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Radiolarian biostratigraphy in the sedimentary cover of the ophiolites of south-western Tuscany, Central Italy[1]

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Key-words: Radiolaria, biostratigraphy, taxonomy, Jurassic, ophiolites, Monte Alpe Chert, Southern Tuscany

ABSTRACT

The Monte Alpe Chert is the oldest biogenic formation in the sedimentary cover of the ophiolites of the Northern Apennines. Lateral age variations are known at the base of this formation from studies of radiolarian biostratigraphy from Tuscany to Liguria. We examine here the age of the Monte Alpe Chert in several sections comprised in a restricted (20 × 10 km) area in south-western Tuscany.

In these sections, the datings of the lowermost levels of the formation are as follows: late Bathonian-early Callovian to late Oxfordian-early Kimmeridgian (Unitary Association Zone, U.A.Z. 7–10); middle Callovian-early Oxfordian to late Oxfordian-early Kimmeridgian (U.A.Z. 8–10); late Oxfordian-early Kimmeridgian (U.A.Z. 10); middle-late Oxfordian to late Oxfordian-early Kimmeridgian (U.A.Z. 9–10).

The ages of the top of the Monte Alpe Chert have been determined in two sections, where they are, respectively, late Oxfordian-early Kimmeridgian to late Kimmeridgian-early Tithonian (U.A.Z. 10–11) and late Berriasian-earliest Valanginian to late Valanginian (U.A.Z. 15–17). Considering other known sections in Liguria and Central Tuscany, age variations at the base of siliceous deposits become larger with increasing distance. The minimum age difference between the bases of the Monte Alpe Chert in these two areas is the interval between early Oxfordian and late Oxfordian (3 Ma.) and the difference could be considerably larger, up to 15 Ma. These areas are over one hundred kilometres from each other. The datings of the lowest levels of the Monte Alpe Chert set an upper age limit to the extrusion of the underlying basalts, which formed in the latest stages of oceanic spreading. The diachroneity of the terminal phases of spreading thus increases when we broaden our field of observation from small to larger oceanic areas. There are however wide areas in which the late phases of crustal spreading and magmatic activity occurred almost at the same time, and age jumps mainly occur when we pass from one of these areas to the next.

Comparable age differences are found regarding the top of siliceous deposits.

Seven new species of radiolarians have been described: *Archaeodictyomitra etrusca, Archaeodictyomitra labronica, Archaeodictyomitra spelae, Cinguloturris venusta, Eucyrtidiellum bortolottii, Stichocapsa tuscanica, Stichocapsa ulivii.* At Monte Vitalba, the presence of the genus *Vallupus* is reported for the first time in the Northern Apennines.

RIASSUNTO

I Diaspri di Monte Alpe sono la più antica formazione biogenica facente parte della copertura sedimentaria delle ofioliti dell'Appennino Settentrionale. Variazioni laterali dell'età della base di questa formazione sono state messe in evidenza dallo studio della biostratigrafia a radiolari dalla Toscana alla Liguria. Viene qui esaminata l'età dei Diaspri di Monte Alpe in diverse sezioni situate in un'area ristretta (20 × 10 km) nella Toscana sud-occidentale.

In queste sezioni, le datazioni dei livelli basali della formazione sono le seguenti: dal Batoniano superiore-Calloviano inferiore all'Oxfordiano superiore-Kimmeridgiano inferiore (U.A.Z. 7–10); dal Calloviano medio-Oxfordiano inferiore all'Oxfordiano superiore-Kimmeridgiano inferiore (U.A.Z. 8–10); Oxfordiano superiore-Kimmeridgiano inferiore (U.A.Z. 10); dall'Oxfordiano medio-Oxfordiano superiore all'Oxfordiano superiore-Kimmeridgiano inferiore (U.A.Z. 9–10).

L'età del tetto dei Diaspri di Monte Alpe è stata determinata in due sezioni, dove risulta essere compresa, rispettivamente, fra l'Oxfordiano superiore-Kimmeridgiano inferiore ed il Kimmeridgiano superiore-Titoniano inferiore (U.A.Z. 10–11), e fra il Berriasiano superiore-Valanginiano iniziale ed il Valanginiano superiore (U.A.Z. 15–17).

Considerando altre sezioni studiate in Liguria e Toscana Centrale, le variazioni di età alla base dei depositi silicei aumentano all'aumentare della distanza. La differenza minima di età per la base dei Diaspri di Monte Alpe in queste due aree è l'intervallo tra l'Oxfordiano inferiore e l'Oxfordiano superiore (3 Ma.) e la differenza potrebbe essere considerevolmente maggiore, fino a 15 Ma. Queste aree sono ad oltre cento chilometri di distanza l'una dall'altra.

Le datazioni dei livelli basali dei Diapri di Monte Alpe fissano un limite di età superiore per l'estrusione dei sottostanti basalti, che si sono formati durante le fasi terminali dell'espansione oceanica. Il diacronismo delle fasi terminali dell'espansione oceanica pertanto aumenta quando si allarghi il campo di osservazione da un'area piccola ad una più grande. Ci sono comunque ampie aree nelle quali le fasi tardive dell'espansione crostale e dell'attività magmatica si sono verificate quasi contemporaneamente, e salti di età si verificano, di norma, quando si passi da una all'altra di queste aree.

Differenze di età comparabili si ritrovano per il tetto dei depositi silicei.

Sono state descritte sette nuove specie di radiolari: *Archaeodictyomitra etrusca, Archaeodictyomitra labronica, Archaeodictyomitra spelae, Cinguloturris venusta, Eucyrtidiellum bortolottii, Stichocapsa tuscanica Stichocapsa ulivii.*

A Monte Vitalba è stato ritrovato, per la prima volta nell'Appennino Settentrionale, il genere *Vallupus.*

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1. Introduction

Radiolarian chert and siliceous shale on top of the Apennines ophiolites constitute a formation called Monte Alpe Chert. Some siliceous levels are intercalated in underlying basalt flows and ophiolite breccias and are not included in this formation. In recent years, the age of these deposits has been clarified by means of radiolarian biostratigraphy (Baumgartner 1984; Conti et al. 1985, 1988; Picchi 1985; Abbate et al. 1986, 1994a; Conti & Marcucci 1986, 1991, 1992; Nozzoli 1986; Marcucci & Marri 1990; Bortolotti et al. 1991; Chiari 1994a, 1994b; Chiari et al. 1994). The lowest siliceous levels above the ophiolites have been exactly dated in many sections, permitting to set an upper age limit to the igneous and tectonic activity which accompanied the opening of the Tethyan ocean. Significant differences in the age of these levels have been found among different regions of the Northern Apennines (Conti et al. 1985; Abbate et al. 1986, 1994a, 1994b; Conti & Marcucci 1986, 1991; Marcucci et al. 1988; Marcucci & Marri 1990; Chiari et al. 1994).

Radiolarian assemblages have been also used to date the end of siliceous deposition, together with calcareous microfossils from overlying limestones (Picchi 1985; Chiari et al. 1994; Chiari 1994a).

The study presented here analyses the radiolarian biostratigraphy of the siliceous deposits on top of the ophiolites in a limited area of Southern Tuscany and refines our knowledge of their age. The study aims at contributing to a detailed reconstruction of the initiation of siliceous sedimentation and, consequently, of the end of magmatic activity in this part of the Tethys.

Variations or uniformity of the ages of the initial siliceous deposition have been formerly recognized comparing sections scattered over a broad region (210 × 140 kms) including Tuscany and Eastern Liguria. These sections generally lie at distances of some tens to hundreds of kilometres from one another (Abbate et al. 1994a). The sections considered here are seated in a smaller area (20 × 10 kms), and are separated by shorter distances, on the order of few kilometres. The distances originally separating these sections in their sedimentary basin may have changed during tectonic transport, but were likely much shorter than those among the more disperse sections mentioned above. In parallel with the discussion of biostratigraphic and paleogeographic problems, the study gives the description of seven new radiolarian species and six open nomenclature radiolarian taxa.

2. Geological framework

In the Northern Apennines, the ophiolite suite is the remnant of a Jurassic oceanic crust, and is part of the upper tectonic units (Ligurid units or Ligurids) building up this chain. The sedimentary successions in the Ligurid units are believed to have been deposited prevalently on oceanic crust, although ophiolites are clearly recognizable in their primary position only in one of these units, at the base of the Vara Supergroup (references in Abbate et al. 1986). The Ligurid units are now tectonically stacked above units with a continental basement (Tuscan and Umbrian Successions). Regarding the mechanism of opening of this section of the oceanic Tethys basin, several models have been presented: the transform fault, the slow (cold) spreading ridge and the crustal delamination hypotheses (references in Abbate et al. 1994b). The dating of the primary sedimentary cover of ophiolites through radiolarian biostratigraphy sets constraints on acceptable models.

The Northern Apennine ophiolites and the sedimentary formations which constituted their primary cover occur in two different settings (Passerini 1965; Abbate et al. 1970, 1980; Bortolotti 1983): they either represent the basal section of the Vara Supergroup (which constitutes the uppermost Ligurid unit in the studied area) or are included as olistoliths in the Late Cretaceous-early Tertiary flysch sequences of lower Ligurid units.

The ophiolite suite in the Vara Supergroup can be divided into two parts: a lower part (substratum) and an upper part (volcano-sedimentary cover) comprising the Monte Alpe Chert and the underlying siliceous levels (Abbate et al. 1994a). The former includes serpentinized mantle ultramafics, mainly lherzolites and subordinate gabbroic and ultramafic cumulites (see Cortesogno et al. 1978). The latter (volcano-sedimentary cover), from bottom to top, consists of:

1) variously alternating ophiolite breccias (0 to 100 m in thickness) and basalt (0 to 500 m in thickness), with minor siliceous shale or chert intercalations;
2) radiolarian chert (Monte Alpe Chert, 0 to 200 m in thickness);
3) marls and siliceous shales (Nisportino and Murlo Formations, 0 to 200 m in thickness);
4) pelagic limestone (Calpionella Limestone, 0 to 300 m in thickness);
5) formations with more or less abundant terrigenous supply (Palombini Shale and overlying turbiditic units).

The ophiolite breccias are mainly diffuse in eastern Liguria. They rest on serpentinites or gabbros of the substratum and exhibit a complicate interfingering with basalt and radiolarian chert. The breccias have been split into several formations according to their composition: Levanto Breccia, Monte Zenone Breccia, Monte Rossola Breccia and Monte Capra Breccia (Cortesogno et al. 1978).

The Monte Alpe Chert consists of ribbon chert and siliceous shale, generally red in colour, and was deposited as pelagic siliceous ooze and siliceous clay. The earliest fossiliferous deposits on top of the ophiolite suite are, in different sections, the Monte Alpe Chert or siliceous sediments intercalated with the basalts and breccias lying underneath. Radiolarian assemblages have been extracted from both. The age of the Monte Alpe Chert (Fig. 4), based on radiolarian assemblages, is middle Bathonian-early Oxfordian (Liguria), or early Oxfordian-early Berriasian (Tuscany) at the base of the formation, and late Tithonian-late Berriasian at its top (data from Conti & Marcucci 1986; Abbate et al. 1986; Conti et al. 1988; Marcucci & Marri 1990; Conti & Marcucci 1991, 1992; Chiari et al. 1994; Chiari 1994a, 1994b, revised according to the zonation presented by Baumgartner et al. 1995). Similar ages have been given by radiolarian assemblages in siliceous intercalations (Abbate et al. 1986; Nozzoli 1986; Marcucci et al. 1994). All these datings set an upper age limit to the extrusion of the basalt underlying the Monte Alpe Chert and breccias. Slightly older ages determined in siliceous intercalations in basalts permit to date the terminal basalt flows. The Nisportino Formation and the Murlo Marls are very discontinuous units consisting of siliceous shales and marls respectively. Their age is early to late Berriasian (Bortolotti et al. 1994; Gardin & Perilli 1995; Aiello et al. 1995). The Calpionella Limestone above the Monte Alpe Chert is a pelagic micritic limestone, deposited from the Berriasian to Valanginian (Andri & Fanucci 1973, 1975; Conti et al. 1985; Bortolotti et al. 1991b; Conti & Marcucci 1991; Cobianchi & Villa 1992; Bortolotti et al. 1994; Chiari et al. 1994; Chiari 1994a). The overlying Palombini Shale consists of gray shale with micritic limestone and turbiditic quartz-arenites. Its age is Neocomian to Albian and could reach the late Tithonian (Abbate 1969; Abbate & Sagri 1970; Andri & Fanucci 1973; Cobianchi & Villa 1992).

The radiolarian deposits considered in this study are part of the volcano-sedimentary cover of the ophiolite suite of the Vara Supergroup. They belong to the Monte Alpe Chert or, in some cases, to intercalations in basalts and breccias. In the study area, only two breccia formations are present: Levanto Breccia (serpentinite breccia with carbonate cement, Cortesogno et al. 1978) lying on top of serpentinized mantle ultramafics, and Monte Zenone Breccia (Mg-gabbro breccia) (Principi 1973; Gianelli & Principi 1974; Cortesogno et al. 1978). Basalts are present in all but one (Le Debbiare) of the examined sections.

3. Methods

Radiolarians have been extracted from chert using differential HF attack, according to the method introduced by Dumitrica (1970), Pessagno & Newport (1972), De Wever (1982), Schaaf (1985).

In this work, we adopt the radiolarian biozonation of Baumgartner et al. (1995).

4. Section descriptions

The examined sections, from north to south, are (see map, Fig. 1): Castel Sonnino, Quercianella, Le Debbiare, Monte Vitalba, Il Terriccio and L'Aiola.

Sample positions and section lithologies are shown in Figures 2–3.

Most typical forms are indicated for each sample. For the complete faunal assemblage see the occurrence charts (Tab. 1a–f, at the end of the paper).

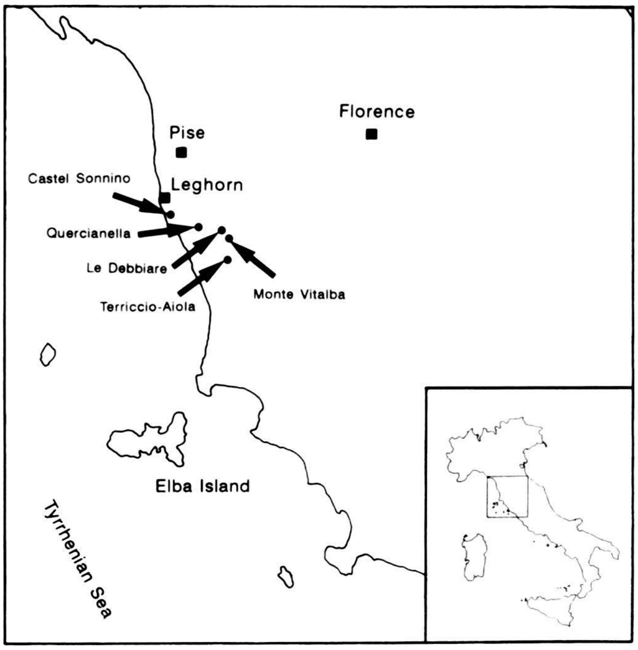

Fig. 1. Map of Tuscany and location of the studied localities.

Castel Sonnino section

Close to Via Aurelia (Aurelia Road) between Leghorn and Quercianella, about thirty metres below Castel Sonnino the Monte Alpe Chert is exposed near the seashore at the stratigraphic top of Monte Zenone Breccia (Fig. 2). The succession is overturned. The Palombini Shale is visible a few tens of metres from this outcrop and according to Principi & Treves (1992) it lies on top of the Monte Alpe Chert.

