
The Carnian/Norian boundary interval at Pizzo Mondello (Sicani Mountains, Sicily) and its bearing for the definition of the GSSP of the Norian Stage

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Introduction

Pizzo Mondello in the Sicani Mountains (Western Sicily, Italy) is one of the best sites in the world for the study of the Carnian/Norian boundary. At this site, a 450 m thick pelagic-hemipelagic limestone succession is exposed. The succession belongs to the Cherty Limestone (*Calcari con selce* or *Halobia limestone Auctorum*), and is impressive for the combination of great thickness, almost uniform facies, good exposure and easy accessibility.

Besides fulfilling these basic conditions for the examination as GSSP candidate section, Pizzo Mondello is located in an area that is very important for the paleontology for the Upper Triassic pelagic facies. The Cherty Limestone of Western Sicily, and especially of Sicani Mountains, is well known all over the world for the exceptionally rich and well preserved Late Carnian to Early Norian ammonoid faunas studied by G.G. Gemmellaro (1904) and for the very rich halobiid record (Gemmellaro, 1882; Montanari & Renda, 1976; Cafiero & De Capoa Bonardi, 1982; De Capoa Bonardi, 1984).

Although Sicani Mountains have been known in literature since XIX century, the Pizzo Mondello section is a rather new locality presented in international journals in mid '90s (Bellanca et al., 1995; Gullo, 1996). In the second half of the '90s, integrated paleomagnetic, isotopic and conodont stratigraphic investigations were carried out, and Pizzo Mondello soon became one of the world references for the unusual combination of Late Carnian-Early Norian magnetostratigraphic, stable isotope and conodont record (Muttoni et al., 2001; 2004).

However, the investigations carried out in the late '90s were not detailed enough from the paleontological point

of view to support the presentation of a GSSP proposal, as pointed out by Krystyn & Gallet (2002). For this reason a new multidisciplinary research programme started in 2006. Aims of this programme, which involves researchers from Milano, Padova, Palermo, Perugia and Lausanne Universities, are, besides the sedimentology, the high resolution integrated bio-chronostratigraphy based on conodonts, ammonoids, halobiids and radiolarians, and the recalibration of magnetostratigraphy and of stable isotope curves.

Here we present the new data available. Two new very dense conodont samplings were carried out in fall 2006 and spring 2007. The first ammonoid and halobiid bed-by-bed sampling was done in spring 2007, and radiolarian sampling was done in 2005 and summer 2007.

Geological setting

Pizzo Mondello is located in the Sicani Mountains, about 4 km SE of the worldwide known Permian megablocks of the Sosio Valley (Fig. 1.1).

The Sicani Mountains belong to the western Sicily segment of the Maghrebian thrust and fold belt. The structural setting of this area consists of a pile of south-verging thrust sheets formed by Permian to Cenozoic deep-water sediments. They are known as Sicanian structural units (Catalano et al., 1995), and are regarded as to be derived from the Neogene contraction of a deep-water basin (Sicanian basin) located along the southern margin of the Ionian Tethys (Di Stefano, 1990; Muttoni et al., 2004). Pizzo Mondello is the exposed part of a large thrust sheet that overthrusts upper Tortonian-Messinian clays. The roughly East-West trending thrust front is dissected by a later (Pliocene) NW-SE right transpressional fault separating the Pizzo Mondello ss. from Pizzo Scavarrante to the West (Fig.

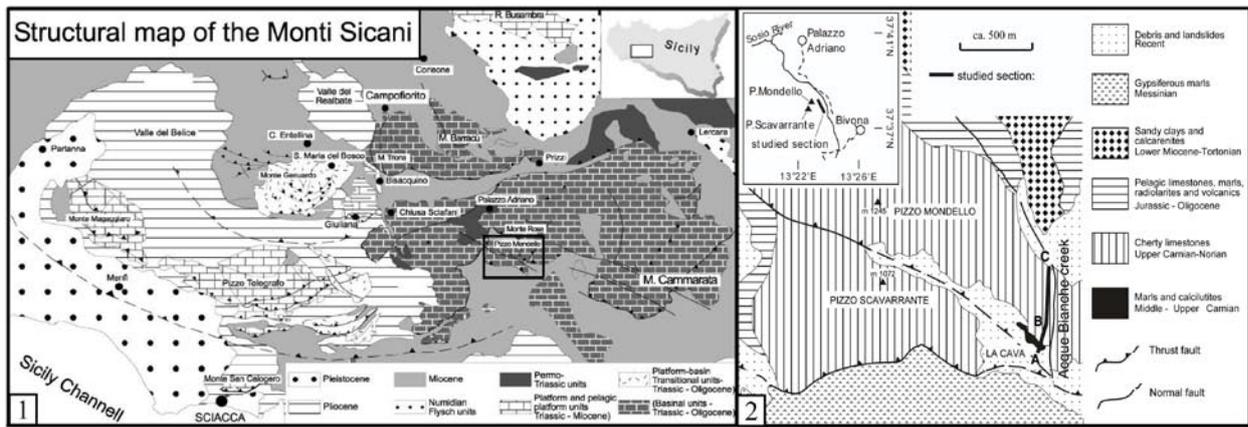


Figure 1: Location map of Pizzo Mondello (Sicani Mountains, Sicily). 1. Geological map of the Sicani Mountains (from Di Stefano et al., 1996). 2. Detailed map of Pizzo Mondello area (from Muttoni et al., 2004).

1.2). Late Miocene-Pliocene thrusting and transpressional movements, associated to clockwise rotations (Muttoni et al., 2001), resulted in a polyphasic folding of the Pizzo Mondello Meso-Cenozoic succession. Northward the Pizzo Mondello unit is in turn overthrusts by another Sicani-type structural unit known as Monte Rose Unit (Masclé, 1979; Di Stefano & Gullo, 1997).

Stratigraphic setting

The Pizzo Mondello succession consists of deep-water Upper Triassic to Eocene calcilutites with a Middle Jurassic intercalation of radiolarites and pillow lavas, covered by Oligo-Miocene clays and glauconitic sandstones. The total thickness can be estimated at about 1500 m.

