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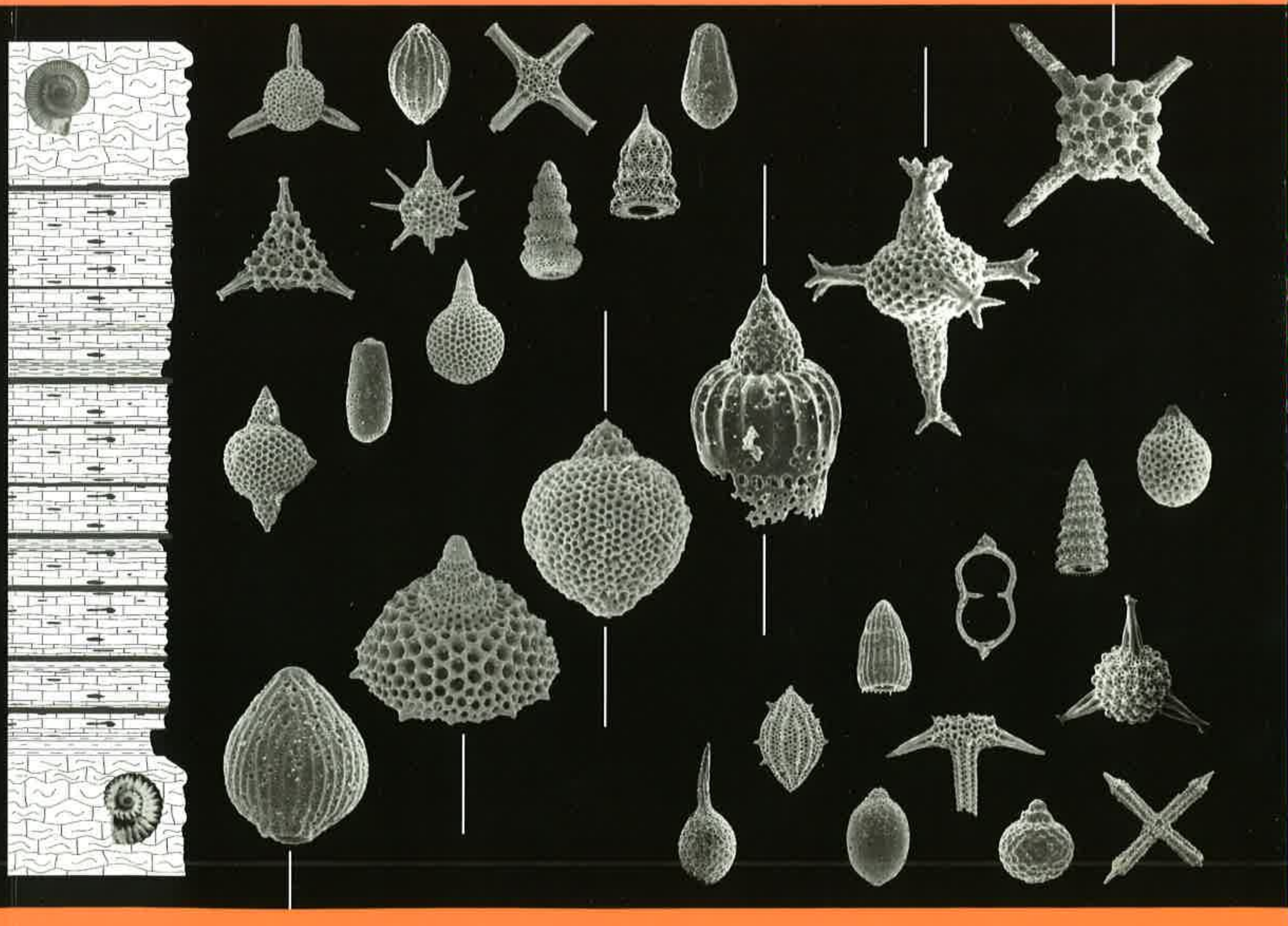

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RADIOLARIAN BIOSTRATIGRAPHY OF MIDDLE-UPPER JURASSIC PELAGIC SILICEOUS SUCCESSIONS OF WESTERN SICILY AND THE SOUTHERN ALPS (ITALY)

Paola Beccaro

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Commit whatever you do to God,

and your plans will succeed.

The human mind plans the way,

but the Lord directs the steps.

[Holy Bible, Proverbs 16: 3, 9]

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ABSTRACT

A rich radiolarian fauna of Middle-Late Jurassic age has been recovered from pelagic siliceous successions in Western Sicily and the Southern Alps (Italy). The crucial complement to this research is the occurrence of ammonites in the same stratigraphical sections: such occurrence allows a good calibration of the radiolarian biozones. This paper represents the PhD research of the author.

In Western Sicily six stratigraphical sections have been described and sampled: Fornazzo Strada, Fornazzo Cava, Castello Inici, Balata di Baida, Favignana (all belonging to Trapanese Plateau), and Sant'Anna (Sicano Basin). In the Southern Alps two stratigraphical sections have been described and sampled (Cava Vianini and Ceniga), and the previously studied radiolarian assemblages of the Coston delle Vette section have been added for the biostratigraphical analysis. The three Alpine sections belong to Trento Plateau. Most successions represent the intermediate pelagic siliceous member (Rosso Ammonitico Medio coded as RAM) of the Rosso Ammonitico Fm. except at Sant'Anna and Coston delle Vette localities. The time-equivalent facies of the Rosso Ammonitico Medio is a basinal succession at Sant'Anna and the Fonzaso Fm. at Coston delle Vette. The radiolarian assemblages of the following sections have been studied for the first time: Fornazzo Strada, Fornazzo Cava, Castello Inici, Balata di Baida, Favignana and Cava Vianini. The radiolarian preservation is generally moderate and it is very good in some samples.

A new regional radiolarian zonation for the Middle-Late Jurassic is presented in this paper. The biochronology has been carried out by means of Unitary Associations method and the software BioGraph. The stratigraphical distribution of 99 taxa in 67 samples from 9 sections constitutes the database for the definition of 16 Unitary Associations, which have been afterwards grouped in 6 Unitary Association Zones (UAZ-SA). The UAZones range as follows: UAZ A (?early-middle Bath. to early Call. *pars*), UAZ B (early Call. *pars*-early Oxf.), UAZ C (middle Oxf.), UAZ D (?middle-?late Oxf.), UAZ E (?late Oxf.-early Kimm. *pars*), UAZ F (early Kimm. *pars*-late Kimm.). These biozones are tied to chronostratigraphy by means of the ammonites found in the studied successions and in the under- and overlying sediments. The stratigraphical correlation of the Sicilian and Alpine sections through the UAZ-SA reveals a significant diachronism for the lower as well as for the upper boundary of the Middle-Upper Jurassic pelagic siliceous facies both between Western Sicily and the Southern Alps, and within the same paleogeographical domain.

The new zonation by UAZ-SA has been compared with the zonation by UAZ95 of Baumgartner et al. (1995a) in order to discuss a tentative recalibration of some UAZ95 through the ammonites found in the studied sections.

By means of the UAZ-SA it has also been discussed the chronostratigraphical assignment of the Ceniga and Sant'Anna sections in comparison to the previous authors. The Ceniga section (Trento Plateau, Southern Alps) is now referred to ?middle Oxfordian-early Kimmeridgian *pars* (UAZ-SA D-E). The Sant'Anna section (Sicano Basin, Western Sicily) is now assigned to ?late Oxfordian-late Kimmeridgian (UAZ-SA E-F). Furthermore, for some taxa (such as *Podocapsa amphitreptera* FOREMAN, *Tetratrabs bulbosa* BAUMGARTNER, *Tetratrabs zealis* (OŽVOLDOVA) and *Acanthocircus trizonalis diacranacanthus* (SQUINABOL), emend. FOREMAN) are suggested different ranges with respect to those stated in Baumgartner et al. 1995a.

Concerning the systematics, 7 new species of radiolarians (4 Nassellaria and 3 Spumellaria) have been discovered in the studied sections, and already described in separate papers. The main feature of most radiolarian assemblages is the extraordinary abundance of Syringocapsids (Nassellaria). Sponge spicules are also abundant and well diversified in most samples: such assemblages are typical of proximal or relatively shallow water environments.

The radiolarian zonation by UAZ-SA undoubtedly contributes to the Jurassic biozonation. The high resolution sampling of sections that crop out in a restricted geographical area results in more Unitary Associations and better defined UAZzones. The radiolarian data of this research will increase the database of the INTERRAD Jurassic-Cretaceous Working Group and will contribute to create new better-defined radiolarian biozones for the Jurassic Mediterranean Tethys.

RIASSUNTO

Una ricca fauna a radiolari del Giurassico medio-superiore è stata rinvenuta in successioni silicee pelagiche della Sicilia occidentale e delle Alpi Meridionali (Italia). La caratteristica più importante della presente ricerca è la presenza di ammoniti nelle sezioni studiate e nei sedimenti sotto- e sovrastanti. La coesistenza di ammoniti e radiolari ben preservati nelle stesse successioni è infatti abbastanza rara e le nuove biozone a radiolari sono state ben calibrate dalle zone ad ammoniti. Questa pubblicazione rappresenta la ricerca completa svolta della Tesi di Dottorato dell'autore.

In Sicilia occidentale sono state descritte e campionate 6 sezioni stratigrafiche: Fornazzo Strada, Fornazzo Cava, Castello Inici, Balata di Baida e Favignana (tutte appartenenti al plateau pelagico del Dominio Trapanese), e la sezione di Sant'Anna (Bacino Sicano). Nelle Alpi Meridionali sono state descritte e campionate 2 sezioni stratigrafiche (Cava Vianini e Ceniga) e i dati relativi alle associazioni a radiolari di una terza sezione (Coston delle Vette) sono stati utilizzati per l'analisi biostratigrafica. Le tre sezioni alpine appartengono al Plateau di Trento. Le successioni studiate rappresentano la porzione silicea della Formazione del Rosso Ammonitico, chiamata Rosso Ammonitico Medio (RAM). Fanno eccezione le sezioni di Sant'Anna (dove affiorano sedimenti di bacino) e Coston delle Vette (dove affiora la Formazione di Fonzaso). In occasione di questa ricerca sono state studiate per la prima volta le associazioni a radiolari delle sezioni di Fornazzo Strada, Fornazzo Cava, Castello Inici, Balata di Baida, Favignana e Cava Vianini. La preservazione dei radiolari è discreta in tutte le sezioni e molto buona in alcuni campioni.

Nel presente lavoro viene illustrata una zonazione regionale a radiolari per il Giurassico medio-superiore. La biostratigrafia a radiolari è stata realizzata con il metodo delle Associazioni Unitarie e il software BioGraph. La distribuzione stratigrafica di 99 taxa in 67 campioni provenienti da 9 sezioni stratigrafiche costituisce il database per la definizione di 16 Associazioni Unitarie, successivamente raggruppate in 6 Zone ad Associazioni Unitarie (UAZ-SA A-F). L'intervallo stratigrafico di ciascuna UAZone è il seguente: UAZ A (Bat. ?inf.-medio - Call. inf. *pars*), UAZ B (Call. inf. *pars*-Oxf. inf.), UAZ C (Oxf. medio), UAZ D (Oxf. ?medio-?sup.), UAZ E (Oxf. ?sup.- Kimm. inf. *pars*), UAZ F (Kimm. inf. *pars*-Kimm. sup.). Le biozone UAZ-SA sono state calibrate

grazie alle ammoniti rinvenute nelle successioni studiate e nei sedimenti sovra- e sottostanti. La correlazione delle sezioni siciliane e alpine tramite le UAZ-SA ha evidenziato un significativo diacronismo per i limiti inferiore e superiore delle facies pelagiche silicee sia tra la Sicilia occidentale e le Alpi Meridionali sia all'interno di uno stesso dominio paleogeografico.

La zonazione con le UAZ-SA è stata confrontata con la zonazione di Baumgartner et al. (1995a) per tentare di ricalibrare alcune UZA95 tramite le ammoniti trovate nelle sezioni studiate.

Alla luce delle nuove biozone UAZ-SA è stata inoltre discussa la datazione dei sedimenti silicei nelle sezioni di Ceniga e Sant'Anna rispetto alla letteratura precedente. La sezione di Ceniga (Trento Plateau, Alpi Meridionali) è ora assegnata all'intervallo Oxf. ?medio-?sup. - Kimm. inf. *pars* (UAZ-SA D-E). La sezione di Sant'Anna (Bacino Sicano, Sicilia) è ora riferita all'intervallo Oxf. ?sup.-Kimm. sup. (UAZ-SA E-F). Per alcuni taxa (come ad esempio *Podocapsa amphitreptera* FOREMAN, *Tetratrabs bulbosa* BAUMGARTNER, *Tetratrabs zealis* (OŽVOLDOVA) e *Acanthocircus trizonalis diacranacanthus* (SQUINABOL), emend. FOREMAN) viene suggerita una distribuzione stratigrafica leggermente diversa rispetto a quella proposta da Baumgartner et al. 1995a.

Per quanto riguarda la sistematica sono state identificate 7 nuove specie (4 Nassellaria e 3 Spumellaria) già descritte in altre pubblicazioni. La caratteristica principale delle associazioni a radiolari studiate è l'abbondante presenza di Syringocapsidi (Nassellaria). Le spicole di spugna sono abbondanti e ben diversificate nella maggior parte dei campioni suggerendo un ambiente di deposizione prossimale o di acque relativamente basse.

La zonazione a radiolari tramite le UAZ-SA rappresenta un contributo molto importante per la biozonazione della Tetide giurassica. Il fitto campionamento di sezioni situate in una ristretta area geografica permette la realizzazione di un maggior numero di Associazioni Unitarie e migliora la definizione delle Zone ad Associazioni Unitarie. Tutti i dati emersi durante questa ricerca incrementeranno il database dell' INTERRAD Jurassic-Cretaceous Working Group e contribuiranno a creare nuove e meglio definite biozone a radiolari per la Tetide giurassica mediterranea.

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Chapter 1

General Introduction

This research concerns the radiolarian biostratigraphy of Middle-Upper Jurassic pelagic siliceous successions (Rosso Ammonitico Medio and time-equivalent facies) in Western Sicily and the Southern Alps (Italy). The main goal is to enrich the database for a better defined radiolarian zonation of the Mediterranean Jurassic Tethys. The crucial complement to this research is the occurrence of radiolarians and ammonites in the same stratigraphical sections, so that the radiolarian zones can be well calibrated by the ammonites zones.

The study of siliceous successions in Western Sicily and the Southern Alps benefits from the fact that such successions are approximately coeval and may be referred to analogous paleogeographical contexts. These similarities enable us to compare radiolarian assemblages of different geographical areas, and to correlate different Tethyan paleogeographical domains. The combined occurrence of radiolarians and ammonites provide both a new Bathonian to late Kimmeridgian radiolarian zonation, and the first radiolarian correlation of the Rosso Ammonitico Medio and time-equivalent facies for Western Sicily and the Southern Alps (Italy).

1.1 - Aim of the research and structure of the paper

The research is centred on the radiolarian biostratigraphy of Middle-Upper Jurassic pelagic siliceous successions of Western Sicily and the Southern Alps (Italy). The most important objectives are:

1) the first description of the radiolarian assemblages of the Rosso Ammonitico Medio in the following sections: Fornazzo Strada, Fornazzo Cava, Castello Inici, Balata di Baida, Favignana and Cava Vianini;
2) the definition of new radiolarian biozones;
3) the calibration of radiolarian biozones by ammonite zones;
4) the biostratigraphical correlation of the studied sections by means of new radiolarian biozones;
5) the comparison of the new radiolarian biozones with the biozones of Baumgartner et al. (1995a).

The General introduction (Chapter 1) concerns the historical literature review of Western Sicily, the Southern Alps and the radiolarian biochronology, and the methods used for carrying out the research. The Chapter 2 and Chapter 3 deal with Western Sicily illustrating the geological setting and the stratigraphical sections. The description of the sections includes the geographical location, the lithology, the radiolarian assemblages and the ammonite data. The Chapter 4 and Chapter 5 regard the Southern Alps through the same topic structure as for Western Sicily. The Chapter 6 and Chapter 7 are dedicated to the radiolarian biochronology: definition of new biozones, calibration with ammonites zones, correlation of stratigraphical sections, diachronism of siliceous facies and comparison with the zonation of Baumgartner et al. 1995a. Finally, the Chapter 8 concerns taxonomic remarks on some genera and species, the main references of those species not included in Baumgartner et al. 1995b, and brief considerations about the sponge spicules content.

In this volume the complete dataset regarding the investigated sections is reported: lithological description, radiolarian content for each sample, detailed explanation of the biozones, illustrations of most recognized species. Preliminary results concerning the radiolarian biostratigraphy of the Trapanese sections (Inici Mt. area, North-western Sicily) were published in Beccaro 2004a. A short review of the zonation by UAZ-SA was partially published in Beccaro (*in press*). The description of seven new taxa of radiolarians (4 Nassellaria and 3 Spumellaria) have been illustrated in Beccaro 2004b, 2004c.

1.2 - Previous works

The Jurassic radiolarian assemblages of Western Sicily and the Southern Alps have been studied by very few authors, and the first papers appeared in 1970s only. On the other hand, many geologists studied the same areas and stratigraphical sections for different goals.

Several authors studied the geology of Western Sicily for sedimentological purposes (Jenkyns 1970; Giunta & Liguori 1972, 1973; Catalano et al. 1989; Catalano et al. 2002), and for ammonites stratigraphy (Wendt 1964, 1971; Bovero 2000; Savary 2000; Cecca et al. 2001; Martire & Pavia 2002). However, the only radiolarian papers regard the Sicano Basin (South-western Sicily): Sant'Anna section has been described by several authors (Mascle 1973, 1979; Riedel & Sanfilippo 1974; Baumgartner et al. 1980; Origlia-Devos 1983; Baumgartner 1984; De Wever et al. 1986; Aita 1987; De Wever 1995) because of its rich fossil content (radiolarians, ammonites, calpionellids, nannofossils); other sections were studied by Kito et al. (1990) and Kito & De Wever (1992, 1994).

First radiolarian papers for the Southern Alps were written by Baumgartner et al. (1980) and Kocher (1981), and concerned some sections belonging to the Lombardian Basin. In the Trento Plateau, the Ceniga section was first described by Fogelgesang (1975), and then studied for radiolarians by Baumgartner (1984) and Baumgartner et al. (1995c). Coston delle Vette section was first described by Dal Piaz (1907), then analysed by Bosellini & Dal Cin (1968) and Della Bruna & Martire (1985), and finally studied for radiolarians by Beccaro (1998) and Beccaro et al. (2002). Cava Vianini was only described by Papa (1994) for sedimentological purposes.

The ammonite data used in this research were provided by Dal Piaz (1907), Della Bruna & Martire (1985), De Wever et al. (1986), Papa (1994), Bovero (2000), Savary (2000).

The radiolarian biochronology developed at the beginning of 1970s when studies provided by the Deep Sea Drilling Project (Moore 1973; Foreman 1973, 1975, 1978; Riedel & Sanfilippo 1974; Pessagno 1976, 1977a, 1977b) clearly demonstrated the biostratigraphical potential of radiolarians. Afterwards, several authors analyzed Mesozoic radiolarian assemblages in Europe (De Wever et al. 1979; Baumgartner et al. 1980; Baumgartner 1984; Goričan 1994; Jud 1994), in North America (Murchey 1984; Pessagno et al. 1984; Pessagno et al. 1987a; Pessagno et al. 1987b; Pessagno et al. 1993), and in Japan (Matsuoka 1982, 1983, 1992, 1993 among the others). In the 1977 the first meeting of radiolarian scientists EURORAD I was held, and their collaboration continued till 1989 when the INTERRAD Jurassic-Cretaceous Working Group was born. The main goals of the INTERRAD Working Group were to define a common radiolarian database and to achieve a biostratigraphical correlation by means of well-calibrated radiolarian biozones for the Middle Jurassic-Early Cretaceous Tethyan realm. INTERRAD researchers well succeeded with the volume of Baumgartner et al. (1995d) that is still the most important publication on radiolarian biochronology.

1.3 - Methods

Nine stratigraphical sections have been studied from Western Sicily and the Southern Alps (Italy), and more than 100 samples were collected for analysing the radiolarian content. The research was divided into four phases: field work, laboratory treatments, microscope study and biostratigraphical analysis.

1.3.1 Field work

Six sections in Western Sicily and three sections in the Southern Alps have been described. The sampling intervals depend on the radiolarian content of the layers. At the Cava Vianini (Southern Alps) and Sant'Anna (South-western Sicily) some samples showed a very good preservation, and large groups (such as Hagiastrids, Syringocapsids, Tetratrabids) were recognizable with lens (20x) after a brief treatment with hydrocloridric acid on the surface of the rocks.

1.3.2 Laboratory treatments

The studied successions are mainly constituted by siliceous limestone alternating with chert beds. Due to the very similar lithology in all the sections, the same laboratory treatments were used for most samples. The laboratory treatments followed the standard method (Dumitrica 1970; Pessagno & Newport 1972; De Wever 1982; De Wever et al. 2001). The first step is the treatment with hydrochloric acid (HCl) whose concentrations varied between 3,6% and 10% for a period of 3-24 hours repeted several times depending on the lithology. Because of the great siliceous component of most samples, the HCl residues did not generally show a good radiolarian content. The second step is the treatment with hydrofluoric acid (HF), whose concentrations varied between 1% and 8% for a period of 4-96 hours repeted several times depending on the lithology. The HF residues usually contained a more abundant and more diversified fauna than the HCl residues. The preservation quality of the radiolarians is expressed by means of the Preservation Index (PI; Kiessling 1996). The average radiolarian preservation is moderate and in some samples of Coston delle Vette and Cava Vianini it is very good.

1.3.3 Microscope analysis

Radiolarians are microfossils whose dimensions mostly vary from 50μ to 200μ, and such dimensions require the use of two different microscopes. The stereoscopic microscope was employed to pick up the specimens of all species contained in a micropaleontological residue. All isolated species were then observed under the Scanning Electron Microscope (SEM) to take photos of the individuals and their structures (pore pattern, sutural aperture, apical horn, etc...) for the taxonomic identification. For detailed information about the microscope analysis see De Wever et al. (2001).

1.3.4 Unitary Associations method

The radiolarian biostratigraphical analysis of the Middle-Upper Jurassic pelagic siliceous successions has been carried out through the Unitary Associations method (Guex 1977, 1991) and the software BioGraph (Savary & Guex 1991, 1999). The Unitary Associations method gathers co-occurrence data from all given sections, compensates the diachronism of FADs and LADs among the sections, and produces maximum ranges for the taxa. The Mesozoic radiolarian preservation is greatly dissolution-controlled, and the application of common biozones based on first/last appearances of taxa is not possible. Poorly preserved samples are common and to include them in the biostratigraphical analysis is very important in order to define a generally applicable zonation. For a full explanation of the Unitary Associations method and the functionality of BioGraph see Guex (1977, 1991) and Savary & Guex (1991, 1999), respectively.

The Unitary Associations method has become standard in radiolarian biochronology (for example, Baumgartner 1984, Goričan 1994, Jud 1994, Baumgartner et al. 1995a) because it seems the best way to elaborate a biochronology that holds the high discontinuous nature of radiolarian fossil record.

Chapter 2

Geological setting of Western Sicily (Italy)

Sicily is a very interesting sector for understanding the geodynamic evolution of the Mediterranean area. The Sicilian Chain represents a segment of the Alpine collisional belt along the boundary between the European and African plates. The Sicilian belt connects the Italian Apennines to the African Maghrebides (Fig. 2.1a), and it is constituted by imbricate units with African vergence (Di Stefano & Gullo 1997). The Maghrebian-Sicilian Chain is formed of a Paleozoic crystalline basement and a Mesozoic sedimentary cover, which belonged to the Tethyan Ocean and the African continental margin. During the Alpine orogenesis new paleogeographical domains formed and Tertiary sediments deposited (Catalano et al. 2002). Nowadays the Jurassic domains are dispersed in the structural mosaic of the Maghrebian-Sicilian belt (Fig. 2.1b) showing complex tectonic relationships, and the mutual position of the Mesozoic paleogeographical domains is still discussed (Catalano et al. 2002).

2.1 - Paleogeographical evolution

The geological history of the Sicily area began in the Late Permian when a wide basin connected the main Tethys to the future Mediterranean area (Catalano et al. 1995).

During the Triassic extensional tectonic movements modified the Permian paleogeography and generated platforms, reefs and basins. These paleoenvironments represented the embryonic stages of the well developed Middle-Late Jurassic paleogeographical domains (Ibleo, Imerese, Panormide, Saccense, Sicano, Trapanese) (Di Stefano & Gullo 1997). The end of the Triassic was characterized by a wide peritidal-lagoonal area (Siculo-Tunisian carbonate platform) bordered by a wide basinal area (Sicano Domain). An irregular and narrow slope (Imerese Domain) separated the Siculo-Tunisian platform from the Sicano Basin (Catalano et al. 1995; Di Stefano 2002) (Fig. 2.2). The Triassic platform limestone represent a common base to follow the subsequent evolution of the different paleogeographical domains in the Sicilian sector.

At the Triassic-Jurassic boundary the tectonic movements progressively dissected the Siculo-Tunisian carbonate platform. In the middle Early Jurassic the tectonic activity dissected definitively the Siculo-Tunisian platform, and generated several blocks with different subsidence rates and timing of drowning. As a consequence, the cessation of oolitic/bioclastic production and a drop of sedimentation rate in the peritidal areas occurred. At the end of the Early Jurassic the Siculo-Tunisian platform turned completely into a complex mosaic of basins (Sicano and Imerese Domains), pelagic plateaux (Trapanese and Saccense Domains) and limited sectors of platform (Panormide and Ibleo Domains) (Di Stefano 2002).

During the Middle-Late Jurassic extensional tectonic movements continued to modify the paleogeography and a general deepening let the basinal areas to reach their maximum depth. The Late Jurassic was the time of the deposition of condensed nodular ammonite-bearing Rosso Ammonitico Fm. on the pelagic plateaux, and of the Tethyan acme of the siliceous sediments (Baumgartner 1987). The still existing sectors of platform recorded different evolutions (as emersion) during the Middle Jurassic, but during the Late Jurassic they were progressively flooded and platform conditions re-established (Di Stefano 2002). The end of the Late Jurassic is marked by a diffuse tendency towards an environmental uniformity: in the basins and on the plateaux the

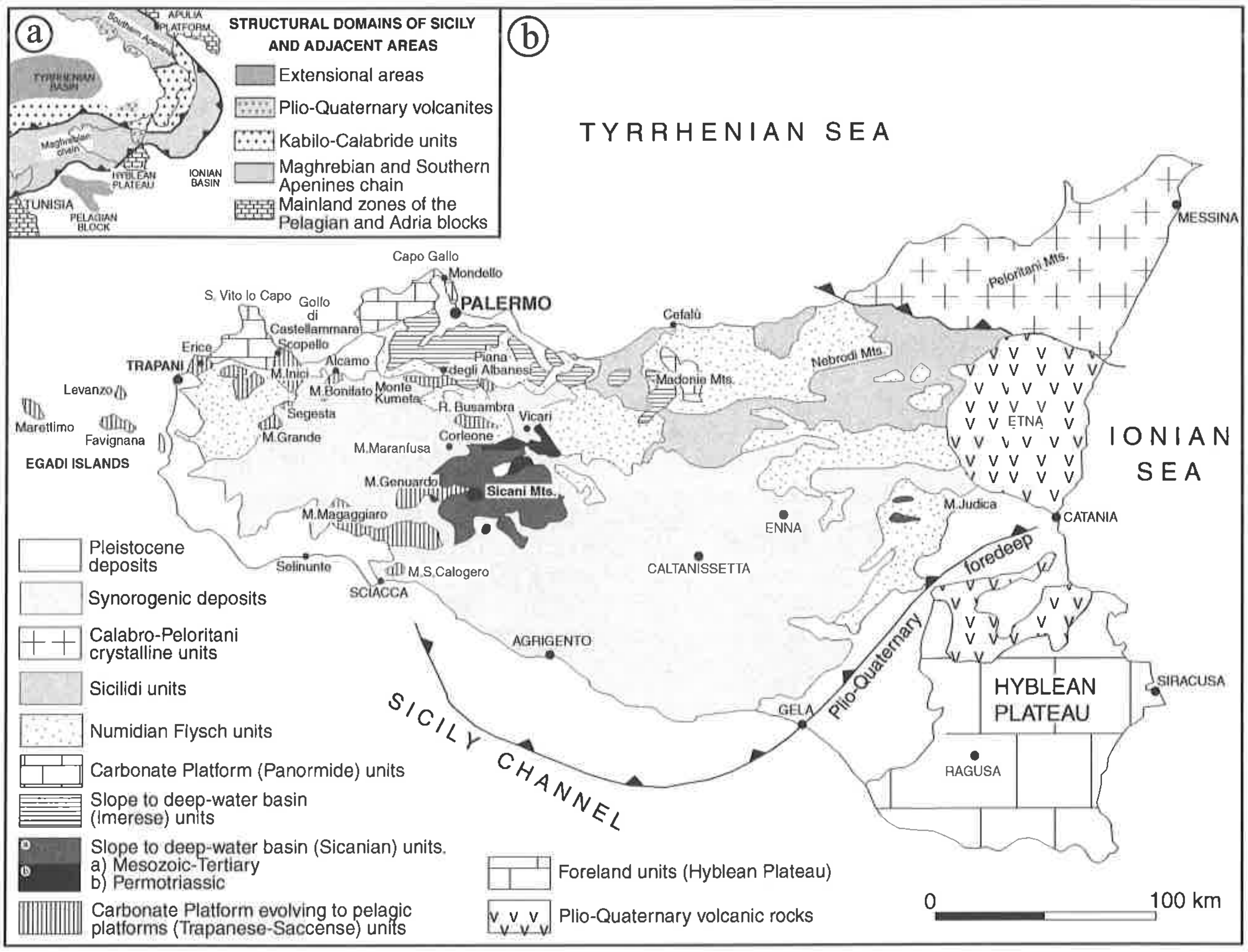


Fig. 2.1 - a: Structural domains of Sicily and adjacent areas: the Sicilian belt connects the Italian Apennines to the African Maghrebides (Catalano et al. 1996). **b:** Structural sketch map of Sicily (Di Stefano 2002).

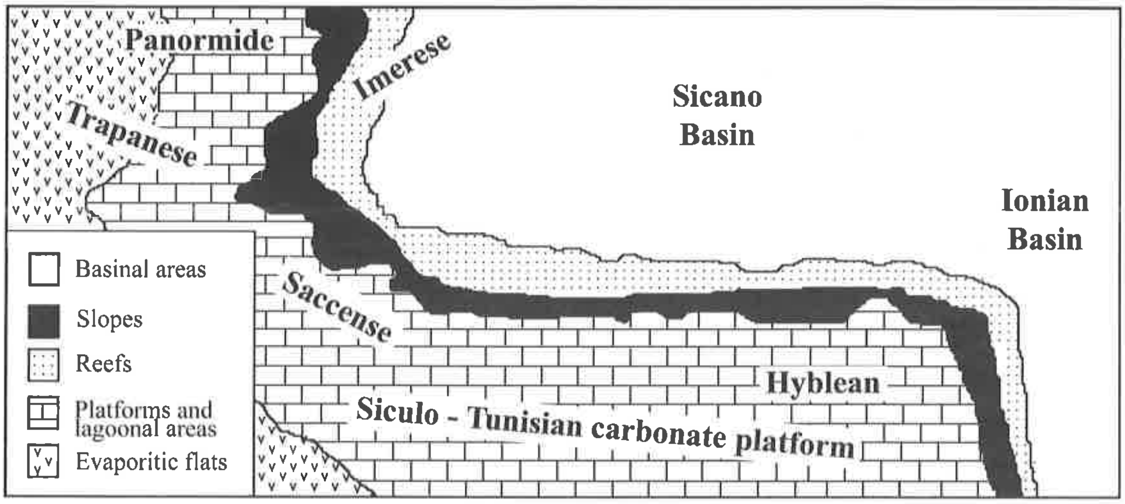


Fig. 2.2 - An attempt of paleogeographical reconstruction of the Sicilian margin at the Late Triassic time (Di Stefano & Gullo 1997).

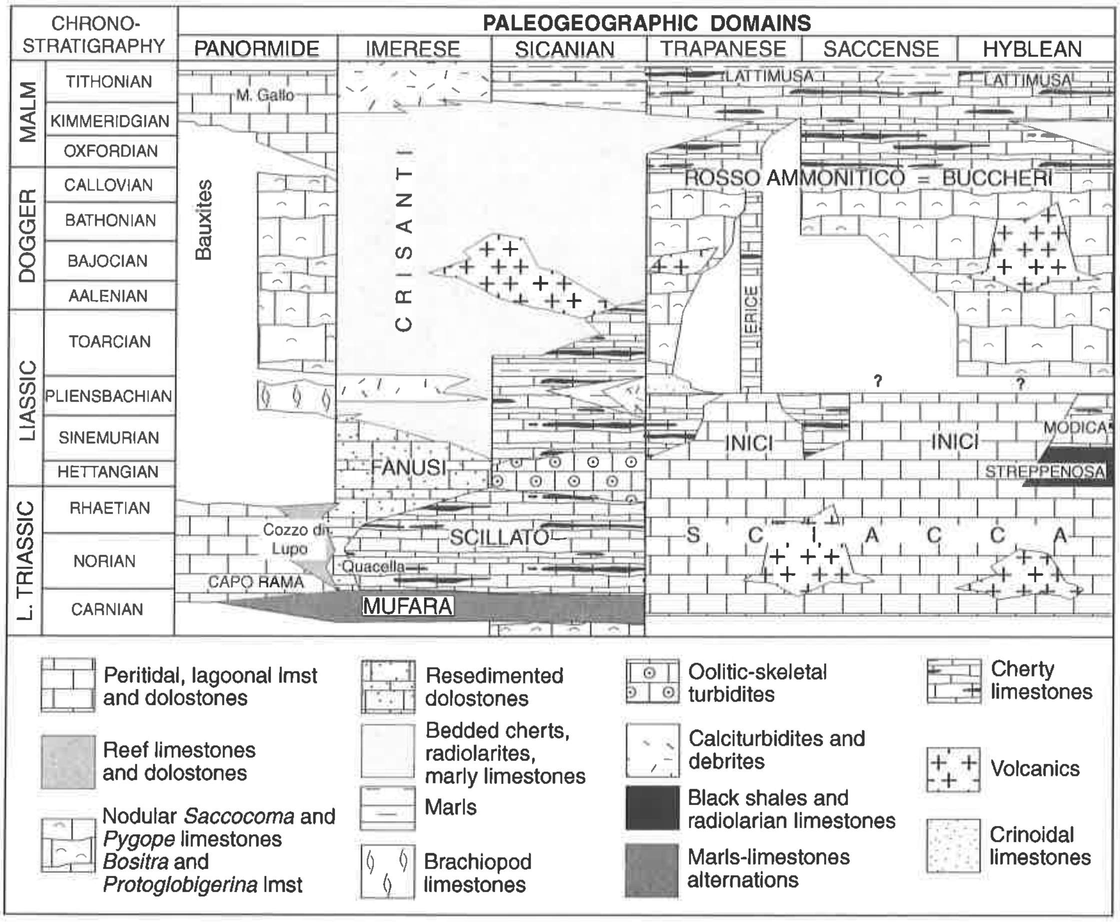


Fig. 2.3 - Late Triassic-Late Jurassic chronostratigraphy of the main sedimentary domains of Western and Southern Sicily (Di Stefano 2002).

pelagic sediments gradually turned into fine grained white calpionellid limestone (Lattimusa Fm.). In the Fig. 2.3 is summarized the stratigraphy of Sicily from the Late Triassic to Late Jurassic.

2.2 - Trapanese Domain

The Trapanese Domain reflects the drowning of the peritidal Late Triassic-Early Jurassic carbonate platform, which leads to the development of a pelagic carbonate plateau covered with Middle Jurassic to Cretaceous pelagic sediments. The difference in thickness and age of the first pelagic deposits varies greatly from one sector to another as a consequence of the different rates of subsidence. In the studied area (Inici Mt.) the typical red nodular ammonite-bearing limestone of the Rosso Ammonitico Fm. can be subdivided into three units:

1) Rosso Ammonitico Inferiore (RAI): packstone and grainstone containing thin bivalve shells and ammonites; a hardground characterizes the boundary with RAM (Wendt 1964; Bovero 2000);

2) Rosso Ammonitico Medio (RAM): red siliceous well-bedded or nodular wackestone alternating with marly limestone and chert beds; the siliceous microfossils content is abundant and the RAM represents the studied successions for this research;

3) Rosso Ammonitico Superiore (RAS): strongly nodular limestone (packstone and grainstone) alternating with nodular chert beds; thin marly layers are sometimes interbedded (Wendt 1964; Bovero 2000).

The Rosso Ammonitico Fm. is followed by white pelagic micrites rich in nannoplankton (Lattimusa Fm.) that mark an environmental uniformity since the Late Jurassic (Fig. 2.3).

2.3 - Sicano Domain

The Sicano Domain was a deep basin since the Permian, and it recorded up to 2000m of Upper Paleozoic to Tertiary basinal deposits (Catalano et al. 1988, 1991). The Late Triassic-Early Jurassic pelagic sedimentation was periodically interrupted by megabreccias along fault-controlled escarpments, indicating a high tectonic instability. At the end of the Early Jurassic the Sicano Basin recorded the progressive changing from carbonate to siliceous sedimentation, and during the Middle Jurassic the siliceous sediments were the most widespread (Di Stefano 2002). In the Late Jurassic deep water limestone and marls replaced the siliceous sedimentation, and during the latest Tithonian to earliest Cretaceous the deposition of Lattimusa Fm. (white pelagic micrites rich in nannoplankton) occurred all over the region (Fig. 2.3).

Chapter 3

Description of the studied sections

The studied successions belonging to the Trapanese Domain represent the Rosso Ammonitico Medio (RAM), i.e., the intermediate pelagic siliceous member of the Rosso Ammonitico Fm. At the Favignana section the relations between the pelagic siliceous sediments and the close cropping out Rosso Ammonitico Fm. are not clear. At the Sant'Anna section (Sicano Domain) the base of the basinal siliceous succession is not visible, and the top is separated by a small fault from the following sediments. The geographical location of the Sicilian sections is illustrated in Fig. 3.1.

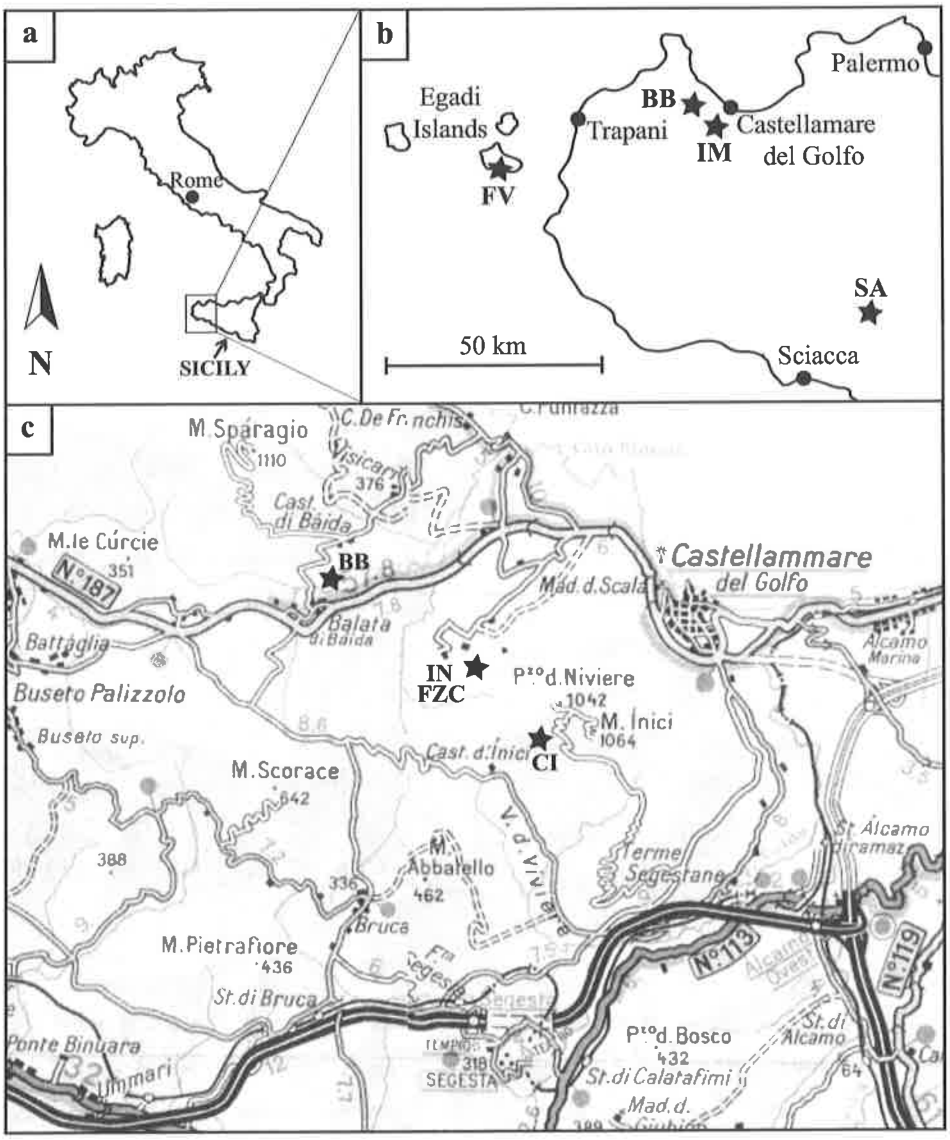


Fig. 3.1 - a: Sicily location in Italy. **b:** Geographical location of the stratigraphical sections in Western Sicily. BB: Balata di Baida, FV: Favignana, IM: Inici Mt. sections, SA: Sant'Anna. **c:** Geographical location of the Inici Mt. sections in North-western Sicily. CI: Castello Inici, FZC: Fornazzo Cava, IN: Fornazzo Strada. Atlante Stradale Touring Club, 1:150.000.

TRAPANESE DOMAIN

3.1 - Fornazzo Strada

3.1.1 Lithological description

The Fornazzo Strada section is located at Fornazzo locality on the Inici Mt., close to Castellammare del Golfo (North-western Sicily; Fig. 3.1). The section crops out along a dirt road at about 500m above sea level (Fig. 3.2).

The RAM is 26m thick and overlies the RAI: the contact is sharp and marked by an undulated surface (Pl. 12, Fig. 1). The base of the RAM is represented by about 1m of whitish-greenish clayey marlstone and pinkish marly limestone, both very altered; the stratification is thin and scattered small chert nodules occur. The RAM essentially consists of an alternation of thinly and evenly bedded red siliceous limestone and calcareous marlstone (Pl. 12, Fig. 2) with abundant chert along the whole section (Fig. 3.3). The siliceous limestone is mainly red, rarely whitish-greyish; the stratification is evident and the layers are 5-15cm thick; thin thickening-upward sequences are also present. The siliceous limestone shows a variable content of red chert nodules of different sizes and some of them have a green rim. At the middle of the section *Saccocoma* appears, and its abundance gradually increases towards the top. The calcareous marlstone is greyish, rarely reddish; the layers are very thin (3-5cm) and often grouped into thicker packages (20-40cm). The chert is widely diffused in the succession, both as beds and as nodules, and the colour is varying (red, brown, black and yellow). The beds are approximately 10-15cm thick and normally red-brown; the nodules range from 3-6cm to 10-12cm in size and the colour is more variable than in the beds. A diffuse silicification is present where beds and nodules are absent. Towards the top of the RAM the limestone shows a greater clay component, the abundance of chert nodules increases, the chert layers prevail and a nodular structure begins to develop in the limestone. The contact with the RAS is very gradual.

