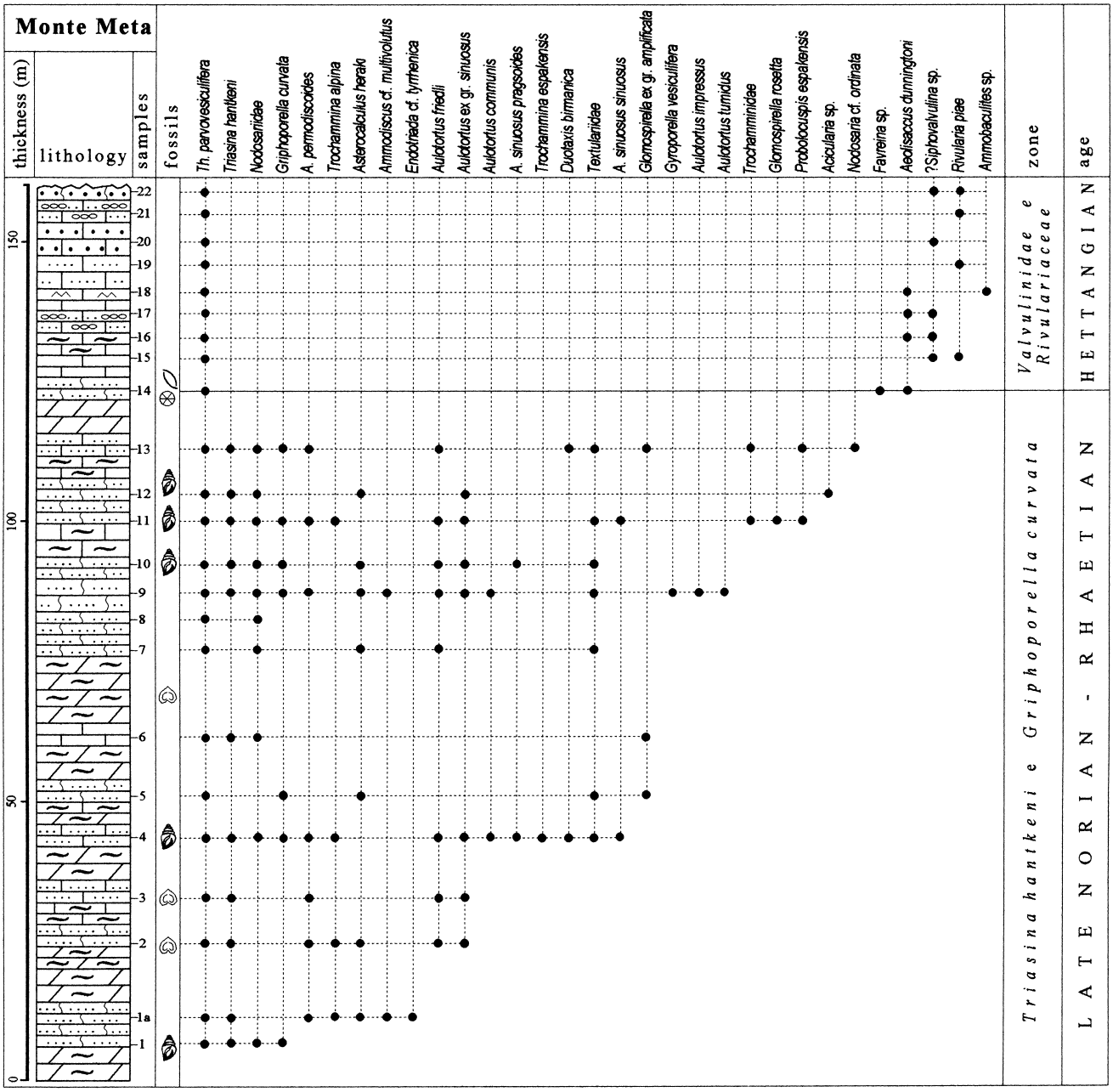


Fig. 4 - Monte Meta section: lithological log and fossil distribution. (biozones after Chiocchini & Mancinelli 1978).

ing the unit below, together with its stratigraphic position. At Monte Meta (Gran Sasso d'Italia) the coeval sediments contain *Ammobaculites* sp., *Aeolisaccus dunningtoni*, *Siphovalvulina* sp., *Thaumatoporella parvovesiculifera*, *Rivularia piae* and *Favreina* sp. and they were referred by Chiocchini & Mancinelli (1978) to the Valvulinidae and Rivulariaceae Zone.

Palaeodasycladus mediterraneus local taxon range Zone

Lower boundary: first occurrence of *Palaeodasycladus mediterraneus.*

Upper boundary: last occurrence of *Palaeodasycladus mediterraneus.*

The unit crops out at Costa dei Frascari and Monte Cefalo sections; the thickness of the sampled sediments varies from 50 to 60 m, respectively.