The stratigraphic succession, from bottom to top, comprises:

1) Monte Zenone Breccia;
2) 40 cm of fine-grained breccia with basalt clasts;
3) Monte Alpe Chert:
   - 35 cm of red siliceous shale and greenish siltstone;
   - 75 cm of red chert alternating with red siliceous shale;
   - 280 cm of red chert.

Samples and most typical forms, from the base of the Monte Alpe Chert upward, are:

Sample CS 2: *Mirifusus dianae s.l.* (Karrer), *Pantanellium riedeli* (Pessagno) and *Paronaella bandyi* Pessagno. U.A.Z. 7–10.

Sample CS 3: poorly preserved fauna. Age not determined.

Sample CS 5B: *Eucyrtidiellum ptyctum* (Riedel & Sanfilippo). U.A.Z. 5–11.

Sample CS 4: poorly preserved fauna. Age not determined.

Sample CS 6B: *Acanthocircus suboblongus* s.l. (Yao), *Archaeodictyomitra apiarium* (Rüst), *Haliodictya* (?) *antiqua anti-*

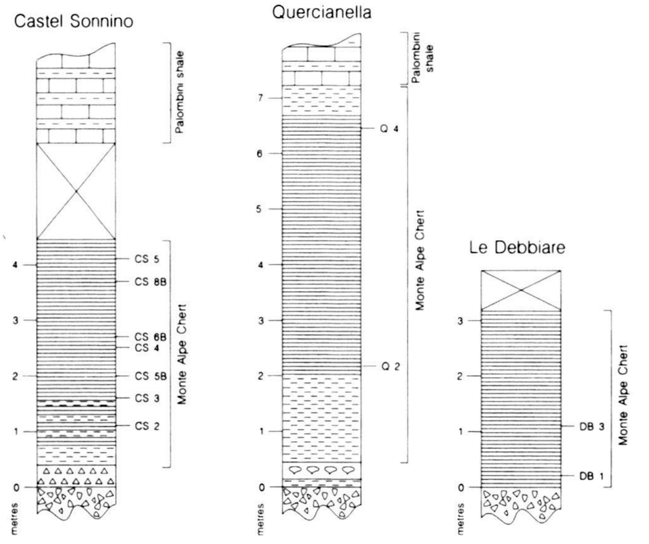

Fig. 2. Sample positions and lithological logs (Castel Sonnino, Quercianella and Le Debbiare localities).

qua (Rüst) sensu Pessagno and *Transhsuum brevicostatum* group (Ozvoldova). U.A.Z. 8–11.

Sample CS 8B: *Tritrabs casmaliaensis* (Pessagno). U.A.Z. 4–10.

Sample CS 5: *Acanthocircus trizonalis* s.l. (Rüst) and *Tritrabs casmaliaensis* (Pessagno). U.A.Z. 6–10.

Considering both the assemblages and the stratigraphic position of the samples, their age ranges can be defined as follows:

CS 2 and CS 5B – late Bathonian-early Callovian to late Oxfordian-early Kimmeridgian, U.A.Z. 7–10.

CS 6B, CS 8B and CS 5 – middle Callovian-early Oxfordian to late Oxfordian-early Kimmeridgian, U.A.Z. 8–10.

Quercianella section

Along Via Aurelia (Aurelia Road), between Leghorn and Quercianella, 200 metres north of Quercianella, a road cut shows the Monte Zenone breccia, stratigraphically overlain, from bottom to top, by the following levels and formations (Fig. 2):

1) 10 cm of siliceous shale;
2) 30 cm of pillow basalt;
3) Monte Alpe Chert:
   - 1.6 m of red siliceous shale;
   - 4.7 m of red chert;
   - 50 cm of red siliceous shale.
4) Palombini Shale
   - gray and greenish shale and limestone.

A stratigraphic gap may separate the Monte Alpe Chert from the Palombini Shale, since the Calpionella Limestone is missing. See chapter 6 for a detailed discussion.

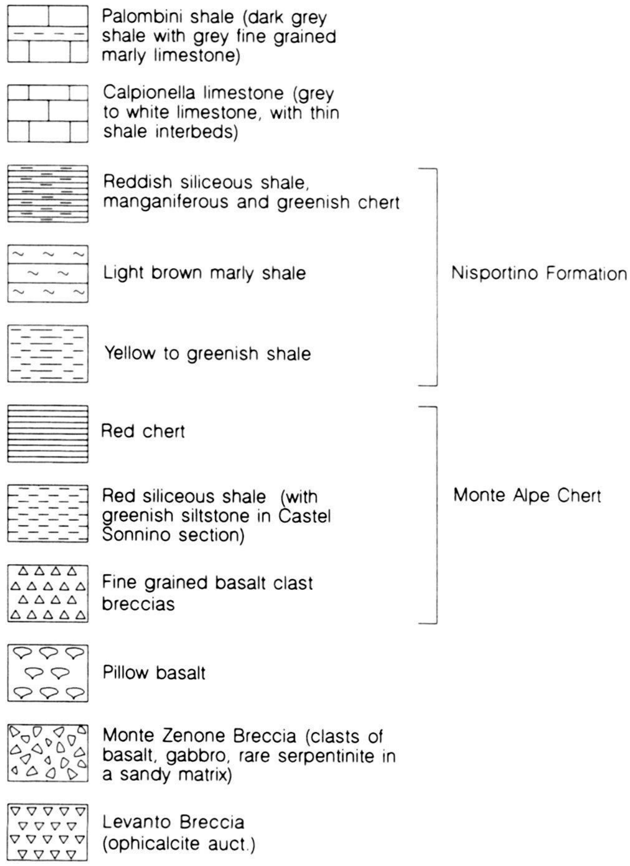

Fig. 2a. Legend to Fig. 2 and 3

The samples and the most typical forms, from the base of the Monte Alpe Chert upward, are:

Sample Q 2: *Emiluvia orea orea* Baumgartner, *Paronaella broennimanni* Pessagno, *Tritrabs casmaliaensis* (Pessagno) and *Tritrabs hayi* (Pessagno). Middle Callovian-early Oxfordian to late Oxfordian-early Kimmeridgian, U.A.Z. 8–10.

Sample Q 4: *Acanthocircus suboblongus suboblongus* (Yao), *Emiluvia orea orea* Baumgartner, *Emiluvia orea ultima* Baumgartner & Dumitrica, *Sethocapsa* (?) *sphaerica* (Ozvoldova) and *Triactoma blakei* (Pessagno). Late Oxfordian-early Kimmeridgian to late Kimmeridgian-early Tithonian, U.A.Z. 10–11.

Le Debbiare section

About 6 km west of the Riparbella village (Leghorn), along a country road, near Case Le Debbiare, the Monte Alpe Chert appears in a succession similar to that described at Castel Sonnino, although not overturned.

The stratigraphic succession, from bottom to top, comprises (Fig. 2):

1) Monte Zenone Breccia;
2) Monte Alpe Chert:
   - 3.1 m of red radiolarian chert.

The samples and the most typical forms, from the base of the Monte Alpe Chert upward, are:

Sample DB 1: *Emiluvia orea ultima* Baumgartner & Dumitrica, *Podobursa helvetica* (Rüst). Late Oxfordian-early Kimmeridgian, U.A.Z. 10.

Sample DB 3: *Acanthocircus suboblongus minor* Baumgartner, *Podocapsa amphitreptera* Foreman, *Sethocapsa* (?) *sphaerica* (Ozvoldova), *Triactoma blakei* (Pessagno) and *Zhamoidellum ventricosum* Dumitrica. Middle-late Oxfordian to late Kimmeridgian-early Tithonian, U.A.Z. 9–11.

The assemblage of sample DB 3 is typical of U.A.Z. 9–11, but its stratigraphic position restricts its age to U.A.Z. 10–11.

Monte Vitalba section

A stratigraphic succession of ophiolite breccias and radiolarian cherts is exposed on the western slope of Monte Vitalba, 4 kilometres east of Castellina Marittima, along the country road going from this locality to the top of Monte Vitalba (Fig. 3). This succession comprises, from bottom to top:

1) Monte Zenone Breccia;
2) Monte Alpe Chert:
   - 15 cm of red, thin bedded radiolarian chert alternating with siliceous shale;
   - 7.9 m of red chert;
3) Nisportino Formation:
   - 2.2 m of yellow to greenish shale;
   - 4 m of light brown marly shale;
   - 1 m of reddish siliceous shale, manganiferous and greenish chert.

The samples and their most typical forms, from the base of the Monte Alp Chert upward, are:

Sample MV 2: *Podocapsa amphitreptera* Foreman. U.A.Z. 9–18.

Sample MV 3: *Acanthocircus trizonalis dicranacanthos* (Squinabol) emended Foreman, *Angulobracchia biordinalis* Ozvoldova, *Emiluvia ordinaria* Ozvoldova, *Pseudoeucyrtis reticularis* Matsuoka & Yao. U.A.Z. 10–11.

Sample MV 4: *Podocapsa amphitreptera* Foreman. U.A.Z. 9–18.

Sample MV 5: *Paronaella broennimanni* Pessagno, *Podocapsa amphitreptera* Foreman and *Zhamoidellum ovum* Dumitrica. U.A.Z. 9–10.

Sample MV 6: poorly preserved fauna. Age not determined.

Sample MV 9: *Acanthocircus trizonalis dicranacanthos* (Squinabol) emended Foreman and *Thanarla pulchra* (Squinabol). U.A.Z. 15–17.

Sample MV 10: *Acanthocircus trizonalis dicranacanthos* (Squinabol) emended Foreman. U.A.Z. 10–17.

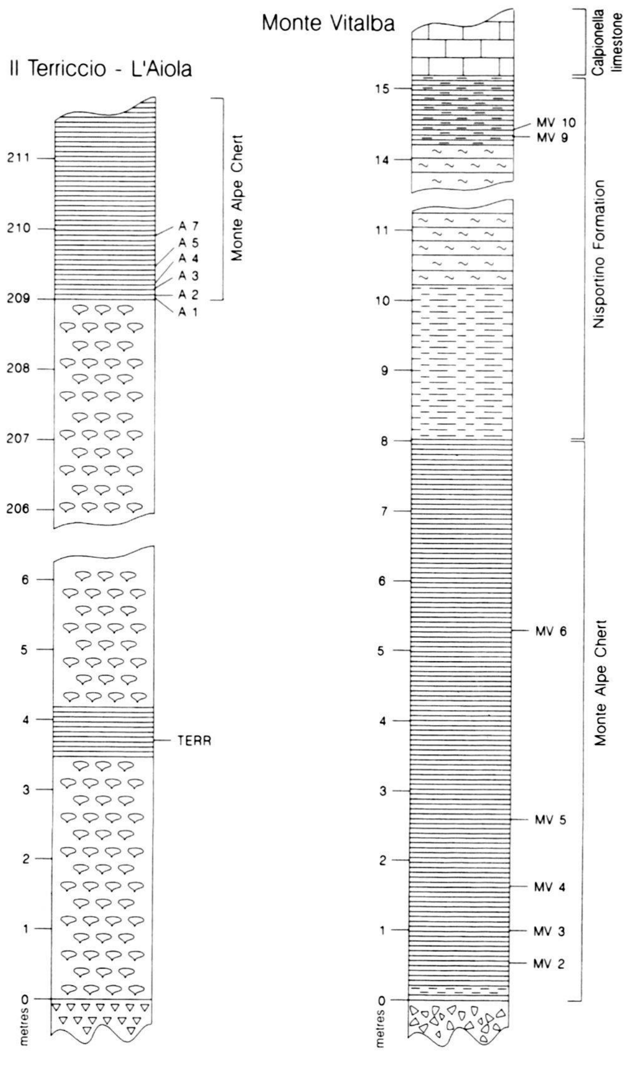

Fig. 3. Sample positions and lithological logs (Terriccio, L'Aiola and Monte Vitalba localities). Legend see Fig. 2a.

Considering both the assemblages and the stratigraphic position of the samples, their age ranges can be defined as follows:

MV 2 – middle-late Oxfordian to late Oxfordian-early Kimmeridgian, U.A.Z. 9–10.

MV 3, MV 4 and MV 5 – late Oxfordian-early Kimmeridgian, U.A.Z. 10.

MV 9 and MV 10 – late Berriasian-earliest Valanginian to late Valanginian, U.A.Z. 15–17.

Since sample MV 3 was collected only 50 cm above sample MV 2, the age of the base of Monte Alpe Chert at Monte Vitalba is, most probably, corresponding to late Oxfordian-early Kimmeridgian (U.A.Z. 10) (see also chapter 5).

Il Terriccio and L'Aiola section

Two localities (indicated here as Il Terriccio, Locality A, and L'Aiola, Locality B) near the farm Il Terriccio, about 3 kilometres SW of Castellina Marittima, show outcrops of radiolarian chert in two distinct stratigraphic positions: in the former locality a chert level is intercalated within the basalt near its base, in the latter the Monte Alpe Chert lies on top of pillow basalt.

Locality A (Il Terriccio) is approximately 200 m east of the farm "Il Terriccio" in an inactive quarry (Fig. 3).

Locality B (L'Aiola) is about 3 km east of the farm "Il Terriccio".

A composite section has been drawn from locality A to locality B, which are separated by a wide area covered by pillow basalts.

The section includes, from bottom to top (Fig. 3):

1) Levanto Breccia;
2) 3.5 m of pillow basalt;
3) a 60 cm thick radiolarian chert level, intercalated between the basalt flows;
4) about 200 m of pillow basalt;
5) Monte Alpe Chert:
   - 8 m of red radiolarian chert.

The succession has been reconstructed in detail in localities A and B: units 1), 2) and 3) are in locality A, unit 5) is in locality B. The thickness of unit 4 (thick pillow basalt) has been estimated along discontinuous outcrops between these localities (Nozzoli 1986).

The upper part of this section (L'Aiola, locality B) is now covered by construction of new trails.

The sample marked Il Terriccio was taken from the radiolarian chert level intercalated in the basalt (unit 3), those marked as l'Aiola from the Monte Alpe Chert (unit 5).

The most typical forms contained in the sample collected at locality A (Il Terriccio) are:

Sample TERR: *Archaeodictyomitra apiarium* (Rüst), *Eucyrtidiellum unumaense pustulatum* Baumgartner, *Zhamoidellum ovum* Dumitrica and *Zhamoidellum ventricosum* Dumitrica. Middle Callovian-early Oxfordian to middle-late Oxfordian, U.A.Z. 8–9.

A latest Oxfordian-early Kimmeridgian (U.A. 7–8, according to Baumgartner, 1984) age had been previously obtained for this level by Nozzoli (1986).

The samples and their most typical forms at locality B (L'Aiola), from the base of the Monte Alpe Chert upward, are listed below. The complete assemblages are listed in the occurrence chart (Tab. 1f):

Sample A 1: *Podocapsa amphitreptera* Foreman and *Tritrabs casmaliaensis* (Pessagno). U.A.Z. 9–10.

Sample A 2: *Acanthocircus trizonalis dicranacanthos* (Squinabol) emended Foreman, *Obesocapsula cetia* (Foreman) and *Emiluvia sedecimporata* (Rüst). U.A.Z. 10–11.

Sample A 3: *Podocapsa amphitreptera* Foreman. U.A.Z. 9–18.

Sample A 4: *Acanthocircus trizonalis dicranacanthos* (Squinabol) emended Foreman. U.A.Z. 10–17.

Sample A 5: poorly preserved fauna. Age not determined.

Sample A 7: poorly preserved fauna. Age not determined.

Considering both the assemblages and the stratigraphic position of the samples, their age ranges can be defined as follows:

A 1 – middle-late Oxfordian to late Oxfordian-early Kimmeridgian, U.A.Z. 9–10.