The Carnian to Rhaetian succession can be easily subdivided into three lithostratigraphic units (Di Stefano, 1990; Gullo, 1996; Di Stefano & Gullo, 1997). The lowermost unit (Fig. 3) consists of a few meters of Upper (p.p.) Carnian dark gray marls alternating to marly limestones. These beds are assigned to the Mufara Formation (Schmidt di Friedberg, 1962), an about 200 m thick lithostratigraphic unit well known from the deep water successions in western Sicily. The Mufara Formation has played the role of major décollement level during the Neogene Maghrebien accretion. At Pizzo Mondello this formation lies tectonically on Tortonian-Messinian clays. An upsection change from marls-calcilutite alternations to monotonous calcilutite beds marks the transition from the Mufara Formation to the next thick unit, informally known as Cherty Limestone or *Halobia* limestones (=Scillato Formation [Schmidt di Friedberg et al., 1960]). In the Sicani Mountains well known sections of this unit, more than 400 m thick, are described at Monte Cammarata and Monte Triona (Masclé, 1979; De Capoa, 1984). At Pizzo Mondello (Fig. 2.1, 2.2) the lower part of this unit is very well exposed in an old quarry (“La Cava”) active until 30 years ago. The intermediate and upper part outcrop extensively along a small creek bounding the eastern slope of Pizzo Mondello: the Acque Bianche creek. In the whole the unit consists of about 450 m of evenly-bedded to nodular *Halobia*-bearing cherty calcilutites. White marly calcilutites (similar to the Maiolica) reaching a thickness of about 20 m follow by a sharp conformable contact. These beds were described by

Gullo (1996) as Portella Gebbia Limestone.

The lower part of the Cherty Limestone, straddling the Carnian/Norian boundary (unit 2 of Muttoni et al., 2001; 2004), is studied in detail.

Lithofacies and sedimentology

Muttoni et al. (2001, 2004) divide the Cherty Limestone of Pizzo Mondello into four parts or lithozones (Fig. 3):

- I. The basal 3 m, above the Mufara Formation, is characterized by calcilutites with rare cherty nodules;
- II. 143.5 m of dm-thick, well-bedded white-yellow calcilutites with black chert nodules, intercalated with cm-thick marly levels, follow. In the calcilutites of this lithozone, thin-shelled bivalves (halobiids), foraminifers, radiolarians, sponge spicules, sparse ammonoids and ostracods (Gullo, 1996), as well as calcispheres and calcareous nanofossils (Bellanca et al., 1993; 1995) are present;

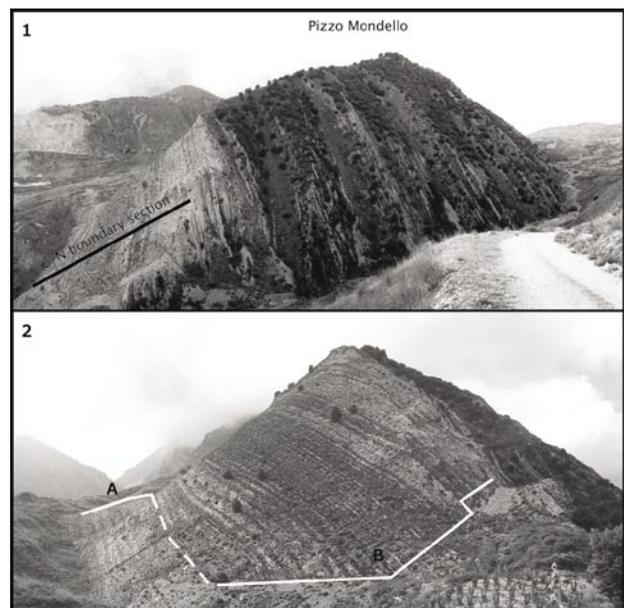


Figure 2: General view of Pizzo Mondello (La Cava) section showing 1) the entire succession of the Cherty Limestone; 2) the interval under study, with the position of the two sampling sites (A and B).

Pizzo Mondello (Muttoni et al., 2004)

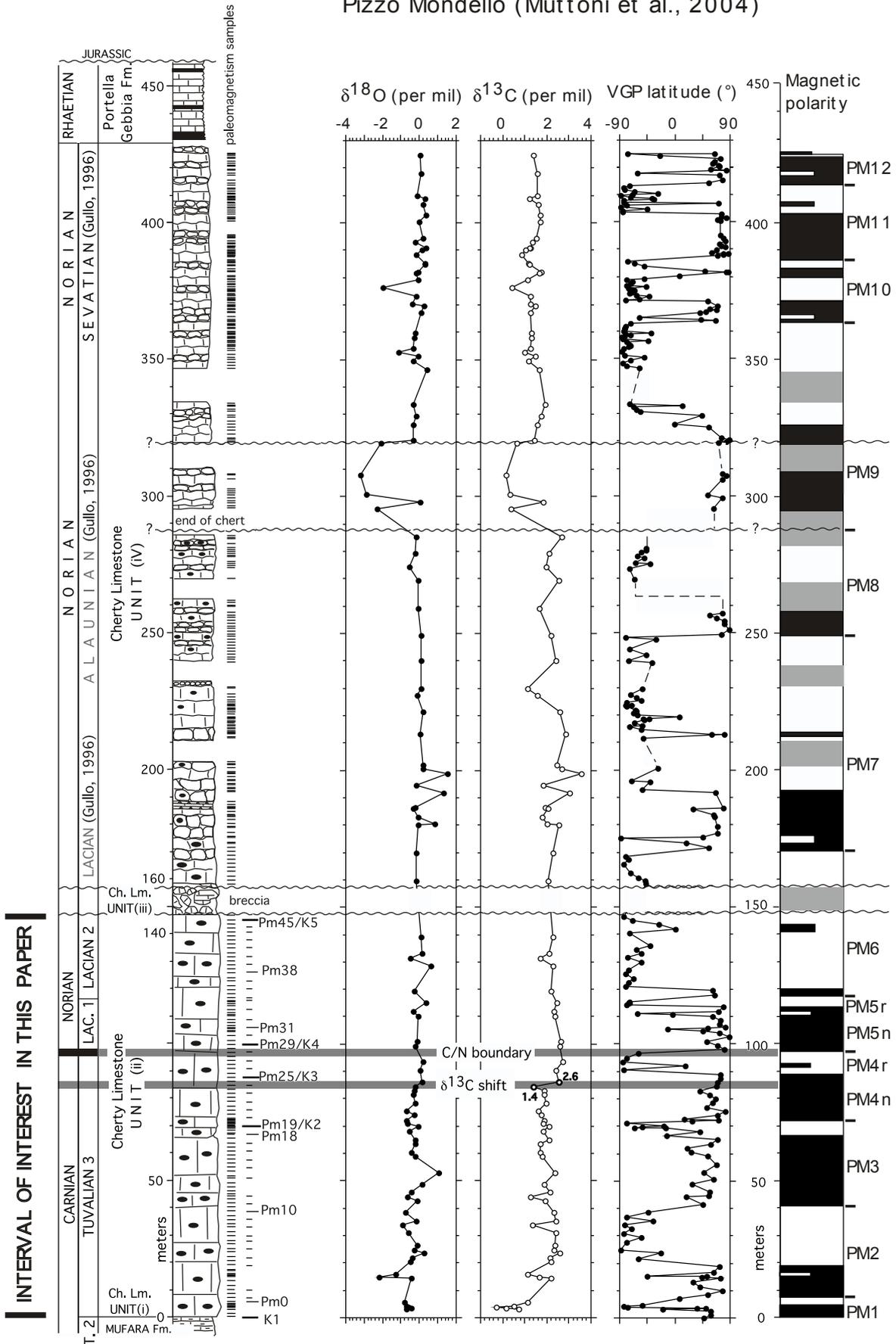


Figure 3: Pizzo Mondello section from Muttoni et al. (2004), with $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ isotope curves and magnetostratigraphy. The lower part of the log, representing the Carnian/Norian boundary interval, is studied in detail in this paper (Fig. 4 and 5).