3.1.2 Radiolarian assemblages

34 samples have been collected and the picking of the radiolarians has been done for 16 samples. The preservation is generally moderate and the PI varies from 3 (good) to 6 (poor). The taxa are listed in App. 1 (Tab. 3.1). Sponge spicules are common and well diversified in most samples.

3.1.3 Ammonite data

Bovero (2000) recorded the following ammonites:

- *Lessiniceras* sp. ind. at 15.50m: it belongs to *Strombecki* Zone and indicates an early Kimmeridgian age for the middle-upper part of the section;
- *Nebrodites cavouri* (GEMMELLARO) at 22m: it belongs to *Cavouri* Zone and refers the upper part of the RAM to the middle late Kimmeridgian;
- a good assemblage at the very base of the RAS consisting of *Hybonoticeras beckeri* (NEUMAYR), *Hybonoticeras ornatum* (SPATH), *Taramelliceras pugile* (NEUMAYR), *Hemihaploceras nobile* (NEUMAYR), *Discophinctoides* sp.; this assemblage belongs to *Beckeri* Zone and dates the base of the RAS as late Kimmeridgian.

3.2 - Fornazzo Cava

3.2.1 Lithological description

The Fornazzo Cava section is situated at Fornazzo locality on the Inici Mt., close to Castellammare del Golfo (North-western Sicily; Fig. 3.1). The section crops out in an old quarry at about 500m above sea level (Fig. 3.2).

The RAM is incomplete and crops out for 8m only (Fig. 3.4). The contact between the RAI and the RAM is sharp and pointed out by a thin hardground. The base of the RAM is represented by about 1m of

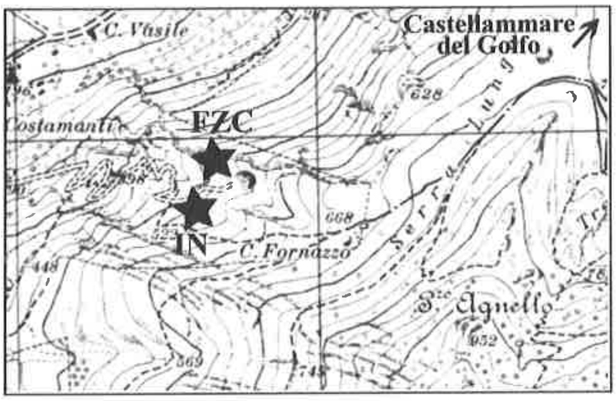


Fig. 3.2 - Geographical location of the Fornazzo Strada (IN) and Fornazzo Cava (FZC) sections (north-western side of the Inici Mt., North-western Sicily, Italy). Foglio n° 248 "Castellammare del Golfo", Carta d'Italia, 1:25.000, IGM.

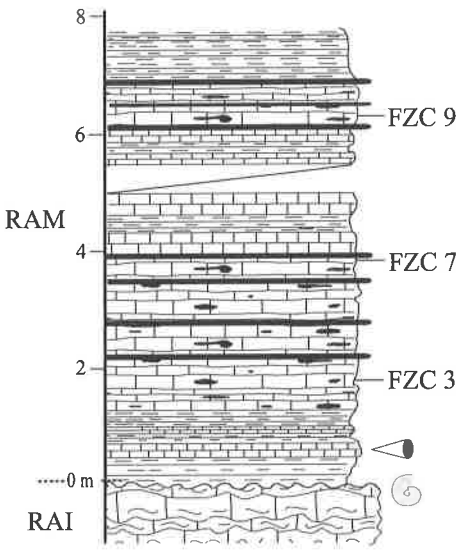


Fig. 3.4 - Fornazzo Cava

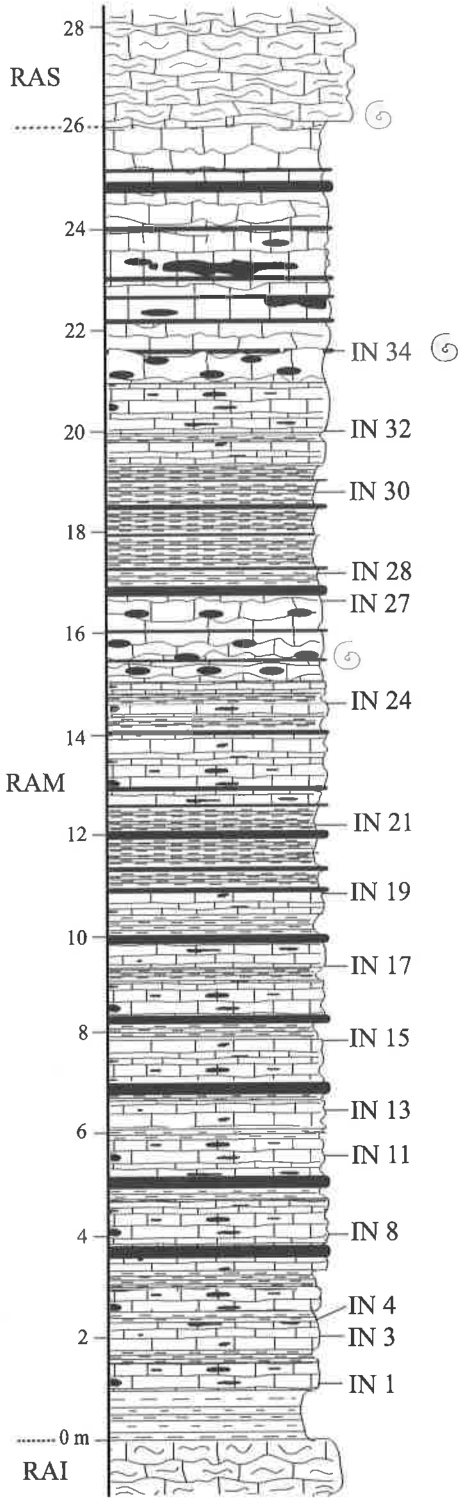


Fig. 3.3 - Fornazzo Strada

Figs. 3.3 and 3.4 - Stratigraphical columns of the RAM (Rosso Ammonitico Medio, i.e., the intermediate pelagic siliceous member of the Rosso Ammonitico Fm.) at the Fornazzo Strada (Fig. 3.3) and Fornazzo Cava (Fig. 3.4) sections (Trapanese Domain, North-western Sicily, Italy).

Legend

- Siliceous limestone
- Stratified limestone
- Marlstone
- RAI and RAS
- Chert nodules and beds
- Ammonites
- Belemnites

whitish-greenish clayey marlstone and pinkish marly limestone beds (both very altered); the stratification is very thin, *Chondrites* occurs and chert nodules are absent. The RAM shows the same lithotypes and organization (Pl. 12, Fig. 3) as in Fornazzo Strada, and the main difference is the occurrence of some macrofossils (poorly preserved ammonite moulds and belemnites) along the Fornazzo Cava section.

3.2.2 Radiolarian assemblages

12 samples have been collected, and the picking of the radiolarians has been done for 3 samples. The preservation is slightly better than at Fornazzo Strada and the PI varies from 3 (good) to 5 (fair). The taxa are listed in App. 1 (Tab. 3.1). Sponge spicules are common and well diversified.

3.2.3 Ammonite data

The occurrence of *Gregoryceras* species at the top of the RAI refers it to the *Transversarium* Zone, topmost middle Oxfordian (Bovero 2000).

3.3 - Castello Inici

3.3.1 Lithological description

The Castello Inici section is located in the south-western side of the Inici Mt. (Fig. 3.1), and it crops out along a dirt road at 550m above sea level (Fig. 3.5).

The RAM is incomplete and it is 12m thick (Fig. 3.6). The section starts with 1.5m of thin alternation of siliceous limestone and limestone. The lithotypes and their organization are very similar to the Fornazzo sections. Between the 7th and 9th meter, the siliceous limestone are interbedded with decimetric marly limestone. Chert layers and nodules are widespread along the whole section and a diffuse silicification is present where beds and nodules are absent. In comparison with the Fornazzo sections, Castello Inici revealed an abundant presence of macrofossils: ammonites, belemnites, aptychi, rhyncholites and bioturbations.

3.3.2 Radiolarian assemblages

15 samples have been collected and the picking of the radiolarians has been done for 9 of them. The preservation is generally moderate and the PI varies from 3 (good) to 6 (poor). The taxa are listed in App. 1 (Tab. 3.1). Sponge spicules are quite common.

3.3.3 Ammonite data

A good assemblage of ammonites occurs at the top of RAI (Savary 2000): *Sowerbyceras* cf. *tortisulcatum* (D'ORBIGNY), *Euaspidoceras* cf. *douvillei* (COLLOT IN DORN), *Euaspidoceras* cf. *litoceroide* (GEMMELLARO), *Tornquistes (Tornquistes)* cf. *romani* (DOUVILLE), *Gregoryceras (Pseudogregoryceras) iteni* JEANNET, *Perisphinctes (Dichotomosphinctes)* gr. *antecedens* SALFELD. This assemblage belongs to the *Plicatilis* Zone of middle Oxfordian age.

Between the 2nd and the 4th meter of RAM other ammonites occur: *Gregoryceras* cf. *riazi* (DE GROSSOUVRE), *Sowerbyceras* sp., *Perisphinctes* sp. This assemblage belongs to the *Transversarium* Zone, topmost middle Oxfordian (Savary 2000).

3.4 - Balata di Baida

3.4.1 Lithological description

Balata di Baida is a small village on the road S.S.187 Trapani-Castellammare del Golfo (Fig. 3.1). The section crops out along the left side of the Sarcona River at 150m above sea level (Fig. 3.7).

At Balata di Baida the entire Rosso Ammonitico Fm. crops out and the RAM is about 21m thick (Fig. 3.8). The contact with the RAI is gradual and the base of the RAM has been fixed at the first layer of red siliceous limestone with red and black chert nodules. The RAM is very similar to the Inici Mts. sections: the

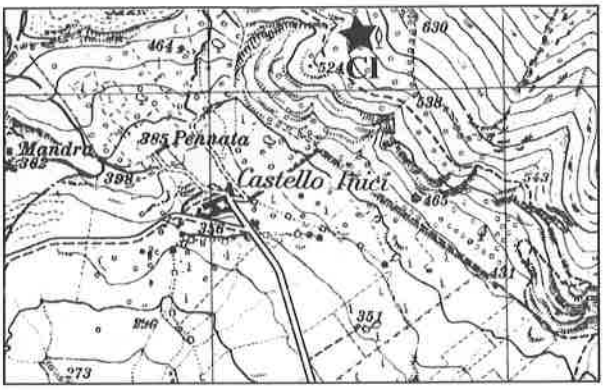


Fig. 3.5 - Geographical location of the Castello Inici section (south-western side of the Inici Mt., North-western Sicily, Italy). Foglio n° 257 "Segesta", Carta d'Italia, 1:25.000, IGM.

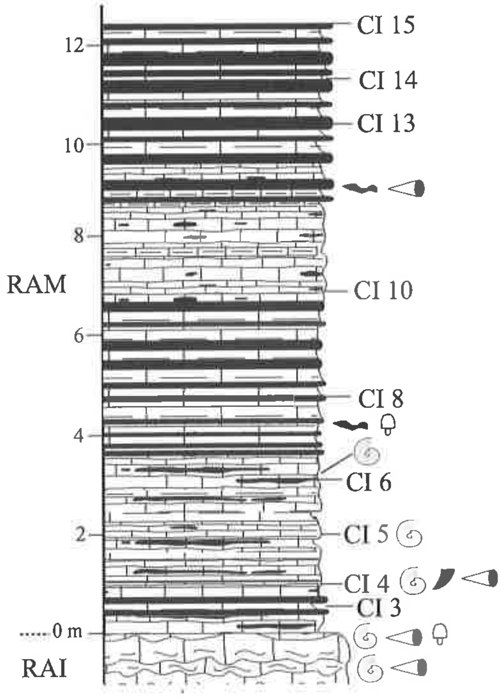


Fig. 3.6 - Castello Inici

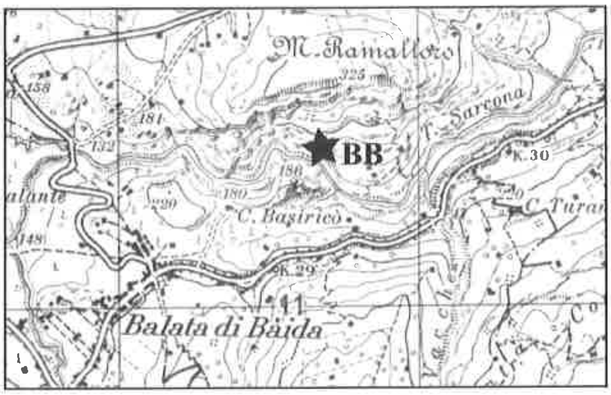


Fig. 3.7 - Geographical location of the Balata di Baida section (road S.S.187 Castellammare del Golfo-Trapani, North-western Sicily, Italy). Foglio n° 248 "Buseto Palizzolo", Carta d'Italia, 1:25.000, IGM.

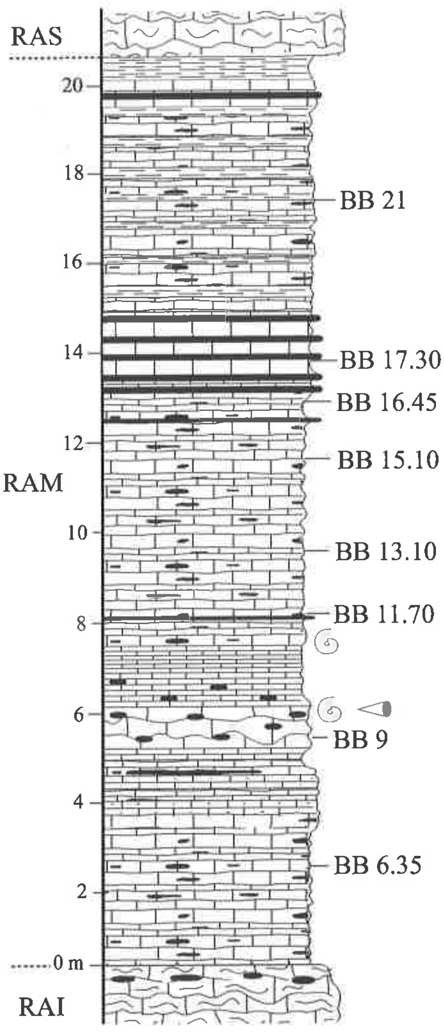


Fig. 3.8 - Balata di Baida

Figs. 3.6 and 3.8 - Stratigraphical columns of the RAM (Rosso Ammonitico Medio, i.e., the intermediate pelagic siliceous member of the Rosso Ammonitico Fm.) at the Castello Inici (Fig. 3.6) and Balata di Baida (Fig. 3.8) sections (Trapanese Domain, North-western Sicily, Italy).

Legend

- Siliceous limestone
- Stratified limestone
- Marlstone
- Marly limestone
- RAI and RAS
- Chert nodules and beds
- Ammonites
- Belemnites
- Rhyncolites
- Bioturbations

succession mainly consists of red siliceous limestone locally interbedded with limestone (stratified and nodular) and marlstone (Pl. 12.4). The marlstone are quite abundant in the last 6 meters of the section. The chert is mostly present as diffuse silicification. Chert nodules occur but their abundance and size are smaller than at the Inici Mts. sections; chert beds are mainly concentrated around the 14th meter. The contact with the RAS is sharp and well exposed.

3.4.2 Radiolarian assemblages

8 samples have been collected and analysed. The preservation is scarce and the PI varies from 4 (average) to 6 (poor). The taxa are reported in App. 1 (Tab. 3.2). The sponge spicules are very common.

3.5 - Favignana

3.5.1 Lithological description

Favignana is one of the Egadi Islands (North-western Sicily) (Figs. 3.1 and 3.9). The stratigraphical section is located on the west-southern coast along the Calamonaci beach. The section is constituted by pelagic siliceous succession whose neither the base nor the top are visible, and the relations with the close cropping out RAI and RAS are not clear.

The section crops out in a very small cave and is 2m thick. The succession consists of a quite regular alternation of siliceous limestone and marlstone, and chert beds (Fig. 3.10). The siliceous limestone is whitish-greenish in colour and the layers are 5-10cm thick. The marlstone is whitish and the levels are 2-5cm thick. The chert is present as thin beds (3-5cm thick) and the colour is red and black.

3.5.2 Radiolarian assemblages

2 samples have been collected and studied. The preservation is good (PI=3), and the taxa are listed in App. 1 (Tab. 3.3). The sponge spicules are abundant and well diversified.

SICANO DOMAIN

3.6 - Sant'anna

3.6.1 Lithological description

Sant'Anna village is located near Caltabellotta, north-east of Sciacca (South-western Sicily; Fig. 3.1). The section crops out at about 1km NE of the Sant'Anna village, a few meters after a chapel along the road to Villafranca Sicula, at 370m above sea level (Fig. 3.11). The studied section is a basinal succession whose base is not visible, and the top is separated by a small fault from the following sediments.

The section is 9m thick and consists of pelagic siliceous limestone alternating with marlstone (Fig. 3.12). The siliceous limestone layers are 5-15cm thick, pink-grey in colour and intercalated with cm-thick greenish siltstone beds. The marlstone beds are 2-5cm thick and white in colour. The alternation limestone-marlstone (Pl. 12, Fig. 5) is quite regular along the section. The chert is scarcely represented: green thin beds occur at the base of the section and hazel-coloured nodules occur in the siliceous limestone between the 4th and 5th meter; the chert is mostly present as diffuse silicification.

About 50cm of cover separate the top of the siliceous sediments from the following white nodular limestone with ammonites.

3.6.2 Radiolarian assemblages

11 samples have been collected and the picking of the radiolarians has been done for 3 samples. The preservation is moderate (PI=4), and the list of the taxa is reported in App. 1 (Tab. 3.4). Nannofossils are present as casts on the radiolarian shell surfaces (Pl. 11, Fig. 22). Sponge spicules are rare and their morphological variability is low.

Fig. 3.9 - Geographical location of the Favignana section (southern coast of Favignana Island, Egadi Archipelago, North-western Sicily, Italy). Foglio n° 256 "Isola Favignana", 1:25.000, IGM.

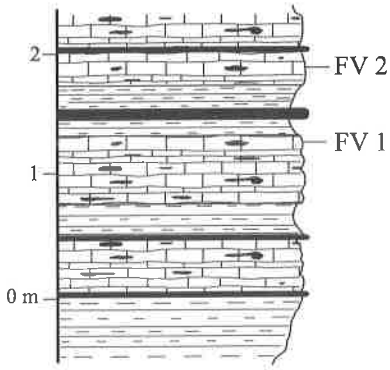


Fig. 3.10 - Stratigraphical column of the pelagic siliceous succession at the Favignana section (Trapanese Domain, North-western Sicily, Italy).

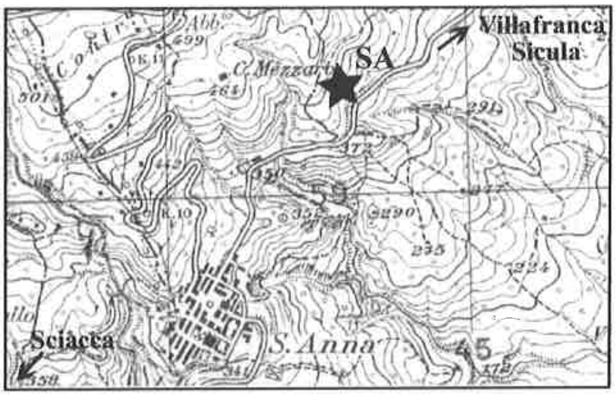


Fig. 3.11 - Geographical location of the Sant'Anna section (Sciacca area, South-western Sicily, Italy). Foglio n° 266 "Caltabellotta", Carta d'Italia, 1:25.000, IGM.

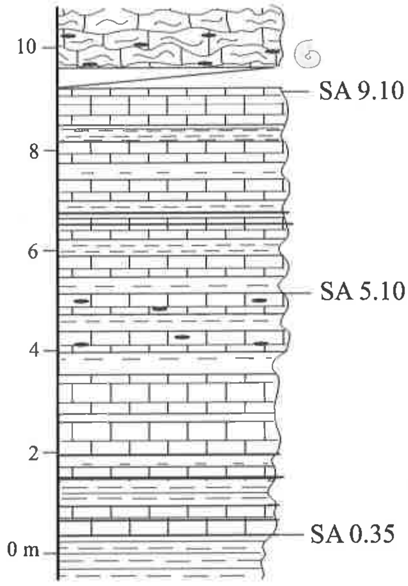


Fig. 3.12 - Stratigraphical column of the basinal siliceous succession at the Sant'Anna section (Sicano Domain, South-western Sicily, Italy).

Legend

Siliceous limestone	Nodular limestone
Stratified limestone	Chert nodules and beds
Marlstone	Ammonites

3.6.3 Ammonite data

No ammonites have been found in the studied siliceous sediments. De Wever et al. (1986) reported a good assemblage of ammonites at the very base of the limestones that follow the investigated section. The ammonite assemblage consists of *Hybonoticeras hybonotum autharis* (OPPEL), *Hybonoticeras hybonotum beneckei* GEYSSANT, *Hybonoticeras* sp. gr. *hybonotum* (OPPEL), *Torquatisphinctes laxus* OLÓRIZ, *Lithacoceras (Virgalithacoceras)* sp. gr. *supremum* (SCHNEID). This assemblages belongs to *Hybonotum* Zone of early Tithonian age.

Chapter 4

GEOLOGICAL SETTING OF THE SOUTHERN ALPS (ITALY)

The Southern Alps include the remnants of one of the best preserved Jurassic passive continental margins exposed in a mountain range (Fig. 4.1). During Mesozoic time this margin was a part of an African promontory, bordered to the West and to the North by the Alpine Tethys. In spite of the important North-South shortening of the Tertiary Alpine orogeny, an East-West transect perpendicular to the strike of the margin can be reconstructed. Along this transect the various paleogeographical domains of the margin are still arranged in their original order (Fig. 4.2). The facies evolution of the upward-deepening pelagic succession of the margin reflects the tectonic evolution of the Western Tethys during the Jurassic and Cretaceous times (Winterer & Bosellini 1981).

4.1 - Paleogeographical evolution

The Southern Alps are formed of a Hercynian basement and a Permian to Tertiary sedimentary cover.

The Permian cover consists of continental deposits and volcanic rocks followed by evaporitic and lagoonal formations. These marine sediments indicate a gradual sea ingression from East (where paleo-Tethys was opening) and characterize the beginning of the Triassic time. Structural highs and basins developed owing to an extensional tectonics, and most of the Triassic time was characterized by a very high environmental variability. Towards the end of the Triassic peritidal environments developed almost everywhere with the deposition of the Dolomia Principale Fm.: it represents a common base to follow the subsequent evolution of the paleogeographical domains of the Southern Alps (Winterer & Bosellini 1981). The Jurassic was the time of maximum growth of the passive continental margin. During the Early Jurassic a rifting phase took place and generated many faults (e.g., Garda Escarpment) which bordered sectors characterized by different subsidence rates. Consequently, several paleogeographical domains were born giving rise to a well defined alternation of platforms and basins: Lombardian Basin, Trento Platform, Belluno Basin, Friuli Platform (from West to East) (Fig. 4.2). At the end of the Early Jurassic the accumulation rate reduced in the Lombardian and the Belluno basins and determined the deposition of the Rosso Ammonitico Lombardo and Igne Fm., respectively. The Middle Jurassic was characterized by a stronger difference of the sedimentation patterns between structural highs and basins, and by the increase of pelagic siliceous sedimentation (Winterer & Bosellini 1981). The Trento Platform drowned completely and became a pelagic plateau where condensed limestones with ammonites (Rosso Ammonitico Veronese) deposited. In the Belluno Trough the sedimentation rate was still high: great amounts of calcareous turbidites (Vajont Limestone) coming from the Friuli Platform were interbedded into normal pelagic deposits, and involved the easternmost

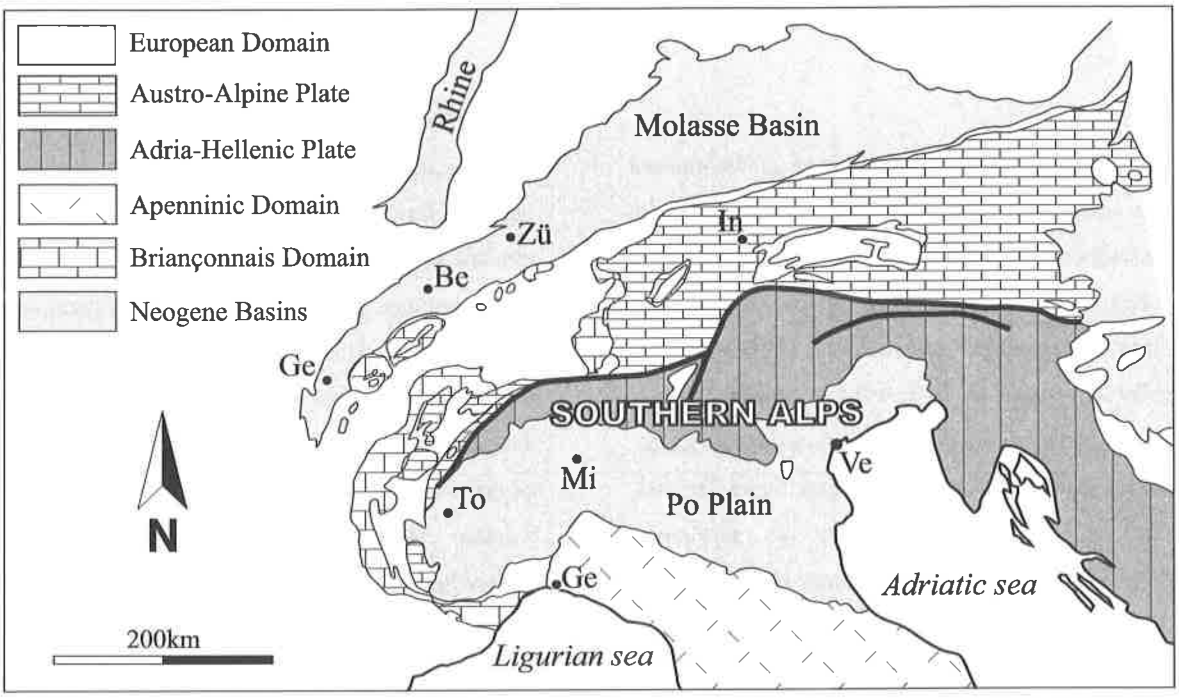


Fig. 4.1 - Principal tectonic domains of the Alps, Apennines and Northern Dinarids (Stampfly et al. 1998).

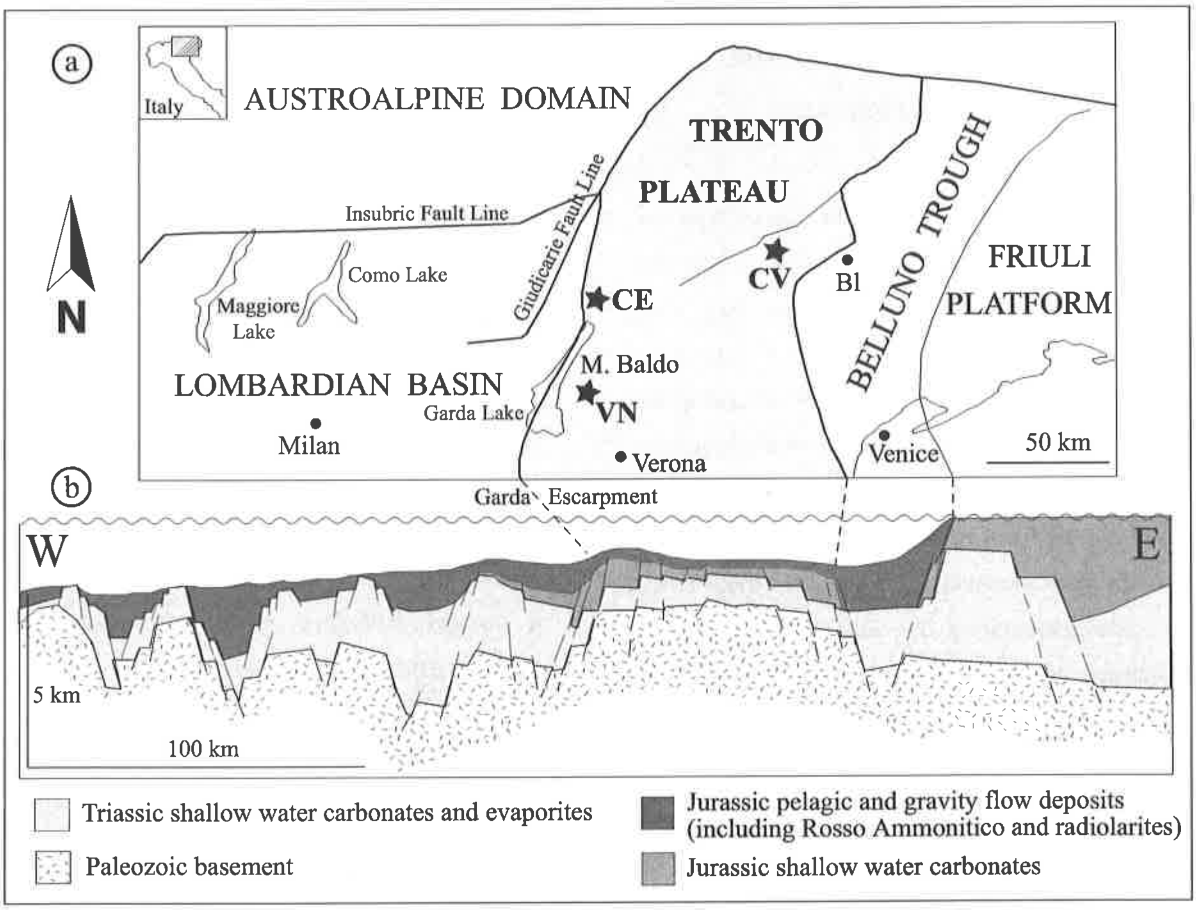


Fig. 4.2 - a: Present day distribution of the Mesozoic paleogeographical domains in the Southern Alps and geographical location of the studied sections (CE: Ceniga, CV: Coston delle Vette, VN: Cava Vianini). **b:** Schematic paleogeographical cross-section at the end of the Jurassic (Bosellini et al. 1981).

part of the Trento Plateau. The Late Jurassic was the time of tectonic calm with a slow but continuous pelagic sedimentation over all the region. During the Oxfordian the development of pelagic siliceous facies was at its maximum (Baumgartner 1987) whereas in the Kimmeridgian the facies were again mostly calcareous.

At the Jurassic-Cretaceous boundary most of the cited areas were in basinal conditions, recording a quite uniform deposition of carbonate pelagic oozes (Maiolica Fm.). During the Cretaceous time the re-activation of Early Jurassic fault systems occurred and the paleogeography started to modify. At the end of the Cretaceous the tectonic activity strongly changed its pattern from extensional to compressional and determined the end of the Jurassic passive continental margin. The sedimentary cycle closed definitively during the Tertiary Alpine orogenesis (Winterer & Bosellini 1981). The stratigraphy of the Southern Alps for the Early Jurassic to Early Cretaceous time is summarized in Fig. 4.3.

4.2 - Trento Plateau

The Trento Platform behaved as a Bahamian platform from the Late Triassic to the Middle Jurassic with the deposition of the Dolomia Principale Fm., Calcari Grigi, San Vigilio Oolite (Fig. 4.3). The Trento Platform was clearly bordered from the Lombardian Basin by the Garda Escarpment to the West (Castellarin 1972), whereas there was a gradual passage (Feltrine Alps area) to the Belluno Trough towards East (Della Bruna & Martire 1985). The carbonate production was interrupted at the end of the Pliensbachian, resulting in a regional unconformity that marked both the end of the superproducing carbonate platforms and the end of high sedimentation rates in the basins (Sarti et al. 1992). During the Toarcian-Aalenian the central part of the Trento Plateau experienced a recovery of the carbonate platform sedimentation (San Vigilio Oolite). In the early Bajocian the final demise of carbonate production took place resulting in a regional unconformity at the top of the San Vigilio Oolite. This demise was synchronous with the onset of mostly lime-free radiolarite sedimentation in the basins (Baumgartner et al. 1995c). The regional unconformity also corresponds to the early Bajocian $\delta^{13}C$ positive Carbon Event and maximum flooding (Bartolini et al. 1996; Bartolini et al. 1999) that brought about moderately eutrophic conditions, spurting radiolarian productivity and stopping carbonate production. San Vigilio Oolite is followed by the Rosso Ammonitico Veronese, a condensed lacunose succession of pelagic red nodular limestone rich in ammonites. The Rosso Ammonitico Veronese can be subdivided into three units (Martire 1996):

1) Rosso Ammonitico Inferiore (RAI): nodular pink limestone mainly composed of packstone and wackestone with bioclasts and bivalve grainstone; it generally shows a thick bedding;

2) Rosso Ammonitico Medio (RAM): well bedded pinkish-greenish siliceous limestone (packstone and wackestone) alternating with marly interbeds and abundant chert (beds and nodules); ammonites are generally absent. RAM does not occur everywhere on the Trento Plateau (Fig. 4.3), and RAI and RAS are separated by a hard-ground when RAM is missing. The silica content is represented by radiolarians and sponge spicules, and the RAM represents the studied successions for this research;

3) Rosso Ammonitico Superiore (RAS): nodular pink pelagic limestone with strong bioturbation; often massive and only faintly stratified; towards the top the pink colour becomes gradually whitish, indicating a change in the sedimentation pattern.

The upper Tithonian deposits reflect a period of tectonic calm and paleoenviromental uniformity: the sedimentation pattern changed and white, scarcely

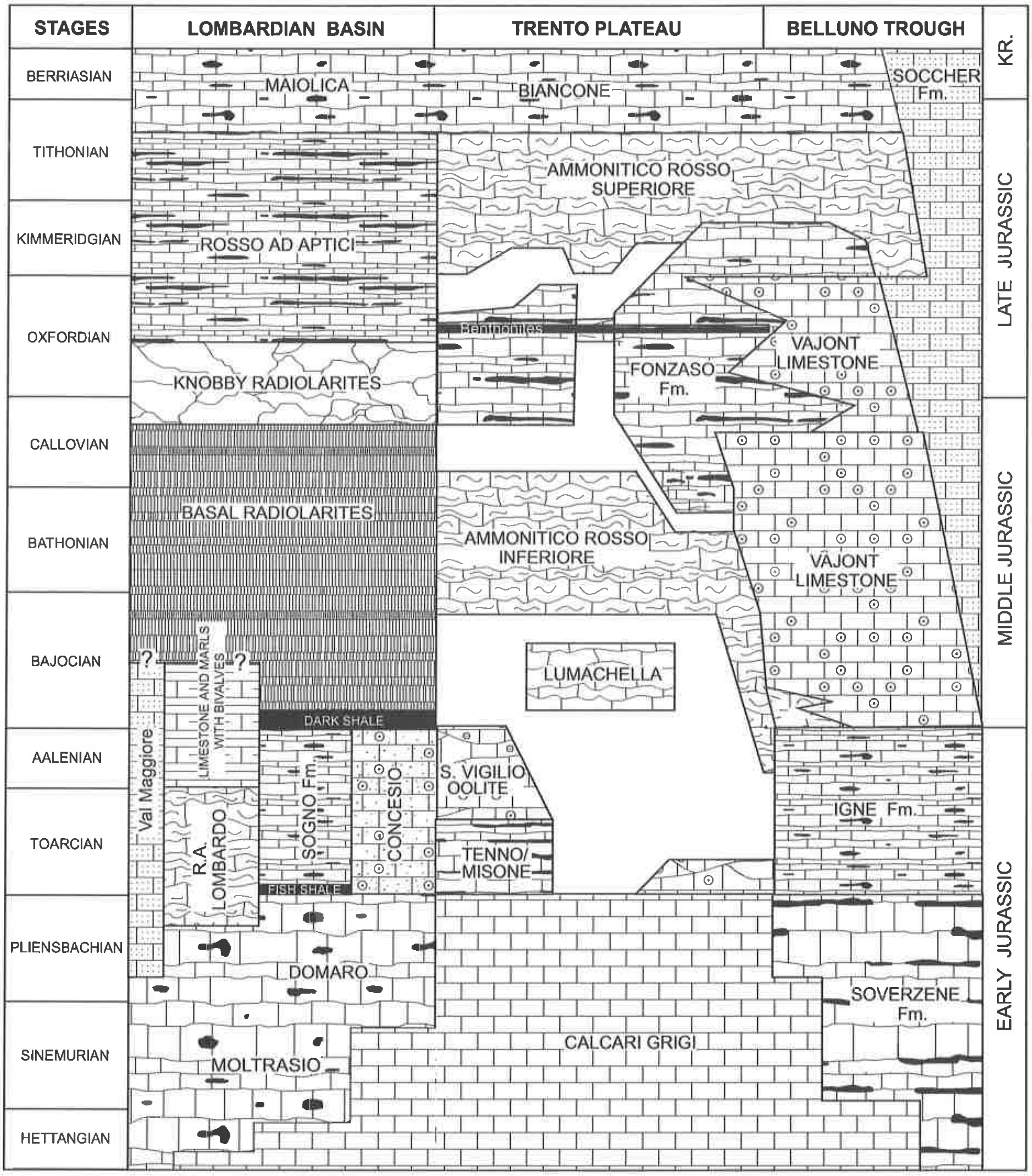


Fig. 4.3 - Chronostratigraphical synopsis of the Jurassic formations in the Southern Alps (Italy) mainly based on ammonite, radiolarian and nannofossil data from the Lombardian Basin, Trento Plateau and Belluno Basin (Winterer & Bosellini 1981; Baumgartner et al. 1995c).

cherty pelagic micrite containing the first calpionellids (Biancone Fm.) occurred (Fig. 4.3).

4.3 - Feltrine Alps: transitional area between Trento Plateau and Belluno Basin

The evolution of the Feltrine Alps started to diverge from the evolution of the Trento Plateau during the middle Early Jurassic, when the Feltrine Alps area constituted an oolitic bar protecting the lagoon located on the central part of the Trento Plateau. The Feltrine Alps typify the eastern part of the Trento Plateau, near its paleogeographical limit towards the Belluno Trough to the East (Fig. 4.2). According to the literature, the Feltrine Alps represent a transitional environment from the Trento Plateau on the West to the adjacent Belluno Basin on the East (Fig. 4.2) (Dal Piaz 1907; Bosellini & Dal Cin 1968; Della Bruna & Martire 1985). Compared to the central part of the Trento Plateau, the Feltrine Alps record an earlier drowning (Domerian) and a thicker pelagic sequence of Middle to Late Jurassic age. A 100m thick lithostratigraphical unit of siliceous limestone is sandwiched between the two members (RAI and RAS) of the Rosso Ammonitico Veronese. Such a siliceous succession is formalized as an independent formation and named Fonzaso Formation (Bosellini & Dal Cin 1968). It consists of beds of oolitic-peloidal grainstone that have been interpreted as the distal part of turbidites advancing from the Friuli Platform and infilling the Belluno Basin (Bosellini et al. 1981; Winterer & Bosellini 1981), providing further evidence of the marginal position of the Feltrine Alps area.

The Fonzaso Fm. can only be broadly correlated to the Rosso Ammonitico Medio (the siliceous middle member of the Rosso Ammonitico Veronese), which is locally present on the Trento Plateau and usually not thicker than 10 meters. At the stratigraphical level of RAM, the Feltrine Alps show clear affinities with the Belluno Basin, where siliceous beds lithologically equivalent to the Fonzaso Formation generally overlie the Vajont Limestone. The Vajont Limestone is a Middle Jurassic wedge of oolitic limestone interpreted as a deep sea fan that was fed by the very productive adjacent Friuli Platform. Beds of oolitic-peloidal grainstone also occur in the upper part of the Fonzaso Fm.: they may be interpreted as the distal parts of the calcareous turbidites coming from the Friuli Platform. This provides, on one side, evidence of the infilling of the Belluno Trough in the Late Jurassic and, on the other side, a further proof of the marginal, downstepped position of the Feltrine Alps in the context of the Trento Plateau (Bosellini et al. 1981; Winterer & Bosellini 1981).

Chapter 5

DESCRIPTION OF THE STUDIED SECTIONS

TRENTO PLATEAU

5.1 - Cava Vianini

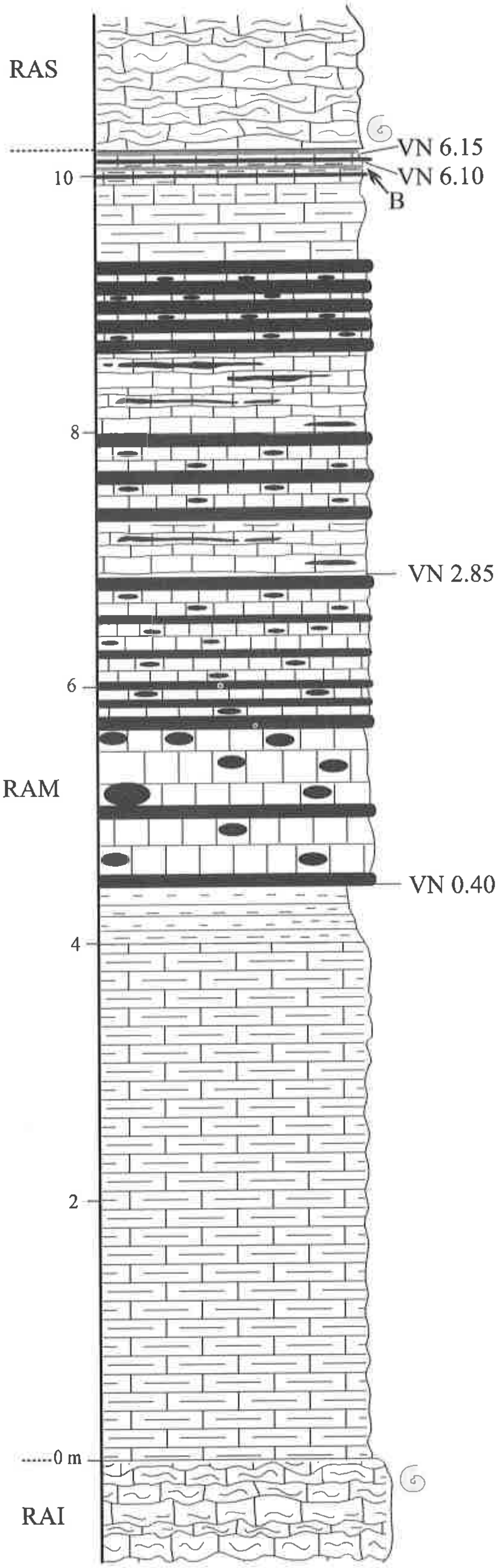
5.1.1 Lithological description

The Cava Vianini section crops out in an active quarry close to Madonna della Corona Sanctuary (eastern side of the Garda Lake) at 750m above sea level (Fig. 5.1). The studied succession is the Rosso Ammonitico Medio (RAM), i.e., the intermediate pelagic siliceous member of the Rosso Ammonitico Veronese.