The paleontological assemblage is composed of *Aeolisaccus dunningtoni*, *Agerina martana*, *Cymbriaella lorigae*, *Duotaxis metula* (Pl. 3j), *Earlandia amplimuralis*, aff. *Lasiotrochus* (Pl. 3l), *Ophthalmidium leischneri* (Pl. 3f), *Siphovalvulina variabilis* (Pl. 3m), aff. Duostominidae (Pl. 3h, k), *Fanesella anae* (Pl. 3b), *Linoporella buseri* (Pl. 3e), *Palaeodasycladus elongatulus* (Pl. 3a, g), *Palaeodasycladus gracilis* (Pl. 3c, d), *Palaeodasycladus mediterraneus*, and *?Petrascula heraki.*

The unit is referred to the late Sinemurian.

***Orbitopsella* local taxon range Subzone**

Lower boundary: first occurrence of *Orbitopsella.*

Upper boundary: last occurrence of *Orbitopsella.*

The unit crops out at Costa dei Frascari where ca 60 m were sampled and at Monte Cefalo sections where only few meters were sampled.

All the microfossils characterizing the unit below are present, besides, *Amijiella amiji*, *Involutina farinacciae* (Pl. 3i), *Lituolipora polimorfa*, *Lituosepta recoarensis*, *Orbitopsella praecursor, Orbitopsella primaeva, Planisepta compressa*, and *Paleomayncina termieri* also occur.

The unit is referred to the Pliensbachian.

Lithostratigraphy

The described biostratigraphic units show different lithological features in the different areas testifying that the sedimentation was conditioned in some cases by variations in water energy; in other cases tectonics and subsidence seem to have played an essential role.

The Norian sediments underlying the first occurrence of *T. hantkeni* and *G. curvata* crop out at the base of the Costa dei Frascari section (ca 170 m thick); they consist, in the lower portion, of alternating grain-supported limestones sometimes oolitic, dolomitic limestones and dolostones; subsequently mud-supported limestones with red stylolites and fenestrae are present. Grain-supported limestones often recrystallized follow. Megalodonts, gastropods, colonial metazoans, chaetetids and echinoderm remains are frequent.

At the base of the Monte Cefalo section laminated dolostones and recrystallized mud-supported limestones (ca 50 m thick) crop out. Recrystallization due to the dolomitization processes has completely obliterated primary fabrics; owing to their stratigraphic position they were referred to the portion of the Norian below the first occurrence of *T. hantkeni* and *G. curvata*.

The overlying sediments referred to the *T. hantkeni* and *G. curvata* Zone at Monte Cefalo consist prevalently of grain-supported limestones, particularly rich in benthic foraminifers, megalodonts and gastropods; laminated mud-supported limestones with red stylolites and rare dolostones are interbedded.

At Monte Meta the coeval sediments are represented by an alternation of laminated and stromatolitic dolostones and grain-supported limestones; these latter, particularly rich in algal debris, prevail upwards. Rare mud-supported limestones, sometimes laminated, are also present. Megalodonts and gastropods are frequent.

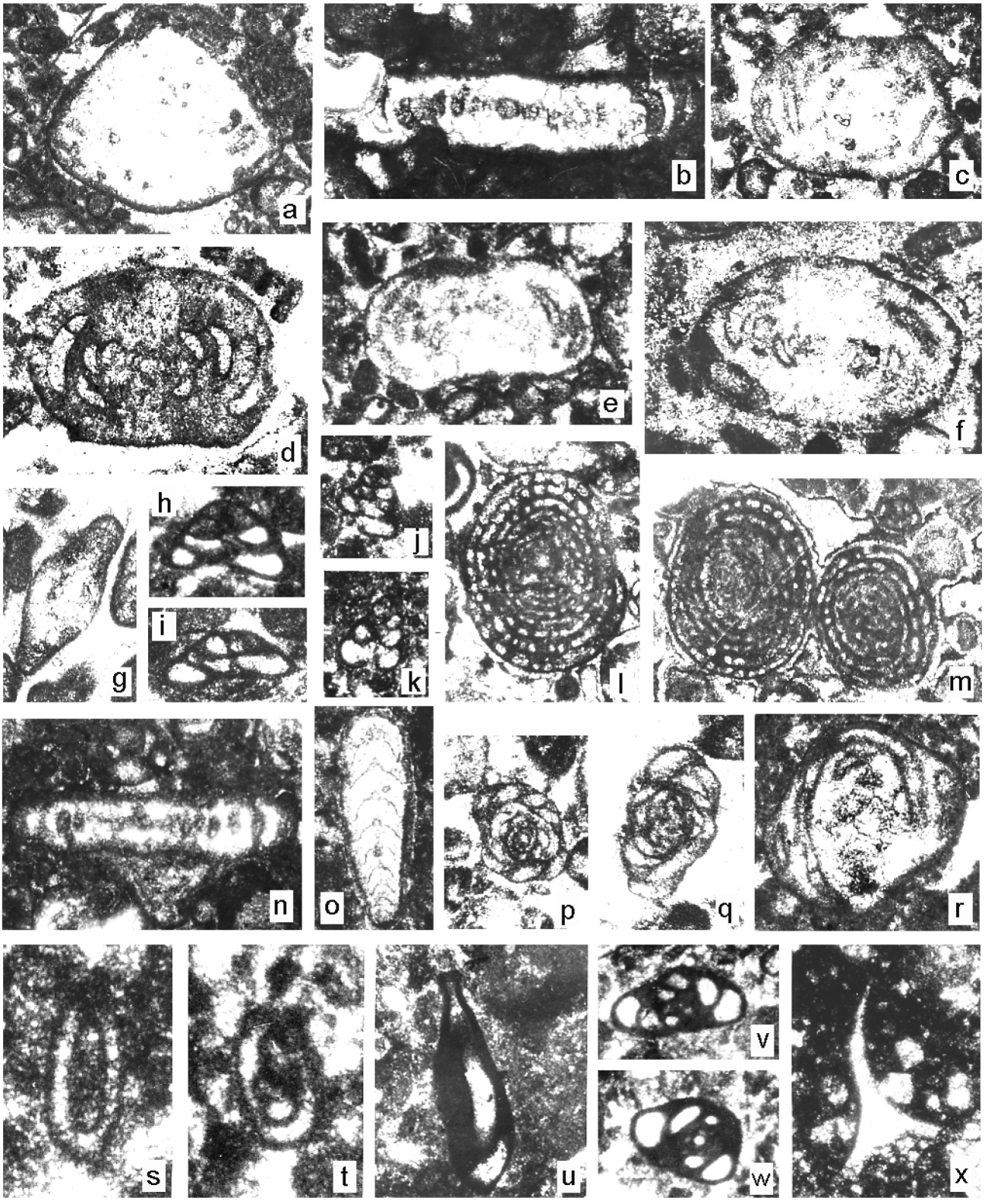
At Costa dei Frascari the sediments referred to the *T. hantkeni* and *G. curvata* Zone (ca 60 m thick) consist of grain-supported limestones sometimes oolitic with frequent colonial metazoan, gastropoda, and echinoderm remains.