III. 11.5 m of brecciated limestones, hereafter referred to as the “*slump-breccia*” level;

IV. 267.5 m of dm- to cm-thick, well-bedded to nodular whitish calcilutites with cherty nodules are found above the “*slump-breccia*” level. Chert disappears at meter 290 ca.

The interval II of Muttoni et al. (2004), ca. 140 m thick, was subject to a high-resolution sedimentological analysis. The succession was logged at cm scale and densely sampled (ca. 2 samples/m). Most of the samples were studied with optical microscope, while selected samples were analyzed at SEM. As a result three facies are recognized (Fig. 4; Pl. 1):

Facies A: well-bedded, dm-thick, white calcilutites with black-brown cherty nodules more abundant in the interlayers. Calcilutite layers are composed mostly of micrite, with thin-shelled bivalves (halobiids), radiolarians, ammonoids, foraminifers and calcispheres; bioturbations and laminations are rare. Bivalve coquinas also occur. The interlayers are composed of mm-thick brownish clays, which are rarely laminated (Pl. 1 A1-3).

Facies B: it is similar to facies A, but layers are nodular, up to 1 m thick, and characterized by stylolitic joints. Thin-shelled bivalves, calcispheres and coquinas are more abundant. Bioturbations and laminations are common (Pl. 1 B1-3).

Facies C: calcilutite layers are even more nodular than in facies B but generally thinner (8-15 cm), and always laminated. Thin-shelled bivalves and calcispheres are very common. Silicified coquinas are very abundant. Cm- to dm-scale interlayers, composed of brown-black dolomitized clay-marls, are more common than in all other facies. This facies is rich in black chert, occurring in 5-7 cm thick beds (Pl. 1 C1-3).

In the logged section (Fig. 4), these three facies alternate following the scheme A-B-C-B-A with interval C centered at m 73 ca.

This facies alternation may represent a combination of oscillations in the carbonate sediment supply from surrounding carbonate platforms, varying dissolution rates at the sea-bottom, and different autochthonous carbonate productivity (e.g., benthic thin-shelled bivalves or calcispheres, supposed to be pelagic according to Bellanca et al., 1993; 1995).

Ammonoid distribution

The biostratigraphic analysis of ammonoids and halobiids started in May, 2007. Two segments of Muttoni et al. (2001) interval II (lower half and upper part of the section in Fig. 4) were selected to test a bed-by-bed sampling for megafossils (Fig. 4). This sampling yielded sparse ammonoids together with very common halobiids. The occurrence of

ammonoids is especially interesting because it solves a problem of apparent inconsistency in literature. Gemmellaro (1904) described a large collection of about 4,000 well preserved ammonoids from Cherty Limestone of several localities in western Sicily. However, since that time only very few citations of ammonoids have been done (i.e., De Wever et al., 1979; Mascle, 1979; Gullo, 1996; Krystyn & Gallet, 2002), but no description of new specimens has never been provided.

The ammonoids are sparse within the beds, but the collection is possible because of the very good exposure of the succession. The beds can be easily followed along strike for tens or even hundreds of meters and some specimens can be recognized on surface.

At the present some tens of ammonoids have been collected. Most of them are of small size. Sometimes the specimens are hard to extract from the matrix. However, some medium- to large-sized very well preserved specimens can also be found (Pl. 2). Preliminary examination of the collection lead to identify some stratigraphic markers.

Discotropites plinii (Mojsisovics) has been collected from level PMAM17 (Pl. 2.5), in the lower part of the studied interval (Fig. 4). This species is index of the *D. plinii* subzone (Krystyn, 1974, 1980), first subzone of the uppermost Carnian *Anatropites spinosus* Zone.

In the middle part of the studied interval, in level PMAM7 a well preserved *Gonionitites maurolico* Gemmellaro has been found (Pl. 2.6). The genus *Gonionitites* ranges across the Carnian/Norian boundary in both the Tethyan realm and North America. In the Tethys it can be found from the *Gonionotites* cf. *italicus* subzone (Krystyn, 1980) of the *Anatropites spinosus* Zone to the *Guembelites jandianus* Zone (Krystyn, 1982), while in North America it is found in the *Macrolobatus* and *Kerri* zones (Tozer, 1994). At the rank of species, the Upper Carnian *Gonionitites* differ from the Lower Norian ones (Krystyn, 1982; Tozer, 1994). Unfortunately *G. maurolico* Gemmellaro has been reported only by Gemmellaro from western Sicily, then the stratigraphic position of this species has never been calibrated with respect to the Carnian/Norian boundary.

Probably the most interesting specimen for the identification of the Carnian/Norian boundary is at present a single specimen of *Dimorphites* sp. (Pl. 2.7) which was found unfortunately from debris. This specimen obviously cannot be used to trace any bio-chronostratigraphic boundary, but it demonstrates that in the Pizzo Mondello succession the ammonoid record documents also the very base of the Norian Stage. *Dimorphites* is restricted to the first zone of the Norian in both the Tethyan realm (*Guembelites jandianus* Zone: Krystyn, 1982) and North America (*Kerri* Zone: Tozer, 1994).

Halobiid distribution

At present, about 300 halobiid specimens (from 44 beds) have been collected (Fig. 4).