A 2 – late Oxfordian-early Kimmeridgian to late Kimmeridgian-early Tithonian, U.A.Z. 10–11.

A 3 and A 4 – late Oxfordian-early Kimmeridgian to late Valanginian, U.A.Z. 10–17.

Since sample A 2 was collected only few cms above sample A 1, the age of the base of Monte Alpe Chert at L'Aiola is, most probably, late Oxfordian-early Kimmeridgian (U.A.Z. 10). This is the age we use for the definition of the age groups in the chapter 6 "Discussion and conclusions".

Sample A 1 sets an upper age limit for the basalt extrusions at middle-late Oxfordian to late Oxfordian-early Kimmeridgian.

Sample TERR gives a middle Callovian-early Oxfordian to middle-late Oxfordian lower limit for the age of the 200 m thick basalt flows between localities A and B. According to the time scale by Odin (1994) the basalt extrusions may have lasted from a minimum of 5 Ma. (middle-late Oxfordian) to a maximum of 13 Ma. (middle Callovian to early Kimmeridgian).

5. Biostratigraphic correlation

Some species which occur in our samples are not included in the adopted zonation (Baumgartner et al. 1995) and a brief discussion about their age significance is therefore needed.

Vallupus hopsoni Pessagno & Blome is used by Pessagno et al. (1987) and by Yang & Pessagno (1989) as a keymarker for their Subzone 4β "upper Tithonian". The base of this Subzone is correlated by Matsuoka (1995, Fig. 3) and by Baumgartner et al. (1995, pages 1036 and 1040) and falls within U.A.Z. 11 (late Kimmeridgian to early Tithonian). Kito et al. (1990) report this species from a sample (Contrada La Ferta section, Sicily) which they date as late Tithonian.

The first occurrence of *V. hopsoni* Pessagno & Blome, according to Matsuoka (1992), is ascribable to the basal part of Zone C2 (Baumgartner 1984, 1987), which is correlated (Baumgartner et al. 1995) to U.A.Z. 11 (late Kimmeridgian to early Tithonian). This species occurs, in our material, in samples (MV 3 and MV 5) which are otherwise dated as U.A.Z. 10. This implies either that the two above mentioned samples could be slightly younger than U.A.Z. 10, or that the first occurrence of *V. hopsoni* Pessagno & Blome must be shifted downwards to the base of U.A.Z. 10 (late Oxfordian to early Kimmeridgian).

The presence of other species supports the first alternative. These species are:

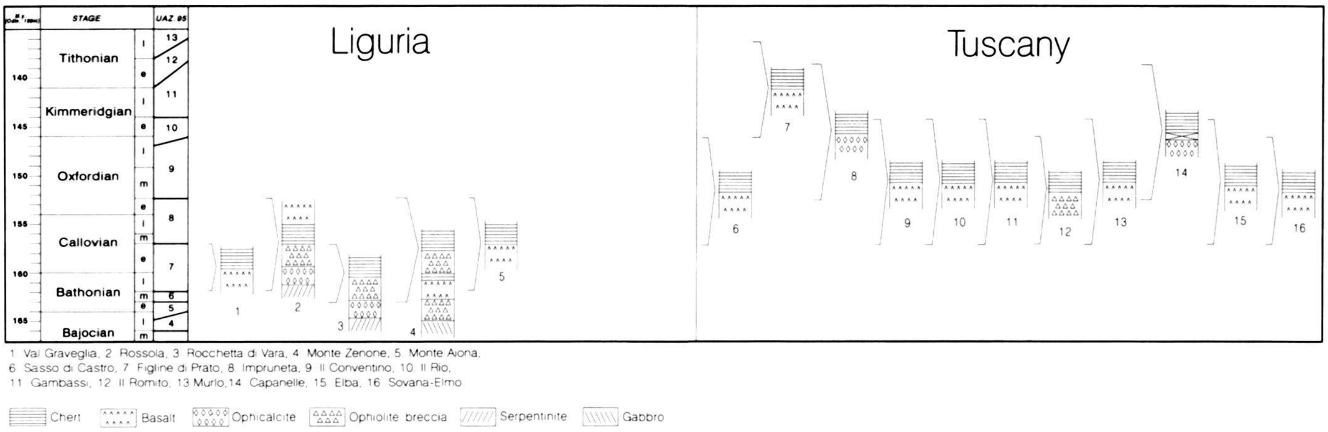

Fig. 4. Age determinations at the base of Monte Alpe Chert and in a chert level below the basalt in Liguria and Tuscany (modified from Chiari et al., 1994). Time scale after Odin, 1994. Radiolarian biozones (UAZ 95) 4–13 after Baumgartner et al. 1995.

Mesovallupus guadalupensis Pessagno & McLeod (MV3, MV5), reported from the middle part of their Subzone 4β "upper Tithonian" by Pessagno et al. (1987).

Pantanellium oligoporum (Vinassa), as *Sphaerostylus oligoporus,* (our sample MV 5) and *Vallupus* sp. cf. *V. laxus* Yang & Pessagno in Matsuoka (1995) (our sample MV 3), reported by Matsuoka (1992, 1995) from his *Pseudodictyomitra primitiva* Zone, which he correlates to C1 and C2 zones of Baumgartner (1984, 1987).

Both ranges are correlative to U.A.Z. 11 (late Kimmeridgian to early Tithonian, Baumgartner et al. 1995).

Saitoum dercourti Widz & De Wever (MV 5), reported (Widz & De Wever 1993) from U.A. 9 (latest Kimmeridgian; Baumgartner 1984, 1987) and from U.A. 26–33 (late Kimmeridgian to earliest Berriasian; Gorican 1994).

Kawabata (1988) reports both *Pantanellium oligoporum* (Vinassa), as *Sphaerostylus lanceola* (Parona), and *Vallupus hopsoni* Pessagno & Blome from his samples Ko-3 and Ko-10, which he dates at latest Tithonian to Berriasian (up to possibly Valanginian).

Taking into consideration all the exposed data, we are inclined to attribute to samples MV 3 and MV 5 an age which corresponds to U.A.Z. 10–11? (late Oxfordian-early Kimmeridgian to, possibly, late Kimmeridgian).

A single specimen of *Angulobracchia trifolia* Steiger has been found in sample MV 3. Steiger (1992) describes this species and reports an early Tithonian to late Berriasian age range for its occurrence. Since this species has not been subsequently used for biostratigraphy by other authors, its range could well be extended down to late Oxfordian-early Kimmeridgian and thus be coherent with our dating of sample MV 3.

The *Vallupus* genus is reported for the first time from the Northern Apennines. The first finding of *Vallupus* in Italy (Kito et al. 1990) is from a continental margin succession at Contrada La Ferta, Galati, Sicily.

The *Vallupus* group (sensu Matsuoka 1995) has, according to this author, an important paleobiogeographical meaning, being representative of subtropical latitudes (inside a 25 degrees latitude belt from the paleo-equator) and water temperatures in excess of 25 °C.

The ranges reported in literature for *Archaeospongoprunum imlayi* Pessagno (present in our samples CS 2, Q 4), *Podobursa triacantha* (Fischli) (CS 6B) and *Parahsuum parvum* Takemura (TERR) are broader than the ages determined for the samples they occur in. These species therefore do not influence our dating of the samples.

6. Discussion and conclusions

The results of radiolarian biostratigraphy in the Monte Alpe Chert south of Leghorn have bearings on the reconstruction of the sedimentary and geodynamic evolution of the Liguride basin. We shall briefly examine the following items:

a) the different ages of the base of the Monte Alpe Chert;
b) the ages of the top of this formation;
c) the pattern of the lateral variations of the ages of the initial siliceous deposition.

a) Regarding the first point (age of the base of the Monte Alpe Chert) the present work refines and completes the earlier data of Picchi (1985), Nozzoli (1986) and Chiari et al. (1994) and updates them in the light of the new radiolarian biostratigraphic scale of Baumgartner et al. (1995).

The deposition of Monte Alpe Chert above the ophiolites of the Northern Apennines began in different times. In the basal levels of the Monte Alpe Chert, we recognize two age groups (Fig. 4, 5): an "older" group (group A) and a "younger" group

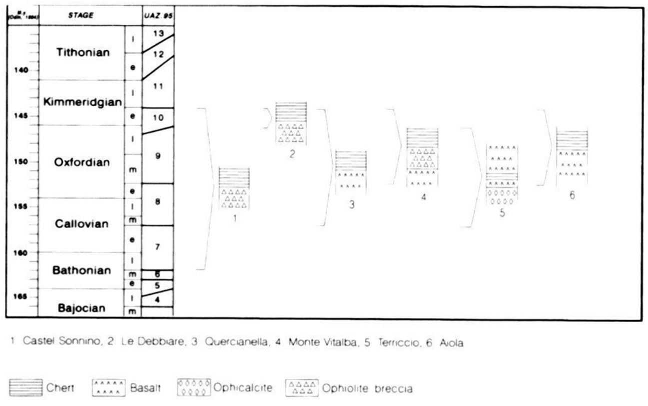

Fig. 5. Age determinations in the examined sections at the base of Monte Alpe Chert and in a chert level intercalated in the basalt. Time scale after Odin, 1994. Radiolarian biozones (UAZ 95) 4–13 after Baumgartner et al. 1995.

(group B). Group A includes the sections Val Graveglia, Mt. Aiona, Mt. Zenone, Rocchetta di Vara, having a late Bathonian–early Oxfordian age (U.A.Z. 7–8 and older). Group B, includes subgroups B1 and B2. Subgroup B1 includes the sections Le Debbiare and Figline di Prato, having a late Oxfordian-early Kimmeridgian (U.A.Z. 10) and a late Oxfordian-Kimmeridgian to early Tithonian age (U.A.Z. 10–12) respectively, and the sections Mt. Vitalba and L'Aiola, most likely having a late Oxfordian-early Kimmeridgian age (U.A.Z. 10) (see chapter 4 and chapter 5). Subgroup B2 includes all the other sections, having an age range centered on the Oxfordian yet marginally extending towards the Callovian and/or Kimmeridgian (U.A.Z. 8–10). The sections of group A are found in the ophiolite complexes of Liguria, whereas those of group B refer to Tuscany. The overlapping between ages of subgroup B2 and those of the other two groups, shown in Figure 4 and Figure 5, is due to dating uncertainties and to the fact that our samples have been dated by a comparison of their faunal content with a zonation (Baumgartner et al. 1995) that is valid only on a global scale. This causes an artificial extension of the ranges of the taxa. This problem could be solved by the elaboration of a local biostratigraphic scheme.

The data presented in this paper concern a limited area in Southern Tuscany and the age of the basal levels of the Monte Alpe Chert can be summarized as follows (Fig. 5):

Castel Sonnino: U.A.Z. 7–10, late Bathonian-early Callovian to late Oxfordian-early Kimmeridgian, Subgroup B2; Quercianella: U.A.Z. 8–10, middle Callovian-early Oxfordian to late Oxfordian-early Kimmeridgian, Subgroup B2; Le Debbiare: U.A.Z. 10, late Oxfordian-early Kimmeridgian, Subgroup B1; L'Aiola: U.A.Z. 9–10, middle-late Oxfordian to late Oxfordian-early Kimmeridgian, Subgroup B1; Monte Vitalba: U.A.Z. 9–10, middle-late Oxfordian to late Oxfordian-early Kimmeridgian, Subgroup B1. According to Picchi (1985), the assemblage at the base of the Monte Alpe Chert at Monte Vitalba corresponds to U.A. 8–9 (late Oxfordian-early Tithonian). Our data permit a more precise age assignment.

At the locality Il Terriccio, a sample collected from a chert layer intercalated in pillow lavas, and therefore not included in the Monte Alpe Chert, has been dated as U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian), and its age corresponds to subgroup B2.

It should be noted that in the Monte Alpe Chert of Southern Tuscany, radiolarian assemblages older than middle Callovian-early Oxfordian are not known (Baumgartner 1984; Conti & Marcucci 1986; Marcucci & Marri 1990) and the groups A and B remain sharply distinct.

b) The top of the Monte Alpe Chert is currently attributed to late Tithonian-early Berriasian (ref. in Conti et al. 1985; Chiari 1994a). The overlying formation may be the Calpionella Limestone, late Tithonian to Valanginian (Andri & Fanucci 1973, 1975; Conti et al. 1985; Bortolotti et al. 1991b; Conti & Marcucci 1991; Cobianchi & Villa 1992; Bortolotti et al. 1994; Chiari et al. 1994; Chiari 1994a), or the Palombini Shale, Neocomian to Albian, possibly down to late Tithonian (Abbate 1969; Abbate & Sagri 1970; Andri & Fanucci 1973; Cobianchi & Villa 1992). This implies either a gap between the Palombini Shale and the Monte Alpe Chert, or a lateral transition between the Calpionella Limestone and the Palombini Shale (Abbate 1969).

At Quercianella, the youngest ages determined by radiolarian biostratigraphy in the upper part of the Monte Alpe Chert (70 cms below the Palombini Shales) are late Oxfordian-early Kimmeridgian to late Kimmeridgian-early Tithonian (Fig. 2, Quercianella section). Here, the Palombini Shale stratigraphically overlies the Monte Alpe Chert (Principi & Treves 1992). At Monte Vitalba, Picchi (1985) used both radiolarian and nannofossil biostratigraphy to date the topmost part of siliceous deposits, that he completely included in the Monte Alpe Chert. The uppermost siliceous levels are now classified as Nisportino Formation (Bortolotti et al. 1994; Gardin & Perilli 1995). The radiolarian assemblage described by Picchi at the top of siliceous deposits indicates a latest Tithonian-early Hauterivian age (U.A. 11–14, Baumgartner 1984), whereas the nannofossil assemblage indicates a late Berriasian age. Radiolarian biostratigraphy (this work) revises these earlier data and gives a late Berriasian-earliest Valanginian to late Valanginian age to the topmost part of Nisportino Formation (80 cm below the Calpionella Limestone, see Fig. 3, Monte Vitalba section). This dating can be restricted to the late Berriasian by means of nannofossil biostratigraphy in the Calpionella Limestone which stratigraphically overlies the Nisportino Formation. It has been dated as late Berriasian by Picchi (1985) and Gardin & Perilli (1995).

The biostratigraphic study of radiolarians at the top of siliceous sediments, although limited to a few sections, shows important age differences. The age variations are of the same order as those recognized at the base of siliceous deposits, and occur over even more limited distances.

In previous studies (Conti et al. 1985; De Wever et al. 1986) it was not possible to recognize, for the end of chert deposition in the ophiolite sequences of the Apennines, age differences which exceed the margins of error of datings. Regarding the overlying carbonate formations, the biostratigraphic data about the top of siliceous deposits lead to two hypotheses:

1) The base of the Palombini Shale has a late Hauterivian age (Abbate & Sagri 1970). At Quercianella a stratigraphic gap covering the latest Oxfordian-early Tithonian to late Hauterivian exists between the top of the Monte Alpe Chert and the base of the Palombini Shale (Lazzarotto & Mazzanti 1964, assume a Cenomanian to Turonian gap at the base of the Palombini Shale). At Monte Vitalba this gap is not present, since calpionellid and nannofossil datings (Picchi 1985; Gardin & Perilli 1995) from the basal levels of the Calpionella Limestone give a late Berriasian age.
2) The Palombini Shale is heteropic with the Calpionella Limestone and the upper part of the Monte Alpe Chert. In this case, the Palombini Shale would reach the late Jurassic (Abbate & Sagri 1970). Abbate (1969) gives a Tithonian to Aptian-Albian age to this formation, possibly down to the Kimmeridgian. At any rate, the new data permit to disprove the scheme according to which the siliceous deposition in the Apenninic sequences terminated with a single, basin-wide event.

c) As to the pattern of lateral age variations of the base of the Monte Alpe Chert, radiolarian assemblages at the base of the Monte Alpe Chert examined in a restricted area are not similar for a majority of the sections. In fact, the forms found in the assemblages of some sections reach down to the late Bathonian-early Callovian, whereas in other sections the forms are limited to late Oxfordian-early Kimmeridgian. These differences in assemblages and age concern sections which are at distances of the order of few kilometres from each other.