In this section the complete succession of the Rosso Ammonitico Fm. crops out, and the RAM (Fig. 5.2 and Pl. 12, Fig. 6) is 10m thick. The contact between the RAI and RAM is clear: the RAM starts with 4m of pink and white marly packstone (containing thin bivalve shells) followed by 40cm of white-pink

Fig. 5.1 - Geographical location of the Cava Vianini section, Spiazzi area (eastern part of the Garda Lake, Veneto, Italy). Atlante Stradale Touring Club, 1:200.000.

Fig. 5.2 - Stratigrafical column of the RAM (Rosso Ammonitico Medio, i.e., the intermediate pelagic siliceous member of the Rosso Ammonitico Fm.) at the Cava Vianini section (Trento Plateau, Southern Alps, Italy).



Legend

- Siliceous limestone
- Stratified limestone
- Marlstone
- Marly limestone
- RAI and RAS
- Chert nodules and beds
- Ammonites
- B Bentonites

calcareous marlstone and then by the siliceous part. The siliceous part of the RAM is 6m thick and consists of a quite regular alternation of siliceous limestone and chert beds. The limestone is mainly pinkish-reddish in colour, the stratification is evident, and the layers are 5-15cm thick with planar or slightly undulated base and top. The chert beds are 4-12cm thick and the thinner ones occur at the beginning of the section; the colour is dark red at the base, and the first black chert bed is at 2.80m, from where the red chert disappears in less than 1m. Chert nodules are also abundant: the colour is dark red in the first 3m and black in the upper part of the section.

Towards the top of the RAM the limestone decrease, the stratification becomes thinner and thick black chert beds prevail. The RAM ends with 20cm of marly limestone containing black chert nodules alternated with bentonites levels. The contact between RAM and RAS is clear in spite of the recent karstification and soil infill along the base of the RAS (Pl. 12, Fig. 6).

5.1.2 Radiolarian assemblages

10 samples have been collected and the picking of the radiolarians has been done for 4 of them. The preservation is generally fair (PI=5) except the sample VN 2.85 that contains very well preserved radiolarians (PI=2). The identified taxa are listed in App. 1 (Tab. 5.1). Sponge spicules are quite abundant and well diversified. Poorly preserved specimens of benthic Foraminifera also occur.

5.1.3 Ammonite data

Papa (1994) reported lower Callovian ammonites (*Choffatia* (*Subgrossouvria*) *recuperoi* (GEMMELLARO) e *Indosphinctes* sp.) from the top of the RAI.

An ammonite assemblage referred to the boundary middle-late Oxfordian occurs at the very base of the RAS at Cava Spiazzi, a section located few kilometers far from Cava Vianini (Papa 1994). This assemblage consists of *Euaspidoceras douvillei* (COLLOT), *Euaspidoceras paucituberculatum* (ARKELL), *Euaspidoceras sparsispinum* (WAAGEN IN DORN), *Gregoryceras fouquei* (KILIAN), *Paraspidoceras* sp. aff. *P. helymense* (GEMMELLARO), *Passendorferia teresiformis* (BROCHWICZ-LEWINSKI).

5.2 - Ceniga

5.2.1 Lithological description

The Ceniga section is located South of Ceniga village (North of Garda Lake). The section is accessed from Arco village and crops out next to the Sarca River at about 100m above sea level (Fig. 5.3).

The studied succession is the Rosso Ammonitico Medio (RAM), i.e., the intermediate pelagic siliceous member of the Rosso Ammonitico Veronese. The Ceniga section differs from all the others illustrated in this paper because it includes also the lower Middle Jurassic platform deposits of San Vigilio Oolite (massive grey oolitic-bioclastic grainstone). The top of San Vigilio Oolite is overlain by the RAI, here reduced to 20cm of pink pelagic limestone rich in Fe-Mn-oxide nodules and crusts. The contact between RAI and RAM is sharp: the RAM starts with 40cm of thinly stratified whitish marly limestone (Pl. 12, Fig. 7). The RAM is 9m thick and consists of siliceous limestone alternated with chert beds. The siliceous limestone are thin bedded (3-5cm), pink in colour, and contain abundant dark red chert nodules. The chert beds are thin (5-7cm) and dark red in colour; large and abundant chert nodules become locally chert bands in the upper part of the section. Between the 5^{th} and 6^{th} meter six bentonite levels occur. The RAM ends with two thick (10-15cm) red chert layers, and the contact with the RAS is clear.

Fig. 5.3 - Geographical location of the Ceniga section (northern part of the Garda Lake, Trentino Alto Adige, Italy). Atlante Stradale Touring Club, 1:200.000.

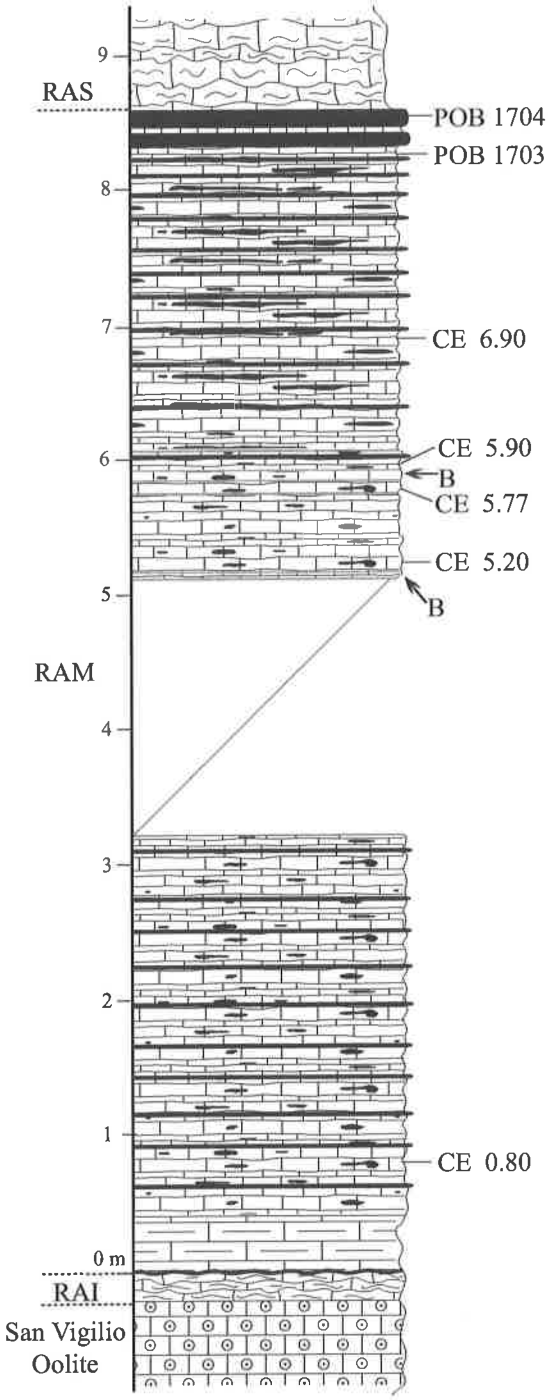


Fig. 5.4 - Stratigrafical column of the RAM (Rosso Ammonitico Medio, i.e., the intermediate pelagic siliceous member of the Rosso Ammonitico Fm.) at the Ceniga section (Trento Plateau, Southern Alps, Italy). The samples coded as "POB" refer to the samples of Baumgartner 1984 and Baumgartner et al. 1995c, and have been used for the radiolarian biozonation.

Legend

- Siliceous limestone
- Marly limestone
- San Vigilio Oolite
- RAI and RAS
- Chert nodules and beds
- B Bentonites

5.2.2 Radiolarian assemblages

9 samples have been collected and the picking of radiolarians has been done for 5 of them. The preservation is generally scarce and the PI ranges from 5 (fair) to 6 (poor). The taxa are listed in App. 1 (Tab. 5.2). The upper part of the section lacks good samples and the radiolarian data of two samples of Baumgartner 1984 and Baumgartner et al. 1995c (POB 1703 and POB 1704) have been added to the Ceniga database. This adding has been necessary for the biostratigraphical analysis in order to have a radiolarian record also from the upper part of the section. Sponge spicules are quite common, and poorly preserved specimens of benthic Foraminifera also occur.

5.3 - Coston delle Vette

At Coston delle Vette the intermediate pelagic siliceous member of the Rosso Ammonitico Veronese corresponds to the Fonzaso Fm. The lithological description and the radiolarian data of the Fonzaso Fm. have been published in Beccaro et al. 2002. The radiolarian data have been added to the database of this research for biostratigraphical purposes.

5.3.1 Lithological description

The Coston delle Vette section is located in the Feltrine Alps (National Park of the Dolomiti Bellunesi, Northern Italy), a thirty-minute walk from the Dal Piaz Refuge, at about 2000m above sea level (Fig. 5.5).

The Fonzaso Fm. is 100m thick and the boundary with the underlying RAI is not exposed. The Fonzaso Fm. is subdivided into three members basing on the colour of the lithotypes and the presence/absence of the oolitic grainstones. The succession begins with the Listato Member (Pl. 12, Fig. 8), which consists of a regularly alternating hazel coloured packstone and wackestone, subordinate oolitic grainstone and mudstone, and chert ribbons and nodules (Fig. 5.6). The quantity of radiolarians allows the use of the term "radiolarian packstone". The central part of the formation is represented by the Resediment Member, characterized by thick deposits of oolitic grainstone with minor amounts of greenish packstone, wackestone, and subordinated mudstone. Beds and nodules of chert are present in varying abundance within all these lithotypes. The last part of the succession is the Scisti ad Aptici Member, which is composed of packstone, wackestone, and subordinated mudstone variously alternating with chert. The colour changes from clear green to reddish. The chert in the middle-upper part of the member is characterized by the acquisition of a more marked reddish colour and an increased nodular aspect. The Fonzaso Fm. gradually passes into the RAS and a bed with abundant and large red nodules has been taken as the last layer of the Fonzaso Fm. (Della Bruna & Martire 1985).

5.3.2 Radiolarian assemblages

14 samples were collected and studied. The PI ranges from 4 (average) to 5 (fair) except for the two first samples (CV 60 and CV 60.4) that show a great diversity of very well preserved species (PI=2). Around one hundred taxa have been identified (App. 1, Tab. 5.3), and most of them have been illustrated in Beccaro et al. (2002). Della Bruna & Martire (1985) recorded abundant sponge spicules content along all Fonzaso Fm.

5.3.3 Ammonite data

The top of the RAI is referred to the early Bathonian on the basis of few ammonites such as *Parkinsonia* sp. and *Cadomites* cf. *rectelobatus* (HAUER) (Della Bruna & Martire 1985). No precise biostratigraphical data are available for the base of the RAS that is generally referred to the late early Kimmeridgian on the basis of *Taramelliceras trachynotum* (OPPEL) and *Orthaspidoceras uhlandi*

Fig. 5.5 - Geographical location of the Coston delle Vette section (Feltrine Alps, National Park Dolomiti Bellunesi, Southern Alps, Italy). Atlante Stradale Touring Club, 1:200.000.

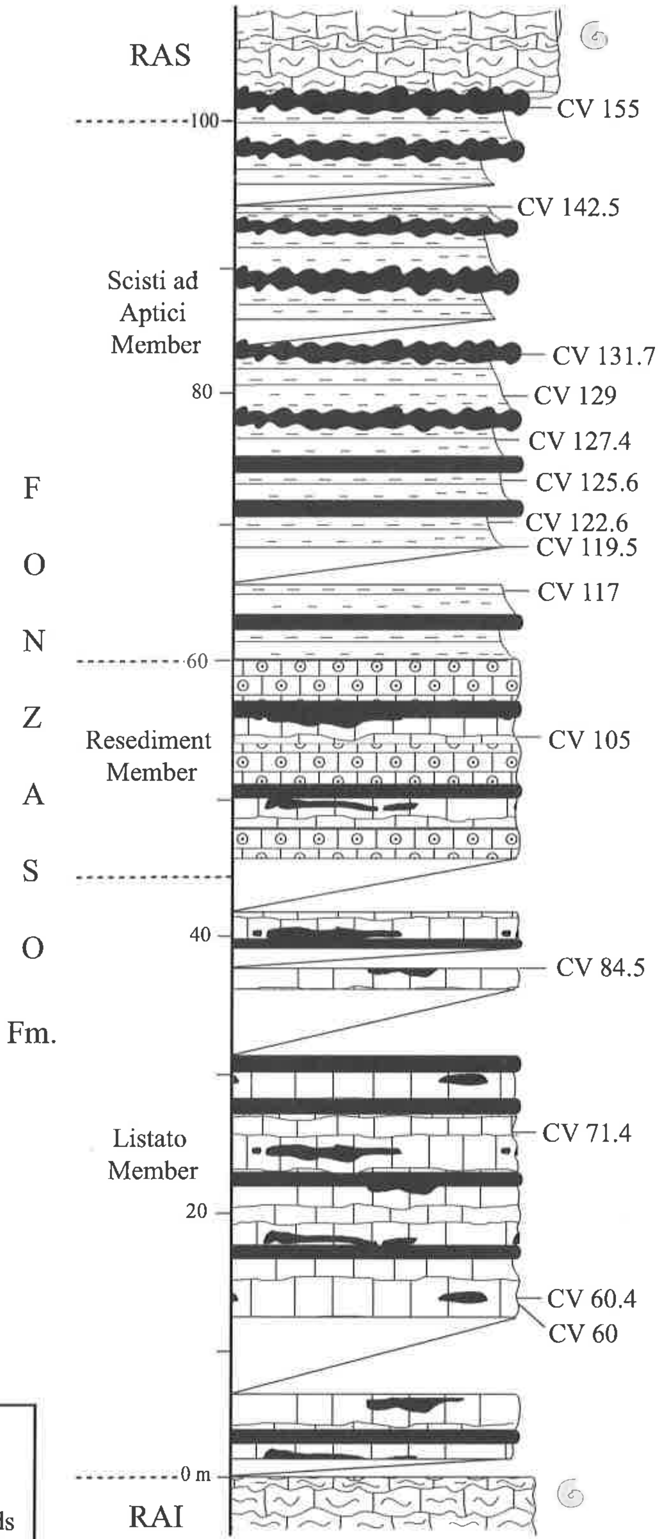


Fig. 5.6 - Stratigraphical column of the Fonzaso Fm. at the Coston delle Vette section (Trento Plateau, Southern Alps, Italy). The Fonzaso Fm. is the time-equivalent facies of the Rosso Ammonitico Medio (RAM) occurring in the other sections.

Legend

- Siliceous limestone
- Oolitic limestone
- Marlstone
- RAI and RAS
- Chert nodules and beds
- Ammonites

(OPPEL) belonging to the uppermost *Divisum* Zone (Dal Piaz 1907).

Chapter 6

RADIOLARIAN BIOCHRONOLOGY OF MIDDLE-UPPER JURASSIC PELAGIC SILICEOUS SUCCESSION IN WESTERN SICILY AND THE SOUTHERN ALPS (ITALY)

6.1 - Introduction

The radiolarian biochronology illustrated in this paper has been carried out using the Unitary Associations method (Guex 1977, 1991), and it proposes a new regional biozonation for Western Sicily and the Southern Alps (Italy). A first attempt of radiolarian stratigraphical correlation among the North-western Sicily sections (Trapanese Domain) was presented in Beccaro (2004a). A short review of the zonation for Western Sicily and the Southern Alps is partially published in Beccaro (*in press*). The chronostratigraphical calibration of each radiolarian biozone (Unitary Associations Zone - UAZ) is provided by ammonites found in the investigated successions and in the under- and overlying sediments. The ammonite data are indicated in the chapters concerning the descriptions of each section and were provided by other authors.

6.2 - Radiolarian zonation: UAZones A to F

About 150 species have been identified in nine stratigraphical sections (six in Western Sicily and three in the Southern Alps), and 99 taxa have been used to construct the biozonation. Species with either of the following properties have been excluded from the database:

1) taxa that only occur either in one section or in one sample, except for those belonging to the lowest and the highest samples of a given section;

or

2) taxa that do not possess distinct morphological features: in this case the certainty of a taxonomic assignment depends on the status of preservation, and the record of these species is likely discontinuous and incomplete. These kind of species are not useful for the correlation and are marked by an asterisk throughout the volume.

The occurrences of the 99 selected taxa constitute the database for the computation by the software BioGraph (Savary & Guex 1991, 1999). The data of two samples (POB 1703 and POB 1704) from the Ceniga section (Southern Alps) published in Baumgartner 1984 and Baumgartner et al. 1995c have also been added to this database. Such addition was necessary in order to have a good radiolarian record from the upper part of the Ceniga section, and for strengthening the correlation. The stratigraphical distribution of the 99 species along the sections is indicated in the database file "SicAlps.DAT" (App. 2). In this file each sample is numbered and is followed by its own taxa content. The species are listed with their codes. The species carrying a numerical code are illustrated in Baumgartner et al. 1995b (for some taxa an updated name has been used), and the species carrying a lettered code are not included in Baumgartner et al. 1995b.

The most useful BioGraph files for building a zonation are:

1) TGJ: "Unitary Associations chart", i.e., the range chart giving the distribution of the taxa in the Unitary Associations (UAs) produced by BioGraph (Fig. 6.1);

2) TGK: the correlation table with the UAs reported for each sample (Fig. 6.2);

3) TGL: the reproducibility table, i.e., the frequency of the UAs in the sections (Fig. 6.3).

By analysing the SicAlps.DAT file BioGraph produced 16 Unitary Associations (UAs). By evaluating the taxa assemblages of each UA (TGJ file; Fig. 6.1) and the lateral reproducibility of each UA (TGL file; Fig. 6.3), the 16 UAs have been manually grouped into 6 Unitary Association Zones (UAZ-SA A to F) (Figs. 6.1 and 6.3). The radiolarian assemblages of each UA is easily readable in the TGJ chart (Fig. 6.1) and only the most characteristic species will be indicated in the following description of each UAZone.

UAZ A: ?early-middle Bathonian to early Callovian *pars*

UAZ A consists of the UA 1, and it is defined by the total range (in the studied dataset) of *Eucyrtidiellum unumaense dentatum* BAUMGARTNER, *Stylocapsa oblongula* KOCHER and *Unuma echinatus* ICHIKAWA & YAO coexisting with 22 species (e.g., *Guexella nudata* (KOCHER), *Beleza decora* (RÜST), *Mirifusus fragilis praeguadalupensis* BAUMGARTNER & BARTOLINI) that range upwards (Fig. 6.1). UAZ A is present only at the Coston delle Vette section (Southern Alps) (Figs. 6.3 and 6.4).

Calibration

The base of UAZ A is younger than at least part of the early Bathonian due to the presence of early Bathonian ammonites at the top of RAI at Coston delle Vette (Figs. 6.4 and 6.5). The top of the UAZ A is not directly constrained by ammonites but by the early Callovian age assignment of the base of the UAZ B.

UAZ B: early Callovian *pars* - early Oxfordian

UAZ B is formed by the union of the UAs 2 to 4. It is characterized by the total range (in the studied dataset) of *Podobursa andreai* BECCARO, *Hiscocapsa robusta* (MATSUOKA), *Kilinora catenarum* (MATSUOKA), *Triactoma enzoi* BECCARO, *Tricolocapsa plicarum* s.l. YAO, by 11 species ranging up to UAZ B (such as *Monotrabs goricanae* BECCARO, *Tethysetta dhimenaensis* ssp. A, *Mirifusus fragilis praeguadalupensis* BAUMGARTNER & BARTOLINI, *Guexella nudata* (KOCHER), *Beleza decora* (RÜST), *Acaeniotylopsis variatus variatus* (OŽVOLDOVA)) and 22 species ranging from UAZ B upwards (such as *Gongylothorax favosus* DUMITRICA, *Pantanellium riedeli* PESSAGNO, *Podobursa chandrika* (KOCHER), *Protunuma japonicus* MATSUOKA & YAO, *Williriedellum carpathicum* DUMITRICA) (Fig. 6.1). UAZ B is present at the Cava Vianini and Coston delle Vette sections (Southern Alps) (Figs. 6.3 and 6.4). In Fig. 6.3 the black circle indicates the presence of the UAZ B in the Fornazzo Strada section (North-western Sicily) as well. This presence is hypothetical and is due to the addition of an artificial sample (containing the species of the UAZ B) in the Fornazzo Strada database in order to strengthen the correlation between Sicily and the Southern Alps.

Calibration

The base of UAZ B is younger than at least part of early Callovian because of lower Callovian ammonites found at Cava Vianini (Southern Alps) below the first sample assigned to the UAZ B (Figs. 6.4 and 6.5). The top of the UAZ B is not directly constrained by ammonites but it must be older than at least middle Oxfordian according to the UAZ C age assignment.

UAZ C: middle Oxfordian

UAZ C comes from grouping the UAs 5 to 7. It is characterized by the coexistence of 3 species ranging up to UAZ C (e.g., *Eucyrtidiellum unumaense* s.l. (YAO) and *Williriedellum (?) marcucciae* CORTESE) and 10 species ranging from UAZ C upwards (e.g., *Xitus magnus* BAUMGARTNER, *Emiluvia orea* BAUMGARTNER, *Podobursa vannae* BECCARO, *Ristola altissima altissima* (RÜST), *Zhamoidellum ventricosum* DUMITRICA, *Podobursa spinosa* (OŽVOLDOVA)) (Fig.

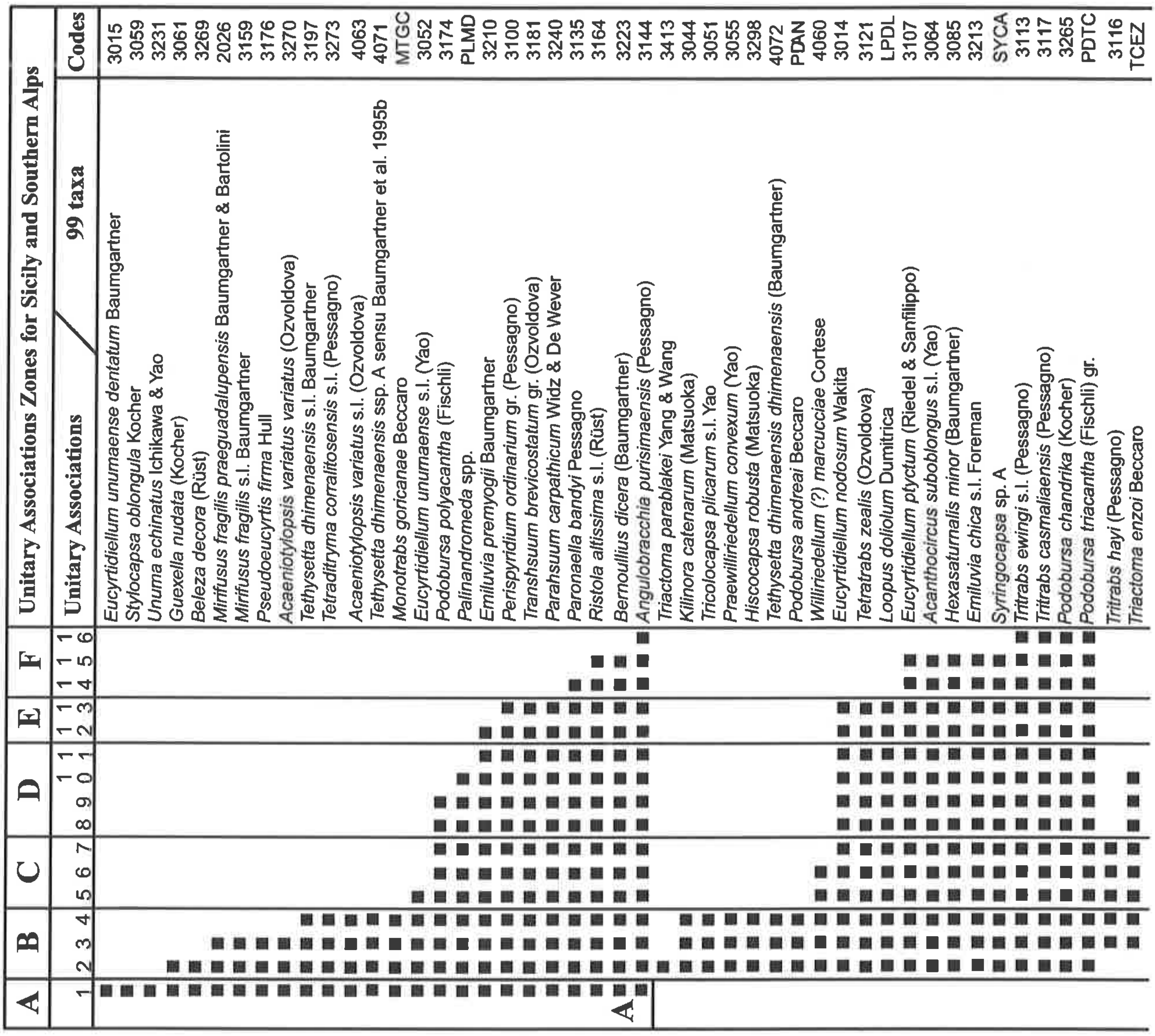
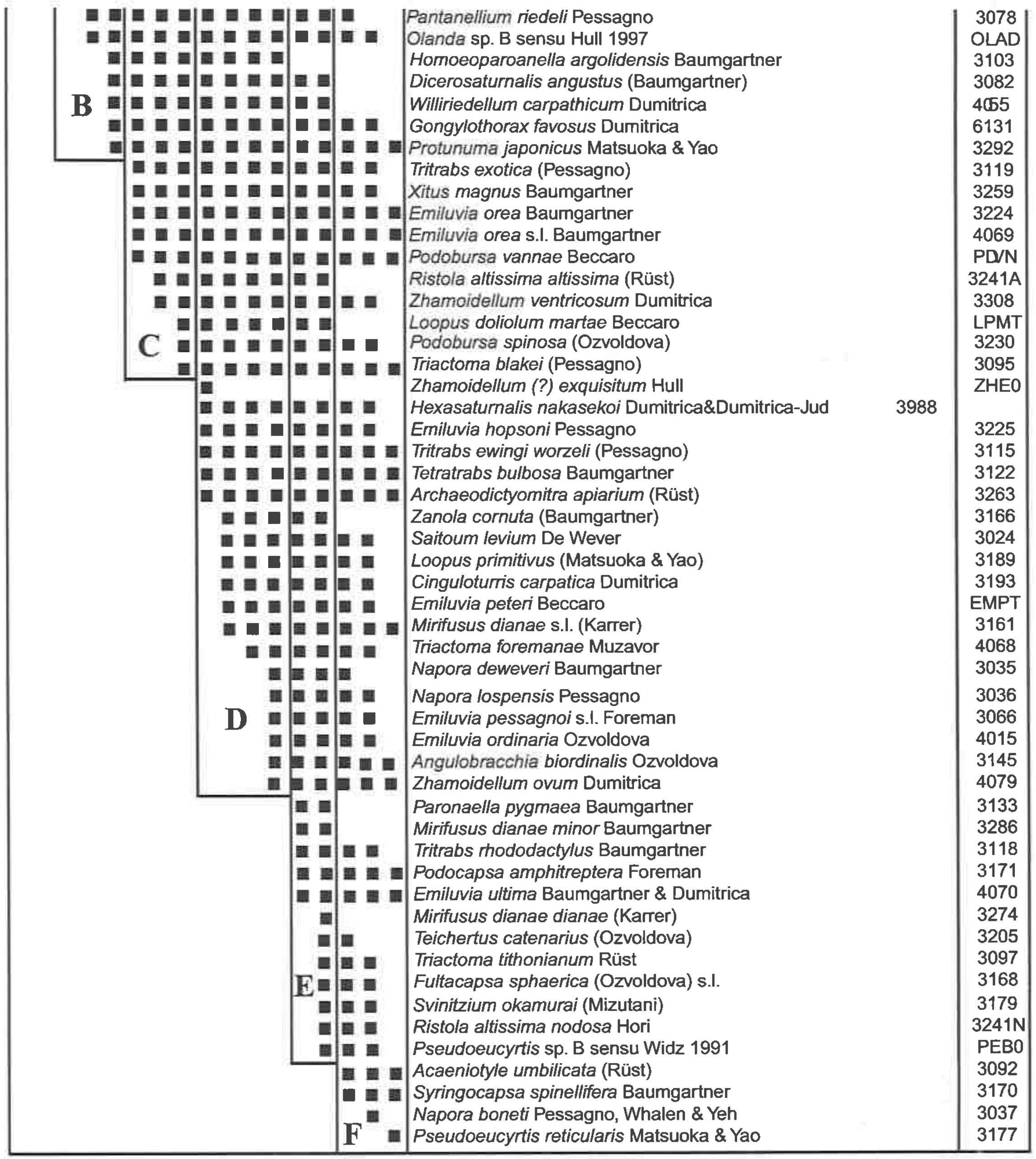


Fig. 6.1 - TGJ: Unitary Associations chart.
Occurrences of 99 taxa in 16 Unitary Associations (UAs). The UAs have been manually grouped in 6 Unitary Associations Zones UAZ-SA A to F.


B
C
D
E
F
Pantanellium riedeli Pessagno 3078
Olanda sp. B sensu Hull 1997 OLAD
Homoeoparoanella argolidensis Baumgartner 3103
Dicerosaturnalis angustus (Baumgartner) 3082
Williriedellum carpathicum Dumitrica 4055
Gongylothorax favosus Dumitrica 6131
Protunuma japonicus Matsuoka & Yao 3292
Tritrabs exotica (Pessagno) 3119
Xitus magnus Baumgartner 3259
Emiluvia orea Baumgartner 3224
Emiluvia orea s.l. Baumgartner 4069
Podobursa vannae Beccaro PDVN
Ristola altissima altissima (Rüst) 3241A
Zhamoidellum ventricosum Dumitrica 3308
Loopus doliolum martae Beccaro LPMT
Podobursa spinosa (Ozvoldova) 3230
Triactoma blakei (Pessagno) 3095
Zhamoidellum (?) exquisitum Hull ZHE0
Hexasaturnalis nakasekoi Dumitrica&Dumitrica-Jud 3988
Emiluvia hopsoni Pessagno 3225
Tritrabs ewingi worzeli (Pessagno) 3115
Tetratrabs bulbosa Baumgartner 3122
Archaeodictyomitra apiarium (Rüst) 3263
Zanola cornuta (Baumgartner) 3166
Saitoum levium De Wever 3024
Loopus primitivus (Matsuoka & Yao) 3189
Cinguloturris carpatica Dumitrica 3193
Emiluvia peteri Beccaro EMPT
Mirifusus dianae s.l. (Karrer) 3161
Triactoma foremanae Muzavor 4068
Napora deweveri Baumgartner 3035
Napora lospensis Pessagno 3036
Emiluvia pessagnoi s.l. Foreman 3066
Emiluvia ordinaria Ozvoldova 4015
Angulobracchia biordinalis Ozvoldova 3145
Zhamoidellum ovum Dumitrica 4079
Paronaella pygmaea Baumgartner 3133
Mirifusus dianae minor Baumgartner 3286
Tritrabs rhododactylus Baumgartner 3118
Podocapsa amphitreptera Foreman 3171
Emiluvia ultima Baumgartner & Dumitrica 4070
Mirifusus dianae dianae (Karrer) 3274
Teichertus catenarius (Ozvoldova) 3205
Triactoma tithonianum Rüst 3097
Fultacapsa sphaerica (Ozvoldova) s.l. 3168
Svinitzium okamurai (Mizutani) 3179
Ristola altissima nodosa Hori 3241N
Pseudoeucyrtis sp. B sensu Widz 1991 PEB0
Acaeniotyle umbilicata (Rüst) 3092
Syringocapsa spinellifera Baumgartner 3170
Napora boneti Pessagno, Whalen & Yeh 3037
Pseudoeucyrtis reticularis Matsuoka & Yao 3177

BIOGRAPH v2.02
(c) 1990 by J.Savary & J.Guex

CE+VN+CV+FV+SA+IN+FZC+CI+BB

CORRELATION TABLE

67 horizons

Section 1_CENIGA
7: 12 - 13
6: 13 - 13
5: 12 - 13
4: 12 - 13
3: 13 - 13
2: 9 - 9
1: 9 - 10

Section 2_CAVA_VIANINI
4: 11 - 11
3: 10 - 10
2: 4 - 4
1: 2 - 2

Section 3_COSTON_DELLE_VETTE
14: 16 - 16
13: 16 - 16
12: 14 - 15
11: 14 - 15
10: 14 - 14
9: 14 - 14
8: 12 - 12
7: 12 - 12
6: 12 - 12
5: 9 - 12
4: 9 - 9
3: 3 - 3
2: 3 - 3
1: 1 - 1

Section 4_FAVIGNANA
2: 13 - 13
1: 9 - 9

Section 5_SANTANNA
3: 15 - 15
2: 15 - 15
1: 13 - 13

Section 6_FORNAZZO_STRADA
17: 14 - 16
16: 16 - 16
15: 15 - 15
14: 13 - 15
13: 13 - 15
12: 13 - 13
11: 13 - 13
10: 13 - 13
9: 11 - 12
8: 12 - 13
7: 11 - 11
6: 11 - 11
5: 11 - 11
4: 8 - 11
3: 8 - 8
2: 6 - 6
1: 2 - 2

Section 7_FORNAZZO_CAVA
3: 13 - 13
2: 11 - 11
1: 5 - 5

Section 8_CASTELLO_INICI
9: 13 - 13
8: 12 - 15
7: 12 - 13
6: 11 - 13
5: 8 - 8
4: 7 - 13
3: 7 - 7
2: 7 - 7
1: 7 - 13

Section 9_BALATA_DI_BAIDA
8: 13 - 15
7: 13 - 15
6: 13 - 13
5: 13 - 13
4: 13 - 13
3: 11 - 11
2: 11 - 11
1: 8 - 11

Fig. 6.2 - TGK: Correlation table. For each sample (i.e., the 67 horizons corresponding to the left column of numbers) is indicated the assignment to one or more Unitary Associations (UAs 1 to 16 in the right column of numbers).

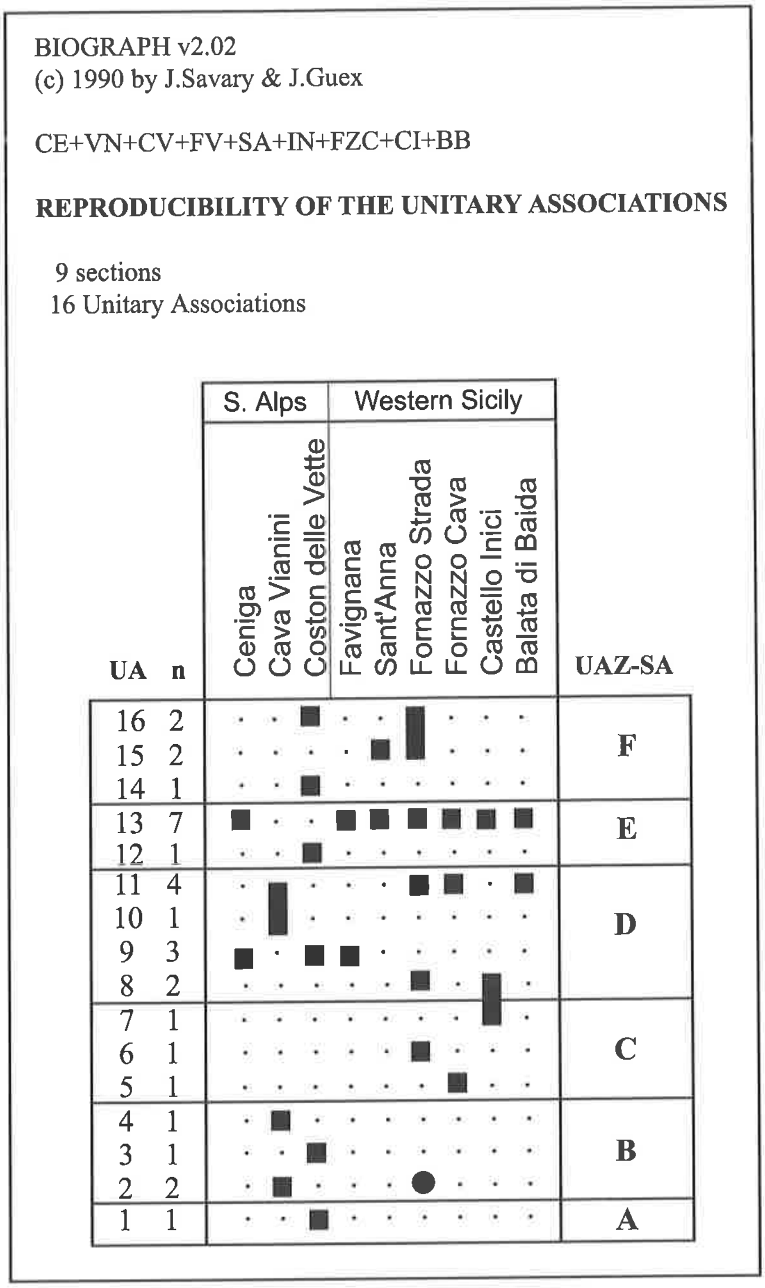


Fig. 6.3 - TGL: Reproducibility table. The frequency of the 16 Unitary Associations (UA) in the sections is shown. "n" indicates the number of sections in which each UA occurs. The 16 UAs have been manually grouped in 6 Unitary Associations Zones: UAZ-SA A to F.

■ UAs identified by BioGraph.

● Artificial sample in the Sicilian database.

6.1). UAZ C has been recognized in the Fornazzo Strada, Fornazzo Cava and Castello Inici sections (North-western Sicily) (Figs. 6.3 and 6.4). No evidence of stratigraphical gaps has been found in the Alpine sections to explain the absence of the UAZ C. Most likely, the UAZ C was not recognized at Coston delle Vette due to the cover, and at Cava Vianini due to the low frequency sampling in that portion of the section. At Ceniga the time interval corresponding to the UAZ C is probably included in the very condensed RAI or in the hardground between the RAI and RAM.

Calibration

UAZ C is directly correlated to the middle Oxfordian by the occurrence of ammonites belonging to *Plicatilis* and *Transversarium* Zones, respectively below and above the radiolarian samples assigned to the UAZ C at the Fornazzo Cava and Castello Inici sections (North-western Sicily) (Figs. 6.4 and 6.5).

UAZ D: ?middle-?late Oxfordian

UAZ D consists of the UAs 8 to 11, and it is defined by the total range (in the studied dataset) of *Zhamoidellum (?) exquisitum* HULL, and by 4 species ranging up to UAZ D (as *Palinandromeda* spp. and *Triactoma enzoi* BECCARO) and 13 species ranging from UAZ D upwards (e.g., *Tetratrabs bulbosa* BAUMGARTNER, *Archaeodictyomitra apiarium* (RÜST), *Zanola cornuta* (BAUMGARTNER), *Emiluvia peteri* BECCARO, *Emiluvia ordinaria* OŽVOLDOVA, *Angulobracchia biordinalis* OŽVOLDOVA, *Zhamoidellum ovum* DUMITRICA). The first occurrences dominate over the last ones (Fig. 6.1) suggesting an important diversification of radiolarian assemblages during the time interval of the UAZ D. In this biozone appears *Hexasaturnalis nakasekoi* DUMITRICA & DUMITRICA-JUD, which was included under *Hexasaturnalis suboblongus* (YAO) for the zonation by UZA95 of Baumgartner et al. (1995a). Recently, *H. suboblongus* (YAO) has been split in two species: *H. suboblongus* (YAO) and *H. nakasekoi* DUMITRICA & DUMITRICA-JUD (Dumitrica & Dumitrica Jud 2005). Dumitrica & Dumitrica-Jud (2005) assert that *H. suboblongus* spans the Bajocian and *H. nakasekoi* ranges within the Bathonian-Kimmeridgian interval. UAZ D is the most widespread and the best recorded biozone in all the sections except at Sant'Anna (Sicano Basin, South-western Sicily) (Figs. 6.3 and 6.4). This absence can be explained either by the fact that the Sant'Anna sediments were deposited in a basin (whereas Rosso Ammonitico Fm. is typical of the pelagic plateaux) or by the incompleteness of the succession (its base does not crop out).

Calibration

UAZ D is not directly constrained by ammonites, and it is questionably assigned to middle-late Oxfordian by the age assignment of the UAZ C (middle Oxf.) and by the occurrence of ammonites referred to the middle-late Oxfordian boundary at the very base of the RAS at Cava Spiazzi (very close to Cava Vianini, Southern Alps) (Figs. 6.4 and 6.5).

UAZ E: ?late Oxfordian - early Kimmeridgian *pars*

UAZ E derives from the union of the UAs 12 and 13, and it is defined by 12 species ranging up to UAZ E (such as *Eucyrtidiellum nodosum* WAKITA, *Tetratrabs zealis* (OŽVOLDOVA), *Dicerosaturnalis angustus* (BAUMGARTNER), *Ristola altissima altissima* (RÜST), *Zanola cornuta* (BAUMGARTNER)) and 9 species ranging from UAZ E upwards (e.g., *Podocapsa amphitreptera* FOREMAN, *Emiluvia ultima* BAUMGARTNER & DUMITRICA, *Fultacapsa sphaerica* (OŽVOLDOVA) s.l., *Ristola altissima nodosa* HORI, *Pseudoeucyrtis* sp. B sensu Baumgartner et al. 1995b). In the studied dataset the total ranges of *Mirifusus dianae dianae* (KARRER), *M. dianae minor* BAUMGARTNER and *Paronaella pygmaea* BAUMGARTNER are included in the UAZ E but it is known from other localities that these taxa have surely longer ranges (Baumgartner et al. 1995a). The UAZ E is present in all the studied sections except at Cava Vianini (Southern Alps) where the time-equivalent facies is the RAS (Figs. 6.3 and 6.4).

Calibration

The base of the UAZ E is not directly dated by ammonites. The top of the UAZ E is thought to be assigned to early Kimmeridgian *pars* by the occurrence of *Strombecki* Zone ammonites (early Kimm.) directly above the last radiolarian sample belonging to the UAZ E at the Fornazzo Strada section (North-western Sicily) (Figs. 6.4 and 6.5). It is likely that the UAZ E also comprises the late Oxfordian because the *Strombecki* ammonite assemblage occurs at the very top of the UAZ E.

UAZ F: early Kimmeridgian *pars* - late Kimmeridgian

UAZ F is formed by the union of the UAs 14 to 16, and it is defined by the coexistence of 4 species (*Acaeniotyle umbilicata* (RÜST), *Napora boneti* PESSAGNO, WHALEN & YEH, *Pseudoeucyrtis reticularis* MATSUOKA & YAO, *Syringocapsa spinellifera* BAUMGARTNER) that have their base in the UAZ F with 51 species that have their top in the UAZ F (in the studied dataset). UAZ F has been recognized at the Coston delle Vette section (Southern Alps), and at the Fornazzo Strada and Sant'Anna sections (Western Sicily) (Figs. 6.3 and 6.4). UAZ F is missing in the incomplete sections of Fornazzo Cava, Castello Inici and Favignana (North-western Sicily), and in the Ceniga and Cava Vianini sections (Southern Alps). In the Alpine sections the time-equivalent facies of the UAZ F are red nodular chert-free limestone (RAS) (Fig. 6.4).