Halobiids have a wide distribution within the succession, ranging from almost the base (sample PM6), to the top of

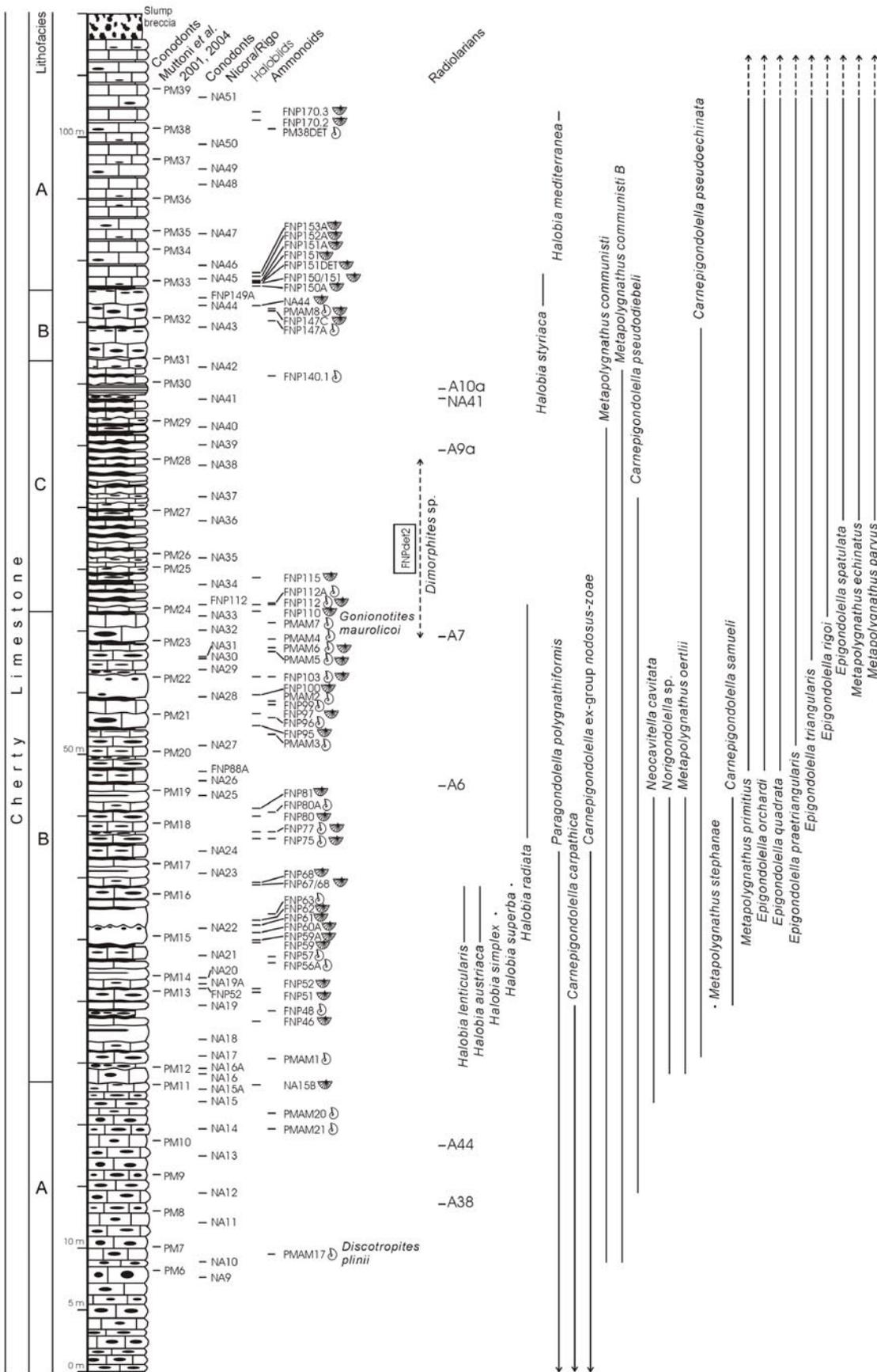


Figure 4: Detailed log of the Carnian/Norian boundary interval with the distribution of ammonoids, halobiids, radiolarian samples and conodonts. Acronym PM: conodont sample from Muttoni et al. 2001 and 2004; NA: conodont sample 2006 and 2007; FNP: lithofacies/halobiid/ammonoid sample 2007; PMAM: ammonoid sample 2007; A: radiolarian sample 2005 and 2007. The increment of the sampling resolution for conodonts might allow the re-calibration of the FOs of some species.

age	LATE CARNIAN				EARLY NORIAN		
	A38	A44	A6	A7	A9a		
taxa							
samples							
Acanthocircus (?) sp. A PESSAGNO, 1979					x	x	x
Braginastrum curvatus TEKIN					x	x	x
Bulbocyrtium reticulatum KOZUR & MOSTLER					x	x	x
Capnodoce sp. cf. C. anapetes DE WEVER					x	x	
Capnodoce sp. cf. C. longibrachium TEKIN							x
Capnuchosphaera deweveri KOZUR & MOSTLER					x	x	x
Capnuchosphaera triassica DE WEVER		x					
Capnuchosphaera lea DE WEVER		x			x	x	
Capnuchosphaera sp. cf. C. lea DE WEVER	x	x	x	x	x	x	
Capnuchosphaera theloides DE WEVER		x			x	x	x
Capnuchosphaera sp. aff. C. crassa YEH	x	x	x	x			
Capnuchosphaera tricornis DE WEVER					x	x	x
Capnuchosphaera sp. indet.	x	x	x	x			
Carinaheliosoma carinata (KOZUR & MOSTLER)					x	x	
Dumitricasphaera (?) sp.					x		
Entactinosphaera (?) sp.1 BRAGIN	x	x	x	x	x	x	x
Enoplacampe sp.					x		
Kahlerosphaera sp. cf. Eptingium sp. A DE WEVER					x		x
Icrioma tetrancistrum DE WEVER					x	x	x

Figure 5: Radiolarian distribution in the studied samples.

the succession below the *slump breccia* (sample PM39). Within this interval, we recognize different distribution patterns for fossils.

The base and the first half of the succession show a quite homogeneous alternation of levels bearing only halobiids or levels bearing only ammonoids, with some intercalated levels bearing both halobiids and ammonoids (e.g. levels FNP52, FNP75, FNP112 in Fig. 4). The halobiids are recorded as small prints of single valves (frequently not more than 1-1.5 cm in diameter for lenticular forms, and not more than 1.5-2 cm in length for elongated forms). The skeletal material is very rarely preserved –mostly recrystallized shells.

The second half of the succession is characterized by a thick beds-set of levels bearing halobiids only, with ammonoids distributed below and over it (i.e. levels from NA44 to FNP153). The halobiids from these levels are larger (mostly more than 3-4 centimeters in diameter), heavily compressed and reduced to thin films or laminas. They occur both as isolated specimens (single valves) and as coquina-like levels, mostly at the base or at the top of beds. In the beds-set comprised between levels NA44 and FNP153A, more than 70% of the levels are made of halobiids' remains. No imbrication could be recognized, while even 70-80% of halobiids are oriented convex-up.