In the broader context of Southern Tuscany radiolarian assemblages at the base of the Monte Alpe Chert have been examined in eleven sections, and group B ages have been found for all of them. Within Southern Tuscany (Chiari et al. 1994, and this paper), the age variability does not increase when we extend the biostratigraphical analysis from the few kilometres wide area of this study to a much larger (over 100 km) region.

Larger age variations are found among some sections which are over one hundred of kilometres apart. Between Eastern Liguria and the area of Florence in Northern Tuscany (Figline di Prato), at a 130–150 km distance, the minimum age difference is the interval between early Oxfordian (Liguria) and late Oxfordian (Figline di Prato), above 3 millions of years (time scale by Odin 1994), and the difference could be considerably larger, up to 15 million years. Differences in age have already been recognized over short distances in the Northern Apennines for the basal levels of the Tuscan Chert, another radiolarian-bearing siliceous formation deposited over continental crust. In two sections at Monte Mosca and at Monte Pratofiorito (Lucca) a middle Callovian-early Oxfordian and a middle Bathonian to late Bathonian-early Callovian age have been determined, respectively (Cortese oral. comm.).

A purpose of this and other related papers (references in Chiari et al. 1994) is to scan the record of different final phases of oceanic crustal spreading in the section of the Tethys corresponding to the Northern Apennines ophiolites, by comparing biostratigraphic data over various distances. The data of radiolarian biostratigraphy about the age of the base of Monte Alpe Chert do not yet permit to opt for one of the proposed models of oceanic spreading, but suggest that any model should account for the diachroneity of the terminal phases of spreading which may increase, or remain unchanged, when we broaden our field of observation from small to larger oceanic areas. The model should moreover account for the occurrence of wide areas in which the late phases of crustal spreading and magmatic activity occurred almost at the same time, and age jumps which are mainly present when we pass from one of these areas to the next.

7. Taxonomic notes

Phylum *Protozoa*
Subphylum *Sarcodina*
Class *Actinopoda* Calkins
Subclass *Radiolaria* Müller 1858
Order *Polycystida* Ehrenberg 1838 emend. Riedel 1967
Sub-Orders *Spumellariina* and *Nassellariina* Ehrenberg 1875

Genus *Archaeodictyomitra* Pessagno
Archaeodictyomitra Pessagno 1976, p. 49, emend. Pessagno 1977b, p. 41.
Type species: Archaeodictyomitra squinaboli Pessagno 1976.

Archaeodictyomitra etrusca n. sp. Chiari, Cortese & Marcucci
Plate 1, Figures 9 (Holotype) and 10

Archaeodictyomitra labronica Cortese 1995a, p. 88, Plate 17, Figure 5.

Description – The proximal part of the test is bell-shaped, the central and distal part are cylindrical. The last segment is cylindrical, narrower and shorter than last but one segment. The test comprises 9–10 post-abdominal segments, each bearing two transverse pore rows, with a slightly irregular trend. One of these rows is located at the proximal end of each segment, and the other is at the distal end. Pores are rounded. At intersegmental divisions costae are scarcely prominent, and form transverse belts. On side view no restrictions are apparent between the segments, with the exception of the last three segments. The transverse pore row situated on the last segment has a more straight trend when compared to the rows present on all other segments.

Remarks – This species differs from *Archaeodictyomitra apiarium* (Rüst) in having a longer and slender test and 12–13 segments instead of 8–10. It differs from *A. labronica* n. sp. in having only 13 costae, which are more continuous, for the slim general test shape, a higher number of segments (12–13 instead of 9–10), a cylindrical last segment, two ondulating pore rows per segment and slightly thicker costae. It differs from *A. minoensis* (Mizutani) in having cylindrical (instead of trapezoidal) segments in the distal half of the test and for the less evident segmental constrictions.

Type locality – Il Terriccio, Castellina Marittima (Southern Tuscany, Italy).

Specimen number of holotype – IGF 3877E (Paleontological Museum, Florence University). Holotype repository at the Marcucci collection, University of Florence.

Measurements, in μm, based on 5 specimens –

	Holotype	Maximum	Minimum	Average (5 spec.)
Test Height	252	252	213	225
Test Width	91	98	87	91

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).
Tuscan Chert: Monte Pratofiorito, Val di Lima, Lucca, locality (Cortese, 1995b): P 4, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).

Etymology – From latin: etruscus, -a, -um = from Etruria, old name of Tuscany.

Archaeodictyomitra labronica n. sp. Chiari, Cortese & Marcucci
Plate 1, Figures 11 (Holotype) and 12

Archaeodictyomitra spp. Gorican 1994, p. 160, Plate 20, Figure 11.
Archaeodictyomitra sp. E Chiari 1994, p. 391, Plate 1, Figur 13.

Description – Conical test comprising 6–7 post-abdominal segments. Fourteen to fifteen continuous costae depart from the cephalis. Some of them coalesce close to the cephalis. A single pore row is present between two adjacent costae. The first four segments have a conical shape, whereas the others are cylindrical. The last segment is slightly constricted distally.

Remarks – This species differs from *Archaeodictyomitra apiarium* (Rüst) since it shows a more conical proximal part of the test and a slender overall test shape. It differs from *A. minoensis* (Mizutani) in having less evident segmental constrictions.

Type locality – Il Terriccio, Castellina Marittima (Southern Tuscany, Italy).

Specimen number of holotype – IGF 3876E (Paleontological Museum, Florence University). Holotype repository at the Marcucci collection, University of Florence.

Measurements, in μm, based on 12 specimens –

	Holotype	Maximum	Minimum	Average (12 spec.)
Test Height	213	232	167	207
Test Width	83	93	67	84

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).

Etymology – From latin: Labro, -onis = name of an ancient Roman harbour (situated close to nowadays Leghorn) mentioned by Cicero.

Archaeodictyomitra spelae n. sp. Chiari, Cortese & Marcucci
Plate 1, Figures 13 (Holotype), 14 and 15

Archaeodictyomitra sp. Marcucci & Prela, 1996, Plate 1, Figure 5, in press
Archaeodictyomitra sp. Chiari, 1994, Plate 1, Figure 14.

Description – Conical test with seven post-abdominal segments. Segmental strictures are well marked. All segments have a trapezoidal outline, evident on some segments (from thorax to second post-abdominal and on the last one). Fifteen continuous costae are present, projecting slightly over the last segment. Some costae coalesce close to the cephalis. Rounded pores, disposed along straight transversal rows, are present at segmental divisions. Still other transversal pore rows, with an irregular arrangement, appear on some post-abdominal segments.

Remarks – This species differs from *Archaeodictyomitra etrusca* n. sp. in having an overall conical shape, fewer post-abdominal segments and particularly well marked strictures between segments. It differs from *Archaeodictyomitra labronica* n. sp. in lacking a continuous pore row between two adjacent costae, for the absence of a restriction on the terminal part of last segment, for the projection of costae over the last segment, and for the overall shape of the last segment, which is trapezoidal and not distally restricted. It differs from *A. apiarium* (Rüst) for the longer and slender test and for the more evident segmental constrictions, which are anyway far less evident than in *A. minoensis* (Mizutani).

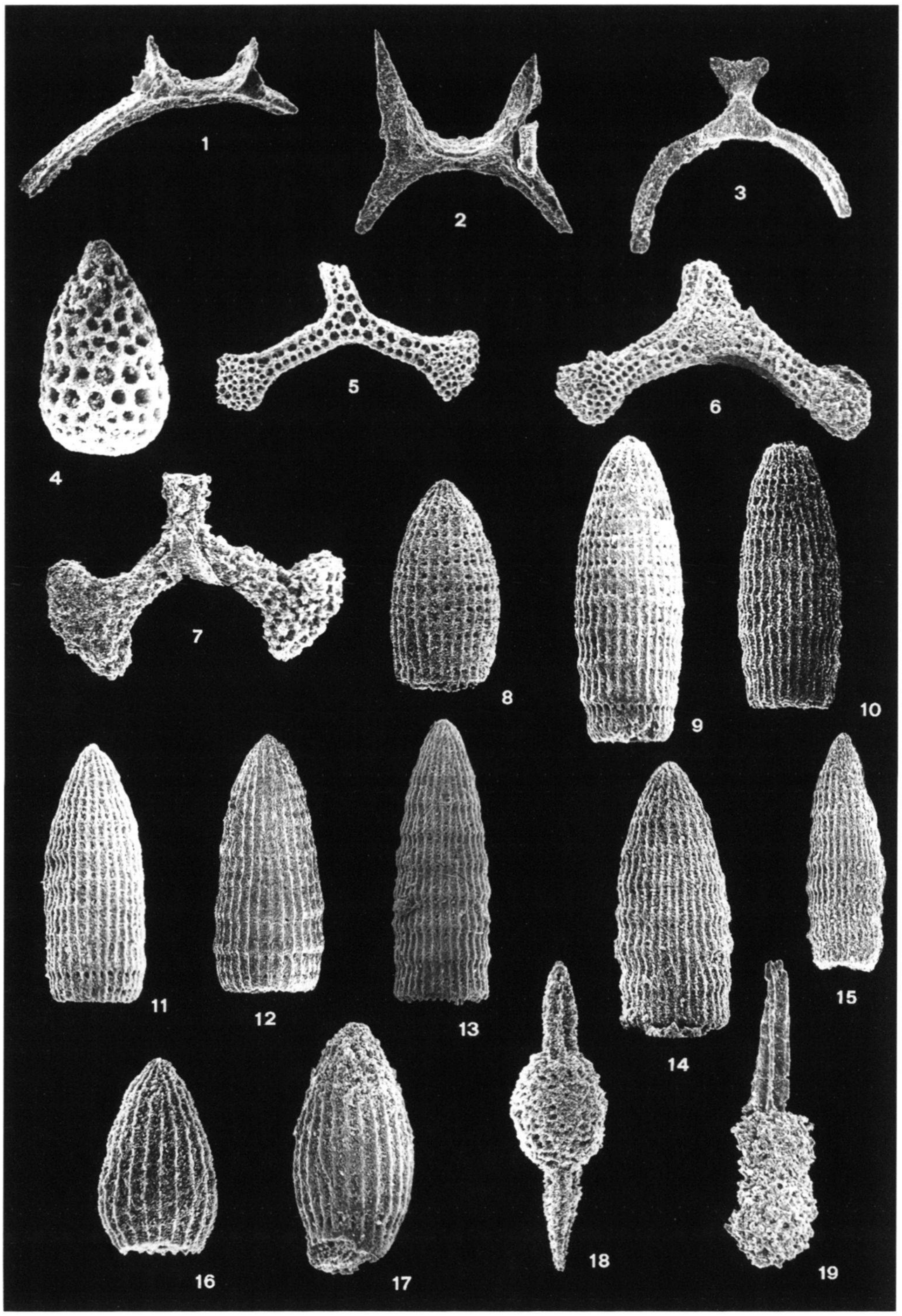

Plate 1

1. *Acanthocircus suboblongus minor* Baumgartner. DB 3. (x160).
2. *Acanthocircus suboblongus suboblongus* (Yao). DB 1. (x160).
3. *Acanthocircus trizonalis dicranacanthos* (Squinabol) emended Foreman. MV 9. (x120).
4. *Amphipyndax* (?) sp. MV 5. (x240).
5. *Angulobracchia biordinalis* Ozvoldova. MV 3. (x80).
6. *Angulobracchia digitata* Baumgartner. TERR. (x120).
7. *Angulobracchia trifolia* Steiger. MV 3. (x120).
8. *Archaeodictyomitra apiarium* (Rüst). TERR. (x160).
9. *Archaeodictyomitra etrusca* n. sp. TERR. (x160).
10. *Archaeodictyomitra etrusca* n. sp. TERR. (x170).
11. *Archaeodictyomitra labronica* n. sp. TERR. (x160).
12. *Archaeodictyomitra labronica* n. sp. TERR. (x160).
13. *Archaeodictyomitra spelae* n. sp. TERR. (x160).
14. *Archaeodictyomitra spelae* n. sp. TERR. (x160).
15. *Archaeodictyomitra spelae* n. sp. TERR. (x120).
16. *Archaeodictyomitra* sp. cf. *A. patricki* Kocher. TERR. (x240).
17. *Archaeodictyomitra* sp. aff. *A. squinaboli* Pessagno TERR. (x200).
18. *Archaeospongoprunum imlayi* Pessagno. CS 2. (x120).
19. *Archaeospongoprunum* sp. cf. *A. macrostylum* (Rüst). TERR. (x160).

Type locality – Il Terriccio, Castellina Marittima (Southern Tuscany, Italy).

Specimen number of holotype – IGF 3878E (Paleontological Museum, Florence University). Holotype repository at the Marcucci collection, University of Florence.

Measurements, in µm, based on 7 specimens –

	Holotype	Maximum	Minimum	Average (7 spec.)
Test Height	230	300	224	254
Test Width	78	117	78	92

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian); SC 9B, U.A.Z. 8–10 (middle Callovian-early Oxfordian to late Oxfordian-early Kimmeridgian), Sasso di Castro locality, about halfway between Florence and Bologna (Chiari, 1994b).

Etymology – Named in honour of Dr. Spela Gorican (University of Ljubljana, Slovenia), in recognition of her contributions to Mesozoic radiolarian biostratigraphy.

Archaeodictyomitra sp. aff. *A. squinaboli* Pessagno
Plate 1, Figure 17

Remarks – This form differs from *A. squinaboli* Pessagno in lacking intersegmental divisions, and for its shorter overall shape.

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).

Genus *Archaeospongoprunum* Pessagno
Archaeospongoprunum Pessagno 1973, p. 57.
Type species: *Archaeospongoprunum venadoensis* Pessagno 1973.

Archaeospongoprunum sp. T
Plate 2, Figure 1

Description – Subcylindrical central body, slightly narrowing at the ends, covered by tiny pores. The central body is slightly larger than the base of polar spines, which are curved and triradiate.

Remarks – This form differs from the other species assigned to the genus *Archaeospongoprunum* sp. in having curved polar spines and a central body only slightly larger than the base of the polar spines.

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).

Genus *Cinguloturris* Dumitrica
Cinguloturris Dumitrica & Mello 1982, p. 23.
Type species: *Cinguloturris carpatica* Dumitrica & Mello 1982.

Cinguloturris (?) *venusta* n. sp. Chiari, Cortese & Marcucci
Plate 2, Figures 4 (Holotype) and 5

Description – Conical test, without clear-cut strictures between segments. Costae on the distal part of the test are equidistant. On the proximal part of the test the costae anastomize and build a bar trellis close to the cephalis. A transversal row of elliptical pores is present in the middle part of last four segments. There is a biunivocal correspondence between these pores and longitudinal costae (to each pore corresponds a costa and vice versa).

Remarks – The genus assignment is uncertain since the costae on the distal part of the test are equidistant and similar to those of the genus *Pseudodictyomitra*. This species differs from *Cinguloturris carpatica* Dumitrica for the shorter test, the less pronounced segmental restrictions and for the presence of pores instead of a spongy network on each segment.

Type locality – Il Terriccio, Castellina Marittima (Southern Tuscany, Italy).

Specimen number of holotype – IGF 3884E (Paleontological Museum, Florence University). Holotype repository at the Marcucci collection, University of Florence.