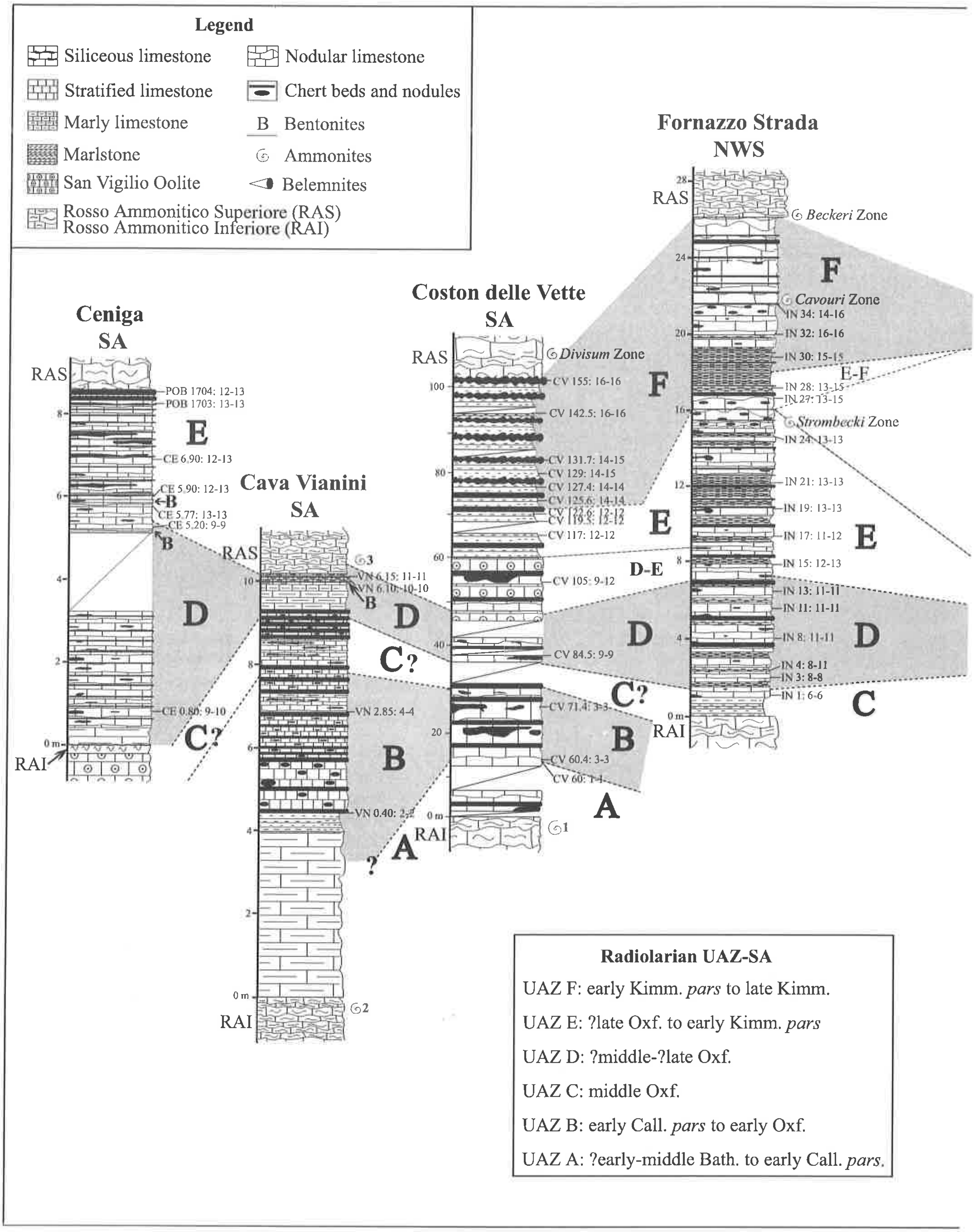
Calibration

The base of the UAZ F is directly correlated with the early Kimmeridgian. At the Coston delle Vette section (Southern Alps) some ammonites belonging to *Strombecki* Zone (early Kimmeridgian) occur about 1m below the first sample of the UAZ F, and *Divisum* Zone ammonites (early Kimmeridgian) occur directly above the last sample of the UAZ F (Figs. 6.4 and 6.5). The top of the UAZ F is assigned to late Kimmeridgian by the occurrence of *Cavouri* Zone ammonites (late Kimmeridgian) very close to the last radiolarian sample in the Fornazzo Strada section (North-western Sicily) (Figs. 6.4 and 6.5). The very base of the RAS at Fornazzo Strada is also dated as late Kimmeridgian thanks to the presence of *Beckeri* Zone ammonites. At Sant'Anna (South-western Sicily) the top of the basinal succession is assigned to the UAZ F, and it is followed by ammonite-bearing limestone whose base is referred to *Hybonotum* Zone (early Tithonian).

6.3 - Diachronism of the siliceous facies between Western Sicily and the Southern Alps

The stratigraphical correlation by means of UAZ-SA reveals a significant diachronism for the lower as well as for the upper boundary of the pelagic siliceous facies in the Alpine and Sicilian sections (Figs. 6.4 and 6.6).

In the Southern Alps (Trento Plateau) the siliceous deposition began in the ?early-middle Bathonian to early Callovian *pars* (UAZ A) at Coston delle Vette, in the early Callovian *pars*-early Oxfordian (UAZ B) at Cava Vianini, and in the ?middle-?late Oxfordian (UAZ D) at Ceniga. In Western Sicily (Trapanese Plateau) the siliceous deposition started in the middle-late Oxfordian: UAZ C (middle Oxfordian) at Fornazzo Strada, Fornazzo Cava and Castello Inici, and UAZ D (?middle-?late Oxfordian) at Balata di Baida and Favignana. On the other hand, the UAZ D (?middle-?late Oxfordian) corresponds to the final phase of the siliceous deposition at Cava Vianini (Southern Alps), and the UAZ E (?late Oxfordian - early Kimmeridgian *pars*) corresponds to the final phase at Ceniga (Southern Alps). The UAZ F (early



Legend
Siliceous limestone
Nodular limestone
Stratified limestone
Chert beds and nodules
Marly limestone
B Bentonites
Marlstone
Ammonites
San Vigilio Oolite
Belemnites
Rosso Ammonitico Superiore (RAS)
Rosso Ammonitico Inferiore (RAI)
Ceniga
SA
RAS
RAI
POB 1704: 12-13
POB 1703: 13-13
CE 6.90: 12-13
CE 5.90: 12-13
CE 5.77: 13-13
CE 5.20: 9-9
CE 0.80: 9-10
Cava Vianini
SA
VN 6.15: 11-11
VN 6.10: 10-10
VN 2.85: 4-4
Coston delle Vette
SA
Divisum Zone
CV 155: 16-16
CV 142.5: 16-16
CV 131.7: 14-15
CV 129: 14-15
CV 127.4: 14-14
CV 117: 12-12
CV 105: 9-12
CV 84.5: 9-9
CV 60.4: 3-3
Fornazzo Strada
NWS
Beckeri Zone
Cavouri Zone
IN 34: 14-16
IN 32: 16-16
IN 28: 13-15
Strombecki Zone
IN 21: 13-13
IN 19: 13-13
IN 17: 11-12
IN 15: 12-13
IN 13: 11-11
IN 11: 11-11
IN 8: 11-11
IN 4: 8-11
IN 3: 8-8
IN 1: 6-6
A
B
C
C?
D
D-E
E
E-F
F
Radiolarian UAZ-SA
UAZ F: early Kimm. pars to late Kimm.
UAZ E: ?late Oxf. to early Kimm. pars
UAZ D: ?middle-?late Oxf.
UAZ C: middle Oxf.
UAZ B: early Call. pars to early Oxf.
UAZ A: ?early-middle Bath. to early Call. pars.

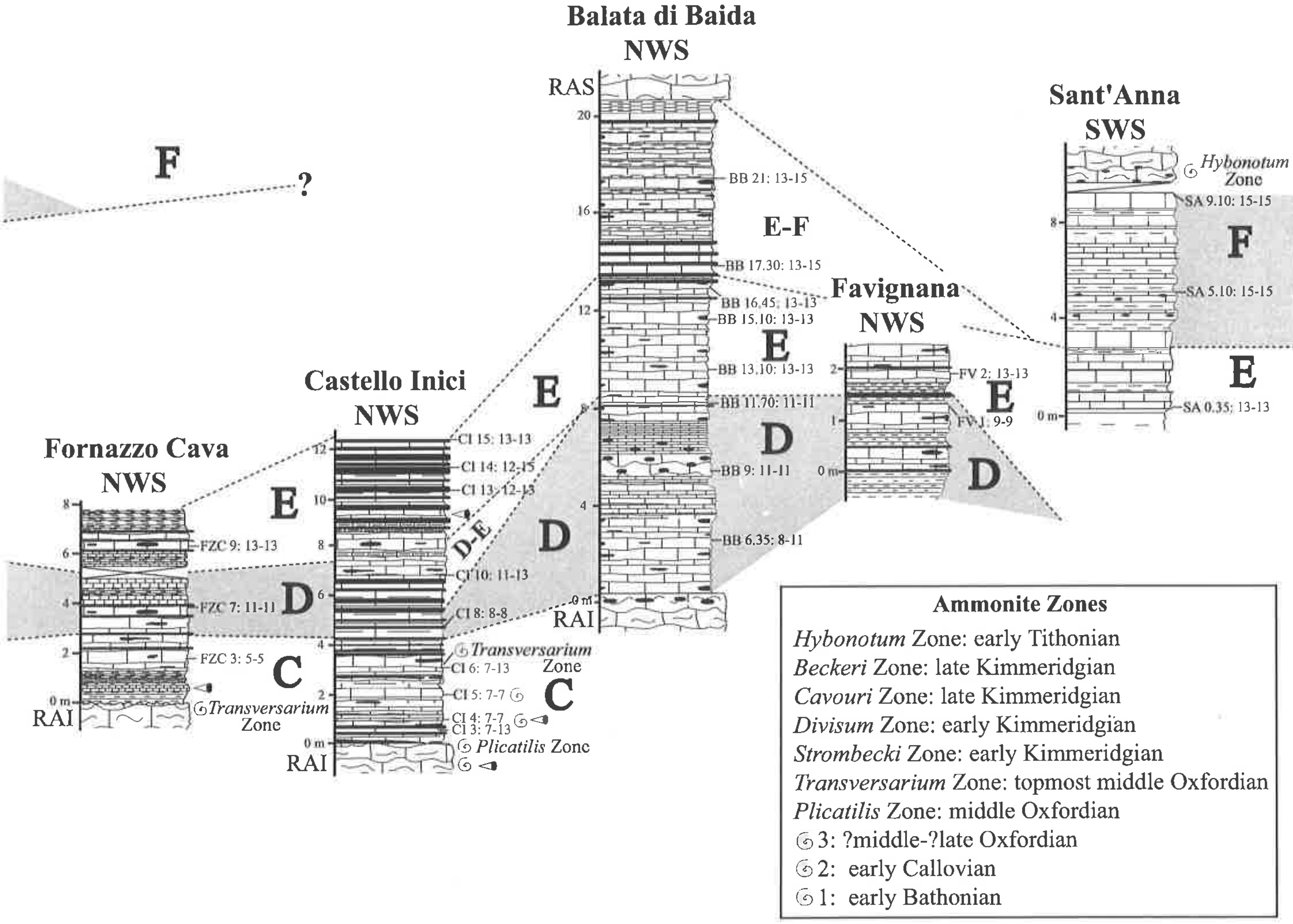


Fig. 6.4 - Radiolarian biostratigraphical correlation between Western Sicily and the Southern Alps (Italy) by six radiolarians biozones UAZ-SA A to F. Three sections from the Southern Alps (SA), six sections from North-western Sicily (NWS), and one section from South-western Sicily (SWS) have been dated and correlated. The investigated successions represent the intermediate pelagic siliceous member (RAM) of the Rosso Ammonitico Fm. in most sections. The time-equivalent facies of RAM at Coston delle Vette is the Fonzaso Fm., at Favignana are siliceous limestones and at Sant'Anna is a basinal succession. The correlation is based on the radiolarian Unitary Associations Zones defined in this research (UAZ-SA A to F). The age of these biostratigraphical units is provided by calibration with ammonite assemblages found in the studied successions and in the under- and overlying sediments. The numbers beside the samples refer to the Unitary Assoctions of each sample (e.g., CI 10: 11-13). The scale differs among the sections. The grey colour has the only intent to facilitate the reading of the lateral traceability of each UAZone.

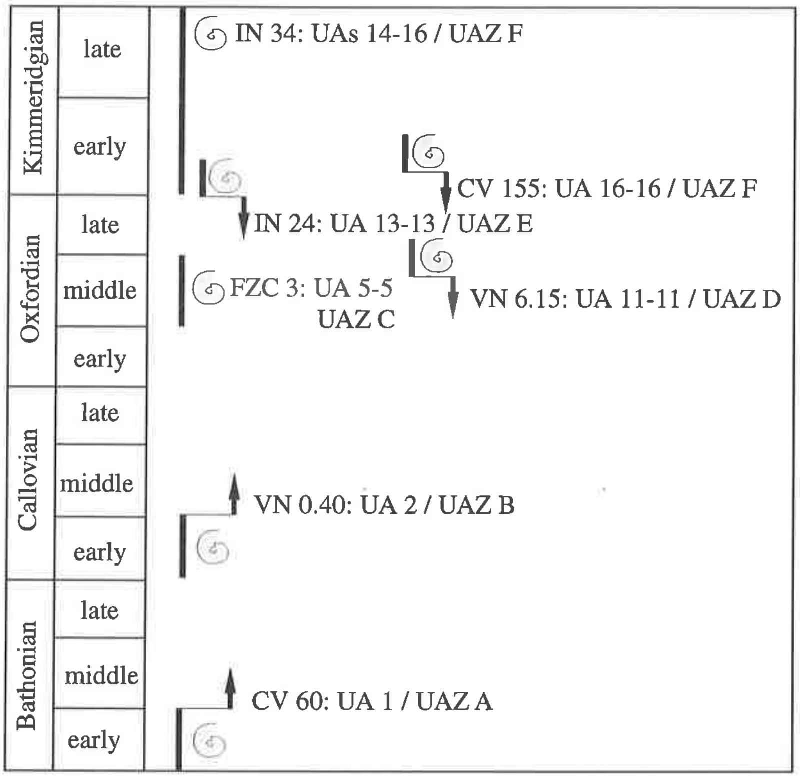


Fig. 6.5 - Calibration by ammonites of the Unitary Association Zones A to F.

The time interval of each UAZone is constrained by ammonites occurring along the studied successions and in the under- and overlying sediments. For each ammonite is indicated the closest radiolarian sample joined with the Unitary Associations and the Unitary Association Zones of such a sample. The codes of the stratigraphical sections are: CV-Coston delle Vette and VN-Cava Vianini (Southern Alps); FZC-Fornazzo Cava and IN-Fornazzo Strada (North-western Sicily) (Italy).

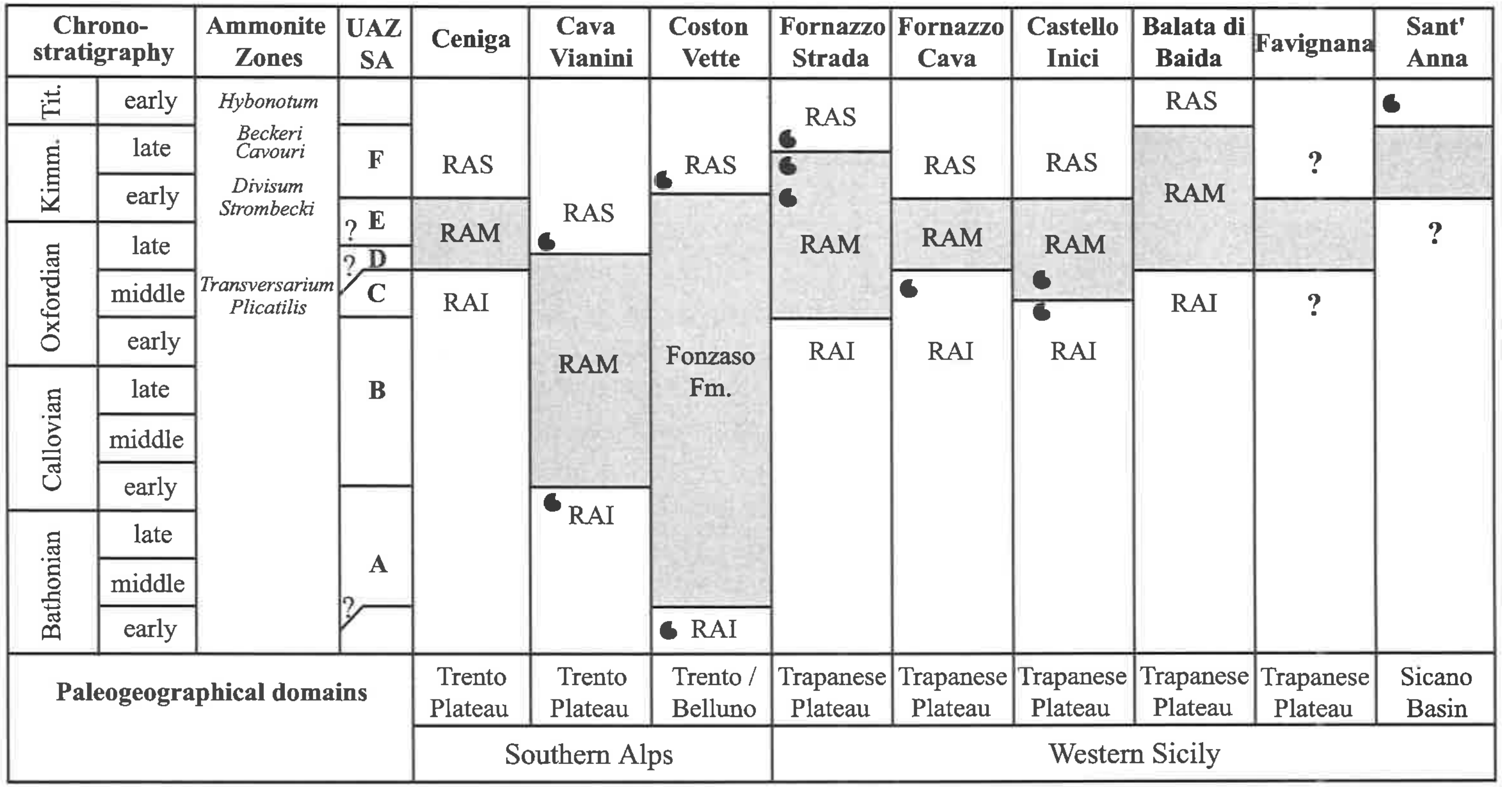


Fig. 6.6 - Diachronism of the Jurassic siliceous facies between the Southern Alps and Western Sicily (Italy).
Based on new radiolarian data, a significant diachronism is evident for the lower as well as for the upper limit of the pelagic siliceous facies in the Alpine and Sicilian sections. The grey squares represent the studied successions: Rosso Ammonitico Medio (RAM) or time-equivalent facies. The Coston delle Vette section is located in the transitional area between the Trento Plateau and the Belluno Basin. Only the ammonites zones recognized in the studied sections have been indicated (ammonites zonation from Cariou & Hantzpergue 1997). RAI: Rosso Ammonitico Inferiore; RAS: Rosso Ammonitico Superiore.

Kimmeridgian *pars*-late Kimmeridgian) indicates the end of the siliceous facies at Coston delle Vette (Southern Alps), Fornazzo Strada and Sant'Anna (Western Sicily). The apparent diachronism of the end of the siliceous facies at Fornazzo Cava, Castello Inici and Favignana is only due to the incompleteness of the sections.

As can be inferred by the above discussion, the diachronism of the siliceous facies occurs within the same paleogeographical domain as well. The three Alpine sections were located in different sectors of the Trento Plateau, and the diachronism suggests that local topography and/or tectonic movements primarily controlled the onset of the siliceous deposition. Different bottom morphology and tectonics may have influenced different spatial and temporal distribution of the siliceous facies: the oldest onset and the youngest end took place at Coston delle Vette (located in a transitional area to the Belluno Basin) while the youngest onset was at Ceniga (located very close to the strongly tectonic active Garda Escarpment). On the other hand, the Sicilian sections belonging to Trapanese Domain were paleogeographically very close to each other, and the diachronism of the onset amongst them is much minor (Fig. 6.4 and 6.6).

Chapter 7

Comparison between the zonations UAZ-SA and UAZ95 of Baumgartner et al. (1995a)

7.1 - Introduction

The new zonation UAZ-SA for Western Sicily and the Southern Alps (Italy) illustrated in the previous chapter has been compared with the zonation for the Tethyan realm of Baumgartner et al. (1995a). Indeed, only the NMRD40 data of the UAZ95 database has been used for the comparison in order to reduce the weight of quite different radiolarian assemblages (e.g., Japanese fauna). NMRD40 database consists of radiolarian data coming from Umbria-Marche Sabina Apennines and Southern Alps (Italy), Budva Zone (Dinarides, East-Europe), Subbetic (Spain), Central Atlantic and British Columbia (Canada) (Baumgartner et al. 1995a).

7.2 - Comparison between UAs^{SA} and UAs^{40}

The comparison between UAZ-SA and UAZ95 via NMRD40 has been made by means of the software BioGraph (Savary & Guex 1991, 1999). The text-files TGI (Numerical range of the taxa) of the SicAlps.DAT and of the NMRD40 databases have been joined in a new database titled "SicAlps+NMRD40" (App. 3). In this database all the data from the sections of the SicAlps.DAT file and from the sections of NMRD40 are considered as belonging to two synthetic sections. Computing the "SicAlps+NMRD40" with BioGraph new UAs resulted that represent the tool for comparing the two zonations UAZ-SA and UAZ95 (Fig. 7.1). "UAs^{SA}" refers to the Unitary Associations of the SicAlps.DAT database (App. 2); "UAs^{40}" refers to the Unitary Associations of the NMRD40 database of Baumgartner et al. 1995a. The comparison of the two zonations is, therefore, based first on the UAs (UAs^{SA} and Uas^{40}) and afterwards on the UAZones (UAZ-SA and UAZ95). The lettered UAZones (e.g., UAZ A) refer to the new zonation UAZ-SA presented in this volume; the numbered UAZones (e.g., UAZ 8) refer to the zonation UAZ95 of Baumgartner et al. (1995a). The following explanation is based on the Fig. 7.1 (TGK text-file of "SicAlps+ NMRD40") in which the ages of all cited UAZones are also reported.

UA^{SA} 1 corresponds to UAs^{40} 23-25 that belong to the UAZ 6. UA 1 forms UAZ A that falls into the UAZ 6.
UAs^{SA} 2-3 correspond to UAs^{40} 26-27 that match with the very base of the UAZ 7. **UA^{SA} 4** corresponds to UAs^{40} 30-31 of the middle of UAZ 7. UAs^{SA} 2-4 constitute the UAZ B, which is consequently included in the UAZ 7.
UA^{SA} 5 corresponds to UAs^{40} 47-48, **UA^{SA} 6** to UAs^{40} 48-49, and **UA^{SA} 7** to UAs^{40} 48-50. UAs^{SA} 5-6 correspond to the very top of the UAZ 8, while UA^{SA} 7 to the limit between UAZ 8 and UAZ 9. UAs^{SA} 5-7 form the UAZ C, which falls in the uppermost part of the UAZ 8.
UA^{SA} 8 corresponds to UAs^{40} 48-49, i.e., the uppermost part of the UAZ 8. **UAs^{SA} 9-10** correspond to UAs^{40} 49-50 that mark the boundary between UAZ 8 and UAZ 9. **UA^{SA} 11** corresponds to UAs^{40} 53-55, i.e., the top of the UAZ 9 and the base of the UAZ 10. UAs^{SA} 8-11 constitute the UAZ D, which mostly belongs to the upper part to the UAZ 8 and then corresponds to the boundary between UAZ 9 and UAZ 10.
UA^{SA} 12 corresponds to UAs^{40} 54-55, i.e., the top of the UAZ 9 and the base of the UAZ 10. **UA^{SA} 13** corresponds to UAs^{40} 55-56, i.e., the base of the UAZ 10. The UAs^{SA} 12-13 form the UAZ E that relates to the limit between UAZ 9 and UAZ 10, or that could be also entirely included in the UAZ 10.
UA^{SA} 14 corresponds to UAs^{40} 55-56 (base of UAZ 10); **UA^{SA} 15** corresponds to UAs^{40} 57-58 (limit between UAZ 10 and UAZ 11), and **UA^{SA} 16** to UAs^{40} 55-58. The UAs^{SA} 14-16 constitute the UAZ F, which partially corresponds to the UAZ 10 and ends at the boundary between UAZ 10 and UAZ 11.

The comparison between the UAs^{SA} and UAs^{40} shows some gaps, for example between UAs^{SA} 4 and 5, i.e., between UAs^{40} 31 and 46. One reason for these gaps is that the time interval represented by some UAs^{40} could have not been recorded in the studied successions due to the deposition of non-siliceous facies at that time. UA^{SA} 4 has only been found in the Southern Alps and it represents the top of the UAZ B, whereas UA^{SA} 5 has only been found in North-western Sicily and it represents the base of the UAZ C. In none section has been observed the superposition of the UAZones B and C: this fact could be related to the diachronism of the siliceous deposition between Western Sicily and the Southern Alps. Moreover, we must note that the gap between the UAs^{SA} 4 and 5 refers to the lack of Unitary Associations that, by definition, have no chronological meaning (Guex 1977, 1991). Time gaps could be possible (even though no sedimentological evidences have been noticed on the field) but the absence of some UAs simply means "lacks of UAs" with no immediate meaning of "time gaps": both UAZones B-C and UAZones 7-8 have been, in fact, recognized.

Furthermore, the examination of the correlation table for the NMRD40 database (Baumgartner et al. 1995d, App. 3) shows that many UAs^{40} occur in one or two sections only. Hence, many of these UAs^{40} have a biogeographical or preservational rather than a chronological significance, which explains their non-correlation with some UAs^{SA}.

7.3 - Comparison between UAZ-SA and UAZ95: tentative recalibration of UAZ95

The occurrence of radiolarians and ammonites in the same sections allowed a good calibration of the UAZ-SA. The following explanation concerns a tentative recalibration of some UAZones of Baumgartner et al (1995a) by means of UAZ-SA and it is based on the Fig. 7.1 (TGK text-file of "SicAlps+NMRD40"). The differences between the two zonations are due both to the presence of ammonites in the studied sections and to the fact that not all UAZ95 were directly dated.

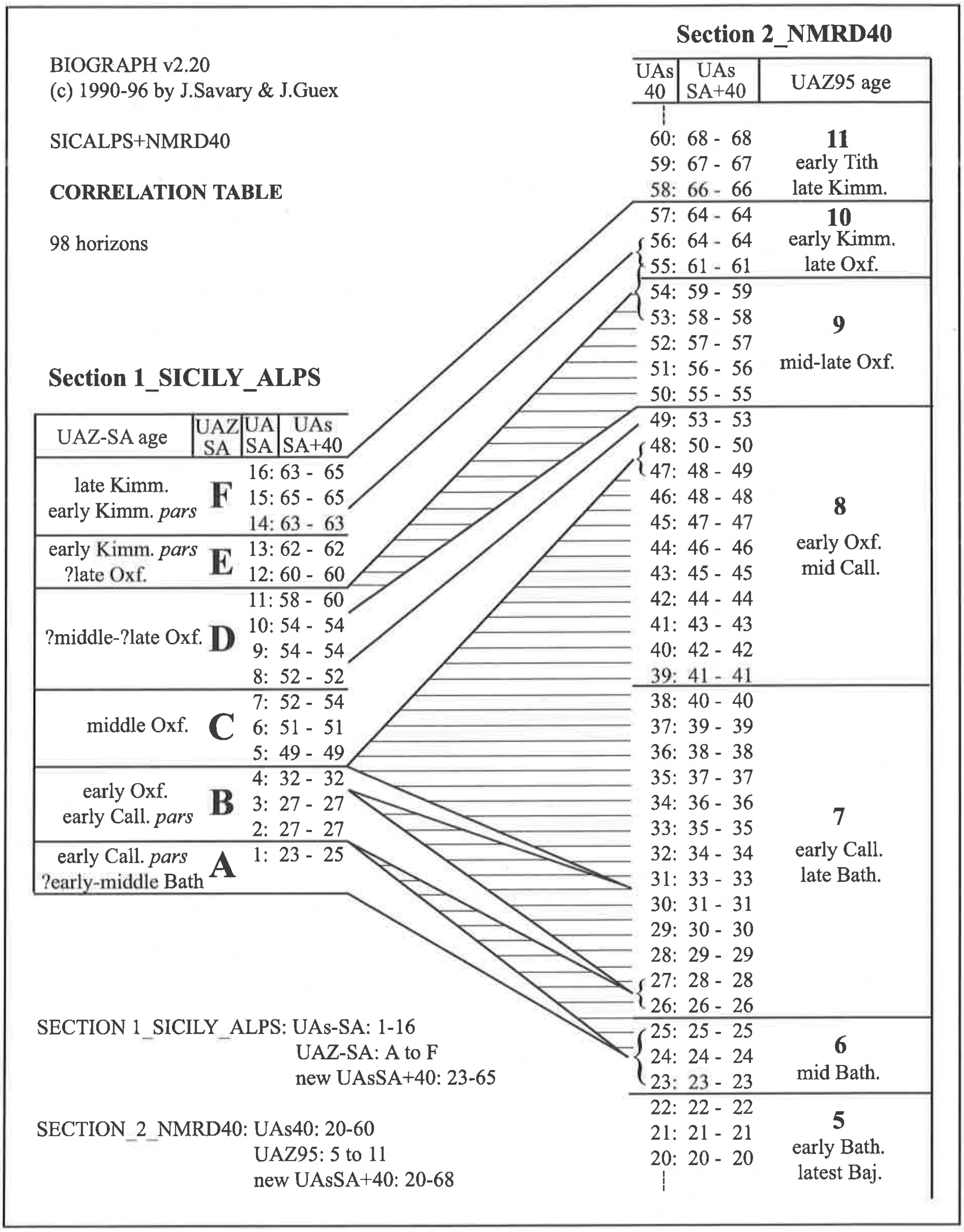


Fig. 7.1 - Comparison between the radiolarian biozonations UAZ-SA and UAZ95 of Baumgartner et al. 1995a. The UAZ-SA have been compared with the UAZ95 via NMRD40 through the respective Unitary Associations (UAs-SA and UAs40).

UAZ A (?early-midle Bath. to early Call. *pars*) falls in UAZ 6 (mid Bath.).

UAZ B (early Call. *pars* - early Oxf.) is entirely included into UAZ 7 (upper Bath.-early Call.). The base of the UAZ B is younger than at least part of early Callovian and corresponds to the base of the UAZ 7, still assigned to late Bathonian. Basing on the UAZ-SA, the late Bathonian interval is included in the UAZ A, suggesting that it cannot be included in the UAZ 7. This observation hints that the calibration of the UAZ 7 was probably not strong enough. The top of the UAZ B is not directly constrained by ammonites but it must be older than at least part of the middle Oxfordian thanks to the precise age assignment of UAZ C. It is therefore possible that the time interval of the UAZ 7 has to be extended into the early Oxfordian.

UAZ C (middle Oxf.) corresponds to the uppermost part of the UAZ 8 (mid Call.-early Oxf.) and partially to the very base of the UAZ 9 (mid-late Oxf.). The radiolarian assemblages of the UAZ C are well calibrated to the middle Oxfordian (*Transversarium* Zone). This implies that part of the UAZ 8 refers with certainty to middle Oxfordian. This does not contrast with the calibration of the UAZ 8, which is not directly constrained to early Oxfordian.

UAZ D (?middle-?late Oxf.) starts in the uppermost UAZ 8 (mid Call.-early Oxf.), includes all UAZ 9 (mid-late Oxf.), and ends at the base of the UAZ 10 (late Oxf.-early Kimm.). UAZ D is not directly constrained by ammonites, and well concurs with the corresponding UAZ95.

UAZ E (?late Oxf.-early Kimm. *pars*) relates partially in the UAZ 9 (mid-late Oxf.) and in the UAZ 10 (late Oxf.-early Kimm.), and shows a good correspondence with the UAZ95.

UAZ F (early Kimm. *pars*-late Kimm.) corresponds to part of the UAZ 10 (late Oxf.-early Kimm.) and ends at the boundary between UAZ 10 and UAZ 11 (late Kimm.-early Tith.). Both UAZ E and UAZ F are included into UAZ 10: this means that inside the UAZ 10 have been recognized two new UAZones, implying that the UAs^{SA} 12-16 (that form the UAZ E and F) are better defined and have more lateral traceability than UAs^{40} 55-57 (that constitute the UAZ 10). UAZ 10 is, therefore, extended to late Kimmeridgian.

7.4 - Discussion about the age assignment of the Ceniga section (Trento Plateau, Southern Alps)

The Ceniga section has been studied by Baumgartner (1984) and Baumgartner et al. (1995c). The time interval stated in these papers spans the UAZ 8 (mid Call.-early Oxf.) to UAZ 10-11 (late Oxf.-early Kimm. to late Kimm.-early Tith.).

The radiolarian assemblages of the new samples CE 0.80 and CE 5.20 (Fig. 6.4) belong to the UAZ D and assign most of the section to the Oxfordian time. The radiolarian assemblages of the new samples CE 5.77, CE 5.90 and CE 6.90 (Fig. 6.4) belong to the UAZ E and refer the upper part of the section to ?late Oxf.-early Kimm. *pars*. To strengthen the correlation with the other studied sections, the radiolarian data of two Baumgartner's samples (POB 1703 and POB 1704; Baumgartner 1984) have been added in the SicAlp.DAT database. The radiolarian assemblages of these samples belong to the UAZ E (?late Oxf.-early Kimm. *pars*).

In account of this research, the age of the RAM (intermediate pelagic siliceous member of the Rosso Ammonitico Fm.) at Ceniga is now restricted to ?middle-?late Oxfordian-early Kimmeridgian *pars* (UAZ D to UAZ E). This age assignment highly differs from those stated for other sections of Trento Plateau, where the RAM is referred to late Callovian-middle Oxfordian (Cava Vianini, this paper; Martire 1996). We must note, however, that the lowest 80cm of the section did not furnish determinable radiolarian samples: this interval could be highly condensed and could correspond to a time interval older than Oxfordian. Paleogeographically, the Ceniga section is on an outer high next to the Garda paleoescarpment facing the Lombardian Basin: this location could explain the age differences of the siliceous facies among the Trento Plateau sections.

Thanks to the new radiolarian data it has also been possible to provide the age of the bentonite levels in the Ceniga section. The first 2 layers occur at the very top of the UAZ D (?middle-?late Oxf.) and the others 4 layers occur at the very base of the UAZ E (?late Oxf.-early Kimm. *pars*). It is reasonable to suppose that the bentonites are Oxfordian in age, and very probably referable to late Oxfordian time.

7.5 - Discussion about the age assignment of the Sant'Anna section (Sicano Basin, South-western Sicily)

Sant'Anna section has been assigned a variety of ages by several authors. Origlia-Devos (1983) referred the pelagic siliceous succession to middle Oxfordian-middle Tithonian. De Wever et al. (1986) indicated a middle Oxfordian-early Kimmeridgian age. De Wever (1995) re-dated the same section by means of UAZ95 of Baumgartner et al. (1995a) and assigned the succession to the UAZ 9-10 (mid-late Oxf. to late Oxf.-early Kimm.).

The radiolarian assemblage of the new sample SA 0.35 (Fig. 6.4) belongs to the UAZ E and constrains the first observed layers of the pelagic siliceous succession to ?late Oxf.-early Kimm. *pars*. The radiolarian assemblages of the new samples SA 5.10 and SA 9.10 (Fig. 6.4) belong to the UAZ F and date the middle and upper parts of the section as early Kimmeridgian *pars* - late Kimmeridgian. This age assignment is consistent with the early Tithonian age of the ammonite assemblages found at the base of the overlying nodular limestone (De Wever et al. 1986).

This study suggests that the age of the pelagic siliceous succession at Sant'Anna is referable to ?late Oxfordian-late Kimmeridgian (UAZ E to UAZ F).

7.6 - Age of the bentonites in the Southern Alps

Traces of Middle Jurassic volcanic activity have been reported from many localities of the Southern Alps (Italy). In Val di Non (north-east of Trento), Bars (1965) found three bentonite levels in the Upper Dogger limestones. In the Monti Lessini area (North of Verona), Sturani (1969) found bentonites in the Rosso Ammonitico Inferiore (RAI) referred to Bajocian-Bathonian age by ammonites. In the Altopiano di Asiago (Venetian Alps, Vicenza), Bernoulli & Peters (1970) described bentonites of Late Jurassic age in the Rosso Ammonitico Superiore (RAS). At Kaberlaba section (Altopiano di Asiago, Venetian Alps, Vicenza), Martire (1989) reported five bentonite layers: the thickest was assigned to middle Oxfordian by *Transversarium* Zone ammonites discovered at the top of the Rosso Ammonitico Medio (RAM). At Madonna della Corona section (Monte Baldo, Adige Valley) the upper part of the RAM contains several bentonite levels (Baumgartner et al. 1995c). At Cava Spiazzi (very close to Madonna della Corona Sanctuary), Papa (1994) discovered ammonites referred to the boundary between *Transversarium* and *Bifurcatus* Zones, i.e., to the limit middle-late Oxfordian. Such ammonites occurred at the base of the RAS and some bentonites were found below (at the top of the RAM) restricting their age to the boundary middle-upper Oxfordian. At the Ceniga section (North of Garda Lake) bentonite levels are described from the middle part of the RAM, which is entirely referred to late Oxfordian-early Kimmeridgian by Fogelgesang (1975).

Most literature seems to narrow the age of the Upper Jurassic bentonites to middle Oxfordian. For some bentonites such a claim is surely correct, because they have been discovered both above (at Kaberlaba section) and below (at Cava Spiazzi section) the middle Oxfordian *Transversarium* Zone.

Looking at the newly presented radiolarian data, however, it is also evident that some bentonites are not strictly referred to middle Oxfordian time. At the Cava Vianini section the bentonites occur inside the UAZ D that also include late Oxfordian. At the Ceniga section the first 2 levels of bentonites occur at the very top of the UAZ D (?middle-?late Oxfordian) and the others 4 layers at the very base of the UAZ E (?late Oxfordian-early Kimmeridgian). These data confirm that some bentonites are Oxfordian in age (and very probably late Oxfordian) but also suggest the possibility that some levels could be early Kimmeridgian in age.

7.7 - Age considerations for radiolarian some species

The comparison between the UAZ-SA and the UAZ95 biozonations, and the subsequent recalibration of the UAZ95 evidently affect the ages of the taxa as stated in Baumgartner et al. (1995a). The affected ages could have no distinctive meaning for most species (as a mere consequence of the recalibration of the UAZones) but they can clearly provide new information for some taxa.

Podocapsa amphitreptera **FOREMAN** (Pl. 9, Figs. 1-3)
Its range is referred to the UAZ 9-18 (mid-late Oxf. to latest Val.-earliest Haut). In the studied sections *P. amphitreptera* appears in the UAZ E (?late Oxf.-early Kimm. *pars*). *P. amphitreptera* is a large, resistant and easily recognizable form, and it is very probable that its presence should also be recorded in the older samples. It is therefore reasonable to hypothesize that *P. amphitreptera* does not appear before late Oxfordian at least in the studied area.

Ristola altissima altissima **(RÜST) and *Ristola altissima nodosa*** **HORI** (Pl. 9, Figs. 13 and 15, 16)
The age of *R. altissima altissima* is stated as UAZ 7-12 (late Bath.-early Call. to early-early late Tith.). In the studied sections *R. altissima altissima* first appears in the UAZ C (middle Oxf.) and its ancestral form *Ristola altissima major* BAUMGARTNER & DE WEVER is present in samples assigned to the UAZ B (early Call. *pars*-early Oxf.) in the Coston delle Vette section (Southern Alps) (Beccaro et al. 2002). Furthermore, *R. altissima altissima* disappears at the top of the UAZ E (late Oxf.?-early Kimm. *pars*) when *R. altissima nodosa* first appears. *R. altissima nodosa* is comprised in the synonymy of *R. altissima altissima* in Baumgartner et al. 1995b and this fact explains the long range (UAZ 7-12) of the latter species. *R. altissima nodosa* is believed to be the transitional form between *R. altissima altissima* and *R. cretacea* (BAUMGARTNER), whose range is UAZ 12-17 (early-early late Tith. to late Val.). It is therefore reasonable to suppose that the range of *R. altissima altissima* (UAZ 7-12: late Bath.-early Call. to early-early late Tith.) as stated in Baumgartner et al. (1995a) could be restricted to the UAZ C-E (middle Oxf. to ?late Oxf.-early Kimm. *pars*) for the studied area.

Tetratrabs zealis **(OŽVOLDOVA) and *Tetratrabs bulbosa*** **BAUMGARTNER** (Pl. 4, Figs. 7-10)
The occurrences of *T. zealis* and its descendant *T. bulbosa* in the studied successions could suggest a review of their age with respect to those stated in Baumgartner et al. 1995a. *T. zealis* (UAZ 4-13: late Baj. to latest Tith.-earliest Berr.) disappears at the top (UA 13) of the UAZ E (?late Oxf.-early Kimm. *pars*) whereas is stated to reach the UAZ 13 (latest Tith.-earliest Berr.) in Baumgartner et al. (1995a). *T. bulbosa* is assigned to the UAZ 7-11 (late Bath.-early Call. to late Kimm.-early Tith.) but in the studied sections it first appears in the UAZ D (?middle-?late Oxf.). *T. bulbosa* is a large and resistant form, and it is truly

reasonable to suppose that it did not appear before the middle Oxfordian. Furthermore, the coexistence of *T. zealis* (UAZ 4-13) with *P. amphitreptera* (UAZ 9-18) has never been observed, whereas the coexistence of *T. bulbosa* (UAZ 7-11) with *P. amphitreptera* is quite common.

Saturnalids (Pl. 1, Figs. 13-16; Pl. 3, Figs. 1-3) Although Saturnalids are present and well preserved in all samples, no *Dicerosaturnalis diacranacanthus* (SQUINABOL), emend. FOREMAN (was *Acanthocircus trizonalis diacranacanthus* in Baumgartner et al. (1995b)) has been found. On the other hand, its ancestor *Dicerosaturnalis angustus* BAUMGARTNER (was *Acanthocircus trizonalis angustus* in Baumgartner et al. (1995b)) is common. Very probably the range of *D. diacranacanthus* (UAZ 10-17: late Oxf.-early Kimm. to late Val.) indicates a too old first appearance.

Chapter 8

SYSTEMATIC PALEONTOLOGY

8.1 - Introduction

Being the biostratigraphical analysis the main purpose of this volume, the remarks on the systematics are only reported for those species which are not included in Baumgartner et al. 1995b and for the transitional forms. The taxa are listed in alphabetical order of genera and species.

About 150 taxa have been identified in this research: Spumellaria and Nassellaria are both well represented, and nassellarians prevail in most samples thanks to the extraordinary abundance of the family Syringocapsidae.