At the moment, the study of the collection is in progress, but we recognize seven species, and four assemblages.

The lower part of the succession is dominated by *Halobia lenticularis* and *H. austriaca*, with rare *H. simplex* and only one specimen of *H. superba* (levels from NA15B to FNP67/68; Fig 5). The middle part is dominated by *H. radiata* forms (levels from FNP75 to FNP115; Fig. 4). The halobiids from levels NA44 to FNP153A are *H. styriaca* (Mojsisovics, 1874) or *H. styriaca*-group specimens (levels from FNP150 to FNP153A; Fig. 4). Finally, the uppermost part of the succession (levels FNP170.2 and FNP170.3; Fig. 4) contains few specimens of *H. mediterranea*.

We identify four halobiid assemblages, named for their dominant species, from bottom to top: *H. lenticularis* (with subordinate *H. austriaca* and *H. simplex*), *H. radiata*, *H. styriaca*, and *H. mediterranea*.

Among these species, five are reported from Upper Carnian to Lower Norian (*H. lenticularis*, *H. superba*, *H. austriaca*, *H. simplex* and *H. radiata*; (Gruber, 1975, 1976; Cafiero & De Capoa Bonardi, 1984; Campbell, 1994) and two as Lower Norian (*H. styriaca* and *H. mediterranea*; Krystyn and Gallet, 2002; Krystyn et al., 2002). In particular, *H. styriaca* is considered in North America and Tethys as marker of the upper part of Lacion 1 (upper *Kerri* Zone in North America; *Jandianus* Zone in the Tethyan realm; Krystyn and Gallet, 2002; Krystyn et al., 2004).

Conodont distribution

At Pizzo Mondello, conodont samples were collected at different times and by different researchers in the past

(Gullo, 1996; Muttoni et al., 2001; Krystyn et al., 2002; Nicora et al., 2006; Guaiumi et al., 2007). A detailed sampling has been carried out in two sites (A and B; Fig. 2.2), because the middle part of the outcrop is rather steep. A bed-by-bed correlation between the two sites guarantee the uniform density of sampling.

Sample numbers are labelled with different capitals referring to the various researchers and times of sampling (reference column in Fig. 4). Sample spacing is minimal in the interval supposed to contain the Carnian/Norian boundary, and the distribution of conodonts is shown in Fig. 4

The number of conodonts in each sample is generally high. With few exceptions, samples from lithofacies A turned out to be particularly poor in conodonts, while lithofacies C is particularly rich in specimens. The conodonts have a Conodont Alteration Index (CAI) of 1.

The nomenclature of the conodont zones is reported according to Moix et al. (2007) and Orchard (1991 a). The most relevant occurrences are here emphasized in roughly chronological order.

- From sample NA10 *Metapolygnathus communisti* (Hayashi) (Plate 4.7) and *Metapolygnathus communisti* B Krystyn (Plate 3.3) are also present. Samples PM0-10 are characterized by the association *Paragondolella polygnathiformis* (Budurov & Stefanov), *Carnepigondolella carpaticha* (Mock), *Carnepigondolella nodosa* (Hayashi) along with *Carnepigondolella* ex gr. *zoeae* (Orchard).

- From sample NA10 *Metapolygnathus communisti* (Hayashi) (Plate 4.7) and *Metapolygnathus communisti* B Krystyn (Plate 3.3) are also present.

- *Carnepigondolella pseudodiebeli* (Kozur) (Plate 3.4) is from NA12 up to NA37.

- *Carnepigondolella pseudoechinata* (Kozur) and *Metapolygnathus stephaniae* Orchard occur from NA17.

- *Neocavitella cavitata* Sudar & Budurov appears, along with the aforementioned species, in NA15 and ranges up to NA25.

- *Norigondolella* sp. (Plate 3.1) and *Metapolygnathus oertlii* (Kozur) (Plate 3.2) occur in NA16.

- *Carnepigondolella samueli* (Orchard) (Plate 3.5) is present from NA19.

- *Metapolygnathus primitius* (Mosher) (Plate 3.10), *Epigondolella quadrata* Orchard (Plates 3.8, 3.9) and *E. orchardi* Kozur (Plates 3.7, 3.11) are rather abundant from FNP88A.

- *Epigondolella praetriangularis* Kozur & Moix (Plate 4.5) occurs in NA27.

- *Epigondolella triangularis* (Budurov) (Plates 4.8, 4.9, 4.10) is present from NA30 upwards.

- *Epigondolella rigoi* Kozur (Plates 3.12, 4.6) was obtained from NA33 upwards.

- *Metapolygnathus parvus* Kozur (Plates 4.2, 4.3), *Epigo-*

ndolella spatulata (Hayashi) and *M. echinatus* (Hayashi) (Plates 4.1, 4.4) characterize the conodont fauna from NA36 upwards.

According to the recent literature, the bio-chronostratigraphic value of the species proposed to determine the Carnian/Norian boundary is here briefly discussed.

- The first conodont association [*Paragondolella polygnathiformis* (Budurov & Stefanov), *Carnepigondolella carpaticha* (Mock), *Carnepigondolella nodosa* (Hayashi) along with *Metapolygnathus stephaniae* Orchard and *Carnepigondolella* ex gr. *zoeae* (Orchard)] can be related to the Middle-Late Tuvallian according to Orchard (1991a,b), Orchard & Tozer (1997), Carter & Orchard (2000), Orchard et al. (2001), Muttoni et al. (2001), Krystyn et al. (2002), Channell et al. (2003), Kozur (2003), Moix et al. (2007)].

- *Metapolygnathus communisti* Hayashi (Muttoni et al., 2001) seems to have a regional distribution (Kozur, 2003; Channell et al., 2003). In the Northern Tethys it appears just before the FAD of *Norigondolella navicula* (Huckriede) and disappears just before the FAD of *Epigondolella quadrata* Orchard, while in Neotethys and North America it occurs significantly earlier below the FAD of *Norigondolella navicula* (Huckriede) (Kozur, 2003).

- *Neocavitella cavitata* Sudar & Budurov range is restricted to the upper part of the Carnian according to Sudar and Budurov (1979), Budurov and Sudar (1990).

- *Norigondolella navicula* (Huckriede) has been regarded as marker for the base of the Norian Stage by Krystyn (1980) and Orchard (1991, b). According to Carter & Orchard (2000) and Kozur (2003), *Norigondolella navicula* seems to be facies controlled and thus not usable as boundary marker.

- *Metapolygnathus oertlii* (Kozur) according to Kozur (1980) and Krystyn et al. (2002) is a short-ranged species of the Latest Tuvallian that ends at the FAD of *Metapolygnathus communisti* Hayashi. But a clear overlapping of *Metapolygnathus communisti* Hayashi with *Metapolygnathus oertlii* (Kozur) has been recently illustrated in Rigo et al. (2007).