Measurements, in µm, based on 4 specimens –

	Holotype	Maximum	Minimum	Average (4 spec.)
Test Height	131	152	97	126
Max. Width	69	74	57	66

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).

Etymology – From Latin adjective: venustus, -a, -um = handsome, beautiful.

Genus *Droltus* Pessagno & Whalen
Droltus Pessagno & Whalen 1982, p. 121.
Type species: *Droltus lyellensis* Pessagno & Whalen 1982.

Droltus sp. aff. *D. hecatensis* Pessagno & Whalen
Plate 2, Figure 8

Remarks – This form differs from *D. hecatensis* Pessagno & Whalen in having more regularly sized and regularly arranged pores and for the presence of pore-framing on distal segments.

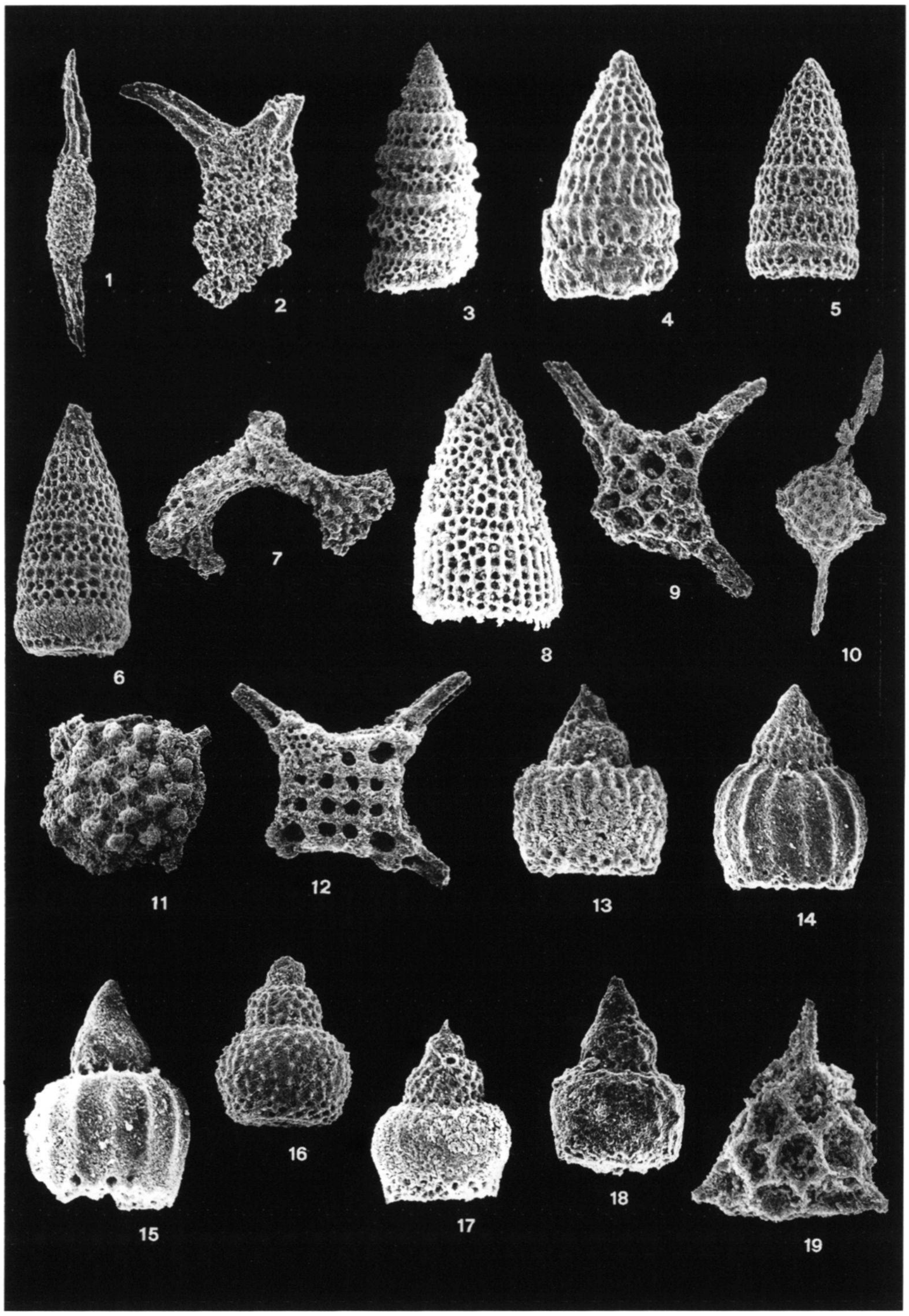

Plate 2

1. *Archaeospongoprunum* sp. T. TERR. (x120).
2. *Bernoullius dicera* (Baumgartner). TERR. (x120).
3. *Cinguloturris carpatica* Dumitrica. MV 5. (x120).
4. *Cinguloturris* (?) *venusta* n. sp. TERR. (x240).
5. *Cinguloturris* (?) *venusta* n. sp. TERR. (x240).
6. *Cinguloturris* (?) sp. TERR. (x240).
7. *Deviatus diamphidius hipposidericus* (Foreman). DB 1. (x120).
8. *Droltus* sp. aff. *D. hecatensis* Pessagno & Whalen. MV 5. (x200).
9. *Emiluvia* sp. cf. *E. ordinaria* Ozvoldova. MV 3. (x120).
10. *Emiluvia orea orea* Baumgartner. TERR. (x60).
11. *Emiluvia orea ultima* Baumgartner & Dumitrica. Q 4. (x80).
12. *Emiluvia sedecimporata* (Rüst). MV 3. (x120).
13. *Eucyrtidiellum bortolottii* n. sp. TERR. (x240).
14. *Eucyrtidiellum ptyctum* (Riedel & Sanfilippo). TERR. (x240).
15. *Eucyrtidiellum* sp. cf. *E. pyramis* (Aita). MV 5. (x240).
16. *Eucyrtidiellum nodosum* Wakita. TERR. (x240).
17. *Eucyrtidiellum unumaense pustulatum* Baumgartner. TERR. (x240).
18. *Eucyrtidiellum* sp. TERR. (x240).
19. *Georgansium* sp. M. CS 6B. (x240).

Occurrence – MV 5, U.A.Z. 10–11? (late Oxfordian-early Kimmeridgian to late Kimmeridgian?).

Genus *Eucyrtidiellum* Baumgartner 1984
Eucyrtidiellum Baumgartner 1984, p. 764.
Type species: *Eucyrtidium* (?) *unumaensis* Yao 1979.

Eucyrtidiellum bortolottii n. sp. Chiari, Cortese & Marcucci
Plate 2, Figure 13 (Holotype)

Eucyrtidiellum bortolottii Cortese, 1995a, Plate 42, Figure 1.

Description – Tricyrtid test. Cephalis is sub-conical and bears a very reduced cephalic horn. Collar constriction is not well marked. Thorax has a trapezoidal outline, its height being 1.5 times the cephalis height, whilst its width is twice as much. At the thorax base some (3–4) sutural pores, disposed on a row, are recognizable. The lumbar constriction is well marked, forming a shoulder which defines a flat surface, totally encircling the thorax base, and having a width equal to one third of the segment. The abdomen, barrel-shaped, has height equal to 2.5 times that of the thorax. On the proximal half of abdomen 10–11 (per lateral view) short costae are present, having an irregular trend. On the contrary, the distal half of the abdomen bears two transverse alternating pore rows.

Remarks – This species differs from *Eucyrtidiellum unumaense pustulatum* Baumgartner in having ten to eleven short irregular costae on the proximal part of abdomen.

Type locality – Il Terriccio, Castellina Marittima (Southern Tuscany, Italy).

Specimen number of holotype – IGF 3873E (Paleontological Museum, Florence University). Holotype repository at the Marcucci collection, University of Florence.

Measurements, in µm, based on 4 specimens –

	Holotype	Maximum	Minimum	Average (4 spec.)
Total Height	112	121	98	109
Abdomen Heigth	66	64	54	60
Abdomen Width	91	94	79	87

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).
Tuscan Chert (Cortese, unpublished data): POD, Podere Cornacchino locality, south of Monte Amiata, Grosseto, U.A.Z. 4–5 (late Bajocian to latest Bajocian-early Bathonian).

Etymology – Dedicated to Prof. Valerio Bortolotti (University of Florence), in recognition of his contributions to the understanding of Northern Apennines stratigraphy.

Genus *Gorgansium* Pessagno & Blome
Gorgansium Pessagno & Blome 1980, p. 234
Type species: *Gorgansium silviesense* Pessagno & Blome 1980.

Gorgansium sp. M
Plate 2, Figure 19

Description – Sub-triangular central body, bearing eight big hexagonal pores. Three radial spines, triradiate and equidistant between each other, stem from the central body. Two spines are remarkably shorter than the third one.

Remarks – This form differs from *Gorgansium pulchrum* Kocher in having less pores on the central body and shorter radial spines. The diameter of the pores is moreover larger than in *G. pulchrum*.

Occurrence – CS 6B, U.A.Z. 8–10 (middle Callovian-early Oxfordian to late Oxfordian-early Kimmeridgian).

Genus *Milax* Blome
Milax Blome 1984, p. 372.
Type species: *Milax alienus* Blome 1984.

Milax sp. A
Plate 3, Fig. 4

Description – Multicyrtid conical test, made up by 7 segments. Strictures between chambers are not evident for all segments but the last. Cephalis, thorax and abdomen are imperforated, covered by a uniform layer of microgranular silica. The first to third post-abdominal segments are sub-rectangular and the last segment (the fourth post-abdominal) is an almost perfect sphere. Pores are rounded with an hexagonal pore framing. The last segment encompasses almost half the height of the test and bears three spines, with a circular transversal section, equally spaced and pointing slightly downwards. The base of each spine is surrounded by 5–6 deformed pores, having an elliptical pore-framing.

Remarks – This form differs from *Milax* sp. V in having 7 segments (rather than six) and a bigger last segment.

Occurrence – MV 5, U.A.Z. 10–11? (late Oxfordian-early Kimmeridgian to late Kimmeridgian?).

Milax sp. V
Plate 3, Fig. 5

Description – Multicyrtid subconical test, with a wavy outline, made up by 6 segments. The cephalis bears a stout cephalic horn, slightly bent, with a circular transversal section. Cephalis,

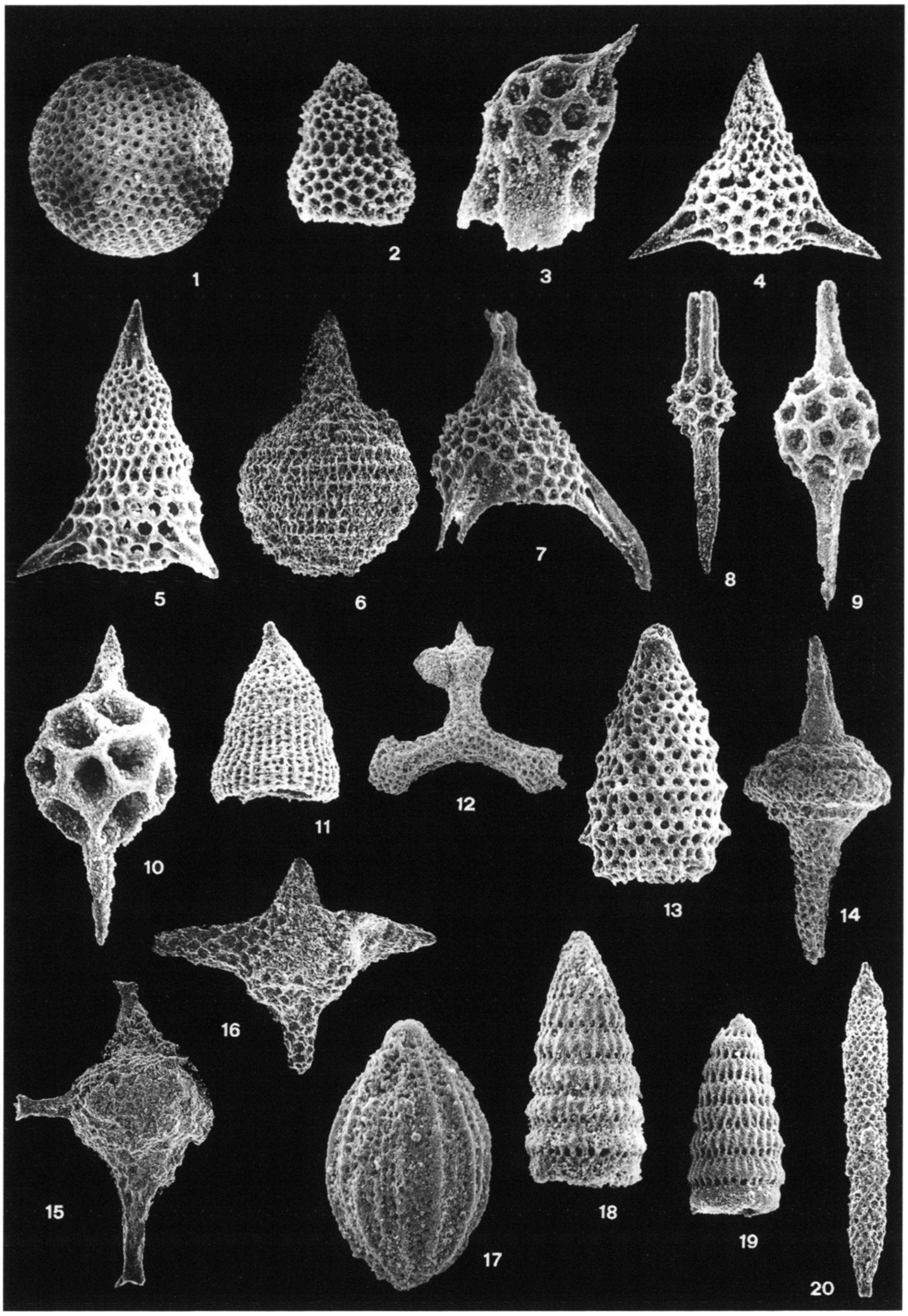

Plate 3

1. *Holocryptocanium barbui* Dumitrica. MV 9. (x160).
2. *Lithomitra* sp. MV 5. (x240).
3. *Mesovallupus guadalupensis* Pessagno & Mac Leod. MV 5. (x240).
4. *Milax* sp. A. MV 5. (x160).
5. *Milax* sp. V. MV 5. (x200).
6. *Mirifusus guadalupensis* Pessagno. CS 5. (x60).
7. *Napora* sp. B in Baumgartner et al., 1995. MV 5. (x200).
8. *Pantanellium oligoporum* (Vinassa). MV 5. (x120).
9. *Pantanellium riedeli* Pessagno. MV 5. (x160).
10. *Pantanellium squinaboli* (Tan). MV 9. (x160).
11. *Parahsuum parvum* Takemura. TERR. (x200).
12. *Paronaella broennimanni* Pessagno. Q 2. (x80).
13. *Parvicingula dhimenaensis dhimenaensis* Baumgartner: TERR. (x240).
14. *Podobursa helvetica* (Rüst) DB 1. (x80).
15. *Podobursa spinosa* (Ozvoldova). Q 4. (x80).
16. *Podocapsa amphitreptera* Foreman. MV 2. (x80).
17. *Protunuma japonicus* Matsuoka & Yao. MV 5. (x240).
18. *Pseudodictyomitra* sp. aff. *P. carpatica* (Lozyniak). MV 5. (x200).
19. *Pseudodictyomitra primitiva* Matsuoka & Yao. MV 5. (x160).
20. *Pseudoeucyrtis reticularis* Matsuoka & Yao. MV 3. (x90).

thorax and abdomen are trapezoidal and imperforated, covered by a uniform layer of microgranular silica. The first post-abdominal segment is sub-spherical, the second post-abdominal segment is sub-rectangular with convex short sides and the last segment (the third post-abdominal) is an almost perfect sphere. The last three segments are covered by circular pores having an hexagonal pore-framing. Nodes slightly in relief are present at each frame corner. Both pore diameter and bar thickness rise sharply going from a segment to the following. The last three segmental divisions are characterized by the presence of a slightly wavy transversal row of elliptical pores, totally different from the pores covering the segments. The last segment bears three equally spaced and pointing slightly downwards spines with a circular transversal section. The base of each spine is surrounded by 5–6 deformed pores, having an elliptical pore-framing.