The overlying strata referred to the *Thaumatoporella parvovesiculifera* Zone at Monte Cefalo are dominated in the lower part by stromatolitic dolostones; upwards grain-supported limestones prevail. Dolostones with reddish paleosoils occur in the middle part of this succession.

At Costa dei Frascari the coeval sediments are composed of oolitic and oncolitic grain-supported limestones at the base; fenestral mud-supported limestones follow. Upwards stratified breccias crop out; they are composed of unsorted angular-subangular lithoclasts, ranging in size from a few mm up to 0.5 m with abundant greenish marly matrix; thin reddish and greenish argillaceous levels are also present. Rare intercalations of mud-supported limestones occur within the breccias. Some lithoclasts from the lowermost portion of the breccias, show laminations and they possibly derive from Upper Triassic/lowermost Jurassic deposits. The breccias, with a thickness varying from 50 meters to a

PLATE 1

a: *Auloconus permodiscoides* subaxial section, Costa dei Frascari succession, sample CM 4 (x 30) Norian. **b**, **n**: *Aulotortus tenuis* axial sections, Monte Cefalo succession, samples CD 14 and CD 22 (x 50) upper Norian-Rhaetian. **c**, **r**: *Aulotortus friedli*. c: subaxial section, Costa dei Frascari succession, sample CM 23; **r**: cross section, Monte Meta succession, sample T 7 (x 50) upper Norian-Rhetian **d**, **f**: *Aulotortus sinuosus sinuosus*. d: axial section. Monte Cefalo succession, samples CD 25; **f**: subaxial section. Monte Meta succession, sample T 11. (x 30) upper Norian-Rhaetian. **e**: *Aulotortus impressus* oblique section, Monte Cefalo succession, sample CD 14 (x 50) upper Norian- Rhaetian. **g**: *Aulotortus tumidus* subaxial section, Monte Cefalo succession, sample CD 12 (x 45) upper