- The FO of *Carnepigondolella samueli* (Orchard) identifies the Upper *nodosus* Zone sensu Orchard (1991, a) of Middle-Late Carnian age.

- *Metapolygnathus primitius* (Mosher) straddles the Carnian/ Norian boundary (Orchard, 1991, a,b; Orchard & Tozer, 1997; Muttoni et al., 2001). According to Kozur (2003), in North America the FAD of *M. primitius* is partly coincident with the FAD of *Norigondolella navicula* while in the Neotethys it is coeval to the FAD of *Epigondolella orchardi* Kozur. However the occurrence of *Metapolygnathus primitius* is very close to the base of the Norian. At Pizzo Mondello *M. primitius* occurs along with *E. orchardi* and *E. quadrata*, and become very abundant after the FO of *M. echinatus* and *M. parvus*.

- *Epigondolella orchardi* Kozur is Latest Carnian-Low-

er Norian in age according to Kozur (2003) and Moix et al. (2007). It occurs along with *Metapolygnathus communisti* and *Metapolygnathus primitius* in the Neotethys while in the Northern Tethys it is associated with *Norigondolella navicula* and transitional forms to *Carnepigondolella pseudodiebeli* (Kozur), as well argued in Kozur (2003).

- *Epigondolella quadrata* Orchard (= *Epigondolella abneptis* subspecies A; Orchard, 1991, b) is Early Norian in age according to Orchard (1991 a, b), Krystyn et al. (2002), Channell et al. (2003), Kozur (2003) and Moix et al. (2007).

- *Epigondolella praetriangularis* Kozur & Moix occurs from the uppermost Tuvalian to the Earliestmost Laciian (Latestmost Carnian-Early Norian; Moix et al., 2007).

- *Epigondolella triangularis* (Budurov) (= *Epigondolella abneptis* subspecies B sensu Orchard, 1991 a) is Late Laciian (Early Norian) according to most of the Authors (e.g.: Orchard, 1991 a, b; Krystyn et al., 2002; Channell et al., 2003; Kozur, 2003 and Moix et al., 2007).

- *Epigondolella rigoi* Kozur ranges from Earliestmost Norian to Alaunian (Middle Norian; Moix et al., 2007)

- *Metapolygnathus parvus* Kozur, according to Kozur (1972), is restricted to the Tuvalian (Late Carnian).

- *Metapolygnathus echinatus* (Hayashi): Orchard (1991b) refers this species to *Metapolygnathus pseudoechintus* (Kozur) and assigne it to the Latestmost Tuvalian.

Radiolarian distribution

The radiolarian faunas from the latest Carnian to Early Norian interval are fairly well to very well preserved in the Pizzo Mondello section and show a rather high diversity. Common spumellarian genera include *Capnuhosphaera* De Wever, *Spongortilispinus* Kozur, Moix & Mostler, and *Kahlerosphaera* Kozur & Mostler. Nassellarians are usually less abundant and are often represented by various Xiphothecidae and Pseudodictyomitridae.

Many of these forms are well known from coeval sections in the Tethys (De Wever et al., 1979; Kozur & Mostler, 1972, 1978, 1979, 1981; Tekin, 1999, etc.), as well as from British Columbia (Carter & Orchard, 2000) and Oregon (Blome, 1984; Yeh, 1989) and can represent useful markers for global correlations. There are, however, some differences between the faunas known in North America and in Western Tethys, as for example, the abundance of genus *Xiphothecaella* De Wever & O'Dogherty in Western Tethys and its scarcity in North America.

As can be seen in Tekin (1999) and was pointed out especially by Carter (in Carter & Orchard, 2000), radiolarians show a gradual change across the Carnian/Norian boundary. However, Carter & Orchard proposed several potential radiolarian datums for the boundary calibrated with conodont zonation.

The study of the present radiolarian sequence is in a preliminary state. A closer sampling around the Carnian/Norian boundary was done quite recently and the study of the new

samples around the boundary is in progress. Anyway, this preliminary study shows that some taxa, previously known as having their LAD in the Late Carnian (*Praeorbiculiformella*, *Spongortilispinus*, *Weverella*, *Dumitricasphaera*, *Monospongella*) range till the Early Norian, and other taxa known until present from the Early Norian (Tekin, 1999) are still present in the latest Carnian.

In the present state of knowledge, A9a (located 1 m above the sample PM28, see Fig. 4, and around 12 meters above the $\delta^{13}\text{C}$ shift, see Fig. 3) is the oldest sample showing noticeable Norian affinities by containing the FAD of certain taxa known only to appear in the lower Laciian: for example some species of *Mesosaturnalis*, and especially *Monocapnuhosphaera* (*M. inflata* Tekin, Pl. 6 fig. 9), etc. (Pl. 5, figs. 14-16 and Pl. 6, figs. 8-16). This sample and some upper samples (A10a, NA41) contain numerous new taxa besides many already known species typical of Early Norian assemblages as reported in particular in Turkey (Tekin, 1999). Other species, as for example *Carinaheliosoma carinata* (Kozur & Mostler) (Pl. 6 fig. 13), known as having their LAD in the Early Norian, are present in this sample. A detailed content can be seen in the occurrence table (Fig. 5).

The sample A10a (2 meters above the sample PM29) is Early Norian on the basis of the presence of *Kahlerosphaera kemerensis adentata* Tekin (Pl. 6, fig. 1), known so far only from the Early Norian. Besides it there are species ranging from the Late Carnian to Early Norian (*Capnuhosphaera deweveri* Kozur & Mostler, *C. tricornis* De Wever, *Kahlerosphaera norica* Kozur & Mock, etc., see Plates 6-7).

The sample NA41 (18 metres above the $\delta^{13}\text{C}$ shift and just above the A10a) is Early Norian on the basis of the presence of the same taxa yielded in A10a (Pl. 6) and of *Icrioma tetrancistrum* De Wever (Early-Middle Norian), *Xiphothecaella longa* (Kozur & Mock) (Early Norian-Middle Norian), and *Xiphothecaella rugosa* (Bragin) (Late Carnian-Early Norian, *Braginastrum curvatum* Tekin, *Podobursa akayi* Tekin, *Capnodoce* sp. cf. *C. longibrachium* Tekin, and *Senelella triassica* Tekin, almost all referable to Early Norian (Pl. 7).