Remarks – This form differs from *Milax alienus* Blome for its wavy (instead of straight) outline, for the presence of a stout cephalic horn, and for the long and robust spines on last post-abdominal chamber.

Occurrence – MV 5, U.A.Z. 10–11? (late Oxfordian-early Kimmeridgian to late Kimmeridgian?).

Genus *Pseudodictyomitra* Pessagno
Pseudodictyomitra Pessagno 1977b, p. 50.
Type species: *Pseudodictyomitra pentacolaensis* Pessagno 1977b.

Pseudodictyomitra sp. aff. *P. carpatica* (Lozyniak)
Plate 3, Figure 18

Remarks – This form differs from *P. carpatica* (Lozyniak) for the constrictions between segments which are not apparent in the outline and for having thin and closely spaced costae.

Occurrence – MV 5, U.A.Z. 10–11? (late Oxfordian-early Kimmeridgian to late Kimmeridgian?).

Genus *Stichocapsa* Haeckel
Stichocapsa Haeckel 1881, p. 439.
Type species: *Stichocapsa jaspidea* Rüst 1885.

Stichocapsa tuscanica n. sp. Chiari, Cortese & Marcucci
Plate 4, Figures 8 (Holotype) and 9

Amphipyndax sp. cf. *A. tuscanaensis* Cortese, 1995a, Plate 12, Figure 6.
Stichocapsa sp. cf. *S. cribata* Hinde, Chiari, 1992, Plate 22, Figure a.
Stichocapsa sp. Chiari, 1992, Plate 24, Figure c.

Description Conical and short test, bearing a distal constriction. Outward indication of segment separations are missing. Pores are rounded to elliptical and irregularly arranged proximally. On the distal half of the test, pores are alternated and lie on horizontal rows, and occasionally have an irregular arrangement. Rows made up by elongated pores alternate with rows of rounded and smaller pores. Pore-frame is hexagonal.

Remarks – This species differs from *Stichocapsa ulivii* n. sp. in having a distally constricted test and for the presence of rounded to elliptical pores. It differs from *Stichocapsa pulchella* (Rüst) in having a bell shaped test with convex sides. It differs from *Stichocapsa cribata* Hinde in having an open test. The specimens figured by Jud bear pores with high size variability.

Type locality – Il Terriccio, Castellina Marittima (Southern Tuscany, Italy).

Specimen number of holotype – IGF 3874E (Paleontological Museum, Florence University). Holotype repository at the Marcucci collection, University of Florence.

Measurements, in μm, based on 7 specimens –

	Holotype	Maximum	Minimum	Average (7 spec.)
Test Height	148	223	112	148
Maximum Width	89	132	68	90

Occurrence – Samples DB 1, U.A.Z. 10 (late Oxfordian-early Kimmeridgian); TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian); Sasso di Castro locality (Chiari, 1994b), SC 4, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).
Tuscan Chert: Monte Mosca locality (Cortese, unpublished data), NE Tuscany, MO 3, U.A.Z. 9–10 (middle-late Oxfordian to late Oxfordian-early Kimmeridgian).

Etymology – From latin: tuscanicus, -a, -um = from Tuscany.

Stichocapsa ulivii n. sp. Chiari, Cortese & Marcucci
Plate 4, Figures 10 (Holotype) and 11

Pseudodictyomitrella sp. Chiari, 1994, Table 4, Figure 10.

Description – Overall shape is conical without a distal constriction. Restrictions between segments are not evident. Pores are rounded, disposed along transverse rows, with a staggered arrangement. The size of pores is highly variable all over the test.

Remarks – This species differs from *S. pulchella* (Rüst) in having a bell-shaped test with convex sides. This species is compared to *S. tuscanica* n. sp. under the latter species.

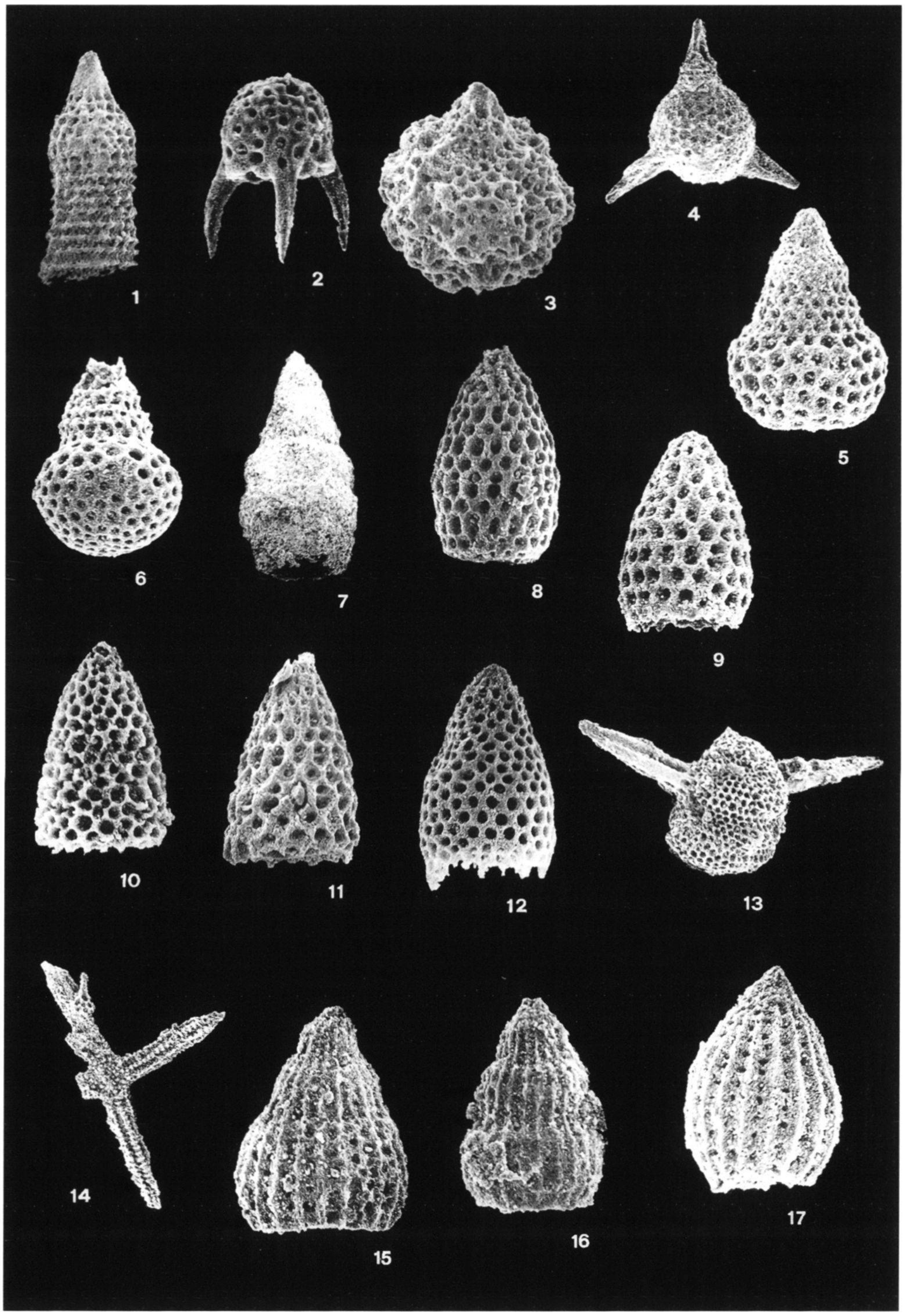

Plate 4

1. *Ristola altissima altissima* (Rüst). DB 1. (x80).
2. *Saitoum dercourti* Widz & De Wever. MV 5. (x160).
3 *Sethocapsa funatoensis* Aita. TERR. (x200).
4. *Sethocapsa* (?) *sphaerica* (Ozvoldova). DB 1. (x80).
5. *Sethocapsa* sp. TERR. (x240).
6. *Sethocapsa* sp. MV 5. (x240).
7. *Spongocapsula palmerae* Pessagno. Q 2 (x80).
8. *Stichocapsa tuscanica* n. sp. TERR. (x200).
9. *Stichocapsa tuscanica* n. sp. TERR. (x240).
10. *Stichocapsa ulivii* n. sp. MV 5. (x240).
11. *Stichocapsa ulivii* n. sp. TERR. (x240).
12. *Stichocapsa* sp. aff. *S. ulivii* n. sp. MV 5. (x240).
13. *Suna echiodes* (Foreman). DB 1. (x80).
14. *Tetratrabs zealis* (Ozvoldova). Q 2. (x40).
15. *Thanarla* sp. cf. *T. brouweri* (Tan) sensu O'Dogherty. MV 9. (x200).
16. *Thanarla* sp. cf. *T. brouweri* (Tan) sensu O'Dogherty. MV 3. (x240).
17. *Thanarla* sp. cf. *T. gutta* Jud. MV 9. (x200).

Type locality – Monte Vitalba (Southern Tuscany, Italy).

Specimen number of holotype – IGF 3875E (Paleontological Museum, Florence University). Holotype repository at the Marcucci collection, University of Florence.

Measurements, in µm, based on 5 specimens –

	Holotype	Maximum	Minimum	Average (5 spec.)
Test Height	121	132	121	126
Maximum Width	76	98	76	85

Occurrence – CS 2, U.A.Z. 7–10 (late Bathonian-early Callovian to late Oxfordian-early Kimmeridgian); CS 5, U.A.Z. 8–10 (middle Callovian-early Oxfordian to late Oxfordian-early Kimmeridgian); MV 5, U.A.Z. 10–11? (late Oxfordian-early Kimmeridgian to late Kimmeridgian?); TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian); and Sasso di Castro locality (Chiari 1994b), SC 9B, U.A.Z. 8–10 (middle Callovian-early Oxfordian to late Oxfordian-early Kimmeridgian).

Etymology – Dedicated to Maurizio Ulivi, S.E.M. technician, whose name did not appear so far in radiolarian bibliography, in spite of his valuable help in all studies of radiolarians carried out in Florence.

Stichocapsa sp. aff. *S. ulivii* n. sp.
Plate 4, Figure 12

Remarks – This form differs from *S. tuscanica* n. sp. since it shows a clear constriction and circular, uniformly sized pores, arranged in regular and alternate transverse rows.

Occurrence – MV 5, U.A.Z. 10–11? (late Oxfordian-early Kimmeridgian to late Kimmeridgian?).

Genus *Transhsuum* Takemura
Transhsuum Takemura 1986, p. 51.
Type species: *Transhsuum medium* Takemura 1986.

Transhsuum (?) sp. G
Plate 5, Figure 4

Description – Multicyrtid test with an overall conical shape, made up by 10–11 segments. Cephalis is spherical, smooth and imperforated. Thorax and the following segments are trapezoidal and increase in height and width as added. The proximal part of the test (cephalis to abdomen) is imperforated or bears only very sparse pores. From the first to the fourth post-abdominal segment, two transversal rows of small pores appear, arranged on the opposite sides of the discontinuous costae marking segmental divisions. From the fifth post-abdominal segment (included) onwards, the pore rows are three: two are arranged on the distal side of each segment, the other on the proximal side of the following segment. The middle part of each segment is always not perforated.

Remarks – This form differs from *Transhsuum brevicostatum* (Ozvoldova) and from the other species of the genera *Transhsuum* and *Hsuum* in having an imperforated middle part in each segment. It somehow recalls *Pseudodictyomitra carpatica* (Lozyniak), but differs from it in lacking two rows of alternating circular pores on each segment and in having an imperforated middle part on each segment.

Occurrence – DB 1, U.A.Z. 10 (late Oxfordian-early Kimmeridgian)

Transhsuum sp. P
Plate 5, Figure 5

Description – Conical test bearing alternate costae which do not continue from one segment to another. Transversal rows of tiny roundish pores mark segmental divisions. Costae are absent on the last segment, which is instead covered by four irregular, transverse rows of rounded pores. In the first of these rows pores are slightly larger.

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).

Genus *Wrangellium* Pessagno & Whalen emended Yeh
Wrangellium Pessagno & Whalen 1982, p. 126.
Type species: *Wrangellium thurstonense* Pessagno & Whalen 1982.

Wrangellium sp. aff. *W. puga* (Schaaf)
Plate 5, Figure 13

Remarks – This form differs from *Wrangellium puga* (Schaaf) in having prominent nodes on the circumferential ridges, an horizontal row of small pores between the latter and larger pores on the distal side of the ridges.

Occurrence – TERR, U.A.Z. 8–9 (middle Callovian-early Oxfordian to middle-late Oxfordian).

Acknowledgements

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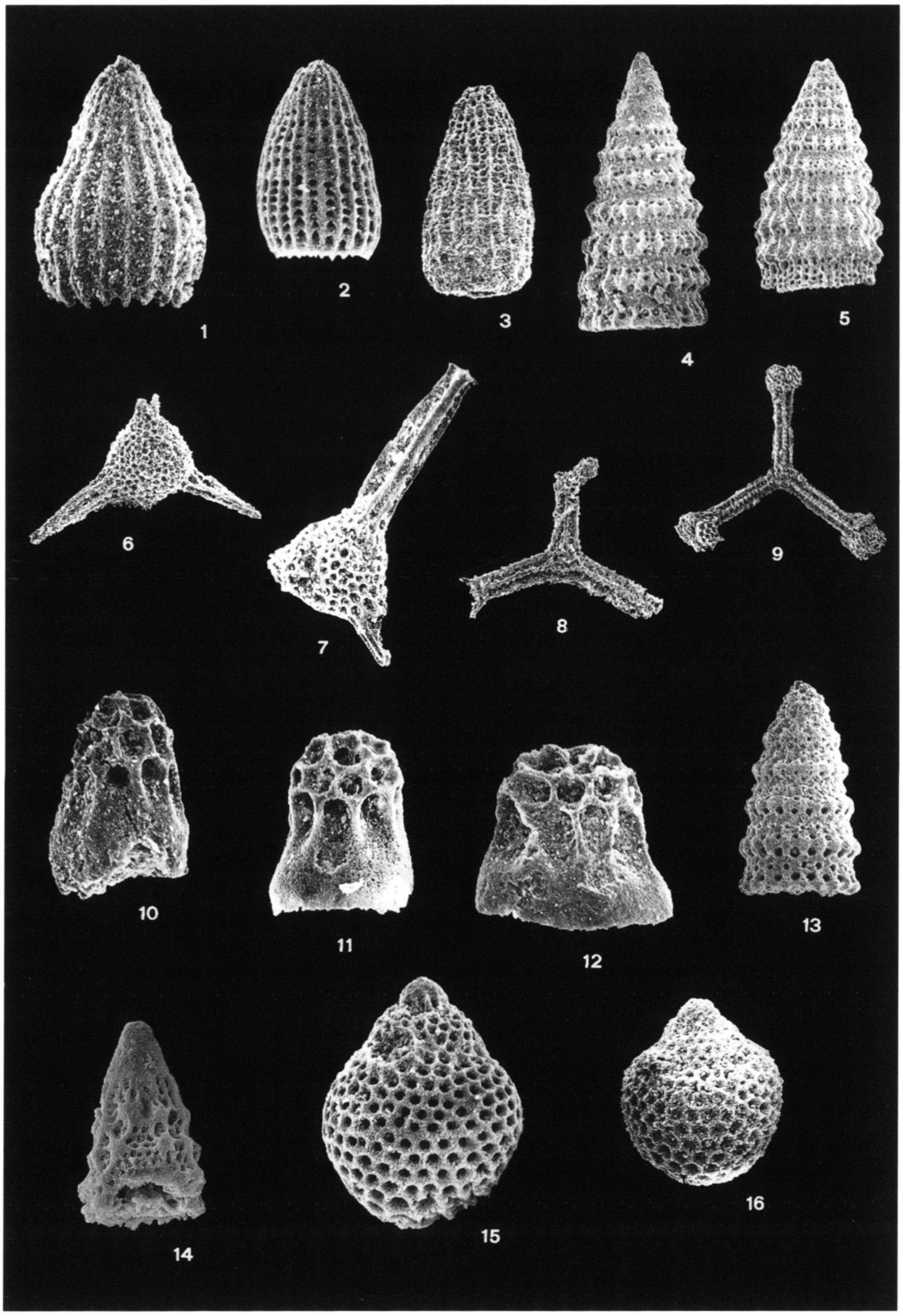