The species carrying a numerical code have been used in the zonation by UAZ-SA and are illustrated in Baumgartner et al. 1995b (where the synonymy is available). In some cases, the taxonomy of Baumgartner et al. 1995b has been revised without changing the morphological concept and maintaining the code. The species carrying a lettered code are not included in Baumgartner et al. 1995b. The species marked with an asterisk have not been used for the zonation by UAZ-SA.

Groups of species have been made in order to give a biostratigraphical potential also to those taxa that are easily recognizable but show either high morphological variability (i.e., *Podobursa triacantha* (FISCHLI) gr.) or low frequency along the sections (i.e., *Palinandromeda* spp.).

8.2 - Systematic remarks

Genus: **Archaeodictyomitra** PESSAGNO 1976

***Archaeodictyomitra pseudomulticostata**
(TAN) 1927
Pl. 5, Fig. 17

Archaeodictyomitra pseudomulticostata (TAN)
Dumitrica et al. 1997, p. 41, pl. 7, fig. 5; pl. 9, fig. 4.

Occurrence: Cava Vianini (Southern Alps).

***Archaeodictyomitra shengi** YANG 1993
Pl. 5, Fig. 18

Archaeodictyomitra shengi YANG
Yang 1993, p. 111, pl. 19, figs. 2, 11; pl. 20, fig. 1.

Occurrence: Favignana (North-western Sicily).

***Archaeodictyomitra wangi** YANG 1993
Pl. 5, Fig. 19

Archaeodictyomitra wangi YANG

Yang 1993, p. 113, pl. 20, figs. 2, 3, 16; pl. 22, fig. 9.

Beccaro 2004a, p. 296, pl.2, fig. 5.

Occurrence: Balata di Baida (North-western Sicily).

Genus: **Emiluvia** FOREMAN 1973,
emend. FOREMAN 1975, emend. PESSAGNO 1977a

Emiluvia peteri BECCARO 2004c
Pl. 2, Figs. 12-14

Emiluvia sedecimporata elegans (WISNIOWSKI)

Ožvoldova 1988, pl. 1, fig. 7.

Emiluvia sedecimporata (RÜST)

Goričan 1994, pp. 67-68, pl. 4, fig. 4.

Beccaro 2004a, p. 293, pl. 1, fig. 10.

Emiluvia peteri

Beccaro 2004c, pp. 16-17, pl. 2, figs. 6-8.

Range: UAZones D-F (?middle-?late Oxf. to ?late Oxf.-late Kimm.).
Occurrence: Ceniga (Southern Alps); Balata di Baida, Favignana and Sant'Anna (Western Sicily).
Code: EMPT

***Transitional forms between**
Emiluvia orea BAUMGARTNER **and**
Emiluvia ultima BAUMGARTNER & DUMITRICA
Pl. 2, Figs. 3-4

Transitional forms between *E. orea* BAUMGARTNER (Pl. 2, Figs. 8, 9) and its descendant *E. ultima* Baumgartner & Dumitrica (Pl. 2, Figs. 12-14) have been recognized in the studied sections. The transitional forms (Pl. 2, Figs. 10, 11) are characterized by having: 1) a reduced number of nodes in comparison with *E. orea*; 2) more prominent nodes than in *E. orea* but not as strong as in *E. ultima*; 3) spines similar to *E. orea* but with less defined ridges and grooves.

Occurrence: Ceniga (Southern Alps); Balata di Baida, Fornazzo Strada and Sant'Anna (Western Sicily).

Genus: **Fultacapsa** OŽVOLDOVA & FRANTOVA 1997
Fultacapsa sphaerica (OŽVOLDOVA) 1988 s.l.
Pl. 6, Figs. 8-10

Lychocanoma sp. cf. *L. xiphophora* (RÜST)

Aita 1987, p. 65, pl. 13, fig. 2.

Lychocanoma sp. cf. *L. longicorne* (RÜST)

Aita 1987, p. 65, pl. 13, fig. 3.

Acotripus sphaericus OŽVOLDOVA

Ožvoldova 1988, p. 376, pl. 5, figs. 1-5, 7; pl. 8, fig. 7.

Birkenmajeria sphaerica (OŽVOLDOVA)

Widz & De Wever 1993, p. 82, pl. 1, figs. 3, 4.

Sethocapsa (?) sphaerica (OŽVOLDOVA)

Baumgartner et al. 1995b, p. 500, pl. 3168.

Fultacapsa sphaerica (OŽVOLDOVA)

Ožvoldova & Frantova 1997, p. 59, pl. 5, figs. 1, 2.

Ožvoldova et al. 2000, pl. 2, fig. 20.

Beccaro 2004a, pl. 1, fig. 2.

Fultacapsa ozvoldovae BECCARO

Beccaro 2004c, pl. 1, fig. 1.

Under the name of *Fultacapsa sphaerica* s.l. are here included two species: **Fultacapsa sphaerica* (Ožvoldova) and **Fultacapsa ozvoldovae* Beccaro, both assigned to *Sethocapsa (?) sphaerica* (OŽVOLDOVA) in the literature. Due to the discontinuous records of these two species in the studied sections, the code of *Fultacapsa sphaerica* (OŽVOLDOVA) (was *Sethocapsa (?) sphaerica* (OŽVOLDOVA) in Baumgartner et al. 1995b) has been maintained in the biostratigraphical analysis.

Range: UAZones E-F (?late Oxf.-early Kimm. *pars* to early Kimm. *pars*-late Kimm.).
Occurrence: Balata di Baida, Fornazzo Cava and Fornazzo Strada (North-western Sicily).
Code: 3168.

Genus: **Hsuum** PESSAGNO 1977a
***Hsuum speciosum** HULL 1997
Pl. 6, Fig. 16

Hsuum speciosum HULL
Hull 1997, p. 87, pl. 35, figs. 2, 10, 17, 18, 22.

Occurrence: Cava Vianini (Southern Alps).

Genus: **Levileugeo** YANG & WANG 1993, emend. HULL 1997
***Levileugeo ordinarius** YANG & WANG 1990
Pl. 3, Fig. 7

Levileugeo ordinarius YANG & WANG
Yang & Wang 1990, p. 203, pl. 1, figs. 2, 14; pl. 2, fig. 1.
Levileugeo ordinarius YANG & WANG
Hull 1997, p. 53, pl. 20, figs. 6, 7.

Occurrence: Cava Vianini (Southern Alps).

Genus: **Loopus** YANG 1993
Loopus doliolum DUMITRICA 1997
Pl. 6, Figs. 19-20

Loopus doliolum DUMITRICA
Dumitrica et al. 1997, p. 30, pl. 5, figs. 3, 5, 14.

Range: UAZones B-E (early Call. *pars*-early Oxf. to ?late Oxf.-early Kimm. *pars*).
Occurrence: Balata di Baida, Castello Inici, Fornazzo Cava, Fornazzo Strada (North-western Sicily), and Cava Vianini (Southern Alps).
Code: LPDL

Loopus doliolum martae BECCARO 2004c
Pl. 6, Figs. 21-22

Dictyomitra sp. C sensu Yao et al. 1982
Danelian et al. 1996, pl. 4, fig. d.
Loopus sp. A
Beccaro 2004a, p. 296, pl. 2, fig. 2.
Loopus doliolum martae BECCARO
Beccaro 2004c, pp. 13-14, pl. 1, figs. 3-5.

Range: UAZones C-E (middle Oxf. to ?late Oxf.-early Kimm. *pars*.).
Occurrence: Ceniga (Southern Alps); Balata di Baida, Castello Inici and Fornazzo Strada (North-western Sicily).
Code: LPMT

Genus: **Monotrabs** BAUMGARTNER 1984
Monotrabs goricanae BECCARO 2004b
Pl. 3, Figs. 8-9

?*Hagiastrid* sp. cf. *Tetraditryma pseudoplena* BAUMGARTNER
Kocher 1981, p. 70, pl. 14, fig. 4
Monotrabs plenoides gr. BAUMGARTNER
Baumgartner et al. 1995b, p. 324, pl. 3152, fig. 4, not figs. 1-3.
Polák et al. 1998, pl. 6, fig. 2.
Tritrabid (?) gen. et sp. indet.
Beccaro et al. 2002, p. 57, pl. 3, fig. 5.
Monotrabs goricanae BECCARO
Beccaro 2004b, pl. 1, figs. 1-8.

Range: A-B (?early-middle Bath. - early Call. *pars* to early Call. *pars*-early Oxf.).
Occurrence: Cava Vianini and Coston delle Vette (Southern Alps).
Code: MTGC

Genus: **Olanda** HULL 1997
Olanda sp. B sensu HULL 1997
Pl. 7, Fig. 11-12

Olanda sp. B
Hull 1997, p. 152, pl. 44, figs. 16, 17.
Beccaro 2004a, p. 296, pl. 2, fig. 26.

Range: UAZones B-F (early Call. *pars*-early Oxf. to early Kimm. *pars*-late Kimm.).
Occurrence: Ceniga and Coston delle Vette (Southern Alps); Balata di Baida and Sant'Anna (Western Sicily).
Code: OLAD

Genus: **Palinandromeda** PESSAGNO, BLOME & HULL 1993
Palinandromeda spp.
Pl. 7, Figs. 13-14

The genus *Palinandromeda* is represented by the species *P. crassa* (BAUMGARTNER) (Pl. 6, Fig. 4) and *P. podbielensis* (OŽVOLDOVA) (Pl. 6, Fig. 5). The range of the genus *Palinandromeda* is well defined (Baumgartner et al. 1995a) and the stratigraphical potential of *P. crassa* and *P. podbielensis* is also good, but their frequency in the studied sections is low. Because of this, the two taxa have been grouped as "*Palinandromeda* spp." in the biostratigraphical analysis. In some sections the identification at species rank has not been possible and the name "*Palinandromeda* spp." could also include the bad preserved specimens.

Range: UAZ A-D (?early-middle Bath. - early Call. *pars* to ?middle-?late Oxf.).
Occurrence: Cava Vianini, Ceniga and Coston delle Vette (Southern Alps); Castello Inici and Favignana (North-western Sicily).
Code: PLMD

Genus: **Parvivacca** PESSAGNO & YANG 1989
***Parvivacca blomei** PESSAGNO & YANG 1989
Pl. 3, Fig. 16

Parvivacca blomei PESSAGNO & YANG
Pessagno & Yang 1989, p. 244, pl. 10, figs. 13, 14, 16, 18, 28.

Occurrence: Coston delle Vette (Southern Alps); Sant'Anna (South-western Sicily).

Genus: **Podobursa** WISNIOWSKI 1889, emend. FOREMAN 1973
Podobursa andreai BECCARO 2004c
Pl. 7, Figs. 17-19

Podobursa sp. A
Danelian 1989, pl. 7, fig. 8.
Podobursa sp. aff. *P. rosea* HULL
Hull 1997, p. 104, pl. 42, fig. 4.
Podobursa sp. D
Arakawa 1998, p. 64, pl. 8, fig. 382.
Favosyringium aff. *quadriaculeatum* STEIGER
Vishnevskaya 2001, pl. 138, fig. 3.
Podobursa andreai BECCARO
Beccaro 2004c, pl. 1, figs. 8-10.

Range: UAZone B (early Call. *pars*-early Oxf.).
Occurrence: Cava Vianini (Southern Alps).
Code: PDAN

Podobursa chandrika (KOCHER) 1981

Pl. 8, Figs. 1-4

Dibolachras chandrika KOCHER

Kocher 1981, p. 61, pl. 13, figs. 1, 2.

Baumgartner 1984, p. 761, pl. 2, fig. 19.

Baumgartner et al. 1995b, p. 180, pl. 3265, figs. 1, 2.

Podobursa chandrika (KOCHER)

Beccaro 2004c, pl. 2, fig. 5.

Range: UAZones B-F (early Call. *pars*-early Oxf. to early Kimm. *pars*-late Kimm.).

Occurrence: Cava Vianini, Ceniga and Coston delle Vette (Southern Alps); Balata di Baida, Castello Inici, Favignana, Fornazzo Cava, Fornazzo Strada and Sant'Anna (Western Sicily).

Code: 3265

***Podobursa rosea** HULL 1997

Pl. 8, Fig. 7

Podobursa rosea HULL

Hull 1997, p. 102, pl. 42, figs. 2, 3, 15, 17, 20.

Occurrence: Castello Inici (North-western Sicily).

Podobursa triacantha (FISCHLI) 1916 gr.

Pl. 8, Figs. 10-14

Theosyringium acanthophorum RÜST var. *triacanthus* FISCHLI

Fischli 1916, p. 47, fig. 38.

Podobursa triacantha (FISCHLI)

Foreman 1973, p. 266, pl. 13, fig. 1.

Podobursa triacantha triacantha (FISCHLI)

Steiger 1992, pp. 71-72, pl. 19, figs. 12, 13.

In this group are included all specimens with a long apical part, an enlarged final chamber, a long terminal tube and three spines. The morphological variability of this group is very high: apical parts, pore patterns and the structure of the spines can greatly differ from one specimen to another.

Range: UAZones B-F (early Call. *pars*-early Oxf. to early Kimm. *pars*-late Kimm.).

Occurrence: Cava Vianini, Ceniga and Coston delle Vette (Southern Alps); Balata di Baida, Castello Inici, Favignana, Fornazzo Cava, Fornazzo Strada and Sant'Anna (Western Sicily).

Code: PDTC

Podobursa vannae BECCARO 2004c

Pl. 8, Figs. 15-17

Podobursa triacantha (FISCHLI)

Danelian 1989, pl. 7, fig. 6.

Podobursa sp.

Chiari 1994, pl. 4, fig. 5.

Podobursa quadriaculeata (STEIGER)

Polák, Ondrejicková & Wieczorek 1998, pl. 8, fig. 9.

Podobursa sp. B

Beccaro 2004a, p. 298, pl. 3, figs. 7, 8.

Podobursa vannae BECCARO

Beccaro 2004c, pl. 2, figs. 1-3.

Range: UAZones C-F (middle Oxf. to early Kimm. *pars*-late Kimm.).

Occurrence: Balata di Baida, Castello Inici, Favignana, Fornazzo Cava, Fornazzo Strada and Sant'Anna (Western Sicily).

Code: PDVN

Genus: **Praezhamoidellum** KOZUR 1984

***Praezhamoidellum yaoi** KOZUR 1984

Pl. 9, Fig. 6

Praezhamoidellum yaoi KOZUR

Kozur 1984, p. 53, pl. 3, fig. 3.

Occurrence: Cava Vianini (Southern Alps).

Genus: **Pseudoeucyrtis** PESSAGNO 1977b

Pseudoeucyrtis firma HULL 1997

Pl. 9, Fig. 9

Pseudoeucyrtis sp. J

Baumgartner et al. 1995b, p. 460, pl. 3167, figs. 1-4.

Pseudoeucyrtis firmus HULL

Hull 1997, p. 158, pl. 49, figs. 7-9.

Range: UAZones A-B (?early-middle Bath. - early Call. *pars* to early Call. *pars*-early Oxf.).
Occurrence: Cava Vianini and Coston delle Vette (Southern Alps).
Code: 3176

Pseudoeucyrtis sp. B sensu WIDZ 1991

Pl. 9, Fig. 12

Pseudoeucyrtis sp. B

Widz 1991, p. 253, pl. 3, fig. 22.

Beccaro 2004a, p. 298, pl. 2, fig. 21.

Range: UAZones E-F (?late Oxf.-early Kimm. *pars* to early Kimm. *pars*-late Kimm.).
Occurrence: Castello Inici, Fornazzo Strada and Sant'Anna (Western Sicily).
Code: PEB0

Genus: **Ristola** PESSAGNO & WHALEN 1982, emend. BAUMGARTNER 1984

Ristola altissima nodosa HORI 1999

Pl. 9, Figs. 15-16

Parvicingula (?) altissima (RÜST)

Baumgartner et al. 1984, p. 58, pl. 5, fig. 4.

Parvicingula (?) altissima (RÜST)

Ožvoldova & Sykora 1984, p. 268, pl. 11, figs. 4, 7, 8; pl. 15, fig. 3.

Yao 1984, pl. 2, fig. 25.

Ristola altissima (RÜST)

Baumgartner 1984, p. 783, pl. 8, fig. 3.

Ožvoldova 1988, pl. 4, fig. 5.

Ristola altissima (RÜST) ssp. B

Widz 1991, p. 253, pl. 3, fig. 25.

Ristola altissima altissima (RÜST)

Goričan 1994, p. 168, pl. 24, figs. 6-7.

Ristola altissima nodosa HORI

Hori 1999, p. 98, pl. 9, figs. 19, 20; pl. 10, figs. 1-4; pl. 11, fig. 8.

Range: UAZones E-F (?late Oxf.-early Kimm. *pars* to early Kimm. *pars*-late Kimm.).
Occurrence: Ceniga (Southern Alps); Balata di Baida, Fornazzo Cava, Fornazzo Strada and Sant'Anna (Western Sicily).
Code: 3241N. In the volume of Baumgartner et al. 1995b *Ristola altissima nodosa* HORI was still included under *Ristola altissima altissima* (RÜST), whose code was 3241. In this research, two different codes have been used to designate the two subspecies: 3241A for *R. altissima altissima* and 3241N for *R. altissima nodosa*.

Genus: **Saitoum** PESSAGNO 1977a

***Saitoum dercourti** WIDZ & DE WEVER 1993

Pl. 9, Fig. 18

Saitoum dercourti WIDZ & DE WEVER

Widz & De Wever 1993, p. 85, pl. 1, fig. 17.

Goričan 1994, p. 86, pl. 26, figs. 3-5.

Beccaro 2004a, p. 298, pl. 2, fig. 24.

Occurrence: Castello Inici and Fornazzo Strada (North-western Sicily).

Code: SAD0

Genus: **Stichocapsa** HAECKEL 1881

***Stichocapsa ulivii** CHIARI, CORTESE & MARCUCCI 1997

Pl. 10, Fig. 2

Stichocapsa ulivii CHIARI, CORTESE & MARCUCCI
Chiari et al. 1997, p. 70, pl. 4, figs. 10, 11.

Occurrence: Fornazzo Strada (North-western Sicily).

Genus: **Suna** WU 1986

***Suna ehrenbergi** HULL 1997

Pl. 4, Figs. 1-2

Suna ehrenbergi HULL
Hull 1997, p. 68, pl. 26, figs. 12, 13, 16, 18, 19, 22.

Occurrence: Balata di Baida, Fornazzo Strada and Sant'Anna (Western Sicily).

Genus: **Syringocapsa** NEVIANI 1900

Syringocapsa sp. A

Pl. 10, Figs. 7-8

Syringocapsa sp. A
Beccaro 2004a, p. 298, pl. 3, figs. 9-10.

Syringocapsa sp. A includes specimens with a short and very stout apical part, a slightly enlarged final chamber, a quite short terminal tube and without spines. Small rounded pores are randomly ordered on the apical part, big pentagonal to hexagonal pores occur on the final chamber and the terminal tube.

Range: UAZones B-F (early Call. *pars*-early Oxf. to early Kimm. *pars*-late Kimm.).

Occurrence: Ceniga and Cava Vianini (Southern Alps); Balata di Baida, Fornazzo Strada and Sant'Anna (Western Sicily).

Code: SYCA

Genus: **Tetracapsa** HAECKEL 1881

***Tetracapsa molengraaffi** (TAN) 1927

Pl. 10, Fig. 12

Cyrtocapsa Molengraaffi TAN
Tan 1927, p. 66, pl. 14, figs. 114-116.
Tetracapsa molengraafi TAN
Kiessling 1999, p. 60, pl. 13, fig. 5.
Beccaro 2004a, p.298, pl. 2, fig. 9.

Occurrence: Balata di Baida (North-western Sicily).

Genus: **Tetratrabs** BAUMGARTNER 1980

***Transitional forms between *Tetratrabs zealis* (OŽVOLDOVA) and *Tetratrabs bulbosa* BAUMGARTNER**

Pl. 4, Figs. 9-10

The genus *Tetratrabs* is represented by two species in the investigated sections: *T. zealis* (OŽVOLDOVA) (Pl. 8, Fig. 11) and *T. bulbosa* BAUMGARTNER (Pl. 8, Fig. 10). The transitional forms (Pl. 8, Figs. 12, 13) are characterized by having: 1) structure of the spines as *T. zealis*; 2) terminal part of the rays slightly enlarged but not as bulky as *T. bulbosa*; 3) prominent nodes at the base of the spines.

Occurrence: Cava Vianini (Southern Alps); Balata di Baida and Sant'Anna (Western Sicily).

Genus: **Triactoma** RÜST 1885

Triactoma enzoi BECCARO 2004c

Pl. 4, Figs. 13-14

Triactoma parablakei YANG & WANG

Yang & Wang 1990, p. 206, pl. 3, fig. 9, not 15.

Triactoma blakei (PESSAGNO)

Ožvoldova & Faupl 1993, pl. 3, fig. 8.

Triactoma parablakei YANG & WANG

Beccaro et al. 2002, pl. 2, fig. 22.

Triactoma enzoi BECCARO

Beccaro 2004c, pl. 2, figs. 10-12.

Range: UAZones B-D (early Call. *pars*-early Oxf. to ?middle-?late Oxf.).

Occurrence: Cava Vianini and Coston delle Vette (Southern Alps).

Code: TCEZ

Genus: **Tripocyclia** HAECKEL 1881, emend. PESSAGNO & YANG 1989

***Tripocyclia brooksi** PESSAGNO & YANG 1989

Pl. 5, Fig. 1

Tripocyclia brooksi PESSAGNO & YANG

Pessagno et al. 1989, p. 216, pl. 5, figs. 7-9, 11-13, 15, 20.

Occurrence: Cava Vianini and Ceniga (Southern Alps); Favignana (North-western Sicily).

Genus: **Zhamoidellum** DUMITRICA 1970

Zhamoidellum (?) exquisitum HULL 1997

Pl. 11, Fig. 20

Zhamoidellum (?) exquisitum HULL

Hull 1997, p. 132, pl. 38, figs. 5, 16, 17, 21.

Zhamoidellum (?) exquisita HULL

Beccaro 2004a, p. 298, pl. 2, fig. 17.

Range: UAZone D (?middle-?late Oxf.).

Occurrence: Castello Inici and Fornazzo Strada (North-western Sicily).

Code: ZHE0

8.3 - Sponge spicules (Porifera)

Abundant and well diversified sponge spicules have been found in all samples. The systematic assignment is based on Wiedenmayer (1994) and Mostler (1976, 1986, 1990a, 1990b).

An estimated amount of the spicule content is indicated in the tables where the radiolarian taxa are reported for each section (App. 1, Tabs. 3.1, 3.2, 3.3, 3.4, 5.1, 5.2). The abundant occurrence of the sponge spicules reveals an ecological meaning: their abundance is, in fact, inversely correlated with the bathymetry or the distance from the shelf. This means that the spicules make a significant contribution to the siliceous microfossils assemblages only in proximal or relatively shallow water environments (Kiessling 1996). Also the morphological diversity of the spicules has a meaning in the ecological interpretation: the decrease of diversity with depth seems, in fact, to be a universal rule (Murchey et al. 1988).

The occurrence of sponge spicules in the studied sections well reflects the sedimentary paleoenvironments: the spicules are mainly "abundant or common" in the pelagic plateaux (Trapanese Domain and Trento Plateau; App. 1, Tabs. 3.1, 3.2, 3.3 5.1, 5.2), and "rare" in the basin (Sicano Domain; App. 1, Tab. 3.4). Della Bruna & Martire (1985) recorded abundant spicule content along all Coston delle Vette section (Trento Plateau, Southern Alps).

CONCLUSIONS

The study of the Jurassic pelagic siliceous successions of Western Sicily and the Southern Alps (Italy) supports the following biostratigraphical and systematic conclusions.

1 - First description of the radiolarian assemblages of the Rosso Ammonitico Medio

The radiolarian assemblages of the RAM (Rosso Ammonitico Medio, i.e., the intermediate pelagic siliceous member of the Rosso Ammonitico Fm.) have been studied for the first time in the following stratigraphical sections:

- Cava Vianini (Trento Plateau, Southern Alps);
- Fornazzo Strada, Fornazzo Cava, Castello Inici, Balata di Baida, Favignana Island (Trapanese Domain, North-western Sicily).

These sections have been directly dated for the first time by means of radiolarian assemblages.

2 - Definition of 6 radiolarian biozones: Unitary Associations Zones A to F

Radiolarian biostratigraphy was carried out using the Unitary Associations method. The occurrences of 99 selected taxa from 9 stratigraphical sections in Western Sicily and the Southern Alps have been computed by the software BioGraph that recognized 16 Unitary Associations (UAs). Afterwards, these UAs have been manually grouped into 6 biostratigraphical units: UAZ-SA A to F (Unitary Association Zones for Sicily and the Southern Alps).

3 - Biostratigraphical correlation of 9 sections by means of UAZ-SA A to F

The radiolarian biozones UAZ-SA A to F show a good reproducibility throughout the investigated sections in Western Sicily and the Southern Alps (Italy). The UAZones A and B occur in the Southern Alps, UAZ C is well represented in North-western Sicily, UAZ D is the most widespread, and UAZ E and F are present in most sections. This distribution allows the first stratigraphical correlation by means of radiolarians of the RAM and time-equivalent facies.

4 - Calibration of the radiolarian zones UAZ-SA A to F by means of ammonite zones

The occurrence of ammonites in the studied successions and in the under- and overlying sediments is a crucial complement to this research. The time intervals of the UAZ-SA A to F are provided by calibration with ammonite ages:

- UAZ F: early Kimmeridgian *pars* - late Kimmeridgian
- UAZ E: ?late Oxfordian-early Kimmeridgian *pars*
- UAZ D: ?middle-?late Oxfordian
- UAZ C: middle Oxfordian
- UAZ B: early Callovian *pars*-early Oxfordian
- UAZ A: ?early-middle Bathonian to early Callovian *pars*.

5 - Diachronism of the siliceous facies between Western Sicily and the Southern Alps

The stratigraphical correlation through the UAZ-SA reveals a significant diachronism for the lower as well as for the upper boundary of the pelagic siliceous facies in the Alpine and Sicilian sections. The diachronism occurs both between Western Sicily and the Southern Alps, and within the same paleogeographical domain.

6 - Comparison of the UAZ-SA with the UAZ95 of Baumgartner et al. (1995a)

Essentially, there is a good correlation between the two zonations, and the main difference regards the Callovian and Oxfordian time intervals. The early Callovian falls into UAZ B (early Call. *pars*-early Oxf.) that is related with the very base of the UAZ 7 (late Bath.-early Call.). The middle Oxfordian (UAZ C) is well calibrated by ammonites and is surely related with the UAZ 8 (middle Call.-early Oxf.). Within the UAZ 10 (late Oxf.-early Kimm.) have been recognized two new UAZones: UAZ E and F (?late Oxfordian-early Kimmeridgian *pars* and early Kimm. *pars*-late Kimm., respectively) implying that the UAZ 10 could be extended to late Kimmeridgian. The new radiolarian and ammonites data suggest a review of the calibration of the UAZones 7, 8 and 10.

7 - Age review of the RAM at Ceniga (Southern Alps)

The chronostratigraphical position of the RAM at Ceniga (Trento Plateau, Southern Alps) has been reviewed and it is now referred to middle Oxfordian-early Kimmeridgian (UAZ D-E). This age is more narrowly defined with respect to the literature and highly differs from the ages of other RAM sections in the Trento Plateau: for example, the base (middle Oxfordian, UAZ D) is younger than the base at Cava Vianini (early Call. *pars*-early Oxf., UAZ B), and even more than the base at Coston delle Vette (?early-middle Bath.-early Call. *pars*, UAZ A).

8 - Age review of the Sant'Anna siliceous succession (South-western Sicily)

The pelagic siliceous succession cropping out at Sant'Anna (Sicano Basin, South-western Sicily) has been dated as ?late Oxf.-early Kimm. *pars* to early Kimm. *pars*-late Kimm. (UAZ E-F). This age assignment slightly differs from the literature: the Sant'Anna section was, in fact, assigned a variety of ages (ranging from middle Oxfordian to middle Tithonian) by several authors.

9 - New considerations about the age of the bentonites in the Southern Alps

The radiolarian biostratigraphy of the Ceniga and Cava Vianini sections allows new considerations on the age of the bentonites in the Southern Alps. In these sections the bentonites occur inside the UAZ D (?middle-?late Oxfordian) and UAZ E (?late Oxfordian-early Kimmeridgian *pars*), confirming that some levels are Oxfordian in age (and more likely late Oxfordian) and truly suggesting the possibility that other levels are early Kimmeridgian in age.

10 - Age considerations for some radiolarian species

Thanks to the new biozones UAZ-SA A to F, the ranges of some taxa show interesting differences with respect to those stated in Baumgartner et al. 1995a.

The range of *P. amphitreptera* FOREMAN could start in the late Oxfordian. The range of *Ristola altissima altissima* (RÜST) could be restricted to middle Oxf.-early Kimm. *pars* due the presence of its descendent *Ristola altissima nodosa* HORI (not separated as a subspecies in Baumgartner et al. 1995a). *Tetratrabs zealis* (OŽVOLDOVA) does not really co-occur with *Podocapsa amphitreptera* FOREMAN, suggesting that the LAD of *Tetratrabs zealis*

(OŽVOLDOVA) was too young in Baumgartner et al. 1995a.

Although Saturnalids well occur in all samples, no *Dicerosaturnalis diacranacanthus* (SQUINABOL), emend. FOREMAN (was *Acanthocircus trizonalis diacranacanthus* in Baumgartner et al. 1995b) has been found: this fact could suggest that the range of *D. diacranacanthus* as indicated in Baumgartner et al. 1995a provide a too old FAD.

11 - Taxonomic considerations on some transitional forms

Two morphogroups of possible transitional forms have been recognized in the studied radiolarian assemblages. The morphogroups concern:

- *Emiluvia orea* BAUMGARTNER and its descendant *Emiluvia ultima* BAUMGARTNER & DUMITRICA;
- *Tetratrabs zealis* (OŽVOLDOVA) and its descendant *Tetratrabs bulbosa* BAUMGARTNER.

12 - Occurrence of sponge spicules

The great abundance and the morphological diversity of the sponge spicules in all stratigraphical sections (except Sant'Anna) confirm the deposition of the siliceous successions (RAM and time-equivalent facies) in relatively shallow pelagic environments.

13 - Publications

The PhD research illustrated in this volume provided the following articles:

Beccaro, P. 2004a: Upper Jurassic Radiolarians from Inici Mt. area (North-western Sicily, Italy): Biochronology and Calibration by Ammonites. Riv.It.Pal.Strat., 110/1, 289-301.

Beccaro, P. 2004b: *Monotrabs goricanae* n. sp.: A new species of Jurassic Tritrabidae (spumellarian Radiolaria). Micropaleontology, 50/1, 81-87.

Beccaro, P. 2004c: New Middle-Upper Jurassic Radiolaria from Western Sicily and the Southern Alps (Italy). Razprave IV, Razreda SAZU, Ljubljana, XLV-3, 5-27.

Beccaro, P. (*in press*): Radiolarian correlation of Jurassic siliceous successions of the Rosso Ammonitico Formation in the Southern Alps and Western Sicily (Italy). Ecl.Geol.Helv.

The radiolarian biostratigraphy illustrated in this publication should be considered as a contribution to a better defined zonation for the Jurassic Mediterranean Tethys. All radiolarian data provided by this research will be used both to improve the zonation of the INTERRAD Jurassic-Cretaceous Working Group (Baumgartner et al. 1995d) and to create a database for the definition of new radiolarian zones for the Jurassic Mediterranean Tethys.

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APPENDICES

Appendix 1

STRATIGRAPHICAL DISTRIBUTION OF RADIOLARIAN TAXA

In this appendix are indicated the stratigraphical distributions of radiolarian taxa in the studied sections (Western Sicily and Southern alps, Italy). The species carrying a numerical code are illustrated in Baumgartner et al. 1995b and for some of them the nomenclature is updated (without changing the morphological concept). The species carrying a lettered code are not included in Baumgartner et al. 1995b. The species carrying an asterisk have not been used for building the UAZ-SA zonation. Black points indicate the occurrences of the taxa; black squares indicate the occurrence of species s.l. for biostratigraphical purposes only. In the column "UAZ-SA" are reported the ranges expressed in Unitary Association Zones A to F defined in this research. The estimated amount of sponge spicules is defined as rare (*), common (**) and abundant (***).

Radiolarian assemblages at Inici Mt. (Trapanese Domain, North-western Sicily)	Codes	Fornazzo Strada																FZC			Castello Inici									UAZ SA
		IN 1	IN 3	IN 4	IN 8	IN 11	IN 13	IN 15	IN 17	IN 19	IN 21	IN 24	IN 27	IN 28	IN 30	IN 32	IN 34	FZC 3	FZC 7	FZC 9	CI 3	CI 4	CI 5	CI 6	CI 8	CI 10	CI 13	CI 14	CI 15	
Acaeniotyle umbilicata (Rüst)	3092															●	●													F
Acanthocircus suboblongus s.l. (Yao)	3064	■	■	■	■				■	■			■					■	■	■	■	■	■	■	■	■		■	■	B-F
Angulobracchia biordinalis Ožvoldova	3145					●	●			●	●				●					●						●	●	●		D-F
Archaeodictyomitra apiarium (Rüst)	3263		●			●				●	●	●					●													D-F
Archaeodictyomitra minoensis * (Mizutani)	3305									●																				
Archaeodictyomitra wangi * Yang																														
Bernoullius dicera (Baumgartner)	3223				●													●							●					A-F
Cinguloturris carpatica Dumitrica	3193				●																								●	D-F
Dicerosaturnalis angustus (Baumgartner)	3082			●		●			●	●								●	●						●		●			B-E
Dicerosaturnalis trizonalis * (Rüst)	3083																●													
Emiluvia hopsoni Pessagno	3225																			●					●					D-F
Emiluvia ordinaria Ožvoldova	4015									●			●		●				●								●			D-F
Emiluvia orea s.l. Baumgartner	4069			■	●	■	■	●	●	■	■	●				■		■	■	■	■	■	■	■	■		■	■	■	C-F
Emiluvia orea Baumgartner	3224			●	●	●	●											●	●	●	●	●	●	●	●					C-F
Emiluvia pessagnoi s.l. Foreman	3066														■															D-F
Emiluvia pesssagnoi multipora * Steiger	3226														●															
Emiluvia peteri Beccaro	EMPT																													D-F
Emiluvia premyogii Baumgartner	3210								●																					A-E
Emiluvia salensis * Pessagno	3215																											●		
Emiluvia ultima Baumgartner & Dumitrica	4070									●	●					●											●	●	●	E-F
Eucyrtidiellum nodosum Wakita	3014		●	●						●																				B-E
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)	3017			●	●		●	●			●	●											●				●		●	B-F
Eucyrtidiellum unumaense s.l. (Yao)	3052																	●												A-C
Fultacapsa sphaerica s.l. (Ožvoldova)	3168												■	■	■															E-F
Fultacapsa ozvoldovae * Beccaro																														
Fultacapsa sphaerica * Beccaro													●	●	●															
Hexasaturnalis minor (Baumgartner)	3085	●	●	●	●					●			●					●	●	●	●	●	●	●	●	●				B-F
Hexasaturnalis nakasekoi Dumitrica & Dumitrica-Jud	3088		●	●	●				●	●															●			●	●	D-F
Homoeoparoanella argolidensis Baumgartner	3103	●		●	●		●												●			●								B-D
Loopus doliolum Dumitrica	LPDL						●		●									●		●							●			B-E
Loopus doliolum martae Beccaro	LPMT		●																				●				●			C-F
Loopus primitivus (Matsuoka & Yao)	3189										●	●															●			D-F
Mirifusus dianae s.l. (Karrer)	3161				●						●	●					●													D-F
Mirifusus dianae minor Baumgartner	3286																												●	E
Mirifusus guadalupaensis * Pessagno	3160						●															●								
Napora boneti Pessagno, Whalen & Yeh	3037														●															F
Napora deweveri Baumgartner	3035				●																									D-F
Napora lospensis Pessagno	3036				●			●		●		●																●	●	D-F
Olanda sp. B sensu Hull 1997	OLAD																													B-F
Palinandromeda podbielensis * (Ožvoldova)	3008																								●					
Palinandromeda spp.	PLMD																								●					A-D
Pantanellium riedeli Pessagno	3078						●																							B-F
Parahsuum carpathicum Widz & De Wever	3240					●	●		●			●						●							●		●			A-E
Parvicngula mashitaensis * Mizutani	3245									●					●															

Tab. 3.1

Radiolarian assemblages at Inici Mt. (Trapanese Domain, North-western Sicily)	Codes	Fornazzo Strada																FZC			Castello Inici									UAZ SA
		IN 1	IN 3	IN 4	IN 8	IN 11	IN 13	IN 15	IN 17	IN 19	IN 21	IN 24	IN 27	IN 28	IN 30	IN 32	IN 34	FZC 3	FZC 7	FZC 9	CI 3	CI 4	CI 5	CI 6	CI 8	CI 10	CI 13	CI 14	CI 15	
Podobursa chandrika (Kocher)	3265		●	●	●	●	●										●	●		●			●		●		●			B-F
Podobursa rosea * Hull																											●			
Podobursa spinosa (Ožvoldova)	3230								●	●	●	●							●	●	●	●				●		●	●	C-F
Podobursa triacantha (Fischli) gr.	PDTC	●	●	●	●		●	●	●	●	●	●	●				●		●	●	●	●		●	●	●	●	●	●	B-F
Podobursa vannae Beccaro	PDVN			●		●											●	●	●			●	●	●						C-F
Podocapsa amphitreptera Foreman	3171												●		●	●	●													E-F
Protunuma japonicus Matsuoka & Yao	3292								●							●	●			●					●				●	B-F
Pseudoeucyrtis reticularis Matsuoka & Yao	3177															●														F
Pseudoeucyrtis sp. B sensu Widz 1991	PEB0											●																	●	E-F
Ristola altissima s.l. (Rüst)	3164	■	■												■					■									■	A-F
Ristola altissima altissima (Rüst)	3241A	●	●																	●									●	C-E
Ristola altissima nodosa Hori	3241N														●					●										E-F
Saitoum dercourti * Widz & De Wever	SAD0													●		●											●			
Sethocapsa leiostraca * Foreman	3062																						●							
Spongocapsula perampla * (Rüst)	3267			●																									●	
Stichocapsa ulivii * Chiari, Cortese & Marcucci						●																								
Suna echiodes * (Foreman)	3094									●	●	●																		
Suna ehrenbergi * Hull															●															
Svinitizium okamurai (Mizutani)	3179									●				●	●					●										E-F
Syringocapsa sp. A	SYCA														●															B-F
Tethysetta boesii gr.* (Parona)	3185						●																							
Tetracapsa molengraafi * (Tan)																														
Tetraditryma pseudoplena * Baumgartner	3123																													
Tetratrabs bulbosa Baumgartner	3122							●		●										●					●					D-F
Tetratrabs zealis (Ožvoldova)	3121		●		●					●								●			●	●								B-E
Transhsuum brevicostatum gr. (Ožvoldova)	3181	●	●		●													●	●				●	●	●					A-E
Triactoma blakei (Pessagno)	3095				●				●												●	●	●							C-F
Triactoma foremanae Muzavor	4068								●	●		●															●	●		D-F
Triactoma jonesi * (Pessagno)	3096																											●		
Triactoma mexicana * Pessagno & Yang	3412																		●											
Triactoma tithonianum Rüst	3097													●																E-F
Tritrabs casmaliaensis (Pessagno)	3117				●	●	●		●										●							●				B-F
Tritrabs ewingi s.l. (Pessagno)	3113					●			●											●					●					B-F
Tritrabs ewingi worzeli (Pessagno)	3115																								●					D-F
Tritrabs exotica (Pessagno)	3119		●		●					●								●	●			●			●				●	C-F
Tritrabs hayi (Pessagno)	3116																					●	●							B-C
Tritrabs rhododactylus Baumgartner	3118							●																			●			E-F
Williriedellum (?) marcucciae Cortese	4060	●																												B-C
Xitus magnus Baumgartner	3259				●					●								●					●		●					C-F
Zanola cornuta (Baumgartner)	3166										●																			D-E
Zhamoidellum (?) exquisitum Hull	ZHE0		●																						●					D
Zhamoidellum ovum Dumitrica	4079						●			●	●	●				●	●													D-F
Zhamoidellum ventricosum Dumitrica	3308	●	●		●															●										C-F
Sponge spicules abundance		*	***	**	**	*	**	*	**	*	*	*	*	*	*	*	**	***	*	**	**	*	**	**	**	*	*	**	*	

Tab. 3.1

Radiolarian assemblages at Balata di Baida (Trapanese Domain, North-western Sicily)	Codes	BB 6.35	BB 9	BB 11.70	BB 13.10	BB 15.10	BB 16.45	BB 17.3	BB 21	UAZ SA
Acanthocircus suboblongus s.l. (Yao)	3064	■	■	■		■	■	■	■	B-F
Angulobracchia biordinalis Ožvoldova	3145			●					●	D-F
Archaeodictyomitra apiarium (Rüst)	3263					●	●			D-F
Archaeodictyomitra minoensis * (Mizutani)	3305						●			
Archaeodictyomitra wangi * Yang				●						
Cinguloturris carpatica Dumitrica	3193			●						D-F
Dicerosaturnalis angustus (Baumgartner)	3082					●	●			B-E
Dicerosaturnalis trizonalis * (Rüst)	3083		●							
Emiluvia ordinaria Ožvoldova	4015					●	●		●	D-F
Emiluvia orea s.l. Baumgartner	4069	■			■	●	■		■	C-F
Emiluvia orea Baumgartner	3224	●			●					C-F
Emiluvia pessagnoi s.l. Foreman	3066		●	●						D-F
Emiluvia peteri Beccaro	EMPT			●		●	●			D-F
Emiluvia salensis * Pessagno	3215			●		●				
Emiluvia ultima Baumgartner & Dumitrica	4070				●	●	●		●	E-F
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)	3017	●		●	●					B-F
Fultacapsa sphaerica s.l. (Ožvoldova)	3168				■				■	E-F
Fultacapsa ozvoldovae * Beccaro									●	
Fultacapsa sphaerica * Beccaro					●				●	
Hexasaturnalis minor (Baumgartner)	3085		●	●		●				B-F
Hexasaturnalis nakasekoi Dumitrica & Dumitrica-Jud	3088	●		●			●	●	●	D-F
Homoeoparoanella argolidensis Baumgartner	3103	●		●						B-D
Loopus doliolum Dumitrica	LPDL						●			B-E
Loopus doliolum martae Beccaro	LPMT	●		●						C-E
Loopus primitivus (Matsuoka & Yao)	3189			●						D-F
Mirifusus dianae s.l. (Karrer)	3161				●	●	●			D-F
Mirifusus dianae minor Baumgartner	3286					●				E
Napora lospensis Pessagno	3036			●			●			D-F
Olanda sp. B sensu Hull 1997	OLAD			●						B-F
Parahsuum carpathicum Widz & De Wever	3240			●	●					A-E
Podobursa chandrika (Kocher)	3265		●	●	●	●	●	●	●	B-F
Podobursa spinosa (Ožvoldova)	3230				●		●	●		C-F
Podobursa triacantha (Fischli) gr.	PDTC		●		●	●	●	●	●	B-F
Podobursa vannae Beccaro	PDVN		●		●		●	●	●	C-F
Podocapsa amphitreptera Foreman	3171							●	●	E-F
Protunuma japonicus Matsuoka & Yao	3292						●			B-F
Ristola altissima s.l. (Rüst)	3164			■	■	■	■			A-F
Ristola altissima altissima (Rüst)	3241A			●						C-E
Ristola altissima nodosa Hori	3241N				●	●	●			E-F
Spongocapsula perampla * (Rüst)	3267						●			
Suna echiodes * (Foreman)	3094				●	●			●	
Suna ehrenbergi * Hull									●	
Svinitizium okamurai (Mizutani)	3179						●			E-F
Syringocapsa sp. A	SYCA			●		●				B-F
Tetracapsa molengraafi * (Tan)				●						
Tetraditryma pseudoplena * Baumgartner	3123			●						
Tetratrabs bulbosa Baumgartner	3122			●		●	●			D-F
Tetratrabs zealis (Ožvoldova)	3121				●					B-E
Transhsuum brevicostatum gr. (Ožvoldova)	3181			●	●	●				A-E
Triactoma blakei (Pessagno)	3095	●			●		●			C-F
Triactoma foremanae Muzavor	4068					●	●	●	●	D-F
Triactoma mexicana * Pessagno & Yang	3412	●								
Tritrabs casmaliaensis (Pessagno)	3117			●	●					B-F
Tritrabs ewingi s.l. (Pessagno)	3113			●	●					B-F
Tritrabs ewingi worzeli (Pessagno)	3115				●					D-F
Tritrabs exotica (Pessagno)	3119			●						C-F
Xitus magnus Baumgartner	3259				●		●			C-F
Zhamoidellum ovum Dumitrica	4079			●	●	●		●	●	D-F
Zhamoidellum ventricosum Dumitrica	3308	●								C-F
Sponge spicules abundance		***	*	**	*	*	*	***	**	