Magnetostratigraphy

A total of 410 paleomagnetic core samples were analysed for magnetostratigraphy (Muttoni et al., 2001; 2004). Rock magnetic experiments showed the presence in all sampled lithologies of dominant magnetite as carrier of the natural remanent magnetization (NRM). The results of stepwise thermal demagnetization of the NRM showed a multi-component structure. There is an initial magnetization component along the north and steep positive present-day field direction, isolated between room temperature and ~200-300°C in the majority of the specimens. At higher demagnetization temperatures, from ~200-300°C to ~400°C up to a (rare) maximum of 500-550°C, about three-quarters (73%) of the specimens show the presence of a southeast-and-down or northwest-and-up (in geographic coordinates) characteristic component, interpreted as acquired during normal and reverse geomagnetic polarity,

respectively. After correction for the homoclinal bedding tilt, the mean normal and reverse characteristic component directions become more easterly and westerly, respectively. Although normal and reverse populations are clearly seen, their means depart from antipodality by $\sim 36^\circ$, which we attribute to residual contamination from present-day field overprinting. The effect of the contaminating bias and/or transitional components on the mean direction can be minimized by first inverting all directions to common polarity, which results in a tilt corrected mean direction of Dec. = 107.0° , Inc. = 34.5° . The corresponding overall paleomagnetic pole, calculated by averaging the virtual geomagnetic pole (VGP) for each characteristic component direction, is located at Long. = 78.0°E , Lat. = 0.4°S .

The latitude of the sample VGP relative to the north pole of the paleomagnetic axis was used for interpreting the polarity stratigraphy. An overall sequence of 27 polarity intervals, labeled from magnetozone PM1 to PM12n has been established starting at the base of the Cherty Limestone (Fig. 3); delineation of magnetozones PM1 to PM6 is from Muttoni et al. (2001). Each magnetozone is subdivided into a lower predominantly normal and an upper predominantly reverse portion, in which submagnetozones can be embedded. The conodont Carnian-Norian boundary was placed at the PM4r/PM5n boundary, whereas the $\delta^{13}\text{C}$ positive shift falls within the upper part of magnetozone PM4n (Fig. 3) (Muttoni et al., 2004 and references therein).

Chemostratigraphy

Stable isotopes ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) data were already presented in literature, but a new detailed sampling of the boundary interval is scheduled. The data by Bellanca et al (1995) for the lowermost part (Carnian) of the section, were complemented by Muttoni et al. (2004), who reported the $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ curves for the whole Cherty Limestone succession (Muttoni et al. 2004, fig. 3; Fig. 3). A 1.2 per mil shift of $\delta^{13}\text{C}$ is reported from the upper part of the magnetozones PM4n and immediately below sample PM25 (Muttoni et al., 2004, fig. 3; Fig. 3). As suggested by Muttoni et al. (2004) this shift could be a proxy for the Carnian/Norian boundary, but further investigation are necessary to better calibrate this physical event.

Tuffitic layers

The upper part of the boundary interval (upper lithofacies A) is under study in order to find tuffitic layers. If the occurrence of tuffitic layers is confirmed, we will process samples to separate and date zircons.

Correlations and possible marker events

The Carnian/Norian boundary Working Group has not yet decided on the guide event of the boundary, however, most of the debate is focused on conodonts (Muttoni et al., 2001; 2004; Channel et al., 2003; Krystyn & Gallet, 2002; Kozur, 2007; Orchard, 2007a, b). For this reason here we discuss the main conodont events potentially useful for the selection of the GSSP marker event.

The following stratigraphically important platform conodont occurrences have been recognized at Pizzo Mondello section from base to top (Fig. 4). A particular attention has been focused to those species which have been historically considered to mark the base of the Norian Stage.

- ***Metapolygnathus communisti* Hayashi, 1968:** *Metapolygnathus communisti* was first stated by Hayashi (1968) from Japan. Subsequently Krystyn (1980) differentiated the *Metapolygnathus communisti* population into two different subspecies: *Metapolygnathus commuinisti* s.s. and *Metapolygnathus communisti* B attributing to *M. communisti* s.s a range Latest Carnian-Earliest Norian and to *M. communisti* B only Early Norian. As suggested by Kozur (2003), *Metapolygnathus communisti* recovered in the Northern Tethys are always advanced forms, while transitional forms between *M. communisti* and its forerunner *P. polygnathiformis noah* (Hayashi) were restricted to North America and Neotethys, allowing the assumption that the FOs of *M. communisti* are diachronous in between the Northern Tethyan-Western Pantalassa and North America and Neotethys. However the occurrence of *M. communisti* is world widely below the FADs of *Norigondolella navicula* and the *Epigondolella* spp. (e.g. *Epigondolella orchardi*, *Epigondolella quadrata*) and at Pizzo Mondello section *M. communisti* Hayashi occurred below the ammonoid *Discotropites plinii*, which is a guide species for the base of the upper Tuvallian (Krystyn 1974, 1980 and Krystyn et al., 2002). With this consideration the first occurrence of *M. communisti* is surely Late Carnian in age.

- ***Metapolygnathus comministi* B Krystyn, 1980:** this species never described and only illustrated in Krystyn (1980) has been proposed by Gallet et al. (1992, 1994) as a guide species for the base of the Norian. Unfortunately, *Metapolygnathus communisti* B is absent in North America and only sporadically present in the Tethys (Krystyn, 1980; Gallet et al., 1992, 1994; Rigo et al., 2007). At Pizzo Mondello section, the FO of *Metapolygnathus communisti* B is below the occurrence of *Discotropites plinii*, an Upper Carnian ammonoid (see above). Thus, the sporadic occurrence, its stratigraphical range and the absence of a clear description makes the FAD on *M. communisti* B not ideal for defining the base of the Norian.

- ***Norigondolella* sp.:** for many years, the FAD of genus *Norigondolella* with the species *Norigondolella navicula* (Huckriede, 1958) has been considered by different authors working both on North American and Tethyan sections to mark the base of the Norian. Krystyn (1980) first supported this occurrence for the definition of the base of the Norian. But genus *Norigondolella* is often rare throughout the Neotethys suggesting it is a facies-controlled taxon (Kozur, 2003) and also in North America, according to Orchard et al. (2000), the mass occurrence of *N. navicula* would confirm this hypothesis. Furthermore, according to Kozur in Channell et al. (2003), the FAD of *Norigondolella navicula*, which is the first representative of genus *Norigondolella*, is close to FAD of *Metapolygnathus communisti* B which in Pizzo Mondello section has been recovered from surely Carnian strata (see above). The species recovered at Pizzo Mondello section and illustrated

in Plate 3, Figure 1 a-c belongs for sure to the genus *Norigondolella* but it is not possible to ascribe this species to *Norigondolella navicula* (Huckriede). It might be a precursor of *Norigondolella navicula* from an ancestral forerunner not yet well identified. Thus it means that the genus *Norigondolella* occurred from Carnian strata but the species *Norigondolella navicula* might even appear somewhere around the Carnian/Norian boundary as first suggested by Krystyn (1980).-

- ***Metapolygnathus primitius* (Mosher, 1970)**: according to Orchard (1983, 1991 a, b) and Kozur (2003), a set of different species have been gathered in *Metapolygnathus primitius*. Orchard (1991 a, b) defines a *M. primitius* Zone subdivided into lower and upper. The lower *M. primitius* Zone is characterized by the development of *M. primitius* from *Metapolygnathus nodosus* Hayashi and it is attributed to the uppermost Carnian. The upper *M. primitius* Zone is defined by the co-occurrence of *Norigondolella navicula* and *M. primitius* and attributed to the *kerri* Zone (Lower Norian). This association is regarded as definitive of the basal Norian.