Plate 5

1. *Thanarla pulchra* (Squinabol). MV 9. (x200).
2. *Thanarla* sp. MV 5. (x240).
3. *Transhsuum maxwelli* group (Pessagno). TERR. (x120).
4. *Transhsuum* sp. G. DB 1. (x120).
5. *Transhsuum* sp. P. TERR. (x120).
6. *Triactoma jonesi* (Pessagno). CS 5. (x80).
7. *Triactoma* sp. cf. *T. luciae* Jud. MV 5. (x120).
8. *Tritrabs casmaliaensis* (Pessagno). CS 5. (x80).
9. *Tritrabs ewingi* s.l. (Pessagno). Q2. (x40).
10. *Vallupus hopsoni* Pessagno & Blome. MV 3. (x240).
11. *Vallupus hopsoni* Pessagno & Blome. MV 5. (x240).
12. *Vallupus* sp. cf. *V. laxus* Yang & Pessagno in Matsuoka (1995). MV 3. (x200).
13. *Wrangellium* sp. aff. *W. puga* (Schaaf). TERR. (x200).
14. *Xitus* sp. TERR. (x200).
15. *Zhamoidellum ovum* Dumitrica. MV 5. (x240).
16. *Zhamoidellum ventricosum* Dumitrica. TERR. (x200).

Tab. 1a. Occurrence chart, Castel Sonnino locality.

Locality Castel Sonnino						
	Samples					
Genus and species name	CS2	CS5B	CS4	CS6B	CS8B	CS5
Acaeniotyle sp.			X			
Acanthocircus suboblongus minor Baumgartner						X
Acanthocircus suboblongus s.l. (Yao)				X		
Acanthocircus trizonalis s.l. (Rüst)				X		X
Angulobracchia sp.	X					
Archaeodictyomitra apiarium (Rüst)				X		
Archaeodictyomitra sp.	X				X	
Archaeospongoprunum imlayi Pessagno	X					
Archaeospongoprunum sp. cf. *A. macrostylum* (Rüst)		X				
Archaeospongoprunum sp. T	X					
Archaeospongoprunum sp.	X			X		
Emiluvia pessagnoi s.l. Foreman	X					
Emiluvia sp. cf. *E. sedecimporata* (Rüst)					X	
Emiluvia sp.	X					
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)		X				
Eucyrtidiellum sp.					X	
Gorgansium sp. M				X		
Gorgansium sp.	X					
Haliodictya (?) *antiqua antiqua* (Rüst) sensu Pessagno				X		
Homoeoparonaella sp.	X				X	
Mirifusus dianae s.l. (Karrer)	X					
Mirifusus guadalupensis Pessagno						X
Napora sp.	X					X
Pantanellium riedeli Pessagno	X					
Pantanellium sp. cf. *P. riedeli* Pessagno	X					
Pantanellium sp.	X	X		X		
Paronaella bandyi Pessagno	X					
Paronaella sp. cf. *P. mulleri* Pessagno					X	
Paronaella sp.	X					
Perispyridium sp. cf. *P. ordinarium* gr. (Pessagno)	X					
Perispyridium sp.	X					
Podobursa sp. cf. *P. spinosa* (Ozvoldova)		X		X		
Podobursa triacantha (Fischli)				X		
Podobursa sp. cf. *P. triacantha* (Fischli)				X		X
Podobursa sp.		X		X	X	
Saitoum sp.	X			X		
Sethocapsa sp.	X			X		
Stichocapsa ulivii n. sp.	X					
Stichocapsa sp. cf. *S. ulivii* n. sp.						X
Stichocapsa sp.		X				
Tetratrabs sp.						X
Transhsuum brevicostatum gr. (Ozvoldova)				X		
Transhsuum sp. cf. *T. brevicostatum* gr. (Ozvoldova)	X		X			
Transhsuum sp.	X			X		
Triactoma jonesi (Pessagno)		X		X		X
Triactoma sp. cf. *T. jonesi* (Pessagno)	X				X	X
Triactoma sp.	X	X			X	
Tritrabs casmaliaensis (Pessagno)					X	X
Tritrabs ewingi s.l. (Pessagno)						X
Tritrabs sp.	X	X			X	

Tab. 1b. Occurrence chart, Quercianella locality.

Locality Quercianella		
	Samples	
Genus and species name	Q2	Q4
Acanthocircus suboblongus suboblongus (Yao)		X
Acanthocircus sp. cf. *A. trizonalis angustus* Baumgartner	X	
Acanthocircus sp.	X	
Archaeospongoprunum imlayi Pessagno		X
Archaeospongoprunum sp.	X	
Bernoullius sp.	X	
Deviatus sp.	X	
Emiluvia orea orea Baumgartner	X	X
Emiluvia orea ultima Baumgartner & Dumitrica		X
Emiluvia sp.	X	
Homoeoparonaella sp.		X
Mirifus dianae sl. (Karrer)		X
Napora sp.	X	
Paronaella broennimanni Pessagno	X	
Podobursa sp.	X	
Podobursa spinosa (Ozvoldova)		X
Protunuma japonicus Matsuoka & Yao		X
Ristola sp.		X
Sethocapsa (?) *sphaerica* (Ozvoldova)		X
Spongocapsula palmerae Pessagno	X	
Stichocapsa sp.		X
Tetratrabs zealis (Ozvoldova)	X	
Tetratrabs sp.	X	
Transhsuum sp. cf. *T. maxwelli* gr. (Pessagno)		X
Transhsuum sp.	X	
Triactoma blakei (Pessagno)		X
Tritrabs casmaliaensis (Pessagno)	X	
Tritrabs ewingi s.l. (Pessagno)	X	X
Tritrabs hayi (Pessagno)	X	
Tritrabs sp.	X	

Tab. 1c. Occurrence chart, Le Debbiare locality.

Locality Le Debbiare		
	Samples	
Genus and species name	DB1	DB3
Acaeniotyle sp.		X
Acanthocircus suboblongus minor Baumgartner		X
Acanthocircus suboblongus suboblongus (Yao)	X	
Acanthocircus sp.		X
Angulobracchia sp.	X	
Archaeodictyomitra sp. cf. *A. apiarium* (Rüst)	X	
Archaeodictyomitra sp.	X	
Archaeospongoprunum sp. cf. *A. imlayi* Pessagno		X
Deviatus diamphidius hipposidericus (Foreman)	X	
Emiluvia sp. cf. *E. ordinaria* Ozvoldova	X	
Emiluvia orea s.l. Baumgartner	X	
Emiluvia orea ultima Baumgartner & Dumitrica	X	
Emiluvia sp.		X
Eucyrtis sp.	X	
Homoeoparonaella sp.		X
Mirifusus dianae s.l. (Rüst)	X	
Mirifusus sp.		X
Parvicingula sp.		X
Podobursa helvetica (Rüst)	X	
Podobursa spinosa (Ozvoldova)	X	X
Podobursa sp. cf. *P. spinosa* (Ozvoldova)		X
Podobursa sp. cf. *P. triacantha* (Fischli)	X	
Podobursa sp.	X	X
Podocapsa amphitreptera Foreman		X
Praeconocaryomma sp.	X	X
Protunuma sp. cf. *P. japonicus* Matsuoka & Yao		X
Pseudoeucyrtis sp.	X	
Ristola altissima altissima (Rüst)	X	X
Ristola sp. cf. *R. altissima altissima* (Rüst)		X
Ristola sp.	X	
Sethocapsa funatoensis Aita	X	
Sethocapsa (?) *sphaerica* (Ozvoldova)	X	X
Sethocapsa sp	X	X
Stichocapsa sp.		X
Stichocapsa tuscanaensis n. sp.	X	
Suna echiodes (Foreman)	X	
Tetracapsa sp.	X	
Triactoma blakei (Pessagno)		X
Tritrabs sp. cf. *T. ewingi* s.l. (Pessagno)		X
Zhamoidellum ventricosum Dumitrica		X

Tab. 1d. Occurrence chart, Monte Vitalba locality.

Locality Monte Vitalba						
	Samples					
Genus and species name	MV2	MV3	MV4	MV5	MV9	MV10
Acanthocircus trizonalis dicranacanthos (Squinabol) emend. Foreman		X			X	X
Amphipyndax (?) sp.				X		
Angulobracchia biordinalis Ozvoldova		X				
Angulobracchia trifolia Steiger		X				
Angulobracchia sp.	X					
Archaeodictyomitra apiarium (Rüst)		X		X	X	X
Archaeodictyomitra sp. cf. *A. apiarium* (Rüst)			X			
Archaeodictyomitra sp. cf. *A. vulgaris* Pessagno					X	
Archaeodictyomitra sp.	X	X			X	
Cingulotumis carpatica Dumitrica				X		
Droltus sp. aff. *D. hecatensis* Pessagno & Whalen				X		
Emiluvia ordinaria Ozvoldova		X				
Emiluvia sp. cf. *E. sedecimporata* (Rüst)		X				
Emiluvia sp.		X				
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)				X		
Eucyrtidiellum sp. cf. *E. ptyctum* (Riedel & Sanfilippo)				X		
Eucyrtidiellum sp. cf. *E. pyramis* (Aita)				X		
Eucyrtidiellum sp.				X		
Hemicryptocapsa sp.					X	
Holocryptocanium barbui Dumitrica					X	
Hsuum sp.					X	
Lithomitra sp.				X		
Mesovallupus guadalupensis Pessagno & Mac Leod		X		X		
Milax sp. A				X		
Milax sp. V				X		
Napora sp. B Baumgartner et al.				X		
Pantanellium sp. cf. *P. cantuchapai* Pessagno & Mac Leod				X		
Pantanellium oligoporum (Vinassa)				X		
Pantanellium riedeli Pessagno				X	X	
Pantanellium squinaboli (Tan)					X	
Pantanellium sp.	X		X	X	X	X
Paronaella broennimanni Pessagno				X		
Paronaella sp.				X		
Parvicingula dhimenaensis dhimenaensis Baumgartner				X		
Parvicingula sp. cf. *P. cosmoconica* (Foreman)					X	
Parvicingula sp.		X	X	X	X	
Podocapsa amphitreptera Foreman	X	X	X	X		
Protunuma japonicus Matsuoka & Yao		X		X		
Pseudodictyomitra sp. aff. *P. carpatica* (Lozyniak)				X		
Pseudodictyomitra sp. cf. *P. carpatica* (Lozyniak)					X	
Pseudodictyomitra primitiva Matsuoka & Yao				X		
Pseudoeucyrtis reticularis Matsuoka & Yao		X				
Saitoum dercourti Widz & De Wever				X		
Saitoum sp.					X	
Sethocapsa sp.		X		X		
Stichocapsa ulivii n. sp.				X		
Stichocapsa sp. aff. *S. ulivii* n. sp.				X		
Stichocapsa (?) sp.			X			
Stichocapsa sp.		X		X	X	
Tetratrabs sp.					X	
Thanarla sp. cf. *T. brouweri* (Tan) sensu O'Dogherty		X		X	X	X
Thanarla sp. cf. *T. gutta* Jud					X	
Thanarla pulchra (Squinabol)					X	
Thanarla sp. cf. *T. pulchra* (Squinabol)					X	
Thanarla sp.				X	X	X
Triactoma sp. cf. *T. luciae* Jud					X	
Triactoma sp.	X			X		
Vallupus hopsoni Pessagno & Blome		X		X		
Vallupus sp. cf. *V. hopsoni* Pessagno & Blome		X				
Vallupus sp. cf. *V. laxus* Yang & Pessagno in Matsuoka 1995		X				
Vallupus sp.		X				
Xitus sp.					X	
Zhamoidellum ovum Dumitrica				X		

Tab. 1e. Occurrence chart, Il Terriccio locality.

Locality Il Terriccio	
	Sample
Genus and species name	TERR
Acaeniotyle diaphorogona gr. Foreman sensu Baumgartner	X
Acanthocircus sp.	X
Acanthocircus suboblongus minor Baumgartner	X
Angulobracchia digitata Baumgartner	X
Archaeodictyomitra apiarium (Rüst)	X
Archaeodictyomitra sp. cf. *A. apiarium* (Rüst)	X
Archaeodictyomitra etrusca n. sp.	X
Archaeodictyomitra labronica n. sp.	X
Archaeodictyomitra sp. cf. *A. patricki* Kocher	X
Archaeodictyomitra sp. cf. *A. simplex* Pessagno	X
Archaeodictyomitra spelae n. sp.	X
Archaeodictyomitra sp. aff. *A. squinaboli* Pessagno	X
Archaeodictyomitra sp.	X
Archaeospongoprunum sp.	X
Archaeospongoprunum sp. cf. *A. macrostylum* (Rüst)	X
Archaeospongoprunum sp. T	X
Bernoullius dicera (Baumgartner)	X
Bernoullius sp.	X
Cinguloturris carpatica Dumitrica	X
Cinguloturris (?) *venusta* n. sp.	X
Cingoloturris (?) sp.	X
Deviatus sp. cf. *D. diamphidius* s.l. (Foreman)	X
Diboloachras chandrika Kocher	X
Eucyrtidiellum bortolotti n. sp.	X
Eucyrtidiellum nodosum Wakita	X
Eucyrtidiellum sp. cf. *E. nodosum* Wakita	X
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)	X
Eucyrtidiellum unumaense pustulatum Baumgartner	X
Eucyrtidiellum sp. cf. *E. unumaense pustulatum* Baumgartner	X
Eucyrtidiellum sp.	X
Hsuum sp.	X
Palinandromeda sp.	X
Pantanellium riedeli Pessagno	X
Pantanellium sp. cf. *P. squinaboli* (Tan)	X
Pantanellium sp.	X
Parahsuum parvum Takemura	X
Paronaella sp.	X
Parvicingula dhimenaensis dhimenaensis Baumgartner	X
Parvicingula sp.	X
Podobursa sp.	X
Protunuma japonicus Matsuoka & Yao	X
Sethocapsa funatoensis Aita	X
Sethocapsa sp. cf. *S. leiostraca* Foreman	X
Sethocapsa sp.	X
Stichocapsa tuscanaensis n. sp.	X
Stichocapsa ulivii n. sp.	X
Stichocapsa sp.	X
Stichomitra sp.	X
Stylocapsa sp.	X
Tetraditryma corralitosensis corralitosensis (Pessagno)	X
Transhsuum brevicostatum gr. (Ozvoldova)	X
Transhsuum maxwelli gr. (Pessagno)	X
Transhsuum sp. P	X
Triactoma blakei (Pessagno)	X
Triactoma sp.	X
Tritrabs sp. cf. *T. rhododactylus* Baumgartner	X
Tritrabs sp.	X
Wrangellium sp. aff. *W. puga* (Schaff)	X
Xitus sp.	X
Zhamoidellum ovum Dumitrica	X
Zhamoidellum sp. cf. *Z. ovum* Dumitrica	X
Zhamoidellum ventricosum Dumitrica	X

Tab. 1f. Occurrence chart, L'Aiola locality.