Norian- Rhaetian. **h**, **i**: *Duotaxis birmanica* subaxial sections, Costa dei Frascari succession, samples CM 13 and CM 2. (x 50) Norian. **j**, **k**: *Trochammina tabasensis* subaxial sections, Monte Cefalo succession, sample CD 3 (x 45) upper Norian- Rhaetian. **l**, **m**: *Triasina hantkeni*. **l**: oblique section; **m**: oblique sections of two forms. Monte Cefalo succession, samples CD 14 and CD 23 (x 30) upper Norian-Rhaetian. **o**: *Nodosaria* cf. *N. ordinata* longitudinal section Monte Meta succession, sample T 13 (x 45) upper Norian-Rhaetian. **p**, **q**: *Gandinella falsofriedli* oblique sections, Costa dei Frascari succession, sample CM 16 (x 50) Norian. **s**, **t**, *Agathammina austroalpina* longitudinal sections, Costa dei Frascari succession, sample CM 9 (x 150) Norian. **u,v,w:** *Paraophthalmidium* sp. **u**: longitudinal section; **v**, **w**: cross sections. Costa dei Frascari succession, sample CM 12 (x 70) Norian. **x**: *Probolocuspis espahkensis* longitudinal section of an individual lateral, Costa dei Frascari succession, sample CM 1 (x 55) Norian.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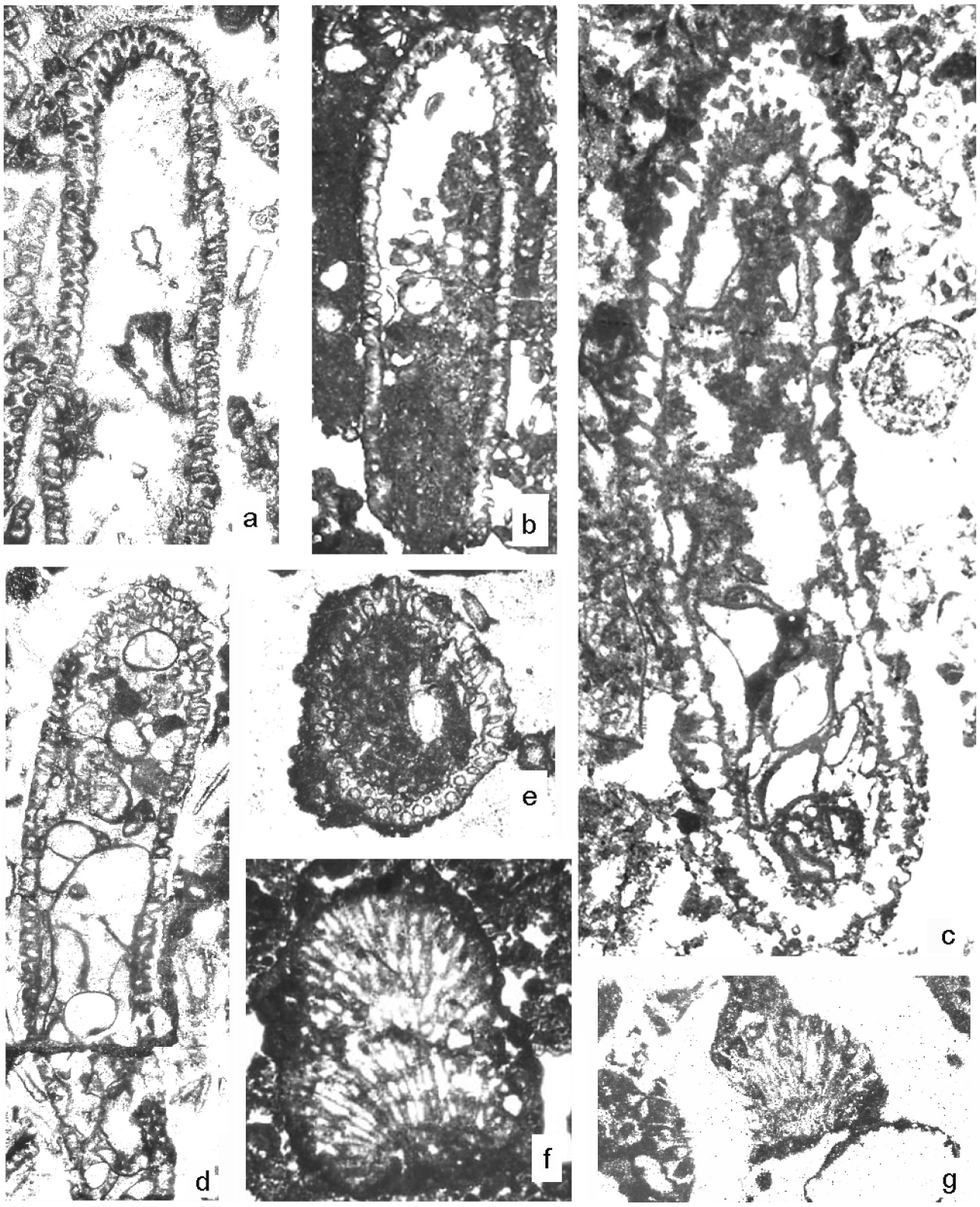

PLATE 2

a, **b**, **d**: *Griphoporella curvata* longitudinal-axial sections, Costa dei Frascari succession, samples CM 23 and CM 24 (x 15) upper Norian-Rhaetian. **c**, **e**: *Gyroporella vesiculifera*. **c**: longitudinal-oblique section, *Triasina hantkeni* is also present on the right side of the figure; **e**: cross section. Monte Meta succession, sample T 13 (x 10) upper Norian- Rhaetian. **f**: *Garwoodia maxima* longitudinal section, Costa dei Frascari succession, sample CM 8 (x 25) Norian. **g**: *Hedstroemia* sp. longitudinal section, Costa dei Frascari succession, sample CM 6 (x 45) Norian.