Tab. 3.2

Radiolarian assemblages at Favignana (Trapanese Domain, North-western Sicily)	Codes	FV 1	FV 2	UAZ SA
Archaeodictyomitra shengi * Yang		●		
Bernoullius dicera (Baumgartner)	3223	●		A-F
Cinguloturris carpatica Dumitrica	3193	●	●	D-F
Dicerosaturnalis angustus (Baumgartner)	3082	●		B-E
Emiluvia peteri Beccaro	EMPT	●		D-F
Eucyrtidiellum nodosum Wakita	3014	●	●	B-E
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)	3017	●	●	B-F
Loopus primitivus (Matsuoka & Yao)	3189	●		D-F
Palinandromeda spp.	PLMD	●		A-D
Pantanellium riedeli Pessagno	3078		●	B-F
Parahsuum carpathicum Widz & De Wever	3240	●		A-E
Podobursa chandrika (Kocher)	3265	●		B-F
Podobursa polyacantha (Fischli)	3174	●		A-D
Podobursa triacantha (Fischli) gr.	PDTC	●		B-F
Podobursa vannae Beccaro	PDVN	●		C-F
Protunuma japonicus Matsuoka & Yao	3292	●		B-F
Saitoum levium De Wever	3024	●		D-F
Teichertus catenarius (Ožvoldova)	3205		●	E-F
Transhsuum brevicostatum gr. (Ožvoldova)	3181	●	●	A-E
Tripocyclia brooksi * Pessagno & Yang			●	
Tritrabs casmaliaensis (Pessagno)	3117	●		B-F
Zanola cornuta (Baumgartner)	3166	●		D-E
Sponge spicules abundance		***	**	

Tab. 3.3

Radiolarian assemblages at Sant'Anna (Sicano Basin, South-western Siciliy)	**Codes**	**SA 0.35**	**SA 5.10**	**SA 9.10**	**UAZ SA**
Acaeniotyle (?) sp. A * sensu Bamgartner et al. 1995b	3091		●	●	
Acanthocircus suboblongus s.l. (Yao)	3064	■	■	■	B-F
Angulobracchia biordinalis Ožvoldova	3145	●	●	●	D-F
Archaeodictyomitra apiarium (Rüst)	3263		●		D-F
Archaeodictyomitra minoensis * (Mizutani)	3305		●		
Archaeospongoprunum imlayi * Pessagno		●		●	
Bernoullius dicera (Baumgartner)	3223		●		A-F
Cinguloturris carpatica Dumitrica	3193		●		D-F
Dicerosaturnalis angustus (Baumgartner)	3082	●			B-E
Dicerosaturnalis trizonalis * (Rüst)	3083	●			
Dicerosaturnalis sp. aff. *D. trizonalis* * (Rüst)		●	●		
Emiluvia chica s.l. Foreman	3213	●	●		B-F
Emiluvia hopsoni Pessagno	3225	●	●		D-F
Emiluvia nana * Baumgartner	3212	●			
Emiluvia orea s.l. Baumgartner	4069	■	●	●	C-F
Emiluvia ordinaria Ožvoldova	4015		●	●	D-F
Emiluvia pessagnoi s.l. Foreman	3066	●		●	D-F
Emiluvia peteri Beccaro	EMPT		●		D-F
Emiluvia ultima Baumgartner & Dumitrica	4070	●	●	●	E-F
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)	3017	●	●	●	B-F
Fultacapsa sphaerica s.l. (Ožvoldova)	3168		■	■	E-F
Fultacapsa sphaerica * Beccaro			●	●	
Gongylothorax favosus Dumitrica	6131		●		B-F
Hexasaturnalis minor (Baumgartner)	3085	●	●	●	B-F
Hexasaturnalis nakasekoi Dumitrica & Dumitrica-Jud	3088		●	●	D-F
Higumastra coronaria * Ožvoldova	3108	●			
Loopus primitivus (Matsuoka & Yao)	3189	●		●	D-F
Mirifusus dianae s.l. (Karrer)	3161	■	●	●	D-F
Mirifusus dianae dianae (Karrer)	3274	●			E
Napora boneti Pessagno, Whalen & Yeh	3037		●	●	F
Napora lospensis Pessagno	3036	●	●	●	D-F
Olanda sp. B sensu Hull 1997	OLAD		●		B-F
Orbiculiforma (?) sp. aff. *O. mclaughlini* * Pessagno sensu Baumgartner et al. 1995b	3206	●			
Paronaella bandyi Pessagno	3135	●			A-F
Paronaella pygmaea Baumgartner	3133	●			E
Parvivacca blomei * Pessagno & Yang		●			
Perispyridium ordinarium gr. (Pessagno)	3100	●			A-E
Podobursa chandrika (Kocher)	3265	●	●		B-F
Podobursa spinosa (Ožvoldova)	3230	●	●	●	C-F
Podobursa triacantha (Fischli) gr.	PDTC	●	●	●	B-F
Podobursa vannae Beccaro	PDVN	●	●	●	C-F
Podocapsa amphitreptera Foreman	3171		●	●	E-F
Poulpus sp. aff. *P. oculatus* * De Wever sensu Baumgartner et al. 1995b	3028		●	●	
Protunuma japonicus Matsuoka & Yao	3292	●	●	●	B-F
Pseudoeucyrtis sp. B sensu Widz 1991	PEB0	●	●		E-F
Ristola altissima s.l. (Rüst)	3164		■	■	A-F
Ristola altissima nodosa Hori	3241N		●	●	E-F
Saitoum levium De Wever	3024		●	●	D-F
Sethocapsa leiostraca * Foreman	3062	●	●		
Spongocapsula perampla * (Rüst)	3267	●			
Suna echiodes * (Foreman)	3094	●		●	
Suna ehrenbergi * Hull			●		
Svinitizium okamurai (Mizutani)	3179	●			E-F
Syringocapsa spinellifera Baumgartner	3170			●	F
Syringocapsa sp. A	SYCA		●	●	B-F
Tetraditryma pseudoplena * Baumgartner	3123	●	●		
Tetratrabs bulbosa Baumgartner	3122	●	●	●	D-F
Triactoma blakei (Pessagno)	3095	●	●		C-F
Triactoma foremanae Muzavor	4068	●	●	●	D-F
Triactoma jonesi * (Pessagno)	3096	●			
Triactoma tithonianum Rüst	3097	●	●		E-F
Tritrabs casmaliaensis (Pessagno)	3117	●	●		B-F
Tritrabs ewingi s.l. (Pessagno)	3113	●			B-F
Tritrabs exotica (Pessagno)	3119		●		C-F
Tritrabs rhododactylus Baumgartner	3118	●	●		E-F
Xitus magnus Baumgartner	3259		●	●	C-F
Zhamoidellum ovum Dumitrica	4079	●	●	●	D-F
Zhamoidellum ventricosum Dumitrica	3308	●	●		C-F
Sponge spicules abundance		*	*	*	

Tab. 3.4

Radiolarian assemblages at Cava Vianini (Trento Plateau, Southern Alps)	Codes	VN 0.40	VN 2.85	VN 6.10	VN 6.15	UAZ SA
Acaeniotylopsis variatus s.l. (Ožvoldova)	4063	●	●			A-B
Acaeniotylopsis variatus variatus (Ožvoldova)	3270	●				A-B
Acanthocircus suboblongus s.l. (Yao)	3064	■	■	■	■	B-F
Amphipyndax durisaeptum * Aita	4005	●				
Angulobracchia biordinalis Ožvoldova	3145				●	D-F
Angulobracchia purisimaensis (Pessagno)	3144	●	●			A-F
Archaeodictyomitra pseudomulticostata * (Tan)			●			
Beleza decora (Rüst)	3269	●				A-B
Cinguloturris carpatica Dumitrica	3193			●		D-F
Dicerosaturnalis angustus (Baumgartner)	3082		●	●		B-E
Dicerosaturnalis trizonalis * (Rüst)	3083			●	●	
Dicerosaturnalis sp. aff. *D. trizonalis* * (Rüst)				●		
Emiluvia chica s.l. Foreman	3213	●	●			B-F
Eucyrtidiellum nodosum Wakita	3014	●				B-E
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)	3017	●	●		●	B-F
Gongylothorax favosus Dumitrica	6131		●	●		B-F
Gongylothorax sakawaensis * Matsuoka	4023		●			
Guexella nudata (Kocher)	3061	●				A-B
Hexasaturnalis minor (Baumgartner)	3085	●	●	●		B-F
Hexasaturnalis nakasekoi Dumitrica & Dumitrica-Jud	3088			●	●	D-F
Higumastra wintereri * Baumgartner & Kito	3148	●				
Hiscocapsa robusta Matsuoka	3298	●	●			B
Homoeoparoanella argolidensis Baumgartner	3103		●		●	B-D
Hsuum speciosum * Hull					●	
Kilinora catenarum (Matsuoka)	3044		●			B
Kilinora sp. aff. *K. catenarum* * (Matsuoka)			●			
Levileugeo ordinarius * Yang & Wang		●				
Loopus doliolum Dumitrica	LPDL	●				B-E
Mirifusus fragilis s.l. Baumgartner	3159	■				A-B
Mirifusus fragilis praeguadalupensis Baumgartner & Bartolini	2026	●				A-B
Mirifusus guadalupaensis * Pessagno	3160			●	●	
Monotrabs goricanae Beccaro	MTGC	●	●			A-B
Palinandromeda crassa * (Baumgartner)	3009	●		●		
Palinandromeda podbielensis * (Ožvoldova)	3008	●				
Palinandromeda spp.	PLMD	●		●		A-D
Pantanellium riedeli Pessagno	3078		●			B-F
Podobursa andreai Beccaro	PDAN	●	●			B
Podobursa chandrika (Kocher)	3265	●			●	B-F
Podobursa spinosa (Ožvoldova)	3230				●	C-F
Podobursa triacantha (Fischli) gr.	PDTC	●				B-F
Praewilliriedellum convexum (Yao)	3055		●			B
Praezhamoidellum yaoi * Kozur			●			
Protunuma japonicus Matsuoka & Yao	3292		●			B-F
Pseudoeucyrtis firma Hull	3176	●				A-B
Pseudoeucyrtis sp. aff. *P. hanni* * (Tan)		●				
Stichocapsa naradaniensis * Matsuoka	3045		●			
Stichocapsa sp. aff. *S. elegans* * Matsuoka			●			
Syringocapsa sp. A	SYCA	●				B-F
Tethysetta dhimenaensis s.l. Baumgartner	3197		■			A-B
Tethysetta dhimenaensis dhimenaensis (Baumgartner)	4072		●			B
Tethysetta dhimenaensis ssp. A sensu Baumgartner et al. 1995b	4071		●			A-B
Tetraditryma corralitosensis s.l. (Pessagno)	3273	●	●			A-B
Tetratrabs zealis (Ožvoldova)	3121	●	●			B-E
Transhsuum brevicostatum gr. (Ožvoldova)	3181	●		●		A-E
Transhuum maxwelli gr. * (Pessagno)	3180	●	●			
Triactoma blakei (Pessagno)	3095			●	●	C-F
Triactoma enzoi Beccaro	TCEZ			●		B-D
Triactoma foremanae Muzavor	4068			●		D-F
Triactoma jonesi * (Pessagno)	3096	●				
Triactoma parablakei Yang & Wang	3413	●				B
Tricolocapsa plicarum s.l. Yao	3051		●			B
Tripocyclia brooksi * Pessagno & Yang		●				
Tritrabs casmaliaensis (Pessagno)	3117	●	●	●		B-F
Tritrabs ewingi s.l. (Pessagno)	3113	●				B-F
Williriedellum carpathicum Dumitrica	4055		●			B-E
Williriedellum (?) marcucciae Cortese	4060		●			B-C
Sponge spicules abundance		*	**	***	**	

Tab. 5.1

Radiolarian assemblages at Ceniga (Trento Plateau, Southern Alps)	Codes	CE 0.80	CE 5.20	CE 5.77	CE 5.90	CE 6.90	POB 1703	POB 1704	UAZ SA
Acanthocircus suboblongus s.l. (Yao)	3064	■		■			●		B-F
Archaeodictyomitra apiarium (Rüst)	3263	●							D-F
Archaeodictyomitra minoensis * (Mizutani)	3305			●					
Cinguloturris carpatica Dumitrica	3193	●		●					D-F
Dicerosaturnalis angustus (Baumgartner)	3082			●	●				B-E
Dicerosaturnalis trizonalis * (Rüst)	3083				●				
Emiluvia chica s.l. Foreman	3213						●		B-F
Emiluvia orea s.l. Baumgartner	4069	■	●	●	■	●	■	■	C-F
Emiluvia orea Baumgartner	3224	●							C-F
Emiluvia peteri Beccaro	EMPT			●					D-F
Emiluvia salensis * Pessagno	3215						●	●	
Emiluvia ultima Baumgartner & Dumitrica	4070			●	●	●	●	●	E-F
Eucyrtidiellum nodosum Wakita	3014	●							B-E
Eucyrtidiellum ptyctum (Riedel & Sanfilippo)	3017	●							B-F
Fultacapsa sphaerica s.l. (Ožvoldova)	3168						●		E-F
Gongylothorax favosus Dumitrica	6131			●		●			B-F
Hexasaturnalis minor (Baumgartner)	3085	●					●		B-F
Hexasaturnalis nakasekoi Dumitrica & Dumitrica-Jud	3088			●					D-F
Loopus doliolum martae Beccaro	LPMT			●					C-F
Mirifusus dianae s.l. (Karrer)	3161		●				●	●	D-F
Mirifusus dianae dianae (Karrer)	3274						●		E
Mirifusus guadalupaensis * Pessagno	3160	●							
Olanda sp. B sensu Hull 1997	OLAD		●	●					B-F
Palinandromeda spp.	PLMD	●							A-D
Podobursa chandrika (Kocher)	3265	●	●			●			B-F
Podobursa polyacantha (Fischli)	3174		●						A-D
Podobursa spinosa (Ožvoldova)	3230			●	●	●	●	●	C-F
Podobursa triacantha (Fischli) gr.	PDTC	●	●	●	●				B-F
Podocapsa amphitreptera Foreman	3171						●	●	E-F
Ristola altissima s.l. (Rüst)	3164			■					A-F
Ristola altissima nodosa Hori	3241N			●					E-F
Ristola procera * (Pessagno)	3163	●							
Spongocapsula perampla * (Rüst)	3267				●				
Syringocapsa sp. A	SYCA		●	●		●			B-F
Tetratrabs bulbosa Baumgartner	3122			●			●		D-F
Tetratrabs zealis (Ožvoldova)	3121			●					B-E
Transhsuum brevicostatum gr. (Ožvoldova)	3181	●		●			●	●	A-E
Triactoma blakei (Pessagno)	3095	●	●				●	●	C-F
Triactoma foremanae Muzavor	4068			●	●				D-F
Triactoma jonesi * (Pessagno)	3096						●		
Tripocyclia brooksi * Pessagno & Yang		●							
Tritrabs casmaliaensis (Pessagno)	3117			●					B-F
Williriedellum carpathicum Dumitrica	4055					●			B-E
Zhamoidellum ovum Dumitrica	4079			●					D-F
Sponge spicules abundance		**	*	*	*	*	**	**	

Tab. 5.2

Radiolarian assemblages at Coston delle Vette (Trento Plateau, Southern Alps)	Codes	CV 60.0	CV 60.4	CV 71.4	CV 84.5	CV 105	CV 117	CV 119.5	CV 122.6	CV 125.6	CV 127.4	CV 129	CV 131.7	CV 142.5	CV 155	UAZ SA
Acaeniotyle umbilicata (Rüst)	3092									●				●	●	F
Acaeniotylopsis variatus s.l. (Ožvoldova)	4063	■	■													A-B
Acaeniotylopsis variatus variatus (Ožvoldova)	3270	●	●													A-B
Acanthocircus suboblongus s.l. (Yao)	3064		■				■			■						B-F
Angulobracchia biordinalis Ožvoldova	3145						●		●	●					●	B-F
Angulobracchia purisimaensis (Pessagno)	3144	●	●			●									●	A-F
Archaeospongoprunum sp. aff. *A. elegans* * Wu		●	●				●									
Beleza decora Rüst	3269	●														A-B
Bernoullius dicera (Baumgartner)	3223	●			●	●	●									A-F
Bernoullius rectispinus s.l. * Kito, De Wever, Danelian & Cordey	4010					■										
Bernoullius rectispinus delnortensis * Pessagno, Blome & Hull	3222					●										
Crucella theokaftensis * Baumgartner	3131	●														
Dicerosaturnalis angustus (Baumgartner)	3082				●		●									B-E
Emiluvia orea s.l. Baumgartner	4069				■		■	■						■	■	C-F
Emiluvia orea Baumgartner	3224				●		●	●						●	●	C-F
Emiluvia premyogii Baumgartner	3210	●	●	●					●							A-E
Emiluvia robusta * Rüst sensu Pessagno	3220	●	●													
Emiluvia ultima Baumgartner & Dumitrica	4070						●							●	●	E-F
Emiluvia sp. aff. *E. hopsoni* * Pessagno		●														
Eospongosaturnalis protoformis * (Yao)	2021	●	●	●		●	●									
Eucyrtidiellum unumaense s.l. (Yao)	3052	■														A-C
Eucyrtidiellum unumaense dentatum Baumgartner	3015	●														A
Guexella nudata (Kocher)	3061	●														A-B
Hexasaturnalis minor (Baumgartner)	3085		●				●									B-F
Hexasaturnalis nakasekoi Dumitrica & Dumitrica-Jud	3088						●			●						D-F
Higumastra imbricata * (Ožvoldova)	3110	●	●													
Hilarisirex quadrangularis * Takemura & Nakaseko	3002	●														
Homoeoparonaella (?) gigantea * Baumgartner	3105							●					●			
Homoeoparonaella (?) pseudoewingi * Baumgartner	3150	●	●													
Leugeo hexacubicus * (Baumgartner)	3244	●	●													
Mirifusus dianae s.l. (Karrer)	3161						●		■							D-F
Mirifusus dianae baileyi * Pessagno	3406								●							
Mirifusus dianae minor Baumgartner	3286						●									E
Mirifusus fragilis s.l. Baumgartner	3159	■		■												A-B
Mirifusus fragilis praeguadalupensis Baumgartner & Bartolini	2026	●		●												A-B
Monotrabs goricanae Beccaro	MTGC	●	●													A-B
Napora deweveri Baumgartner	3035									●						D-F
Napora lospensis Pessagno	3036						●			●						D-F
Obesacapsula morroensis * Pessagno	3266		●													
Olanda sp. B sensu Hull 1997	OLAD		●										●			B-F
Palinandromeda spp.	PLMD	●	●													A-D
Pantanellium riedeli Pessagno	3078		●		●	●				●						B-F
Parahsuum carpathicum Widz & De Wever	3240	●	●			●	●									A-E
Paronaella bandyi Pessagno	3135	●	●			●	●			●	●					A-F
Paronaella mulleri * Pessagno	3139	●			●									●	●	
Paronaella pristidentata * Baumgartner	3138						●									
Paronaella pygmaea Baumgartner	3133						●									E
Parvivacca blomei * Pessagno & Yang							●			●						
Perispyridium ordinarium gr. (Pessagno)	3100	●	●													A-E
Podobursa chandrika (Kocher)	3265							●			●	●				B-F

Tab. 5.3

Radiolarian assemblages at Coston delle Vette (Trento Plateau, Southern Alps)	Codes	CV 60	CV 60.4	CV 71.4	CV 84.5	CV 105	CV 117	CV 119.5	CV 122.6	CV 125.6	CV 127.4	CV 129	CV 131.7	CV 142.5	CV 155	UAZ SA
Podobursa helvetica * (Rüst)	3169	●	●			●									●	
Podobursa polyacantha (Fischli)	3174	●	●		●											A-D
Podobursa spinosa (Ožvoldova)	3230				●		●	●	●		●	●				C-F
Podobursa triacantha (Fischli) gr.	PDTC								●	●						B-F
Podocapsa amphitreptera Foreman	3171							●	●	●		●	●	●	●	E-F
Poulpus sp. aff. *P. oculatus* * De Wever sensu Baumgartner et al. 1995b	3028	●														
Praewilliriedellum convexum (Yao)	3055		●													B
Pseudocrucella sanfilippoae * (Pessagno)	3126	●														
Pseudoeucyrtis firma Hull	3176	●		●												A-B
Pseudoeucyrtis reticularis Matsuoka & Yao	3177													●	●	F
Ristola altissima s.l. (Rüst)	3164	■		■	■		■									A-F
Ristola altissima altissima (Rüst)	3241A				●		●									C-E
Ristola altissima major * Baumgartner & De Wever	3238	●		●												
Saitoum elegans * De Wever	3022				●											
Saitoum pagei * Pessagno	3020	●	●													
Saitoum trichylum * De Wever	3021	●	●													
Sethocapsa funatoensis * Aita	3070	●														
Spongocapsula palmerae * Pessagno	3199					●			●							
Stylocapsa oblongula Kocher	3059	●														A
Suna echiodes * (Foreman)	3094						●									
Syringocapsa spinellifera Baumgartner	3170									●				●	●	F
Teichertus catenarius (Ožvoldova)	3205									●						E-F
Teichertus (?) heliotropicus * (Baumgartner)	3204						●									
Tethysetta dhimenaensis s.l. Baumgartner	3197	■														A-B
Tethysetta dhimenaensis ssp. A sensu Baumgartner et al. 1995b	4071	●														A-B
Tetraditryma corralitosensis s.l. (Pessagno)	3273	■	■													A-B
Tetradytrima corralitosensis bifida * Conti & Marcucci	4048	●	●													
Tetradytrima corralitosensis corralitosensis * (Pessagno)	3124	●														
Tetradytrima praeplena * Baumgartner	3125		●			●										
Tetratrabs bulbosa Baumgartner	3122					●	●			●	●				●	D-F
Tetratrabs zealis (Ožvoldova)	3121		●					●								B-E
Transhsuum brevicostatum gr. (Ožvoldova)	3181	●	●													A-E
Triactoma blakei (Pessagno)	3095						●	●	●	●	●			●		C-F
Triactoma enzoi Beccaro	TCEZ		●													B-D
Triactoma jonesi * (Pessagno)	3096				●			●								
Triactoma tithonianum Rüst	3097									●						E-F
Tritrabs casmaliaensis (Pessagno)	3117		●	●	●	●	●	●		●		●		●	●	B-F
Tritrabs ewingi s.l. (Pessagno)	3113						●			■	●			●	●	B-F
Tritrabs ewingi worzeli (Pessagno)	3115									●				●		D-F
Tritrabs exotica (Pessagno)	3119					●				●						C-F
Tritrabs hayi (Pessagno)	3116		●													B-C
Tritrabs rhododactylus Baumgartner	3118						●									E-F
Tritrabs simplex * Kito & De Wever	3303	●														
Turanta buntonense * Pessagno & Blome		●	●													
Unuma echinatus Ichikawa & Yao	3231	●														A
Zanola cornuta (Baumgartner)	3166				●	●										D-E

Tab. 5.3

Appendix 2

Database of the zonation UAZ-SA: SicAlps.DAT file

The distribution of the radiolarian species in the stratigraphical sections of the Southern Alps (sections 1-3) and Western Sicily (sections 4-9) (Italy) is listed in the database for the zonation: the SicAlps.DAT file.

For computing the SicAlps.DAT with the software BioGraph (Savary & Guex 1991, 1999) it is necessary to indicate the format of data input ("SAMPLES", i.e., the taxa are listed for each sample of each section), the title of the database ("CE+VN+CV+FV+SA+IN+FCZ+CI+BB", i.e., the codes of each sections), the names of the sections joined with the total number of the samples (e.g., "SECTION 2_Cava_Vianini: bottom 1 - top 4"), and the list of samples followed by their own taxa content (e.g., <1 {VN 0.40} : 4063, 3270, etc...). Each taxon is indicated by a code. The species carrying a numerical code are illustrated in Baumgartner et al. 1995b, while those species carrying a lettered code are not included in such a volume. Taxa in {} parenthesis have not been used for the zonation.

```
Samples
Title "CE+VN+CV+FV+SA+IN+FZC+CI+BB"

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< 6{POB 1703}: 3064, 3213, 4069, {3215}, 4070, 3168, 3085, 3161, 3274,
3230, 3171, 3122, 3181, 3095, 3265
< 5{CE 6.90} : 4069, 4070, 6131, 3265, 3230, SYCA, 4055
< 4{CE 5.90} : 3082, 4069, 4070, 3230, PDTC, 4068
< 3{CE 5.77} : 3064, 3193, 3082, 4069, EMPT, 4070, 6131, 3088, LPMT, OLAD,
3230, PDTC, 3164, 3241N, SYCA, 3122, 3121, 3181, 4068, 3117, 4079
< 2{CE 5.20} : 4069, 3161, OLAD, 3265, 3174, PDTC, SYCA, 3095
< 1{CE 0.80} : 3064, 3263, 3193, 4069, 3224, 3014, 3017, 3085, {3160},
PLMD, 3265, PDTC, {3163}, 3181, 3095

SECTION 2_CAVA_VIANINI: bottom 1 - top 4
< 4{VN 6.15} : 3064, 3145, 3017, 3088, 3103, {3160}, 3265, 3230, 3095
< 3{VN 6.10} : 3064, 3193, 3082, 6131, 3085, 3088, {3160}, PLMD, 3181,
3095, TCEZ, 4068, 3117
< 2{VN 2.85} : 4063, 3064, 3144, 3082, 3213, 3017, 6131, {4023}, 3085,
3103, MTGC, 3078, PDAN, 3292, 3055, {3045}, 3298, 3044, 3197, 4072, 4071,
3273, 3121, {3180}, 3051, 3117, 4055, 4060
< 1{VN 0.40} : 4063, 3270, 3064, {4005}, 3144, 3269, 3213, 3014, 3017,
3061, 3085, {3148}, LPDL, 3159, 2026, MTGC, PLMD, 3265, PDTC, PDAN, 3176,
3298, SYCA, 3273, 3121, 3181, {3180}, 3413, 3117, 3113

SECTION 3_COSTON_DELLE_VETTE: bottom 1 - top 14
< 14{CV 155} : {3139}, 3144, {3169}, 3117, 4069, 3224, 3122, 3113, 3145,
4070, 3171, 3092, 3170, 3177
< 13{CV 142.5} : {3139}, 3117, 4069, 3224, 3095, 3113, 4070, 3171, 3115,
3092, 3170, 3177
< 12{CV 131.7} : OLAD, {3105}, 3171
< 11{CV 129} : 3117, 3230, 3265, 3171
< 10{CV 127.4} : 3135, 3230, 3122, 3095, 3113, 3265
< 9{CV 125.6} : 3135, 3064, 3078, 3117, 3119, 3122, 3036, 3088, 3095, 3113,
3145, 3171, PDTC, 3035, 3097, 3205, 3115, 3092, 3170,
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< 7{CV 119.5} : 3121, 3117, 4069, 3224, 3230, 3095, 3265, {3105}, 3171

< 6{CV 117} : 3164, 3223, 3240, {2021}, 3135, 3064, 3085, 3117, 4069, 3224, 3241A, 3082, 3230, 3122, {3094}, {3204}, {3138}, 3133, 3118, 3161, 3286, 3036, 3088, 3095, 3113, 3145, 4070

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< 4{CV 84.5} : 3164, 3174, 3223, {3139}, 3078, 3117, 4069, 3224, {3022}, 3166, 3241A, 3082, 3230

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< 1{FV 1} : 3223, 3193, 3082, EMPT, 3014, 3017, 3189, PLMD, 3240, 3265, 3174, PDTC, PDVN, 3292, 3024, 3181, 3117, 3166

SECTION 5_SANTANNA: bottom 1 - top 3

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< 2{SA 5.10} : {3091}, 3064, 3145, 3263, 3223, 3193, 3213, 4069, 3225, 4015, EMPT, 4070, 3017, 3168, {FCSS}, 6131, 3085, 3088, 3161, 3037, 3036, OLAD, 3265, 3230, PDTC, PDVN, 3171, {3028}, 3292, PEB0, 3164, 3241N, 3024, SYCA, 3122, 3095, 4068, 3097, 3117, 3119, 3118, 3259, 4079, 3308

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SECTION 6_FORNAZZO_STRADA: bottom 1 - top 17

< 17{IN 34} : 3092, 3263, 3161, 3265, PDTC, PDVN, 3171, 3292, 4079

< 16{IN 32} : 3092, 4069, 4070, 3171, 3292, 3177, {SAD0}, 4079

< 15{IN 30} : 3145, 4015, 3066, {3226}, 3168, {FCSS}, 3037, 3171, 3164, 3241N, 3179, SYCA

< 14{IN 28} : 3168, {FCSS}, {SAD0}, 3179,3097

< 13{IN 27} : 3064, 4015, 3168, {FCSS}, 3085, PDTC, 3171

< 12{IN 24} : 3263, 4069, 3017, 3189, 3161, 3036, 3240, 3230, PDTC, PEB0, {3094}, 4068, 4079

< 11{IN 21} : 3145, 3263, 4069, 4070, 3017, 3189, 3161, 3230, PDTC, {3094}, 3166, 4079

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< 8{IN 15} : 4069, 3017, 3036, PDTC, 3122, 3118, 3259

< 7{IN 13} : 3145, 4069, 3224, 3017, 3103, LPDL, {3160}, 3078, 3240, 3265, PDTC, 3117, 4079

< 6{IN 11} : 3145, 3263, 3082, 4069, 3224, 3240, 3265, PDVN, 3117, 3113

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< 3{IN 3} : 3064, 3263, 3014, 3085, 3088, LPMT, 3265, PDTC, 3164, 3241A, 3121, 3181, 3119, ZHE0, 3308

< 2{IN 1} : 3064, 3085, 3103, PDTC, 3164, 3241A, 3181, 4060, 3308

< 1{IN 0 artificial} : 4063, 3270, 3269, 3061, 3159, 2026, 3055, 3298, 3044, 3197, 4072, 4071, 3273, 3413, 3051, 4060

SECTION 7_FORNAZZO_CAVA: bottom 1 - top 3

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< 1{FZC03} : 3064, 3223, 3082, 4069, 3224, 3052, 3085, LPDL, 3240, 3265, PDVN, 3121, 3181, 3119, 3259

SECTION 8_CASTELLO_INICI: bottom 1 - top 9

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< 8{CI 14} : 3064, 3145, {3215}, 4069, 4070, 3088, 3036, 3230, PDTC, 4068

< 7{CI 13} : 3145, 3082, 4015, 4069,4070, 3017, LPDL, 3189, LPMT, 3240, 3265, PDTC, {SAD0}, 4068, 3118

< 6{CI 10} : 3064, 3145, 3085, 3230, PDTC, 3117

< 5{CI 8} : 3064, 3223, 3082, 3225, 4069, 3224, 3085, 3088, PLMD, 3240, 3265, PDTC, 3292, 3122, 3181, 3119, 3113, 3115, 3259, ZHE0

< 4{CI 6} : 3064, 4069, 3224, 3085, PDTC, PDVN, 3181

< 3{CI 5} : 3064, 4069, 3224, 3017, 3085, LPMT, 3265, PDVN, 3181, 3095, 3116, 3259

< 2{CI 4} : 3064, 4069, 3224, 3085, 3103, {3160}, 3230, PDTC, PDVN, 3121, 3095, 3119, 3116

< 1{CI 3} : 3064, 4069, 3224, 3085, 3230, PDTC, 3121, 3095

SECTION 9_BALATA_DI_BAIDA: bottom 1 - top 8

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< 7{BB 17.30} : 3064, 3088, 3265, 3230, PDTC, PDVN, 3171, 4068, 4079

< 6{BB 16.45} : 3064, 3263, 3082, 4015, 4069, EMPT, 4070, 3088, LPDL, 3161, 3036, 3265, 3230, PDTC, PDVN, 3292, 3164, 3241N, 3179, 3122, 3095, 4068, 3259

< 5{BB 15.10} : 3064, 3263, 3082, 4015, 4069, EMPT, {3215}, 4070, 3085, 3161, 3286, 3265, PDTC, 3164, 3241N, {3094}, SYCA, 3122, 3181, 4068, 4079

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< 3{BB 11.70} : 3064, 3145, 3193, 3066, EMPT, {3215}, 3017, 3085, 3088, 3103, 3189, LPMT, 3036, OLAD, 3240, 3265, 3164, 3241A, SYCA, 3122, 3181, 3117, 3119, 3113, 4079

< 2{BB 9} : 3064, 3066, 3085, 3265, PDTC, PDVN

< 1{BB 6.35} : 3064, 4069, 3224, 3017, 3088, 3103, LPMT, 3095, {3412,} 3308

Appendix 3

DATABASE FOR THE COMPARISON UAZ-SA/UAZ95: TGI FILES

The text-files TGI (Numerical range of the taxa) of the SicAlps.DAT and NMRD40 databases have been joined in a new database called "SicAlps+NMRD40" in order to compare the zonations UAZ-SA and UAZ95 via NMRD40. In this new database all the taxa (left columns of numbers, i.e., 0001, 2001, etc…) of the NMRD40 and SicAlps.DAT are considered as belonging to two synthetic sections. By computing the "SicAlps+NMRD40" by BioGraph new Unitary Associations resulted (right column of numbers, i.e., 1-1, 1-8, etc…), which represent the tool for comparing the two zonations UAZ-SA and UAZ95.

```
TITLE:
"SicAlps+NMRD40"