Locality Aiola						
	Samples					
Genus and species name	A1	A2	A3	A4	A5	A7
Acanthocircus tr. dicranacanthos (Squinabol) emend. Foreman		X		X		
Acanthocircus sp.	X			X		
Angulobracchia sp.	X					
Archaeodictyomitra sp.	X					
Bistarkum sp.		X				
Diboloachras sp.				X		
Emiluvia sedecimporata (Rüst)		X				
Emiluvia sp.			X		X	
Eucyrtidiellum sp.	X					
Holocryptocanium sp.	X					
Homeoparonaella sp.	X			X		
Mirifusus dianae s.l. (Karrer)		X				
Mirifusus sp. cf. *M. guadalupensis* Pessagno		X				
Mirifusus sp.	X	X				X
Napora sp.	X			X		
Obesocapsula cetia (Foreman)		X				
Pantanellium sp.	X				X	
Paronaella sp.	X					
Podobursa sp.	X		X	X		
Podocapsa amphitreptera Foreman	X	X	X	X		
Podocapsa sp. cf. *P. amphitreptera* Foreman	X					
Podocapsa sp.		X	X			
Protunuma japonicus Matsuoka & Yao	X					
Ristola altissima altissima (Rüst)	X	X				
Ristola sp.		X				
Saitoum sp.	X		X			
Sethocapsa sp.	X					
Triactoma sp.	X	X				
Tritrabs casmaliaensis (Pessagno)	X					
Tritrabs sp.	X		X			

REFERENCES

ABBATE, E. 1969: Geologia delle Cinque Terre e dell'entroterra di Levanto (Liguria Orientale). Mem. Soc. geol. ital. 8, 923–1014.

ABBATE, E. & SAGRI, M. 1970: The eugeosynclinal sequences. In: Development of the Northern Apennines geosyncline. (Ed. by SESTINI, G.). Sed. Geol. 4 (1–4), 251–340.

ABBATE, E., BORTOLOTTI, V., PASSERINI, P. & SAGRI, M. 1970: Introduction to the geology of the Northern Apennines. In: Development of the Northern Apennines geosyncline. (Ed. by SESTINI, G.). Sed. Geol. 4 (1–4), 207–249.

ABBATE, E., BORTOLOTTI, V. & PRINCIPI, G. 1980: Apennine ophiolites: a peculiar oceanic crust. Ofioliti, Special Issue on Tethyan Ophiolites 1, 59–96.

ABBATE, E., BORTOLOTTI, V., CONTI, M., MARCUCCI , M., PRINCIPI, G., PASSERINI, P. & TREVES, B. 1986: Apennines and Alps ophiolites and evolution of the western Tethys. Mem. Soc. Geol. It 31, 23–44.

ABBATE, E., BORTOLOTTI, V., MARCUCCI, M., PASSERINI, P. & PRINCIPI, G. 1994A: Radiolarian biostratigraphy in the siliceous deposits above Northern Apennines ophiolites: a further clue to the generation of oceanic crust. Ofioliti 19 (2b), 333–347.

ABBATE, E., BORTOLOTTI, V., PASSERINI, P., PRINCIPI, G. & TREVES, B. 1994B: Oceanization process and sedimentary evolution of the Northern Apennine ophiolite suite: a discussion. Mem. Soc. geol. ital. 48, 117–136.

AIELLO, I.W., GARDIN, S. & PERILLI, N. 1995: The transition from radiolarian-bearing to coccolith-bearing sediments in the Western Tethys oceanic domain: an example from the Ligurian-Piedmontese Basin (Northern Apennines). Poster Session. IOS Meeting, Pavia, September 1995.

ANDRI, E. & FANUCCI, F. 1973: Osservazioni sulla litologia e stratigrafia dei Calcari a Calpionelle liguri (Val Graveglia, Val di Vara). Boll. Soc. geol. ital. 92, 161–192.

– 1975: La risedimentazione dei Calcari a Calpionelle liguri. Boll. Soc. geol. ital. 94, 915–925.

BAUMGARTNER, P.O. 1984: A middle Jurassic-early Cretaceous low-latitude radiolarian zonation based on Unitary Associations and age of Tethyan radiolarites. Ecl. geol. Helv. 77, 729–837.

– 1987: Age and genesis of Tethyan Jurassic radiolarites. Ecl. geol. Helv. 80, 831–879.

BAUMGARTNER, P.O., BARTOLINI, A.C., CARTER, E.S., CONTI, M., CORTESE, G., DANELIAN, T., DE WEVER, P., DUMITRICA, P., DUMITRICA-JUD, R.,

GORICAN, S., GUEX, J., HULL, D.M., KITO, N., MARCUCCI, M., MATSUOKA, A., MURCHEY, B., O'DOGHERTY, L., SAVARY, J., VISHNEVSKAYA, V., WIDZ, D. & YAO, A. 1995: Middle Jurassic to Early Cretaceous Radiolarian biochronology of Tethys based on Unitary Associations. In: Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. (Ed. by BAUMGARTNER, P.O. et al.), Mém. Géologie (Lausanne) 23, 1013–1048.

BORTOLOTTI, V. 1983: Stratigrafia, tettonica ed evoluzione geodinamica delle ofioliti della Toscana. Mem. Soc. geol. ital. 25, 63–74.

BORTOLOTTI, V., MARCUCCI, M. & PRINCIPI, G. 1991A: Guidebook of the field trip in Tuscany and Liguria. InterRad VI post-congress excursion: Sedimentary cover in ophiolitic and oceanic sequences (Firenze, 4–6 October, 1991).

BORTOLOTTI, V., GARDIN, S. & PRINCIPI, G. 1991B: The Nisportino Formation: a transitional unit between the Mt. Alpe Cherts and the Calpionella Limestone, Elba Island. Sedimentary cover in ophiolitic and oceanic sequences in Interrad VI, Florence, Abstract.

BORTOLOTTI, V., GARDIN, S., MARCUCCI, M. & PRINCIPI, G. 1994: The Nisportino Formation: a transitional unit between the Mt. Alpe Cherts and the Calpionella Limestone (Vara Supergroup, Elba Island, Italy). Ofioliti 19 (2b), 349–365.

CHIARI, M. 1992: Biostratigrafia a Radiolari dei Diaspri di Monte Alpe nelle zone di Sasso di Castro e Figline di Prato. Unpublished Master Degree thesis, Florence University.

CHIARI, M. 1994A: Radiolarian assemblage from ophiolite sequence of Northern Apennines: 1 – Figline di Prato sections. Ofioliti 19 (2a), 177–192.

– 1994B: Radiolarian assemblage from ophiolite sequence of Northern Apennines: 2 – Sasso di Castro sections. Ofioliti, 19 (2b), 377–395.

CHIARI, M., CORTESE, G. & MARCUCCI, M. 1994: Radiolarian biostratigraphy of the jurassic cherts of the Northern Apennines. Ofioliti 19 (2a), 307–312.

COBIANCHI, M. & VILLA, G. 1992: Biostratigrafia del Calcare a Calpionelle e delle Argille a Palombini nella sezione di Statale (Val Graveglia, Appennino Ligure). Atti Ticinensi Sci. della Terra (Pavia) 35, 199–211.

CONTI, M. & MARCUCCI, M. 1986: The onset of radiolarian deposition in ophiolite sequences of the Northern Apennines. Marine Micropaleontology 11, 129–138.

– 1991: Radiolarian assemblage in the Monte Alpe Chert at Ponte di Lagoscuro, Val Graveglia (Eastern Liguria, Italy). Ecl. Geol. Helv. 84 (3), 791–817.

– 1992: Radiolarian dating of the Monte Alpe Chert at Il Conventino, Monti Rognosi (Eastern Tuscany, Italy). Ofioliti 17 (2), 243–248.

CONTI, M., MARCUCCI, M. & PASSERINI, P. 1985: Radiolarian cherts and ophiolites in the Northern Apennines and Corsica: age, correlations and tectonic frame of siliceous deposition. Ofioliti 10 (2), 203–224.

CONTI, M., MARCUCCI, M. & ZANZUCCHI, G. 1988: Radiolarian dating of the Mt. Alpe Cherts at Costa Scandella, Mt. Penna, Mt. Aiona group, Ligurian Apennines. Ofioliti 13 (1), 81–84.

CORTESE, G. 1995A: Applicazioni dei radiolari in paleoecologia ed in biostratigrafia. Unpublished Ph.D. Thesis. Modena University, Italy.

– 1995B: Radiolarian biostratigraphy of Tuscan Cherts (Tuscan Succession) from Val di Lima (Tuscany, Northern Apennines, Italy). In: Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: occurrences, systematics, biochronology. (Ed. by. BAUMGARTNER, P.O. et al.) MÉM. GÉOLOGIE (LAUSANNE) 23, 813–816.

Cortesogno, L., Galbiati, B., Principi, G. & Venturelli, G. 1978: Le breccie ofiolitiche della Liguria orientale: nuovi dati e discussione sui modelli paleogeografici. Ofioliti 3, 99–160.

DE WEVER, P. 1982: Radiolaires du Trias et du Lias de la Téthys (Systématique, Stratigraphie). Soc. géol. du Nord 7, 1–600.

DE WEVER, P., RICOU, L.-E. & FOURCADE, E. 1986: La fin brutale de l'optimum radiolaritique au Jurassique terminal: l'effet de la circulation océanique. C. R. Acad. Sc. (Paris), Série II, 302 (9), 665–670.

DUMITRICA, P. 1970: Cryptocephalic and cryptothoracic Nassellaria in some Mesozoic deposits of Romania. Rev. Roum. Géol. Géophys. Géogr. sér. Géol. 14 (1), 45–124.

GARDIN, S. & PERILLI, N. 1995: Early Cretaceous calcareous nannofossil biostratigraphy of the Internal Ligurids (Northern Apennines, Italy) and the onset of coccolith-bearing sediments in the Ligurian-Piedmont oceanic domain. Poster session, IOS Meeting, Pavia, September 1995.

GIANELLI, G. & PRINCIPI, G. 1974: Studies on mafic and ultramafic rocks. 4 – Breccias of the ophiolitic suite in the Monte Bocco area (Ligurian Apennine). Boll. Soc. geol. ital. 93, 277–308.

GORICAN, S. 1994: Jurassic and Cretaceous Radiolarian biostratigraphy and sedimentary evolution of the Budva Zone (Dinarides, Montenegro). Ph.D. Thesis. Mém. de Géol. (Lausanne) 18, 1–178.

KAWABATA, K. 1988: New species of Latest Jurassic and Earliest Cretaceous radiolarians from the Sorachi Group in Hokkaido, Japan. Bull. Osaka Museum of Natural History 43, 1–13.

KITO, N., DE WEVER, P., DANELIAN, T. & CORDEY, F. 1990: Middle to Late Jurassic Radiolarians from Sicily (Italy). Marine Micropaleontology 15, 329–349.

LAZZAROTTO, A. & MAZZANTI, R. 1964: Stratigrafia delle formazioni alloctone della Toscana Marittima. 1. – Studio geologico e micropaleontologico di tre sezioni fra le valli di Milia e di Cornia (Foglio 119, Tavoletta di Frassine). Boll. Soc. geol. Ital. 83, 125–157.

MARCUCCI, M., PASSERINI, P. & PRINCIPI, G. 1988: Appenninic and Alpine ophiolites and the Atlantic Ocean opening. 2nd International Symposium on Jurassic stratigraphy, Lisboa 1988, 983–1015.

MARCUCCI-PASSERINI, M. & MARRI, C. 1990: Radiolarian assemblages in ophiolite sequence of southern Tuscany: new data. Ofioliti 15, 185–190.

MARCUCCI, M., CHIARI, M., CORTESE, G. & NOZZOLI, N. 1994: New data on the radiolarian assemblages in the Jurassic cherts of the western and southern Tuscany, Italy. Interrad VII, Osaka 1994, Abstract, 84.

MARCUCCI, M. & PRELA, M. 1996: The Lumi i Zi (Puke) section of the Kalur Cherts: radiolarian assemblages and comparison with other sections in Northern Albania. Ofioliti 21 (1), in press.

MATSUOKA, A. 1992: Jurassic and early Cretaceous radiolarians from Leg 129, Sites 800 and 801, western Pacific ocean. In: Proceedings of the Ocean Drilling Project 129, 203–220.

– 1995: Late Jurassic tropical Radiolaria: *Vallupus* and its related forms. Palaeogeography, Palaeoclimatology, Palaeoecology 119, 359–369.

NOZZOLI, N. 1986: Micropaleontological study of radiolarian chert in the ophiolitic sequence south of Leghorn. Ofioliti 11 (3), 339–342.

ODIN, G.S. 1994: Geological time scale. C. R. Acad. Sci. Paris 318 (II), 59–71.

PASSERINI, P. 1965: Rapporti fra le ofioliti e le formazioni sedimentarie tra Piacenza e il Mare Tirreno. Boll. Soc. geol. ital. 84 (5), 93–176.

PESSAGNO, E.A. & NEWPORT, L.A. 1972: A technique for extracting Radiolaria from radiolarian chert. Micropaleontology 18 (2), 231–234.

PESSAGNO, E.A., LONGORIA, J.F., MACLEOD, N. & SIX, W.M. 1987: Studies of North America Jurassic Radiolaria. Part I, Upper Jurassic (Kimmeridgian-upper Tithonian) Pantanelliidae from the Taman Formation east-central Mexico: tectonostratigraphic, chronostratigraphic, and phylogenetic implications. Cush. Found. for For. Res. Spec. Publ. 23 (I), 1–51.

PICCHI, F. 1985: Late Jurassic-early Cretaceous ophiolite cover, Castellina M., Pise, Italy. Ofioliti 10 (1), 77–80.

PRINCIPI, G. 1973: Il conglomerato di Monte Zenone. Boll. Soc. geol. ital. 92, 75–84.

PRINCIPI, G. & TREVES, B. 1992: Guide alle escursioni post-congresso. 76° Congresso della Soc. geol. ital. Firenze, 18–34.

SCHAAF, A. 1985: Un nouveau canevas biochronologique du Crétacé inférieur et moyen: les biozones à radiolaires. Sci. géol. (Strasbourg) Bull. 38 (3), 227–269.

STEIGER, T. 1992: Systematik, Stratigraphie und Palökologie der Radiolarien des Oberjura-Unterkreiden-Grenzbereiches im Osterhorn-Tirolikum (Nördliche Kalkalpen, Salzburg und Bayern). Zitteliana 19, 3–188.

WIDZ, D. & DE WEVER, P. 1993: Nouveaux Nassellaires (Radiolaria) des radiolarites jurassiques de la coupe de Szeligowy Potok (Zones de Klippes de Pieniny, Carpathes occidentales, Pologne). Rev. Micropaléontologie 36 (1), 77–91.

YANG, Q. & PESSAGNO, E.A. JR. 1989: Upper Tithonian Vallupinae (Radiolaria) from the Taman Formation, east-central Mexico. Micropaleontology 35 (2), 114–134.

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