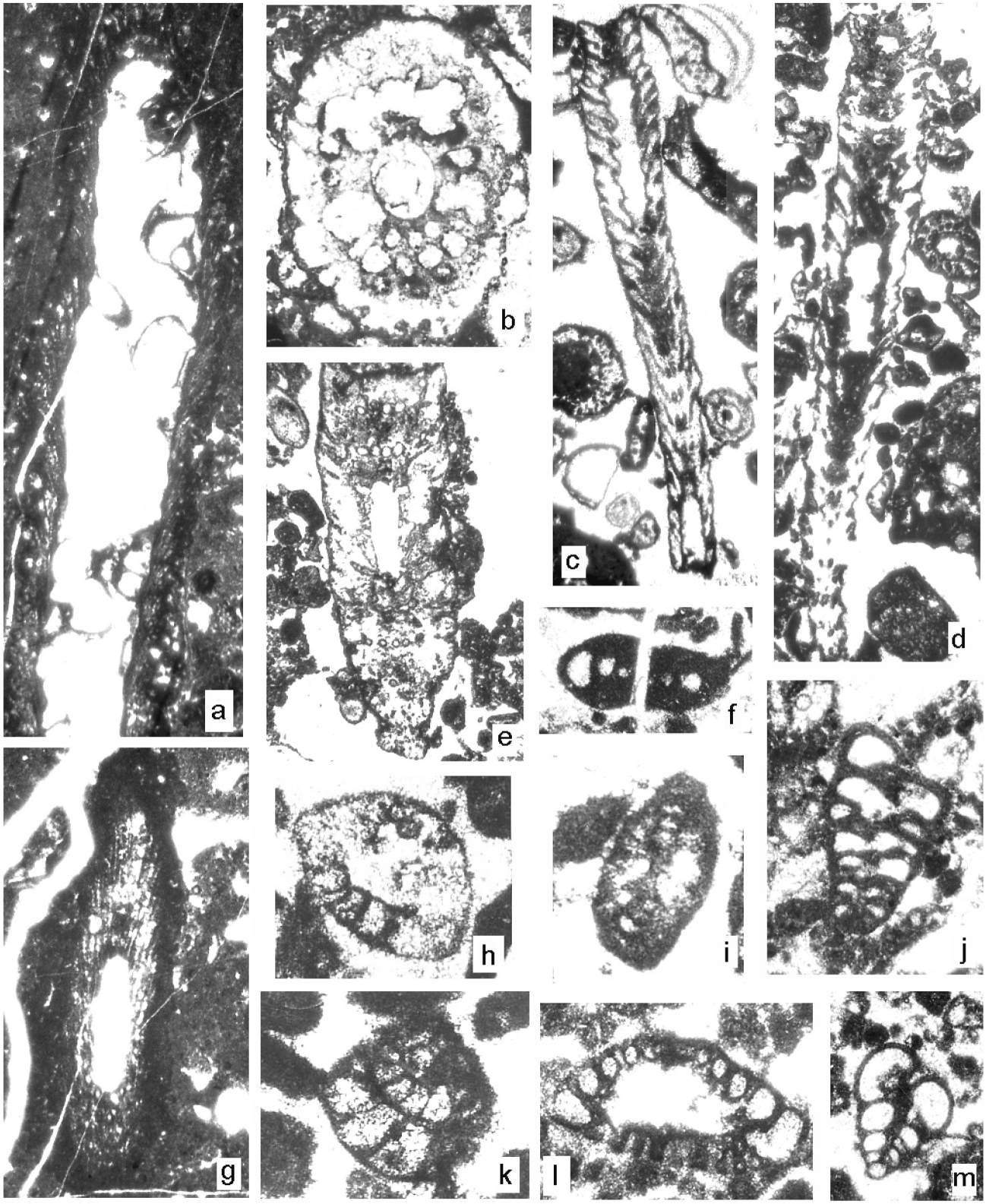

PLATE 3

a, **g**: *Palaeodasycladus elongatulus* **a**: longitudinal section; **g**: oblique section. Monte Cefalo succession, sample CD 61 (x 15) upper Sinemurian. **b**: *Fanesella anae* oblique section, Monte Cefalo succession, sample CD 56 (x 15) upper Sinemurian. **c**, **d**: *Palaeodasycladus gracilis* longitudinal sections, Costa dei Frascari succession, sample CM 45 (x 15) upper Sinemurian. **e**: *Linoporella buseri* longitudinal-oblique section, Monte Cefalo succession, sample CD 55 (x 15) upper Sinemurian. **f**: *Ophthalmidium leischneri* axial section, Monte Cefalo succession, sample CD 61 (x 75) upper Sinemurian. **h**, **k**: aff. Duostominidae longitudinal-oblique section. Monte Cefalo succession, sample CD 61 (x 75) upper Sinemurian. **i**: *Involutina farinacciae* axial section, Monte Cefalo succession, sample CD 63 (x 100) Pliensbachian. **j**: *Duotaxis metula* subaxial section, Monte Cefalo succession, sample CM 61 (x 50) Sinemurian. **l**: aff. *Lasiotrochus* sp. axial section, Monte Cefalo succession, sample RR 31 (x 75) upper Sinemurian. **m**: *Siphovalvulina variabilis* axial section, Costa dei Frascari succession, sample CM 46 (x 50) upper Sinemurian.

few meters are laterally replaced by laminated limestones and by *Thaumatoporella* algal mat.