Section 1_UA_NMRD : bottom 1 - top 82
```

0001: 1 - 1	3033: 4 - 45	3108: 51 - 51	3182: 58 - 72	3265: 34 - 64
2001: 1 - 8	3034: 30 - 70	3109: 10 - 43	3184: 11 - 11	3266: 22 - 77
2002: 3 - 12	3035: 28 - 62	3110: 19 - 48	3185: 64 - 82	3267: 25 - 58
2003: 1 - 5	3036: 43 - 70	3111: 70 - 70	3187: 28 - 32	3268: 28 - 32
2004: 1 - 9	3037: 60 - 60	3112: 51 - 76	3188: 60 - 62	3269: 20 - 36
2005: 1 - 6	3039: 3 - 14	3113: 20 - 78	3189: 31 - 66	3270: 20 - 49
2006: 11 - 24	3040: 13 - 13	3115: 35 - 62	3192: 9 - 34	3271: 5 - 40
2007: 3 - 5	3041: 9 - 14	3116: 34 - 54	3193: 26 - 60	3273: 14 - 51
2008: 2 - 11	3042: 5 - 5	3117: 24 - 55	3194: 6 - 14	3274: 31 - 65
2009: 3 - 6	3043: 29 - 32	3118: 21 - 70	3195: 2 - 15	3276: 23 - 38
2010: 2 - 3	3044: 26 - 38	3119: 38 - 62	3197: 9 - 60	3277: 19 - 46
2011: 2 - 30	3045: 26 - 34	3121: 20 - 69	3199: 24 - 70	3278: 9 - 36
2012: 2 - 12	3046: 26 - 38	3122: 37 - 64	3202: 58 - 77	3279: 26 - 41
2013: 2 - 9	3047: 23 - 38	3123: 15 - 63	3203: 59 - 78	3280: 68 - 77
2014: 3 - 8	3048: 3 - 10	3124: 14 - 51	3204: 31 - 53	3281: 70 - 78
2015: 3 - 3	3049: 21 - 45	3125: 3 - 30	3205: 26 - 51	3282: 70 - 78
2016: 5 - 5	3051: 16 - 42	3126: 33 - 55	3206: 51 - 51	3283: 70 - 78
2017: 6 - 28	3052: 9 - 47	3127: 44 - 51	3210: 11 - 54	3284: 48 - 78
2018: 2 - 2	3054: 25 - 38	3129: 15 - 54	3212: 24 - 51	3285: 70 - 78
2019: 2 - 24	3055: 3 - 64	3131: 36 - 60	3213: 28 - 78	3286: 53 - 79
2020: 6 - 6	3059: 26 - 43	3133: 29 - 53	3215: 23 - 70	3287: 65 - 82
2021: 9 - 41	3061: 20 - 48	3135: 11 - 56	3216: 10 - 63	3288: 76 - 76
2022: 8 - 9	3062: 29 - 78	3137: 34 - 53	3217: 24 - 60	3289: 50 - 76
2023: 12 - 44	3063: 29 - 77	3138: 60 - 60	3218: 24 - 60	3290: 26 - 76
2024: 24 - 44	3064: 14 - 57	3139: 25 - 54	3220: 20 - 51	3291: 69 - 77
2025: 24 - 30	3065: 23 - 80	3140: 11 - 53	3221: 22 - 40	3292: 29 - 67
2026: 12 - 12	3066: 45 - 78	3144: 9 - 51	3222: 5 - 36	3293: 66 - 79
3001: 2 - 14	3069: 31 - 63	3145: 50 - 62	3223: 11 - 55	3294: 63 - 67
3002: 31 - 38	3070: 12 - 62	3147: 12 - 51	3224: 41 - 64	3295: 55 - 77
3003: 29 - 34	3071: 5 - 14	3148: 1 - 47	3225: 24 - 77	3297: 15 - 30
3004: 9 - 10	3072: 5 - 10	3149: 3 - 27	3226: 45 - 77	3298: 26 - 30
3005: 12 - 35	3073: 2 - 12	3150: 11 - 38	3227: 61 - 77	3301: 3 - 12
3006: 2 - 37	3074: 7 - 33	3151: 7 - 7	3228: 69 - 78	3302: 3 - 22
3007: 10 - 54	3076: 25 - 47	3152: 20 - 47	3230: 42 - 68	3303: 3 - 14
3008: 21 - 54	3078: 28 - 60	3158: 8 - 17	3231: 3 - 25	3305: 52 - 67

3009: 28 - 57	3081: 35 - 60	3159: 11 - 47	3235: 23 - 38	3307: 15 - 16
3010: 3 - 10	3082: 23 - 54	3160: 21 - 61	3236: 29 - 38	3309: 16 - 16
3011: 8 - 16	3083: 51 - 51	3161: 31 - 80	3237: 18 - 27	3310: 1 - 8
3012: 9 - 47	3085: 21 - 59	3162: 24 - 77	3238: 19 - 30	3406: 50 - 62
3013: 19 - 39	3087: 56 - 82	3163: 22 - 52	3239: 28 - 38	3407: 2 - 5
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3015: 24 - 38	3089: 2 - 18	3165: 67 - 78	3241: 35 - 67	3409: 1 - 8
3016: 34 - 34	3090: 36 - 81	3166: 39 - 56	3243: 30 - 60	3410: 3 - 4
3017: 26 - 63	3091: 51 - 60	3167: 29 - 74	3244: 16 - 48	3411: 1 - 4
3019: 65 - 73	3092: 60 - 80	3168: 50 - 62	3245: 50 - 60	3412: 22 - 54
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3024: 29 - 51	3100: 27 - 62	3176: 20 - 55	3258: 60 - 60	3717: 70 - 77
3028: 32 - 32	3103: 20 - 63	3177: 49 - 63	3259: 47 - 63	3813: 9 - 35
3030: 10 - 14	3104: 24 - 52	3179: 50 - 62	3261: 31 - 51	3911: 66 - 77
3031: 28 - 38	3105: 40 - 55	3180: 9 - 54	3263: 46 - 78	3912: 69 - 77
3032: 24 - 29	3106: 34 - 51	3181: 16 - 64	3264: 77 - 77	3918: 70 - 75
3919: 69 - 75	4044: 15 - 32	4073: 50 - 82	5243: 70 - 78	5565: 73 - 78
3924: 69 - 78	4045: 19 - 19	4077: 3 - 11	5253: 70 - 77	5568: 70 - 78
3947: 70 - 78	4047: 24 - 24	4079: 50 - 63	5332: 70 - 70	5577: 71 - 78
3955: 68 - 77	4048: 20 - 27	5003: 69 - 75	5396: 71 - 74	5578: 71 - 78
4004: 51 - 51	4049: 15 - 15	5011: 81 - 82	5408: 70 - 77	5580: 70 - 77
4005: 24 - 31	4053: 20 - 20	5042: 69 - 78	5409: 70 - 78	5607: 68 - 78
4006: 27 - 30	4054: 19 - 21	5044: 77 - 77	5410: 69 - 77	5636: 72 - 82
4009: 2 - 17	4055: 26 - 63	5055: 70 - 77	5416: 62 - 78	5674: 72 - 77
4010: 2 - 50	4058: 11 - 20	5065: 68 - 75	5417: 70 - 77	5712: 79 - 82
4011: 2 - 12	4059: 9 - 15	5073: 80 - 82	5426: 70 - 82	5716: 75 - 75
4014: 9 - 28	4060: 18 - 47	5132: 68 - 78	5433: 72 - 78	5721: 69 - 78
4015: 53 - 62	4061: 2 - 23	5163: 70 - 71	5436: 69 - 77	5785: 68 - 77
4018: 62 - 62	4063: 4 - 49	5166: 77 - 77	5453: 70 - 77	5796: 68 - 78
4023: 26 - 26	4064: 6 - 6	5183: 69 - 78	5462: 74 - 82	5824: 69 - 78
4026: 79 - 82	4066: 2 - 28	5186: 78 - 78	5464: 75 - 75	6101: 66 - 78
4027: 2 - 12	4068: 35 - 62	5193: 77 - 77	5481: 70 - 82	6121: 70 - 78
4028: 3 - 8	4069: 41 - 64	5194: 70 - 77	5506: 68 - 78	6129: 68 - 78
4031: 2 - 9	4070: 57 - 62	5204: 82 - 82	5510: 70 - 78	
4032: 23 - 23	4071: 9 - 41	5209: 69 - 78	5532: 82 - 82	
4034: 17 - 26	4072: 12 - 30	5229: 79 - 82	5544: 27 - 77	

Section 2_UA_SicAlp: bottom 1 -top 16

2026: 1 - 3	3092: 14 - 16	3166: 9 - 13	3240: 1 - 13	4069: 5 - 16
3014: 2 - 13	3095: 7 - 16	3168: 13 - 15	3241A: 6 - 13	4070: 12 - 16
3015: 1 - 1	3097: 13 - 15	3170: 14 - 16	3241N: 13 - 15	4071: 1 - 4
3017: 2 - 15	3100: 1 - 13	3171: 12 - 16	3259: 5 - 15	4072: 2 - 4
3024: 9 - 15	3103: 4 - 11	3174: 1 - 9	3263: 8 - 16	4079: 11 - 16
3035: 11 - 14	3113: 2 - 16	3176: 1 - 3	3265: 2 - 16	6131: 4 - 15
3036: 11 - 15	3115: 8 - 16	3177: 16 - 16	3269: 1 - 2	EMPT: 9 - 15
3037: 15 - 15	3116: 3 - 7	3179: 13 - 15	3270: 1 - 3	LPDL: 2 - 13
3044: 2 - 4	3117: 2 - 16	3181: 1 - 13	3273: 1 - 4	LPMT: 7 - 13
3051: 2 - 4	3118: 12 - 15	3189: 9 - 15	3274: 13 - 13	MTGC: 1 - 4
3052: 1 - 5	3119: 5 - 15	3193: 9 - 15	3286: 12 - 13	OLAD: 3 - 15
3055: 2 - 4	3121: 2 - 13	3197: 1 - 4	3292: 4 - 16	PDAN: 2 - 4
3059: 1 - 1	3122: 8 - 16	3205: 13 - 14	3298: 2 - 4	PDTC: 2 - 16
3061: 1 - 2	3133: 12 - 13	3210: 1 - 12	3308: 6 - 15	PDVN: 5 - 16
3064: 2 - 15	3135: 1 - 14	3213: 2 - 15	3413: 2 - 2	PEB0: 13 - 15

3066: 11 - 15	3144: 1 - 16	3223: 1 - 15	4015: 11 - 15	PLMD: 1 - 10
3078: 3 - 14	3145: 11 - 16	3224: 5 - 16	4055: 4 - 13	SYCA: 2 - 15
3082: 4 - 13	3159: 1 - 3	3225: 8 - 15	4060: 2 - 6	TCEZ: 3 - 10
3085: 2 - 15	3161: 9 - 16	3230: 7 - 15	4063: 1 - 4	ZHE0: 8 - 8
3088: 8 - 15	3164: 1 - 15	3231: 1 - 1	4068: 10 - 15	

Appendix 4

ALPHABETICAL LIST OF RADIOLARIAN GENERA AND SPECIES

In this appendix are reported the alphabetical list of genera and species illustrated in the plates, the codes of the taxa, the Unitary Associations Zones for Sicily and Southern Alps (UAZ-SA) and the Unitary Associations Zones of Baumgartner et al. 1995a (UAZ95). The species carrying a numerical code are shown in Baumgartner et al. 1995b and in some cases the taxonomy has been updated (without changing the morphological concept of the species). The species carrying a lettered code are taxa not included in Baumgartner et al. 1995b. Those species marked with an asterisk were not used for building the UAZ-SA zonation.

The ages of the UAZ-SA are the followings:

UAZ F: early Kimmeridgian *pars* - late Kimmeridgian
UAZ E: ?late Oxfordian - early Kimmeridgian *pars*
UAZ D: ?middle - ?late Oxfordian
UAZ C: middle Oxfordian
UAZ B: early Callovian *pars* - early Oxfordian
UAZ A: ?early - middle Bathonian to early Callovian *pars*.

The ages of the UAZ95 are the followings:

UAZ 11: late Kimmeridgian - early Tithonian
UAZ 10: late Oxfordian - early Kimmeridgian
UAZ 9: middle-late Oxfordian
UAZ 8: middle Callovian - early Oxfordian
UAZ 7: late Bathonian - early Callovian
UAZ 6: middle Bathonian
UAZ 5: latest Bajocian - early Bathonian
UAZ 4: late Bajocian
UAZ 3: early-middle Bajocian
UAZ 2: late Aalenian
UAZ 1: early-middle Aalenian

UAZ 22: late Barremian - early Aptian
UAZ 21: early Barremian
UAZ 20: late Hauterivian
UAZ 19: early Hauterivian
UAZ 18: latest Valanginian - earliest Hauterivian
UAZ 17: late Valanginian
UAZ 16: early Valanginian
UAZ 15: late Berriasian - earliest Valanginian
UAZ 14: early-early late Berriasian
UAZ 13: latest Tithonian - earliest Berriasian
UAZ 12: early-early late Tithonian

Name of radiolarian species, plates and figures	Codes	UAZSA	UAZ95
Acaeniotyle umbilicata (Rüst), Pl. 1, Fig. 1	3092	F	10-22
Acaeniotyle (?) sp. A sensu Baumgartner et al. 1995b, Pl. 1, Fig. 2	3091		8-11
Acaeniotylopsis variatus variatus (Ožvoldova), Pl. 1, Fig. 3	3270	A-B	3-8
**Amphipyndax durisaeptum* Aita, Pl. 5, Fig. 13	4005		3-7
Angulobracchia biordinalis Ožvoldova, Pl. 1, Figs. 4, 5	3145	D-F	9-11
Angulobracchia purisimaensis (Pessagno), Pl. 1, Fig. 6	3144	A-F	3-10
Archaeodictyomitra apiarium (Rüst), Pl. 5, Figs. 14, 15	3263	D-F	8-22
* *Archaeodictyomitra minoensis* (Mizutani), Pl. 5, Fig. 16	3305		9-12
* *Archaeodictyomitra pseudomulticostata* (Tan), Pl. 5, Fig. 17			
* *Archaeodictyomitra shengi* Yang, Pl. 5, Fig. 18			
* *Archaeodictyomitra wangi* Yang, Pl. 5, Fig. 19			
**Archaeospongoprunum imlayi* Pessagno, Pl. 1, Fig. 7			
**Archaeospongoprunum* sp. aff. *A. elegans* Wu, Pl. 1, Fig. 8			
Beleza decora (Rüst), Pl. 5, Fig. 20	3269	A-B	4-7
Bernoullius dicera (Baumgartner), Pl. 1, Figs. 10, 11	3223	A-F	3-10
**Bistarkum* sp., Pl. 1, Fig. 9			
**Cenosphaera* sp., Pl. 1, Fig. 12			
Cinguloturris carpatica Dumitrica, Pl. 5, Figs. 21, 22	3193	D-F	7-11
Dicerosaturnalis angustus (Baumgartner), Pl. 1, Figs. 13, 14	3082	B-E	6-10
**Dicerosaturnalis trizonalis* (Rüst), Pl. 1, Fig. 15	3083		8-11
**Dicerosaturnalis* sp. aff. *D. trizonalis* (Rüst), Pl. 1, Fig. 16			
Emiluvia chica s.l. Foreman, Pl. 1, Fig. 17	3213	B-F	3-18
Emiluvia hopsoni Pessagno, Pl. 1, Figs. 18, 19	3225	D-F	6-15
**Emiluvia* sp. aff. *E. hopsoni* Pessagno, Pl. 1, Fig. 20			
**Emiluvia nana* Baumgartner, Pl. 1, Fig. 21	3212		6-9
Emiluvia ordinaria Ožvoldova, Pl. 1, Figs. 22, 23	4015	D-F	9-11
Emiluvia orea Baumgartner, Pl. 2, Figs. 1, 2	3224	C-F	8-11
*Transitional forms between *Emiluvia orea* Baumgartner and *E. ultima* Baumgartner & Dumitrica, Pl. 2, Figs. 3, 4			
Emiluvia pessagnoi s.l. Foreman, Pl. 2, Fig. 7	3066	D-F	4-17
**Emiluvia pessagnoi multipora* Steiger, Pl. 2, Fig. 8	3226		8-14
Emiluvia premyogii Baumgartner, Pl. 2, Figs. 9, 10	3210	A-E	3-10
**Emiluvia robusta* (Rüst) sensu Pessagno 1977a, Pl. 2, Fig. 11	3220		4-10
Emiluvia peteri Beccaro, Pl. 2, Figs. 12, 13, 14	EMPT	D-F	
**Emiluvia salensis* Pessagno, Pl. 2, Fig. 15	3215		4-13
Emiluvia ultima Baumgartner & Dumitrica, Pl. 2, Figs. 5, 6	4070	E-F	10-11

Eucyrtidiellum nodosum Wakita, Pl. 6, Figs. 1, 2	3014	B-E	3-10
Eucyrtidiellum ptyctum (Riedel & Sanfilippo), Pl. 6, Figs. 3, 4, 5	3107	B-F	5-11
Eucyrtidiellum unumaense s.l. (Yao), Pl. 6, Fig. 6	3052	A-C	3-8
Eucyrtidiellum unumaense dentatum Baumgartner, Pl. 6, Fig. 7	3015	A	6-7
**Fultacapsa ozvoldovae* Beccaro, Pl. 6, Fig. 8			
**Fultacapsa sphaerica* (Ožvoldova), Pl. 6, Figs. 9, 10			
Gongylothorax favosus Dumitrica, Pl. 6, Figs. 11, 12	6131	B-F	8-10
**Gongylothorax sakawaensis* Matsuoka, Pl. 6, Fig. 13	4023		6-7
Guexella nudata (Kocher), Pl. 6, Fig. 14	3061	A-B	5-8
Hexasaturnalis minor (Baumgartner), Pl. 3, Fig. 1	3085	B-F	3-11
Hexasaturnalis nakasekoi Dumitrica & Dumitrica-Jud, Pl. 3, Figs. 2, 3	3988	D-F	3-11
**Higumastra coronaria* Ožvoldova, Pl. 3, Fig. 4	3108		8-9
**Higumastra wintereri* Baumgartner & Kito, Pl. 3, Fig. 5	3148		1-8
Hiscocapsa robusta (Matsuoka), Pl. 6, Fig. 15	3298	B	5-7
Homoeoparonaella argolidensis Baumgartner, Pl. 3, Fig. 6	3103	B-D	4-11
**Hsuum speciosum* Hull, Pl. 6, Fig.16			
Kilinora catenarum (Matsuoka), Pl. 6, Fig. 17	3044	B	6-7
**Kilinora* sp. aff. *K. catenarum* (Matsuoka), Pl. 6, Fig. 18			
**Levileugeo ordinarius* Yang & Wang, Pl. 3, Fig. 7			
Loopus doliolum Dumitrica, Pl. 6, Figs. 19, 20	LPDL	B-E	
Loopus doliolum martae Beccaro, Pl. 6, Figs. 21, 22	LPMT	C-E	
Loopus primitivus (Matsuoka & Yao), Pl. 6, Fig. 23	3189	D-F	7-12
Mirifusus dianae dianae (Karrer), Pl. 7, Fig. 1	3274	E	7-12
Mirifusus dianae minor Baumgartner, Pl. 7, Figs. 2, 3	3286	E	9-20
Mirifusus fragilis praeguadalupensis Baumgartner & Bartolini, Pl. 7, Fig. 4	2026	A-B	3-8
**Mirifusus guadalupensis* Pessagno, Pl. 7, Figs. 5, 6	3160		5-11
Monotrabs goricanae Beccaro, Pl. 3, Figs. 8, 9	MTGC	A-B	
Napora boneti Pessagno, Whalen & Yeh, Pl. 7, Fig. 7	3037	F	10-11
Napora deweveri Baumgartner, Pl. 7, Fig. 8	3035	D-F	7-11
Napora lospensis Pessagno, Pl. 7, Figs. 9, 10	3036	D-F	8-13
Olanda sp. B sensu Hull 1997, Pl. 7, Figs. 11, 12	OLAD	B-F	
**Orbiculiforma* (?) sp. aff. *O. mclaughlini* Pessagno sensu Baumgartner et al. 1995b, Pl. 3, Fig. 10	3206		8-9
**Palinandromeda crassa* (Baumgartner), Pl. 7, Fig. 13	3009		7-10
**Palinandromeda podbielensis* (Ožvoldova), Pl. 7, Fig. 14	3008		5-9
Pantanellium riedeli Pessagno, Pl. 3, Fig. 11, 12	3078	B-F	7-12
Parahsuum carpathicum Widz & De Wever, Pl. 7, Fig. 15	3240	A-E	7-11
Paronaella bandyi Pessagno, Pl. 3, Figs. 13, 14	3135	A-F	3-10

Paronaella pygmaea Baumgartner, Pl. 3, Fig. 15	3133	E	7-9
**Parvicingula mashitaensis* Mizutani, Pl. 7, Fig. 16	3245		8-15
**Parvivacca blomei* Pessagno & Yang, Pl. 3, Fig. 16			
Perispyridium ordinarium gr. (Pessagno), Pl. 3, Fig. 17	3100	A-E	5-11
Podobursa andreai Beccaro, Pl. 7, Figs. 17, 18, 19	PDAN	B	
Podobursa chandrika (Kocher), Pl. 8, Figs. 1, 2, 3, 4	3265	B-F	7-11
Podobursa polyacantha (Fischli), Pl. 8, Figs. 5, 6	3174	A-D	5-8
**Podobursa rosea* Hull, Pl. 8, Fig. 7			
Podobursa spinosa (Ožvoldova), Pl. 8, Figs. 8, 9	3230	C-F	8-13
Podobursa triacantha (Fischli) gr., Pl. 8, Figs. 10, 11, 12, 13, 14	PDTC	B-F	
Podobursa vannae Beccaro, Pl. 8, Figs. 15, 16, 17	PDVN	C-F	
Podocapsa amphitreptera Foreman, Pl. 9, Figs. 1, 2, 3	3171	E-F	9-18
**Poulpus* sp. aff. *P. oculatus* De Wever sensu Baumgartner et al. 1995b, Pl. 9, Fig. 4	3028		3-7
**Praeconocaryomma* sp., Pl. 3, Fig. 18			
Praewilliriedellum convexum (Yao), Pl. 9, Fig. 5	3055	B	1-11
**Praezhamoidellum yaoi* Kozur, Pl. 9, Fig. 6			
Protunuma japonicus Matsuoka & Yao, Pl. 9, Figs. 7, 8	3292	B-F	7-12
Pseudoeucyrtis firma Hull, Pl. 9, Fig. 9	3176	A-B	5-10
Pseudoeucyrtis reticularis Matsuoka & Yao, Pl. 9, Fig. 10	3177	F	8-11
**Pseudoeucyrtis* sp. aff. *P. hanni* (Tan), Pl. 9, Fig. 11			
Pseudoeucyrtis sp. B sensu Widz 1991, Pl. 9, Fig. 12	PEB0	E-F	
Ristola altissima altissima (Rüst), Pl. 9, Fig. 13	3241A	C-E	7-12
**Ristola altissima major* Baumgartner, Pl. 9, Fig. 14	3238		5-7
Ristola altissima nodosa Hori, Pl. 9, Figs. 15, 16	3241N	E-F	7-12
**Ristola procera* (Pessagno), Pl. 9, Fig. 17	3163		5-9
**Saitoum dercourti* Widz & De Wever, Pl. 9, Fig. 18	SAD0		
Saitoum levium De Wever, Pl. 9, Fig. 19	3024	D-F	4-9
**Saitoum trichylum* De Wever, Pl. 9, Fig. 20	3021		7-9
**Sethocapsa leiostraca* Foreman, Pl. 9, Figs. 21, 22	3062		4-20
**Spongocapsula perampla* (Rüst), Pl. 9, Figs. 23, 24	3267		6-11
**Stichocapsa naradaniensis* Matsuoka, Pl. 10, Fig. 1	3045		6-7
**Stichocapsa ulivii* Chiari, Cortese & Marcucci, Pl. 10, Fig. 2			
**Stichocapsa* sp. aff. *S. elegans* Matsuoka, Pl. 10, Fig. 3			
Stylocapsa oblongula Kocher, Pl. 10, Fig. 4	3059	A	6-8
**Suna echiodes* (Foreman), Pl. 3, Figs. 19, 20	3094		9-22
**Suna ehrenbergi* Hull, Pl. 4, Figs. 1, 2			
Svinitzium okamurai (Mizutani), Pl. 10, Fig. 5	3179	E-F	E-F

Syringocapsa spinellifera Baumgartner, Pl. 10, Fig. 6	3170	F	9-12
Syringocapsa sp. A, Pl. 10, Figs. 7, 8	SYCA	B-F	
Teichertus catenarius (Ožvoldova), Pl. 4, Fig. 3	3205	E-F	7-9
**Tethysetta boesii* gr. (Parona), Pl. 10, Fig. 9	3185		9-22
Tethysetta dhimenaensis dhimenaensis (Baumgartner), Pl. 10, Fig. 10	4072	B	3-11
Tethysetta dhimenaensis ssp. A sensu Baumgartner et al. 1995b, Pl. 10, Fig. 11	4071	A-B	3-8
**Tetracapsa molengraafi* (Tan), Pl. 10, Fig. 12			
Tetraditryma corralitosensis s.l. (Pessagno), Pl. 4, Fig. 4	3273	A-B	3-10
**Tetraditryma pseudoplena* Baumgartner, Pl. 4, Figs. 5, 6	3123		4-11
Tetratrabs bulbosa Baumgartner, Pl. 4, Fig. 7	3122	D-F	7-11
*Transitional forms between *T. bulbosa* Baumgartner and *T. zealis* (Ožvoldova), Pl. 4, Figs. 9, 10			
Tetratrabs zealis (Ožvoldova), Pl. 4, Fig. 8	3121	B-E	4-13
Transhsuum brevicostatum gr. (Ožvoldova), Pl. 10, Figs. 13, 14	3181	A-E	3-11
**Transhsuum maxwelli* gr. (Pessagno), Pl. 10, Fig. 15	3180		3-10
Triactoma blakei (Pessagno), Pl. 4, Figs. 11, 12	3095	C-F	4-11
Triactoma enzoi Beccaro, Pl. 4, Figs. 13, 14	TCEZ	B-D	
Triactoma foremanae Muzavor, Pl. 4, Figs. 15, 16	4068	D-F	7-11
**Triactoma jonesi* (Pessagno), Pl. 4, Figs. 17, 18	3096		2-13
**Triactoma mexicana* Pessagno & Yang, Pl. 4, Fig. 19	3412		5-9
Triactoma parablakei Yang & Wang, Pl. 4, Fig. 20	3413	B	4-7
Triactoma tithonianum Rüst, Pl. 4, Fig. 21	3097	E-F	6-22
Tricolocapsa plicarum s.l. Yao, Pl. 10, Fig. 16	3051	B	3-8
**Tricolocapsa* sp., Pl. 10, Fig. 17			
**Tripocyclia brooksi* Pessagno & Yang, Pl. 5, Fig. 1			
Tritrabs casmaliaensis (Pessagno), Pl. 5, Figs. 2, 3	3117	B-F	4-10
Tritrabs ewingi s.l. (Pessagno), Pl. 5, Figs. 4, 5	3113	B-F	4-22
Tritrabs ewingi worzeli (Pessagno), Pl. 5, Fig. 6	3115	D-F	7-12
Tritrabs exotica (Pessagno), Pl. 5, Figs. 7, 8	3119	C-F	4-11
Tritrabs hayi (Pessagno), Pl. 5, Fig. 9	3116	B-C	3-10
Tritrabs rhododactylus Baumgartner, Pl. 5, Fig. 10	3118	E-F	3-13
**Turanta buntonense* Pessagno & Blome, Pl. 5, Fig. 11			
Unuma echinatus Ichikawa & Yao, Pl. 10, Fig. 18	3231	A	1-6
Williriedellum carpathicum Dumitrica, Pl. 10, Fig. 19	4055	B-E	7-11
Williriedellum (?) marcucciae Cortese, Pl. 10, Figs. 20, 21	4060	B-C	4-8
Xitus magnus Baumgartner, Pl. 10, Figs. 22, 23	3259	C-F	8-11
Zanola cornuta (Baumgartner), Pl. 5, Fig. 12	3166	D-E	8-10
Zhamoidellum ovum Dumitrica, Pl. 10, Figs. 24, 25, 26	4079	D-F	9-11

Zhamoidellum ventricosum Dumitrica, Pl. 11, Figs. 1, 2	3308	C-F	8-11
Zhamoidellum (?) exquisitum Hull, Pl. 11, Fig. 3	ZHE0	D	

PLATES