At Monte Meta the ca 50 m of sampled sediments referred to the Valvulinidae and Rivulariaceae Zone are represented in the lowermost part by dolostones and subsequently, by alternating grain-supported and mud-supported limestones; they both frequently appear laminated and recrystallized. Fenestrae and red stylolites are frequent. Upwards grain-supported limestones sometimes with fenestrae crop out. These sediments were referred to the "Calcare Massiccio del Monte Nerone" formation (Centamore et al. 1971), characterized by a cyclothemic sedimentation (Pialli 1971).

The strata referred to the *Palaeodasycladus mediterraneus* Zone at Monte Cefalo consist dominantly of fenestral grain-supported limestones with secondary interbedded mud-supported limestones. In the lowermost portion dolostones occur.

At Costa dei Frascari crop out the underlying breccias, previously described; rare mud-supported limestones are interbedded within the breccias.

The sediments at the top of the Monte Cefalo and Costa dei Frascari sections have been referred to the *Orbitopsella* Subzone. At Monte Cefalo, where only a few meters of sediments were sampled, these consist of mud-supported limestones sometimes with fenestrae.

At Costa dei Frascari the coeval sediments consist of calcareous stratified breccias with rare mud-supported limestones interbedded. These breccias differ from the previous ones in having poorly-sorted lithoclasts, mostly derived from the coeval carbonate platform deposits; they show sutured contacts and a packed fabric. Besides, only a limited amount of sterile marly matrix is present. Upwards mud-supported limestones and rare oncolitic rudstones crop out.

Discussion of the biostratigraphic data

The comparative analysis of the vertical distribution of microfossils (benthic foraminifers and algae) reveals that the succession of biostratigraphic events is identical in all the study sections; this allowed reliable bio- and chronostratigraphic correlations to be made (Fig. 5). The lowermost portion of the Monte Cefalo section and the lower portion of the Costa dei Frascari section were referred to the portion of the Norian below the *Triasina hantkeni* Zone (Marcoux et al. 1993); the presence at Costa dei Frascari section of abundant Pseudoudoteaceae algae (Mancinelli et al. 2004) already known from the Norian deposits of Hydra, Greece, below the first occurrence of *Triasina hantkeni* (Dragastan et al. 1999), confirms this age assignment.

The following sediments referred to the *Triasina hantkeni* and *Griphoporella curvata* Zone were referred to late Norian-Rhaetian. The difficulties in defining the lower boundary of the Rhaetian stage make its definition controversial; in this work the Rhaetian is considered as a stage, as recommended by the Subcommission on Triassic Stratigraphy (Gaetani 1992) with its lower boundary at the base of the *S. reticulatus* Zone (Rhaetian sensu Dagys 1988). The later part of the Norian (Sevatian 2) is so included in the Rhaetian, so that *T. hantkeni* spans the time interval of the Late Norian and Rhaetian (Marcoux et al. 1993; Di Bari & Rettori 1996).

The sediments belonging to the coeval *Thaumatoporella parvovesiculifera* Zone and the *Valvulinidae* and *Rivulariaceae* Zones were referred to the Hettangian-early Sinemurian, owing to the desappearence of all the Triassic foraminifers and algae, together with their stratigraphic position. These sediments are characterized by extremely poor associations, therefore the Late Triassic-Early Jurassic boundary was presumed to coincide with the disappearance of all the Triassic forms characterizing the unit below.

The following sediments referred to the *Palaedasycladus mediterraneus* Zone were assigned to the late Sinemurian, owing to the occurence of *Palaedasycladus mediterraneus*; the presence of large sized Dasycladales such as *Fanesella anae*, *Palaeodasycladus elongatulus* and *Palaeodasycladus gracilis* confirm this age assignment.

The occurrence of *Orbitopsella* allows the sediments cropping out at the top of the succession to be referred to the Pliensbachian.

Conclusions

Paleoecological data obtained from biofacies analysis combined with lithological features of coeval units, allowed some hypothesis on the paleogeographic evolution of the study areas to be inferred.

The Upper Triassic-Lower Jurassic sediments were deposited in a wide carbonate "paleoplatform" environment. According to Passeri & Zaninetti (1985) and Ciarapica & Passeri (1998) this platform separated the La Spezia and Prepiemontese anoxic basins to the north-west, from the Lagonegrese-Molisano basin to the south-east. The paleoenvironmental features of this platform could have varied laterally, giving rise to a sedimentation strongly controlled by different chemical-physical factors (i.e. temperature, O^2, salinity, nutrients) related to variability in water energy variability, as well as the water exchanges with open marine environment. During Late Triassic times, the Monte Cefalo and Monte Meta deposits were deposited in a restricted-lagoon-intertidal environment (stromatolitic dolostones and limestones) with subtidal episodes (foraminiferal-algal grain-supported limestones). It is worth noticing the higher frequency of subtidal episodes at Monte Meta, testified by the abundance of the dasycladacean

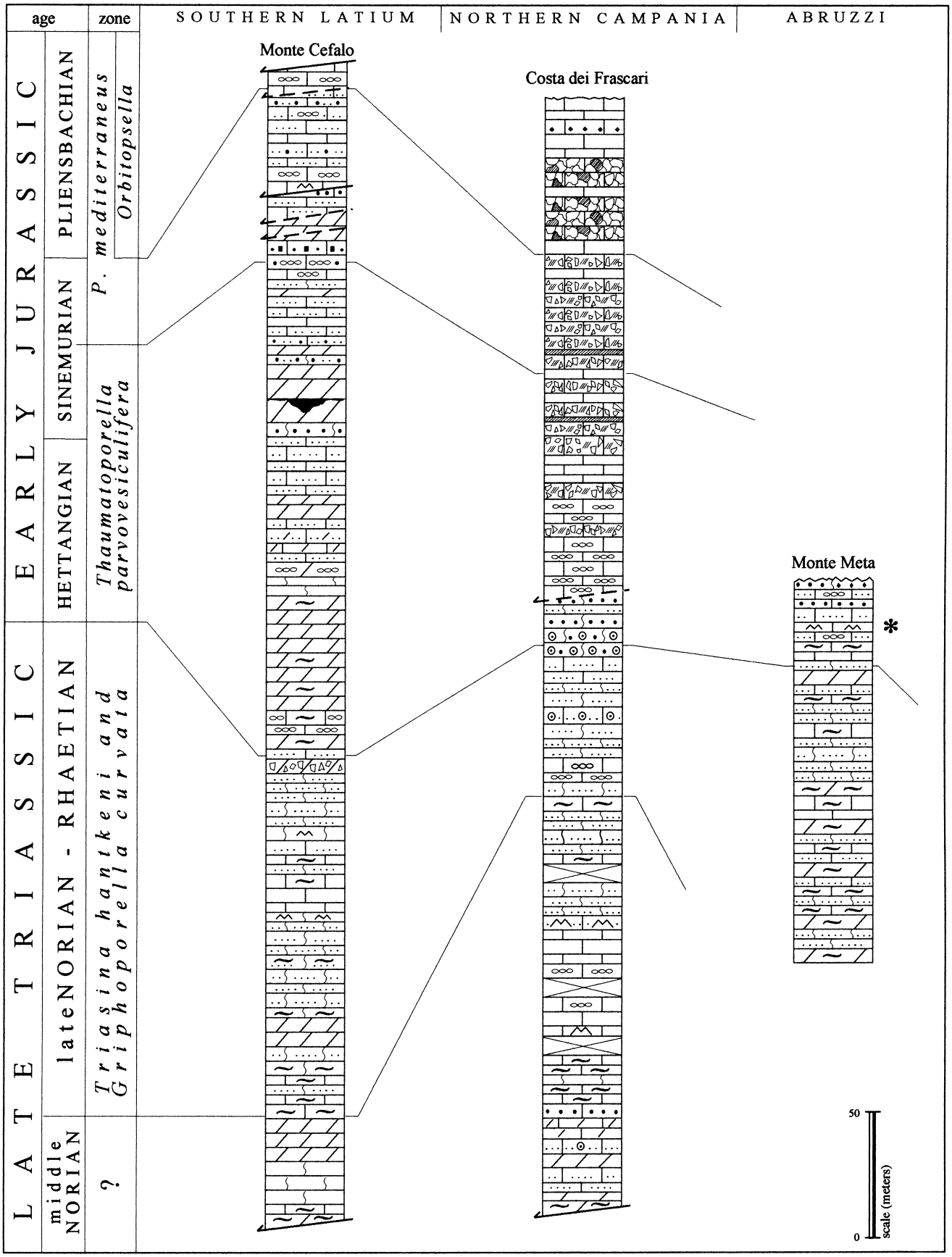

Fig. 5 - Correlation between the study sections (biozones after Chiocchini et al. 1994). Asterisc on the right side of the Monte Meta log refers to the "Calcare Massiccio del Monte Nerone" formation, *Valvulinidae* and *Rivulariaceae* Zone (Chiocchini & Mancinelli 1978).

grain-supported limestones (Barattolo & Bigozzi 1996). By contrast, at Costa dei Frascari the sedimentation, as indeed the microfossil associations were strongly influenced by a rather high water energy; and by a more active water circulation compared with the inner platform. The abundance of organisms such as colonial metazoans, large sized gastropods, Pseudoudoteaceae algae, and echinoderms, which are completely lacking in inner platform facies, suggests the development of an open lagoon environment, always characterized by oxygenated waters, during Norian times; in particular echinoderms are interpreted as indicator of normal marine environment (Pantic & Rampnoux 1972; Berra & Rettori 2001). Such environmental characteristics could be unfavorable for the development of some specimens of foraminifers and dasycladaceans; therefore the reduced thickness of the sediments belonging to the *Triasina hantkeni* and *Griphoporella curvata* Zone at Costa dei Frascari could be linked to the facies control.