Scanning electron micrographs of Middle-Upper Jurassic radiolarians from Western Sicily and the Southern Alps (Italy). The taxa are listed in alphabetical order (Spumellaria and Nassellaria separately), and the code and the UAZ-SA of the sample are given. The codes of the section are the followings: BB-Balata di Baida, CI-Castello Inici, FZC-Fornazzo Cava, FV-Favignana, IN-Fornazzo Strada, SA-Sant'Anna (Western Sicily), and CE-Ceniga, CV-Coston delle Vette, VN-Cava Vianini (Southern Alps). The species carrying an asterisk have not been used for building the UAZ-SA zonation.

The scanning electron micrographs have been taken at MEMA (Center of Electronic Microscopy and MicroAnalysis, University of Florence, Italy), at Paleontološki Inštitut Ivana Rakovca (ZRC-SAZU, Ljubljana, Slovenia) and at Bristol University (Bristol, Great Britain).

PLATE 1

1 - *Acaeniotyle umbilicata* (Rüst), IN 32, UAZ F, x100

2 - **Acaeniotyle* (?) sp. A sensu Baumgartner et al. 1995b, SA 5.10, UAZ F, x125

3 - *Acaeniotylopsis variatus variatus* (Ožvoldova), VN 0.40, UAZ B, x100

4 - *Angulobracchia biordinalis* Ožvoldova, BB 11.70, UAZ D, x150

5 - *Angulobracchia biordinalis* Ožvoldova, IN 19, UAZ E, x150

6 - *Angulobracchia purisimaensis* (Pessagno), VN 2.85, UAZ B, x150

7 - **Archaeospongoprunum imlayi* Pessagno, SA 0.35, UAZ E, x200

8 - **Archaeospongoprunum* sp. aff. *A. elegans* Wu, CV 60, UAZ A, x200

9 - **Bistarkum* sp., SA 0.35, UAZ E, x100

10 - *Bernoullius dicera* (Baumgartner), CI 8, UAZ D, x150

11 - *Bernoullius dicera* (Baumgartner), FV 1, UAZ D, x150

12 - **Cenosphaera* sp., VN 2.85, UAZ B, x600

13 - *Dicerosaturnalis angustus* (Baumgartner), CI 8, UAZ D, x100

14 - *Dicerosaturnalis angustus* (Baumgartner), VN 2.85, UAZ B, x100

15 - **Dicerosaturnalis trizonalis* (Rüst), VN 6.10, UAZ D, x100

16 - **Dicerosaturnalis* sp. aff. *D. trizonalis* (Rüst), VN 6.10, UAZ D, x100

17 - *Emiluvia chica* s.l. Foreman, VN 0.40, UAZ B, x100

18 - *Emiluvia hopsoni* Pessagno, CV 60, UAZ A, x100

19 - *Emiluvia hopsoni* Pessagno, SA 0.35, UAZ E, x150

20 - **Emiluvia* sp. aff. *E. hopsoni* Pessagno, CV 60, UAZ A, x150

21 - **Emiluvia nana* Baumgartner, SA 0.35, UAZ E, x175

22 - *Emiluvia ordinaria* Ožvoldova, IN 19, UAZ E, x125

23 - *Emiluvia ordinaria* Ožvoldova, SA 9.10, UAZ F, x125

PLATE 1

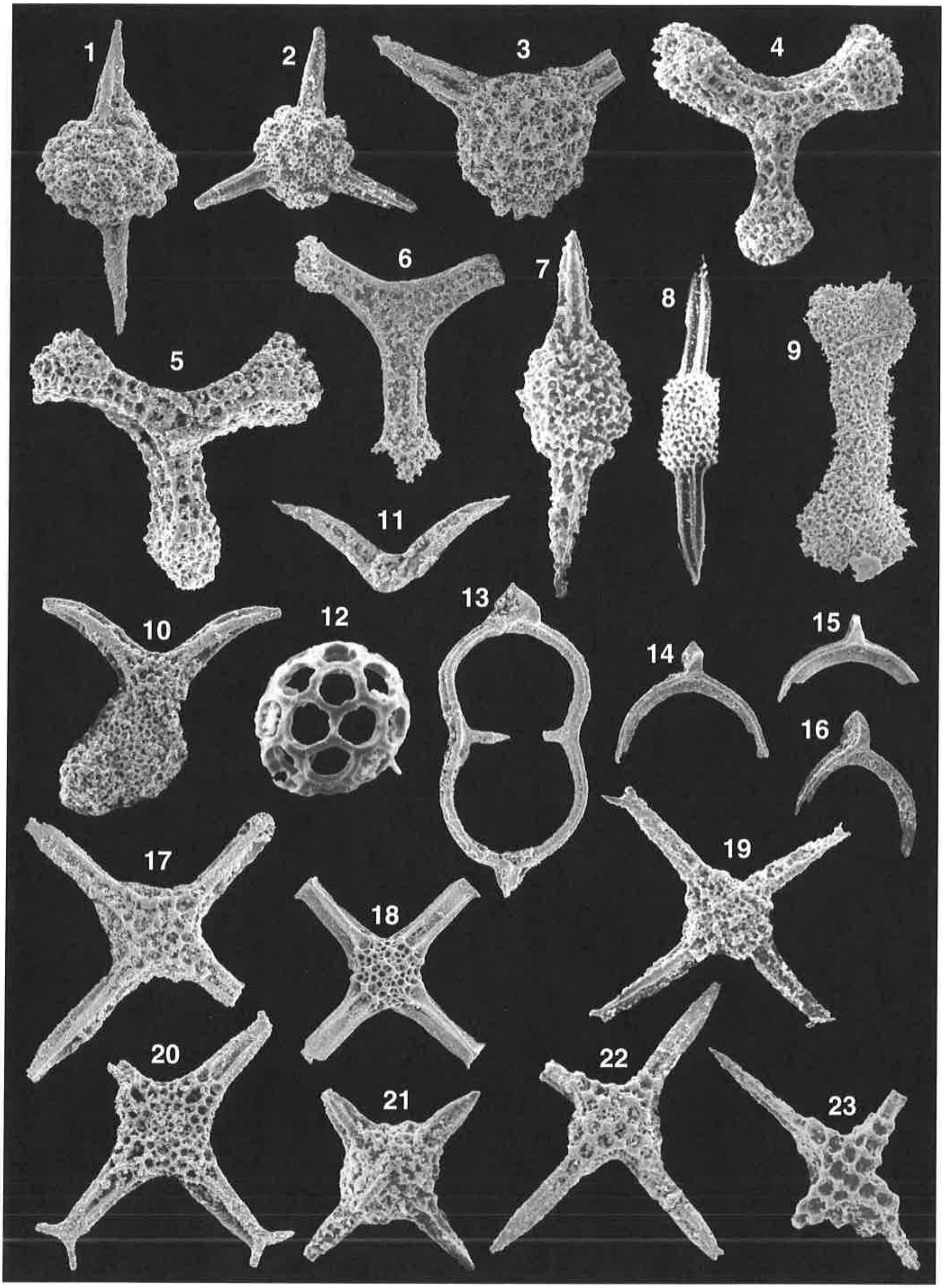

PLATE 2

1 - *Emiluvia orea* Baumgartner, IN 8, UAZ D, x100

2 - *Emiluvia orea* Baumgartner, CI 8, UAZ D, x100

3 - *Transitional form between *E. orea* Baumgartner and *E. ultima* Baumgartner & Dumitrica, SA 5.10, UAZ F, x200

4 - *Transitional form between *E. orea* Baumgartner and *E. ultima* Baumgartner & Dumitrica, IN 8, UAZ D, x100

5 - *Emiluvia ultima* Baumgartner & Dumitrica, SA 5.10, UAZ F, x150

6 - *Emiluvia ultima* Baumgartner & Dumitrica, SA 0.35, UAZ E, x150

7 - *Emiluvia pessagnoi* s.l. Foreman, BB 11.70, UAZ D, x100

8 - **Emiluvia pessagnoi multipora* Steiger, IN 30, UAZ F, x100

9 - *Emiluvia premyogii* Baumgartner, IN 17, UAZ E, x100

10 - *Emiluvia premyogii* Baumgartner, CV 122.6, UAZ E, x150

11 - **Emiluvia robusta* (Rüst) sensu Pessagno 1977a, CV 60, UAZ A, x100

12 - *Emiluvia peteri* Beccaro, SA 5.10, UAZ F, x200

13 - *Emiluvia peteri* Beccaro, CE 5.77, UAZ E, x200

14 - *Emiluvia peteri* Beccaro, BB 15.10, UAZ E, x200

15 - **Emiluvia salensis* Pessagno, BB 15.10, UAZ E, x150

PLATE 2

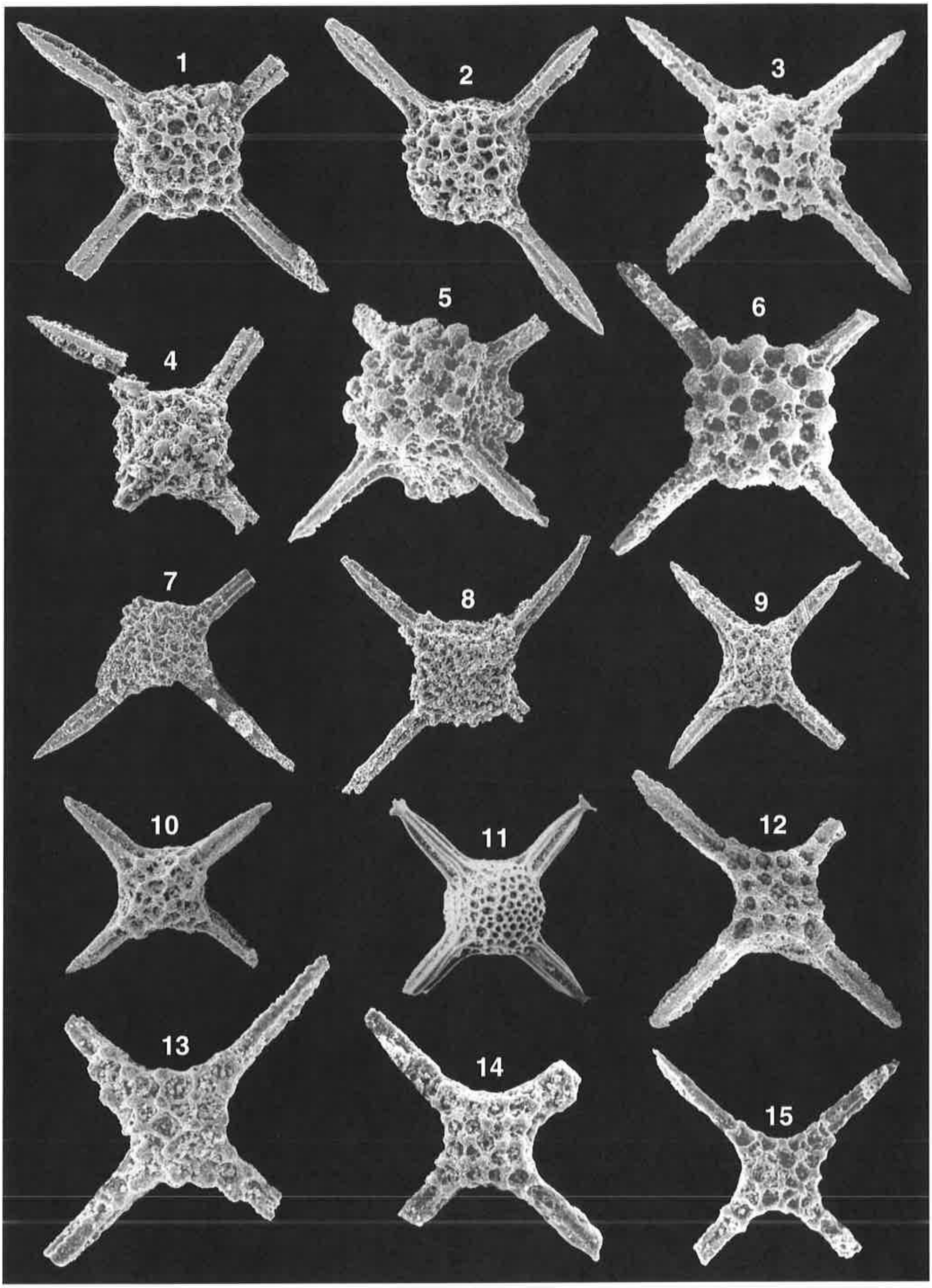

Plate 3

1 - *Hexasaturnalis minor* (Baumgartner), CI 8, UAZ D, x80

2 - *Hexasaturnalis nakasekoi* Dumitrica & Dumitrica-Jud, CV 125.6, UAZ F, x100

3 - *Hexasaturnalis nakasekoi* Dumitrica & Dumitrica-Jud, CI 14, UAZ E, x100

4 - **Higumastra coronaria* Ožvoldova, SA 0.35, UAZ E, x100

5 - **Higumastra wintereri* Baumgartner & Kito, VN 0.40, UAZ B, x100

6 - *Homoeoparonaella argolidensis* Baumgartner, BB 11.70, UAZ D, x100

7 - **Levileugeo ordinarius* Yang & Wang, VN 0.40, UAZ B, x100

8 - *Monotrabs goricanae* Beccaro, CV 60, UAZ A, x150

9 - *Monotrabs goricanae* Beccaro, VN 0.40, UAZ B, x150

10 - **Orbiculiforma* (?) sp. aff. *O. mclaughlini* Pessagno sensu Baumgartner et al. 1995b, SA 0.35, UAZ E, x100

11 - *Pantanellium riedeli* Pessagno, VN 2.85, UAZ B, x300

12 - *Pantanellium riedeli* Pessagno, FV 2, UAZ E, x200

13 - *Paronaella bandyi* Pessagno, CV 105, UAZ D-E, x200

14 - *Paronaella bandyi* Pessagno, SA 0.35, UAZ E, x200

15 - *Paronaella pygmaea* Baumgartner, SA 0.35, UAZ E, x200

16 - **Parvivacca blomei* Pessagno & Wang, CV 125.6, UAZ F, x150

17 - *Perispyridium ordinarium* gr. (Pessagno), SA 0.35, UAZ E, x150

18 - **Praeconocaryomma* sp., SA 9.10, UAZ F, x150

19 - **Suna echiodes* (Foreman), SA 0.35, UAZ E, x150

20 - **Suna echiodes* (Foreman), BB 15.10, UAZ E, x150

PLATE 3

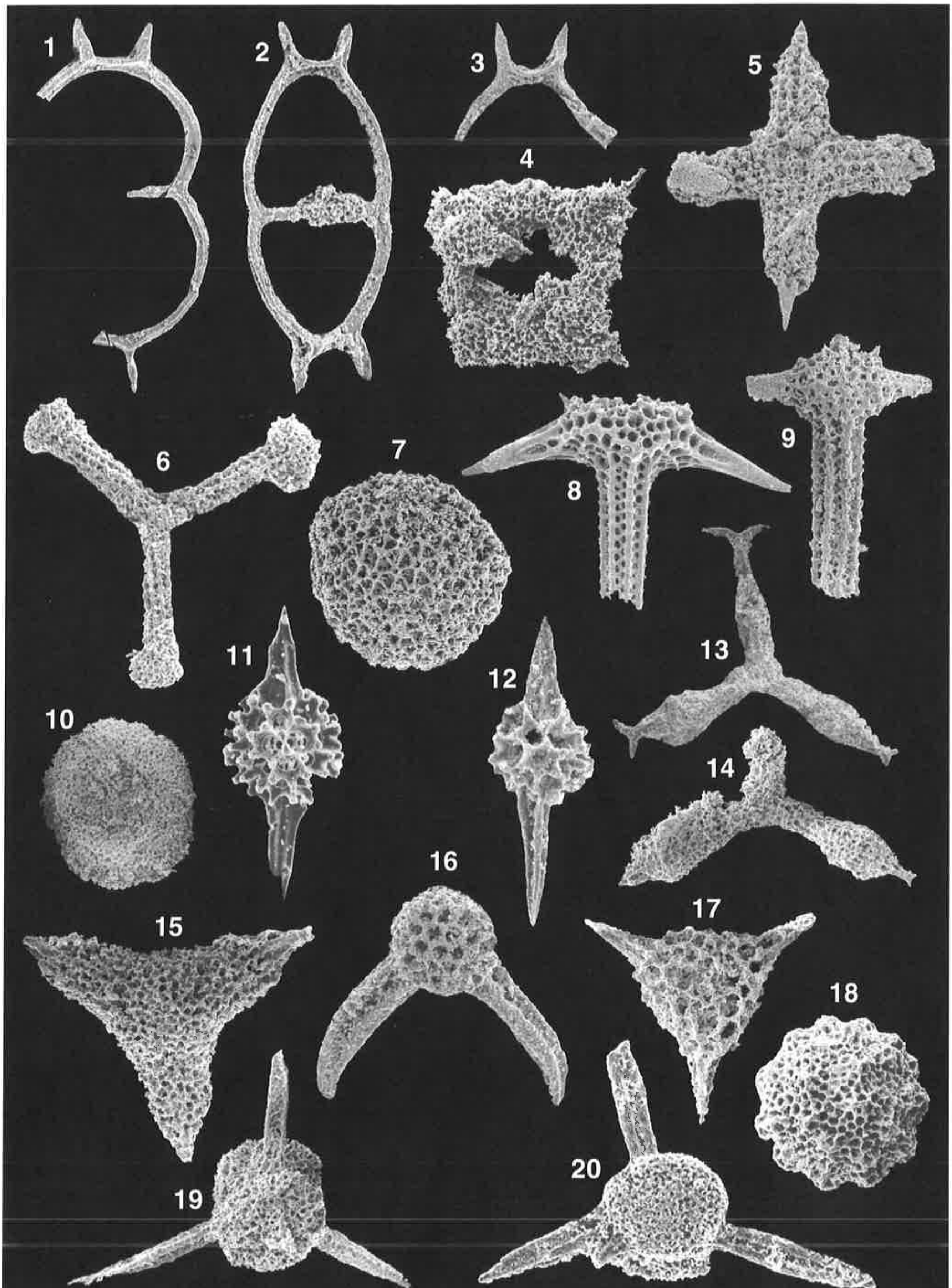

Plate 4

1 - **Suna ehrenbergi* Hull, BB 21, UAZ E-F, x100

2 - **Suna ehrenbergi* Hull, SA 5.10, UAZ F, x150

3 - *Teichertus catenarius* (Ožvoldova), FV 2, UAZ E, x100

4 - *Tetraditryma corralitosensis* s.l. (Pessagno), VN 2.85, UAZ B, x150

5 - **Tetraditryma pseudoplena* Baumgartner, CV 60, UAZ A, x100

6 - **Tetraditryma pseudoplena* Baumgartner, SA 5.10, UAZ F, x100

7 - *Tetratrabs bulbosa* Baumgartner, IN 19, UAZ E, x70

8 - *Tetratrabs zealis* (Ožvoldova), IN 3, UAZ D, x70

9 - *Transitional form between *T. bulbosa* Baumgartner and *T. zealis* (Ožvoldova), VN 2.85, UAZ B, x100

10 - *Transitional form between *T. bulbosa* Baumgartner and *T. zealis* (Ožvoldova), BB 11.70, UAZ D, x80

11 - *Triactoma blakei* (Pessagno), SA 5.10, UAZ F, x100

12 - *Triactoma blakei* (Pessagno), IN 17, UAZ E, x100

13 - *Triactoma enzoi* Beccaro, VN 6.10, UAZ D, x150

14 - *Triactoma enzoi* Beccaro, VN 6.10, UAZ D, x150

15 - *Triactoma foremanae* Muzavor, SA 9.10, UAZ F, x100

16 - *Triactoma foremanae* Muzavor, IN 19, UAZ E, x100

17 - **Triactoma jonesi* (Pessagno), CV 84.5, UAZ D, x100

18 - **Triactoma jonesi* (Pessagno), CI 14, UAZ E, x100

19 - **Triactoma mexicana* Pessagno & Yang, FZC 7, UAZ D, x100

20 - *Triactoma parablakei* Yang & Wang, VN 0.40, UAZ B, x100

21 - *Triactoma tithonianum* Rüst, SA 0.35, UAZ E, x100

PLATE 4

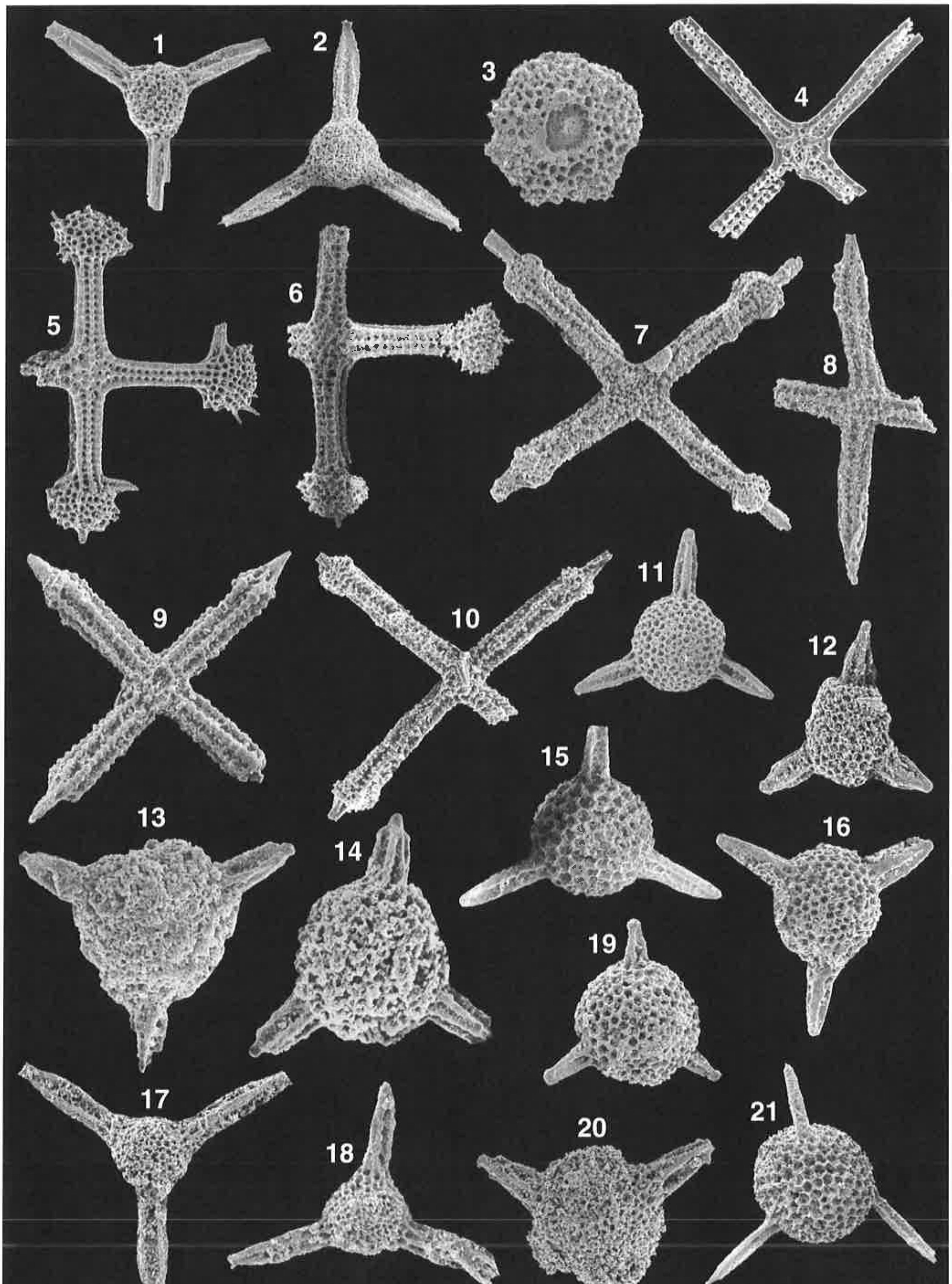

PLATE 5

1 - **Tripocyclia brooksi* Pessagno & Yang, FV 2, UAZ E, x100

2 - *Tritrabs casmaliaensis* (Pessagno), IN 11, UAZ D, x150

3 - *Tritrabs casmaliaensis* (Pessagno), CV 117, UAZ E, x150

4 - *Tritrabs ewingi* s.l. (Pessagno), IN 11, UAZ D, x80

5 - *Tritrabs ewingi* s.l. (Pessagno), CV 117, UAZ E, x100

6 - *Tritrabs ewingi worzeli* (Pessagno), CI 8, UAZ D, x80

7 - *Tritrabs exotica* (Pessagno), CI 8, UAZ D, x100

8 - *Tritrabs exotica* (Pessagno), FZC 3, UAZ C, x100

9 - *Tritrabs hayi* (Pessagno), CI 5, UAZ C, x80

10 - *Tritrabs rhododactylus* Baumgartner, IN 15, UAZ E, x100

11 - **Turanta buntonense* Pessagno & Blome, CV 60.40, UAZ A, x100

12 - *Zanola cornuta* (Baumgartner), CV 60, UAZ A, x100

13 - **Amphipyndax durisaeptum* Aita, VN 0.40, UAZ B, x200

14 - *Archaeodictyomitra apiarium* (Rüst), IN 24, UAZ E, x200

15 - *Archaeodictyomitra apiarium* (Rüst), CE 0.80, UAZ D, x200

16 - **Archaeodictyomitra minoensis* (Mizutani), IN 19, UAZ E, x150

17 - **Archaeodictyomitra pseudomulticostata* (Tan), VN 2.85, UAZ B, x400

18 - **Archaeodictyomitra shengi* Yang, FV 1, UAZ D, x200

19 - **Archaeodictyomitra wangi* Yang, BB 11.70, UAZ D, x200

20 - *Beleza decora* (Rüst), CV 60, UAZ A, x250

21 - *Cinguloturris carpatica* Dumitrica, SA 5.10, UAZ F, x200

22 - *Cinguloturris carpatica* Dumitrica, CE 0.80, UAZ D, x200

PLATE 5

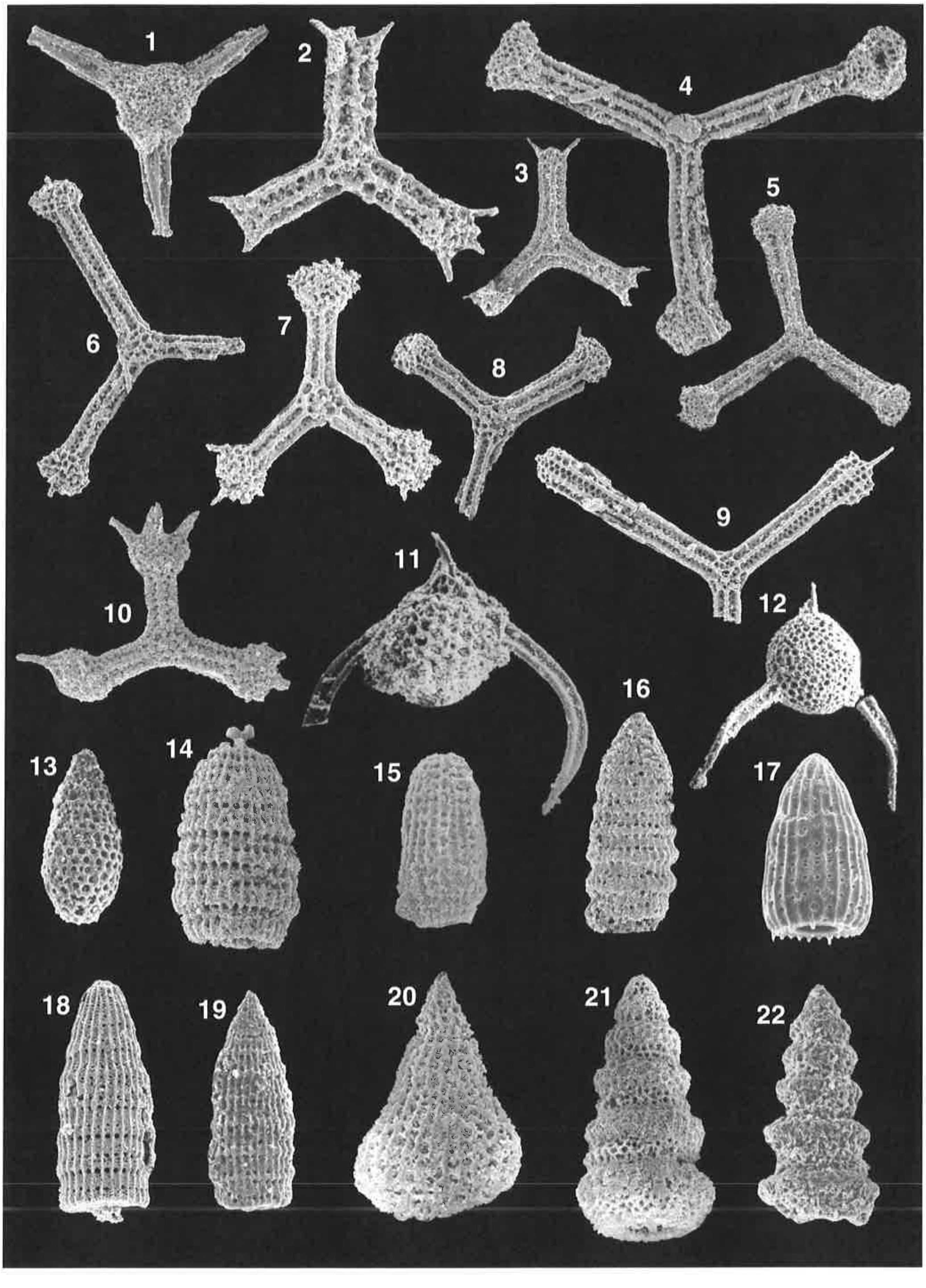

PLATE 6

1 - *Eucyrtidiellum nodosum* Wakita, IN 19, UAZ E, x350

2 - *Eucyrtidiellum nodosum* Wakita, VN 0.40, UAZ B, x350

3 - *Eucyrtidiellum ptyctum* (Riedel & Sanfilippo), FV 1, UAZ D, x350

4 - *Eucyrtidiellum ptyctum* (Riedel & Sanfilippo), VN 2.85, UAZ B, x350

5 - *Eucyrtidiellum ptyctum* (Riedel & Sanfilippo), VN 0.40, UAZ B, x350

6 - *Eucyrtidiellum unumaense* s.l. (Yao), FZC 3, UAZ C, x350

7 - *Eucyrtidiellum unumaense dentatum* Baumgartner, CV 60, UAZ A, x350

8 - **Fultacapsa ozvoldovae* Beccaro, BB 21, UAZ E-F, x100

9 - **Fultacapsa sphaerica* (Ožvoldova), SA 9.10, UAZ F, x100

10 - **Fultacapsa sphaerica* (Ožvoldova), BB 21, UAZ E-F, x100

11 - *Gongylothorax favosus* Dumitrica, SA 5.10, UAZ F, x250

12 - *Gongylothorax favosus* Dumitrica, CE 6.90, UAZ E, x250

13 - **Gongylothorax sakawaensis* Matsuoka, VN 2.85, UAZ B, x300

14 - *Guexella nudata* (Kocher), CV 60, UAZ A, x300

15 - *Hiscocapsa robusta* (Matsuoka), VN 2.85, UAZ B, x200

16 - **Hsuum speciosum* Hull, VN 6.15, UAZ D; a: face view, x200; b: detail of the pore pattern, x600

17 - *Kilinora catenarum* (Matsuoka),VN 2.85, UAZ B, x400

18 - **Kilinora* sp. aff. *K. catenarum* (Matsuoka),VN 2.85, UAZ B, x400

19 - *Loopus doliolum* Dumitrica, CI 13, UAZ E, x300

20 - *Loopus doliolum* Dumitrica, VN 0.40, UAZ B, x300

21 - *Loopus doliolum martae* Beccaro, IN 3, UAZ D, x300

22 - *Loopus doliolum martae* Beccaro, FV 1, UAZ D, x300

23 - *Loopus primitivus* (Matsuoka & Yao), SA 0.35, UAZ E, x250

PLATE 6

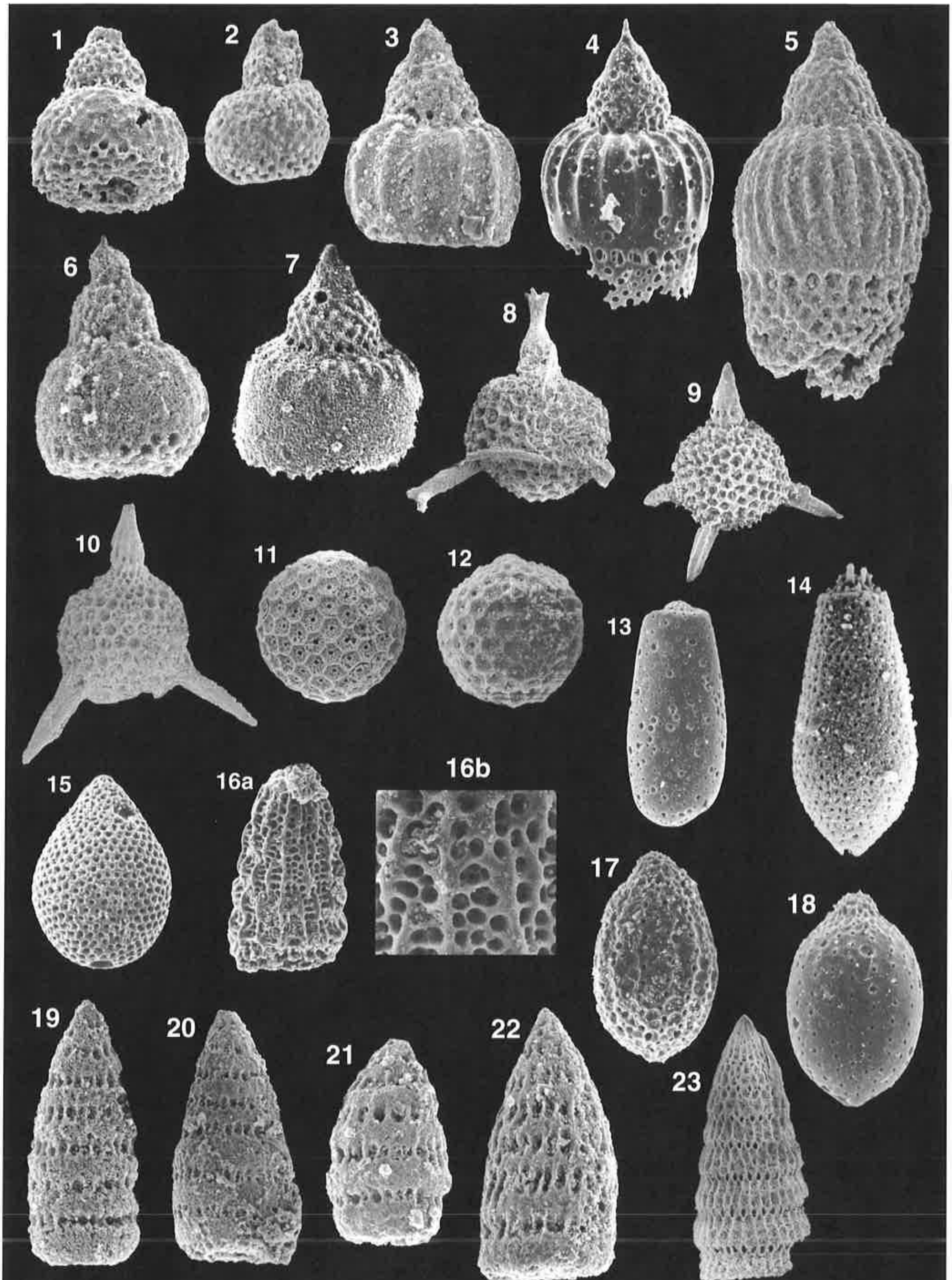

PLATE 7

1 - *Mirifusus dianae dianae* (Karrer), SA 0.35, UAZ E, x100

2 - *Mirifusus dianae minor* Baumgartner, CI 15, UAZ E, x100

3 - *Mirifusus dianae minor* Baumgartner, CV 117, UAZ E, x100

4 - *Mirifusus fragilis praeguadalupensis* Baumgartner & Bartolini, VN 0.40, UAZ B; a: face view, x100; b: detail of the pore pattern, x350

5 - **Mirifusus guadalupensis* Pessagno, CI 4, UAZ C, x100

6 - **Mirifusus guadalupensis* Pessagno, VN 6.15, UAZ D, x100

7 - *Napora boneti* Pessagno, Whalen & Yeh, IN 30, UAZ F, x150

8 - *Napora deweveri* Baumgartner, IN 8, UAZ D, x100

9 - *Napora lospensis* Pessagno, IN 8, UAZ D, x100

10 - *Napora lospensis* Pessagno, CV 125.6, UAZ F, x100

11 - *Olanda* sp. B sensu Hull 1997, BB 11.70, UAZ D, x200

12 - *Olanda* sp. B sensu Hull 1997, SA 5.10, UAZ F; a: face view, x150; b: detail of the proximal part, x250

13 - **Palinandromeda crassa* (Baumgartner), VN 0.40, UAZ B, x150

14 - **Palinandromeda podbielensis* (Ožvoldova), CV 60.40, UAZ A, x100

15 - *Parahsuum carpathicum* Widz & De Wever, IN 13, UAZ D, x200

16 - **Parvicingula mashitaensis* Mizutani, IN 19, UAZ E, x150

17 - *Podobursa andreai* Beccaro, VN 2.85, UAZ B, x150

18 - *Podobursa andreai* Beccaro, VN 0.40, UAZ B, x150

19 - *Podobursa andreai* Beccaro, VN 0.40, UAZ B, x120

PLATE 7

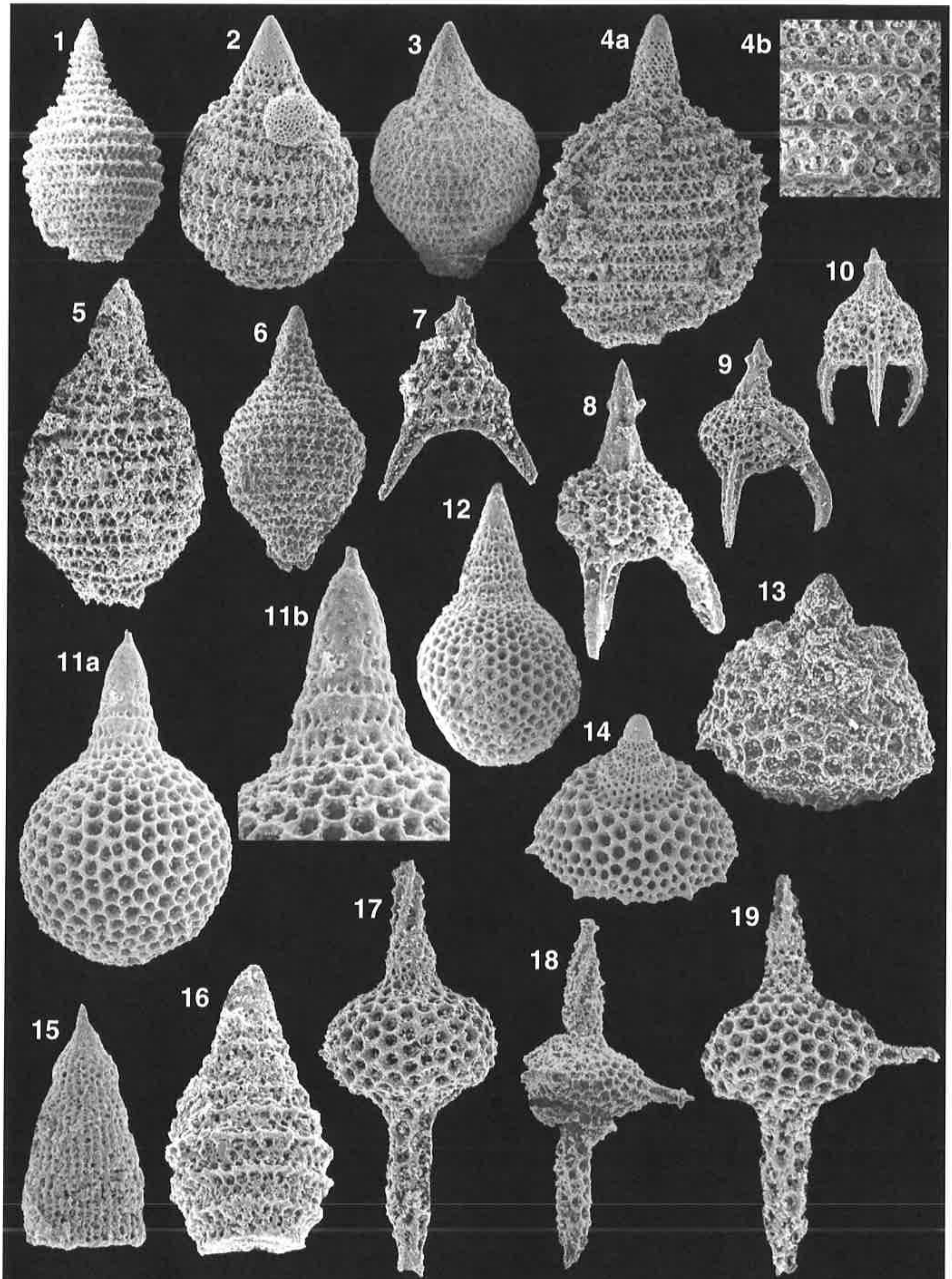

Plate 8

1 - *Podobursa chandrika* (Kocher), SA 5.10, UAZ F, x150

2 - *Podobursa chandrika* (Kocher), BB 17.30, UAZ E-F, x175

3 - *Podobursa chandrika* (Kocher), BB 11.70, UAZ D, x175

4 - *Podobursa chandrika* (Kocher), CE 0.80, UAZ D, x175

5 - *Podobursa polyacantha* (Fischli), FV 1, UAZ D, x150

6 - *Podobursa polyacantha* (Fischli), CE 5.20, UAZ D, x150

7 - **Podobursa rosea* Hull, CI 13, UAZ E, x150

8 - *Podobursa spinosa* (Ožvoldova), CV 117, UAZ E, x150

9 - *Podobursa spinosa* (Ožvoldova), IN 19, UAZ E, x125

10 - *Podobursa triacantha* (Fischli) gr., FZC 7, UAZ D, x150

11 - *Podobursa triacantha* (Fischli) gr., IN 17, UAZ E, x125

12 - *Podobursa triacantha* (Fischli) gr., IN 15, UAZ E, x150

13 - *Podobursa triacantha* (Fischli) gr., CI 3, UAZ C, x150

14 - *Podobursa triacantha* (Fischli) gr., CE 5.77, UAZ E, x150

15 - *Podobursa vannae* Beccaro, CI 4, UAZ C, x150

16 - *Podobursa vannae* Beccaro, FZC 3, UAZ C, x100

17 - *Podobursa vannae* Beccaro, CI 4, UAZ C, x150

PLATE 8

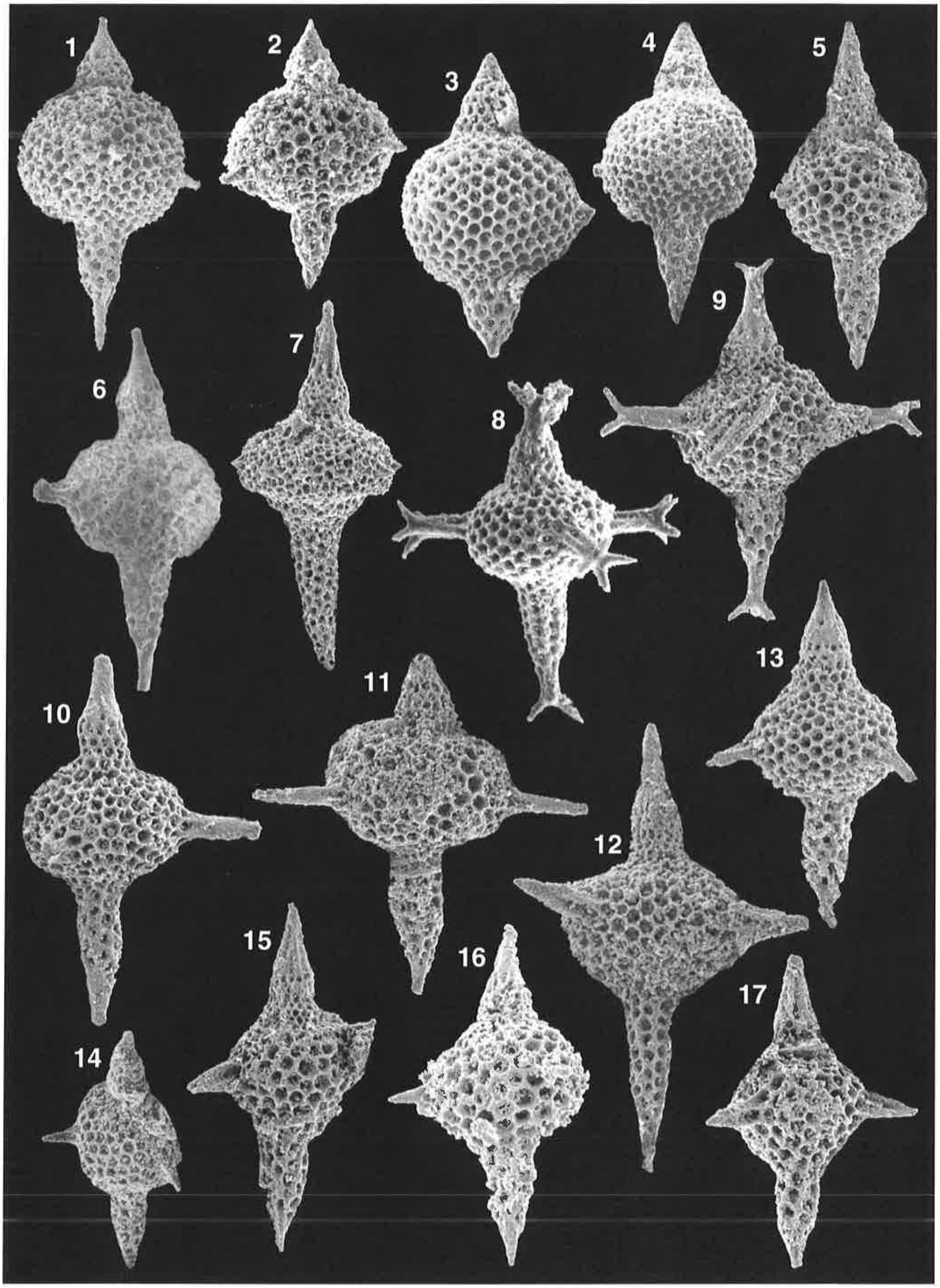

Plate 9

1 - *Podocapsa amphitreptera* Foreman, CV 125.6, UAZ F, x150

2 - *Podocapsa amphitreptera* Foreman, IN 30, UAZ F, x150

3 - *Podocapsa amphitreptera* Foreman, SA 5.10, UAZ F, x150

4 - **Poulpus* sp. aff. *P. oculatus* De Wever sensu Baumgartner et al. 1995b, SA 5.10, UAZ F, x350

5 - *Praewilliriedellum convexum* (Yao), VN 2.85, UAZ B, x250

6 - **Praezhamoidellum yaoi* Kozur, VN 2.85, UAZ B, x350

7 - *Protunuma japonicus* Matsuoka & Yao, SA 5.10, UAZ F, x300

8 - *Protunuma japonicus* Matsuoka & Yao, VN 2.85, UAZ B, x300

9 - *Pseudoeucyrtis firma* Hull, VN 0.40, UAZ B, x150

10 - *Pseudoeucyrtis reticularis* Matsuoka & Yao, IN 32, UAZ F, x150

11 - **Pseudoeucyrtis* sp. aff. *P. hanni* (Tan), VN 0.40, UAZ B, x150

12 - *Pseudoeucyrtis* sp. B sensu Widz 1991, SA 0.35, UAZ E, x150

13 - *Ristola altissima altissima* (Rüst), CI 15, UAZ E, x100

14 - **Ristola altissima major* Baumgartner & De Wever, CV 71.4, UAZ B, x100

15 - *Ristola altissima nodosa* Hori, SA 9.10, UAZ F, x150

16 - *Ristola altissima nodosa* Hori, BB 15.10, UAZ E, x150

17 - **Ristola procera* (Pessagno), CE 0.80, UAZ D, x100

18 - **Saitoum dercourti* Widz & De Wever, CI 13, UAZ E, x250

19 - *Saitoum levium* De Wever, SA 5.10, UAZ F, x350

20 - **Saitoum trichylum* De Wever, CV 60, UAZ A, x250

21 - **Sethocapsa leiostraca* Foreman, CV 60.40, UAZ A, x200

22 - **Sethocapsa leiostraca* Foreman, CI 8, UAZ D, x200

23 - **Spongocapsula perampla* (Rüst), CI 15, UAZ E, x100

24 - **Spongocapsula perampla* (Rüst), BB 16.45, UAZ E, x80

PLATE 9

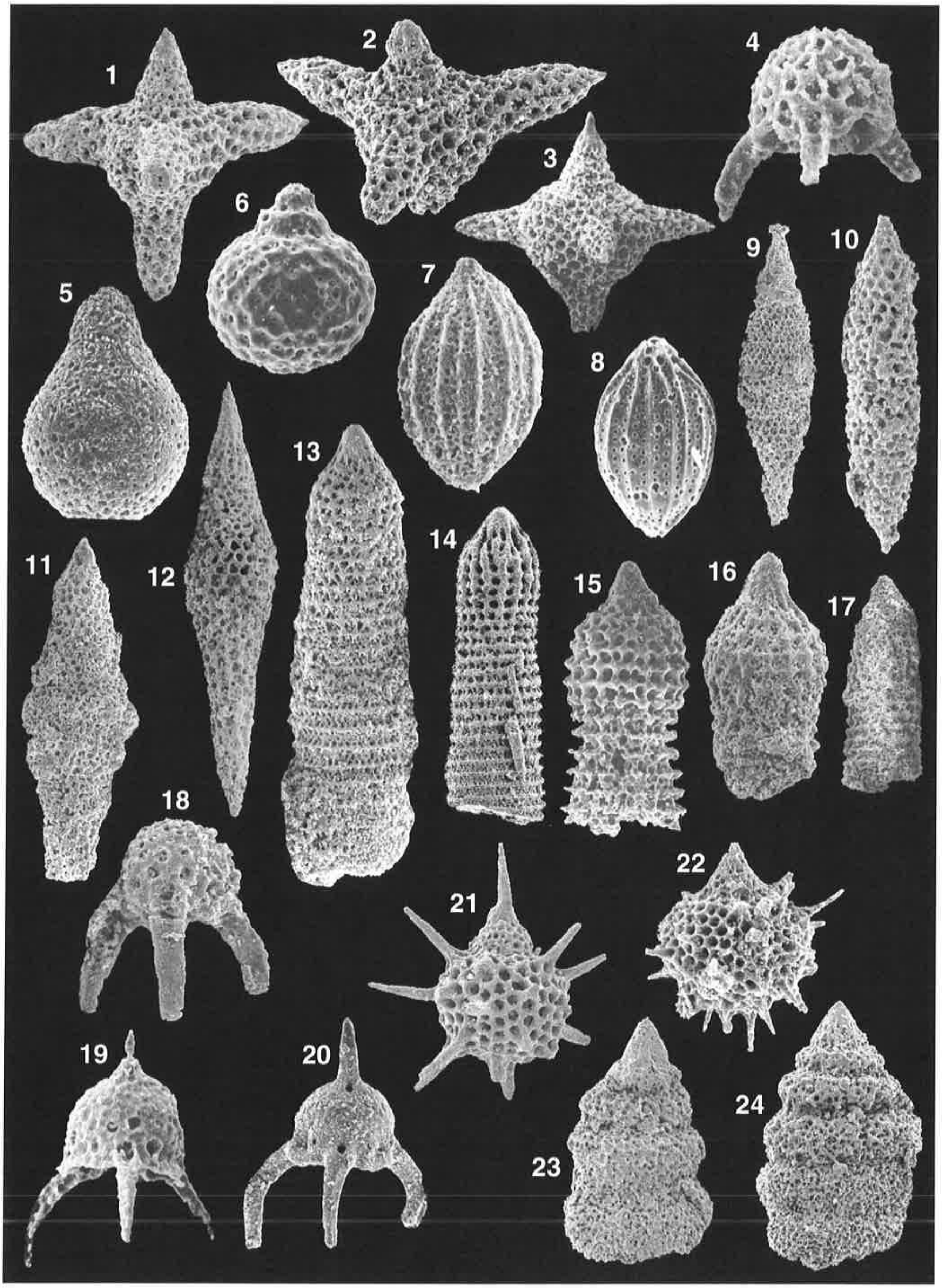

PLATE 10

1 - **Stichocapsa naradaniensis* Matsuoka, VN 2.85, UAZ B, x400

2 - **Stichocapsa ulivii* Chiari, Cortese & Marcucci, IN 11, UAZ D, x300

3 - **Stichocapsa* sp. aff. *S. elegans* Matsuoka, VN 2.85, UAZ B, x400

4 - *Stylocapsa oblongula* Kocher, CV 60, UAZ A, x250

5 - *Svinitzium okamurai* (Mizutani), IN 19, UAZ E, x150

6 - *Syringocapsa spinellifera* Baumgartner, CV 125.6, UAZ F, x100

7 - *Syringocapsa* sp. A, IN 30, UAZ F, x200

8 - *Syringocapsa* sp. A, BB 15.10, UAZ E, x225

9 - **Tethysetta boesii* gr. (Parona), IN 13, UAZ D, x150

10 - *Tethysetta dhimenaensis dhimenaensis* (Baumgartner), VN 2.85, UAZ B, x350

11 - *Tethysetta dhimenaensis* ssp. A sensu Baumgartner et al. 1995b, VN 2.85, UAZ B, x350

12 - **Tetracapsa molengraafi* (Tan), BB 11.70, UAZ D, x300

13 - *Transhsuum brevicostatum* gr. (Ožvoldova), FZC 3, UAZ C, x150

14 - *Transhsuum brevicostatum* gr. (Ožvoldova), CV 60, UAZ A, x150

15 - **Transhsuum maxwelli* gr. (Pessagno), VN 2.85, UAZ B, x200

16 - *Tricolocapsa plicarum* s.l. Yao, VN 2.85, UAZ B; a: face view, x300; b: detail of the sutural pore, x300

17 - **Tricolocapsa* sp., VN 2.85, UAZ B, x350

18 - *Unuma echinatus* Ichikawa & Yao, CV 60, UAZ A, x200

19 - *Williriedellum carpathicum* Dumitrica,VN 2.85, UAZ B, x250

20 - *Williriedellum (?) marcucciae* Cortese, VN 2.85, UAZ B, x350

21 - *Williriedellum (?) marcucciae* Cortese, IN 1, UAZ C, x350

22 - *Xitus magnus* Baumgartner, IN 15, UAZ E, x150

23 - *Xitus magnus* Baumgartner, CI 5, UAZ C, x150

24 - *Zhamoidellum ovum* Dumitrica, SA 0.35, UAZ E, x300

25 - *Zhamoidellum ovum* Dumitrica, CE 5.77, UAZ E, x300

26 - *Zhamoidellum ovum* Dumitrica, IN 11, UAZ D, x250

PLATE 10

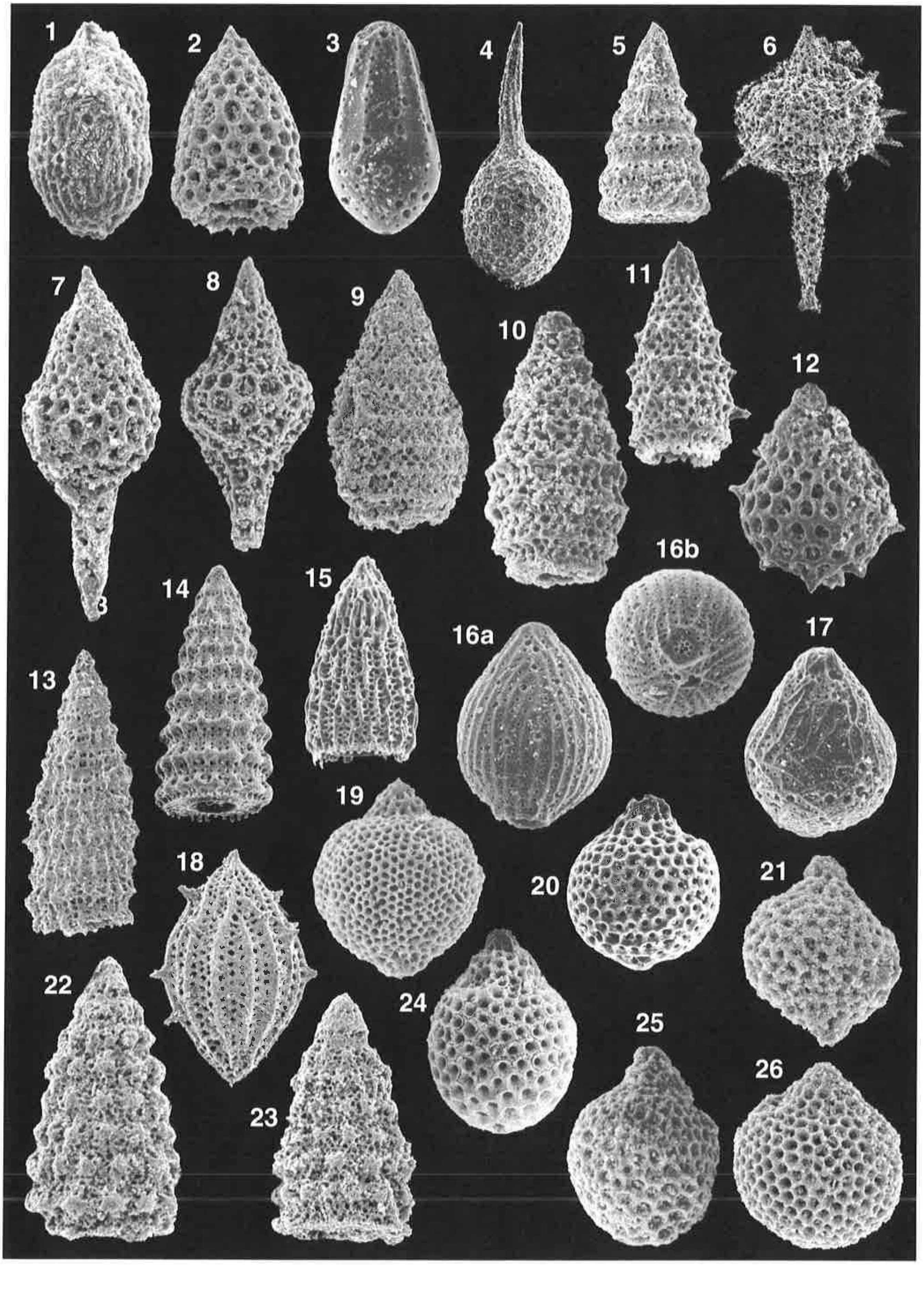

PLATE 11

1 - *Zhamoidellum ventricosum* Dumitrica, SA 0.35, UAZ E, x200

2 - *Zhamoidellum ventricosum* Dumitrica, IN 3, UAZ D, x200

3 - *Zhamoidellum (?) exquisitum* Hull, IN 3, UAZ D, x200

SPONGE SPICULES (PORIFERA)

4 - Criccorhabd (Diactine), BB 21, UAZ E-F, x200

5 - Tylostyle (Monoactine), VN 6.10, UAZ D, x100

6 - Anatriaene (Tetractine), CI 14, UAZ E, x50

7 - Criccorhabd (Diactine), VN 6.10, UAZ D, x150

8 - Amphiox (Diactine), CE 5.20, UAZ D, x150

9 - Fragment of Dichotriaene (Tetractine), VN 6.10, UAZ D, x150

10 - Dichotriaene (Tetractine), VN 6.10, UAZ D, x100

11 - Dichotriaene (Tetractine), IN 8, UAZ D, x100

12 - Oxycalthrop (Tetractine), IN 8, UAZ D, x100

13 - Criccalthrop (Tetractine), CE 5.77, UAZ E, x250

14 - Criccalthrop (Tetractine), VN 6.10, UAZ D, x250

15 - Fragment of Hemiphyllotriaene (Tetractine), CI 3, UAZ C, x80

16 - Oxyaster (Polyactine), CE 5.77, UAZ E, x200

17 - Phyllotriaene (Tetractine), IN 4, UAZ D, x80

18 - Pycnaster (Polyactine), SA 0.35, UAZ E, x150

19 - Rhax (Polyactine), VN 6.10, UAZ D, x300

20 - Hexactinellid (Polyactine), SA 0.35, UAZ E, x80

21 - Pinakid (Tetractine), SA 5.10, UAZ F, x150

NANNOPLANKTON

22 - Nannoplankton cast, Watznaueriaceae, SA 9.10, UAZ F, x2000

PLATE 11

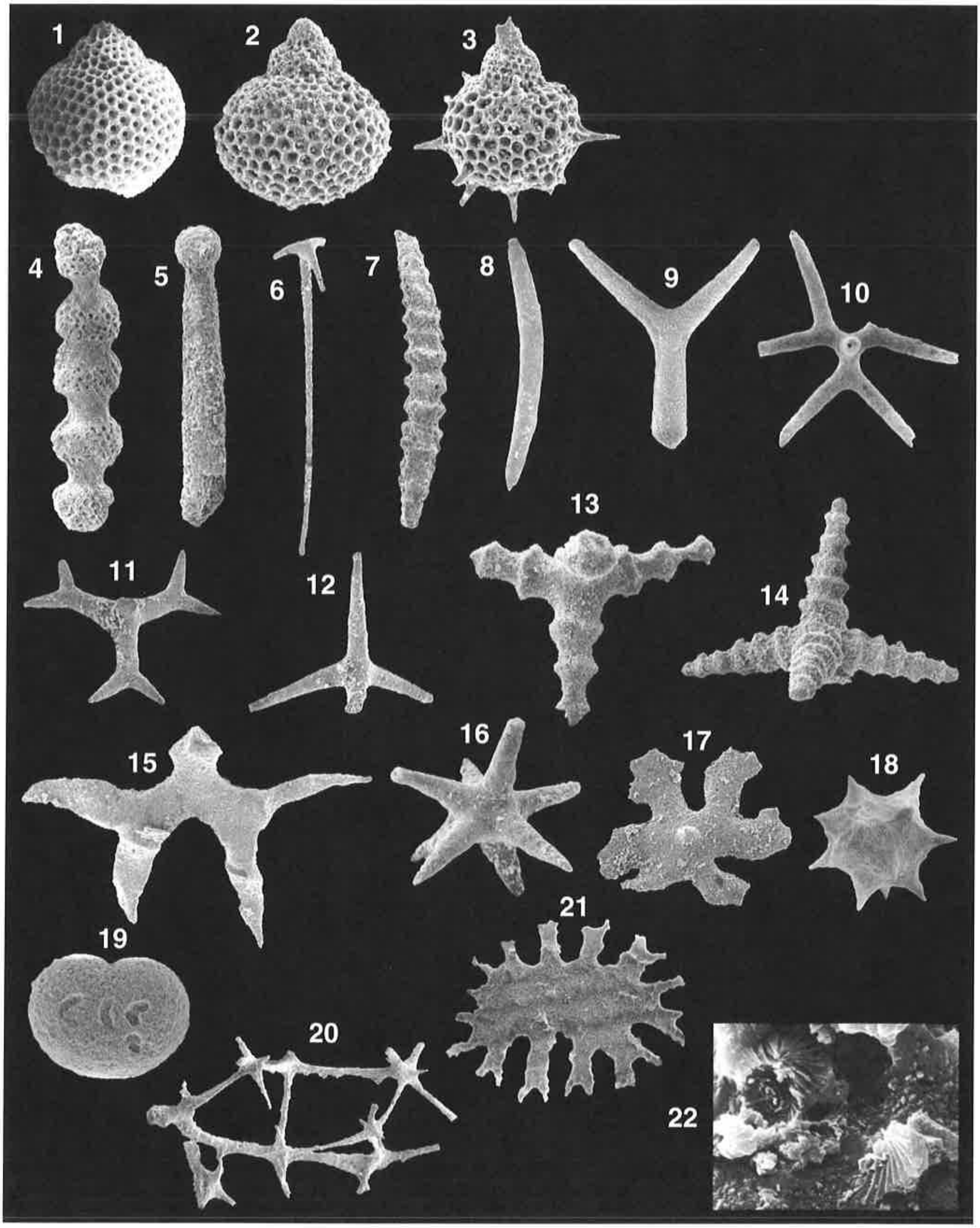

PLATE 12

1 - Sharp contact between the Rosso Ammonitico Inferiore (RAI) and Rosso Ammonitico Medio (RAM) at Fornazzo Strada (Trapanese Domain, North-western Sicily). The base of the RAM consists of about 1m of very altered clayey marlstone and marly limestone.

2 - General view of the Rosso Ammonitico Medio at Fornazzo Strada (Trapanese Domain, North-western Sicily). The alternation of well bedded red siliceous limestone and calcareous marlstone is illustrated.

3 - Upper part of the Rosso Ammonitico Medio section at Fornazzo Cava (Trapanese Domain, North-western Sicily). The alternation of well bedded red siliceous limestone and thin marlstone is shown.

4 - Detail of the Rosso Ammonitico Medio at Balata di Baida (Trapanese Domain, North-western Sicily). Well bedded red siliceous limestone and very thin marlstone are visible.

5 - Basinal pelagic siliceous succession at Sant'Anna (Sicano Domain, South-western Sicily). Thick pink-grey layers of limestone are intercalated with cm-thick levels of white marlstone.

6 - General view of the Cava Vianini active quarry (Trento Plateau, Southern Alps). The complete Rosso Ammonitico Fm. crops out: RAI (Rosso Ammonitico Inferiore), RAM (Rosso Ammonitico Medio) and RAS (Rosso Ammonitico Superiore).

7 - Base of the Rosso Ammonitico Medio (RAM) at Ceniga (Trento Plateau, Southern Alps). Platform limestone of San Vigilio Oolite crops out in the left corner of the photo followed by a very thin RAI (not visible) and RAM, that is characterized by the alternation of thin bedded pink siliceous limestone and thin chert beds.

8 - The Fonzaso Fm. at Coston delle Vette (Trento Plateau, Southern Alps). Detail of the Listato Member, characterized by regularly alternating hazel coloured limestone and hazel chert ribbons and nodules.

PLATE 12