During Hettangian-Sinemurian times, at Monte Cefalo laminated dolostones and *Thaumatoporella* algal mat initially suggest a restricted lagoon depositional setting; subsequently (late Sinemurian), the appearance of large sized dasycladales together with new specimens of benthic foraminifers indicate an open lagoon environment. By contrast, at Monte Meta the cyclothemic "Calcare Massiccio del Monte Nerone" formation was deposited and is characterized by subtidal (massive algal grain-supported limestones), intertidal (laminated limestones) and supratidal (red residual sediments and paleosoils) cycles.

At the beginning of Pliensbachian sedimentation continued at Monte Cefalo in an open lagoon, while pelagic sediments of the "Corniola" formation settled at Monte Meta, testifying to different paleogeographic evolution of the two areas during the Pleinsbachian.

A different paleoenvironmental setting occurred at Costa dei Frascari (Matese) in the Lower Jurassic. The deposition of breccias suggests protracted emersion episodes of this area during the Hettangian-lower Sinemurian. Subsequently (Pliensbachian), an open subtidal setting is suggested by the deposition of mud-supported limestones interbedded within the breccias; these limestones, together with the lithoclasts of the breccias, contain benthic foraminifers and large sized dasycladales. These Pliensbachian breccias possibly derived from the erosion of partially consolidated coeval platform deposits; open subtidal limestones are the most likely source of the clasts. Owing to the lack of any pelagic organisms in the scarce matrix, these breccias were more probably deposited at the base of intraplatform morphological scarp, by repeated rock-falls.

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Appendix

Alphabetical list of mentioned taxa.
Foraminiferida:
Aeolisaccus dunningtoni Elliott, 1957
Agathammina austroalpina Kristan-Tollmann & Tollmann, 1964
Agerina martana (Farinacci, 1959)
Amijiella amiji (Henson, 1948)
Ammodiscus multivolutus Reytlinger, 1949
Auloconus permodiscoides (Oberhauser, 1964)
Aulotortus communis (Kristan, 1957)
Aulotortus friedli (Kristan-Tollmann & Tollmann, 1962)
Aulotortus impressus (Kristan-Tollmann, 1964)
Aulotortus ex gr. *sinuosus* Weynschenck, 1956
Aulotortus sinuosus pragsoides (Oberhauser, 1964)
Aulotortus sinuosus sinuosus Weynschenck, 1956
Aulotortus tenuis (Kristan, 1957)
Aulotortus tumidus (Kristan-Tollmann, 1964)
Cymbriaella lorigae Fugagnoli, 1999
Diplotremina cf. *subangulata* Kristan-Tollmann, 1960
Duotaxis birmanica Zaninetti & Bronnimann, 1975
Duotaxis metula Kristan, 1957
Earlandia amplimuralis (Pantic, 1968)
Earlandia tintinniformis (Misik, 1971)
Endotriada cf. *tyrrhenica* Vichard, Martini, Rettori & Zaninetti, 1994
Gandinella falsofriedli (Salaj, Borza & Samuel, 1983)
Glomospirella ex gr. *amplificata* Kristan-Tollmann,
Glomospirella rosetta Ciarapica, Cirilli & Zaninetti, 1978
Involutina farinacciae Bronnimann & Koehn-Zaninetti, 1969
Lituolipora polymorpha Gusic & Velic, 1978
Lituosepta recoarensis Cati, 1959
Nodosaria cf. *ordinata* Trifonova, 1993
Ophthalmidium leischneri (Kristan-Tollmann, 1957)
Orbitopsella praecursor (Guembel, 1872)
Orbitopsella primaeva Henson, 1948
Paleomayncina termieri (Hottinger, 1967)
Pilammina sulawesiana Martini, Vachard & Zaninetti, 1995
Planisepta compressa (Hottinger, 1967)
Siphovalvulina variabilis Septfontaine, 1988
?*Tetrataxis inflata* Kristan, 1957
Triasina hantkeni Majzon, 1955
Triasina oberhauseri Kohen-Zaninetti & Bronnimann, 1968
Trochammina alpina Kristan-Tollmann, 1964
Trochammina espahkensis Bronnimann, Zaninetti, Moshtaghian & Huber, 1974
Trochammina tabasensis Bronnimann, Zaninetti, Moshtaghian & Huber, 1974.

Calcareous Algae:
Asterocalculus heraki Sokac & Grgasovic, 1998
Fanesella anae Sokac, 1988
Garwoodia maxima Dragastan, 1989
Garwoodia toomeji Dragastan, 1989
Griphoporella curvata (Gümbel, 1872)
Gyroporella vesiculifera Gümbel, 1872
Linoporella buseri Radoicic, 1975
Palaeodasycladus mediterraneus (Pia, 1920)
Palaeodasycladus gracilis Cros & Lemoine 1967
?*Petrascula heraki* Nikler & Sokac, 1966
Pseudoudotea magna Dragastan, 1997
Probolocuspis espahkensis Bronnimann, Zaninetti, Moshtaghian & Huber, 1974
Thaumatoporella parvovesiculifera (Raineri, 1922).

Cyanobacteria:
Rivularia piae (Frollo, 1938)