Krystyn (1980) locates his *Metapolygnathus primitius* Assemblage Zone within the upper *Anatropites* Zone (~*Macrolobatus* Zone, Upper Carnian) and to the Lower Norian *Jandianus* (~lower *Kerri* Zone) ammonoid Zones considering "this zone of worldwide utility because the index species is distributed in the Tethyan region as far as Canada and Western North America".

After Kozur (2003) the FAD of *M. primitius* occurs contemporaneously or a little earlier than the FAD of *E. orchardi*, which is common in the Northern Tethys and in the Neotethys and represents a good correlation biomarker. Furthermore, real *Metapolygnathus primitius* occurs only from the Neotethys (Sicani, Lagonegro and Mersin area) and the Western North America, sometimes as transitional forms between *Metapolygnathus communisti* and *Metapolygnathus primitius* in the Sicani Basin (Muttoni et al., 2001) as suggested by Kozur (2003). Instead, in the Northern Tethys only rare *Metapolygnathus* cf. *primitius* are present but no transitional forms occurred.

The base of the *M. primitius* Zone both in North America and in the Neotethys is close to the base of the *Stikinoceras kerri* Zone. It corresponds to the FAD of *M. primitius* in North America and in the Neotethys, while in the Northern Tethys it corresponds to the FAD of *E. orchardi* and, insignificantly later, the FAD *Norigondolella navicula* (Kozur, 2003).

Moix et al. (2007), refer the *M. pimitius* Zone to the lower part of the *Kerri* Zone, but assign this interval to the uppermost Carnian.

At Pizzo Mondello, *M. primitius* appears in sample FNP88A, 27m below *Gonionotites maurolicoi*, along with *Epigondolella orchardi* and *Epigondolella quadrata*.

- ***Epigondolella praetriangularis* Kozur & Moix, 2007**: this species was recently described by Moix et al. (2007) and its range straddles their *E. orchardi* Zone and *E.*

quadrata Zone. *Epigondolella praetriangularis*, which represents a transitional form from *Carnepigondolella pseudodiebeli* (Kozur) to *Epigondolella triangularis* (Budurov) (Moix et al., 2007), even if not common, may suggest the interval around the Carnian/Norian boundary. At Pizzo Mondello, stratigraphically older representatives of this species occurs, along with *Halobia radiata*, about 11 meters below *Gonionotites maurolicoi*.

- ***Metapolygnathus parvus* Kozur, 1972**: this species has been considered for long time as a juvenile stage of the *Metapolygnathus communisti* (Budurov and Sudar, 1991) probably due to the short platform and the absence of nodes on the anterior margins of the platform. But juvenile forms of metapolygnathids are characterized by a more posterior position of the pit respect to the adult forms, which is situated in or just before the middle of the platform (Kozur, 2003). Instead, in *Metapolygnathus parvus* the position of the pit is strongly shifted forwards, and this is a very peculiar feature for a *Metapolygnathus* species. Thus, *Metapolygnathus parvus* should be considered as an independent species, and a possible biomarker for the base of the Norian.

- ***Epigondolella triangularis* (Budurov, 1972)**: this species is an advanced *Epigondolella*, subdivided by Orchard (1991, b) into two subspecies (*E. triangularis triangularis* (Budurov) and *E. triangularis uniformis* Orchard). It ranges the middle-upper part of the Lacian (Early Norian). At Pizzo Mondello, this species occurs 3m below *Gonionotites maurolicoi*.

- ***Epigondolella orchardi* (Kozur, 2003)**: this species has been established by Kozur in 2003, and it is described as a primitive *Epigondolella*, the perfect transition form between *Carnepigondolella* and *Epigondolella*. In detail, *E. orchardi* is considered to be the transitional species between *Carnepigondolella pseudodiebeli* (Kozur) and *Epigondolella quadrata* Orchard (Kozur, 2003). This species is common in the lower Lacian (upper *Kerri* Zone, Early Norian) of the Northern Tethys together with *Norigondolella navicula* (Huckriede) while it is rare in the Latest Carnian, immediately below the *kerri* Zone (Kozur, 2003).

At Pizzo Mondello, *E. orchardi* appears together with *Epigondolella quadrata* Orchard, 10 meters below the finding of *Gonionotites maurolicoi*.

- ***Epigondolella quadrata* Orchard, 1991**: this species has been called for many years *Epigondolella abneptis*, since 1991, when Orchard described it as a new species and named it *Epigondolella quadrata*. It is considered to be one of the most suitable conodonts to define the base of the Norian. In 2003 Channell et al. still considered *E. quadrata* as a junior synonym of *E. abneptis*, and replaced the name *E. quadrata* Zone by the name *E. abneptis* Zone. They used this zone to indicate the base of the Norian Stage (Channell et al., 2003), placing it within the *Stikinoceras kerri* ammonoid Zone, but close to the upper boundary of this zone. The base of the *E. abneptis* Zone (= *E. quadrata* Zone) seemed to be ideal to define the Carnian/Norian boundary, because it corresponded closely to the appear-

ance of *Halobia styriaca* (Krystyn, 2002), and it was well defined by the FAD of *E. abneptis* both in the Tethys and in North America (Channel et al., 2003).

Also in Moix et al. (2007), *E. quadrata* is used to mark the base of the Norian, which begins with the FAD of this species and corresponds to the base of the *E. quadrata* Zone.

According to the new biostratigraphic data collected at Pizzo Mondello, *E. quadrata* can be considered a possible biomarker for the base of the Norian. The FAD of *E. quadrata* has been found 10 meters below *Gonionotites maurolicoi*, together with the FAD of *E. orchardi*.

- ***Epigondolella rigoi* Kozur, 2007**: this species has been recently established by Moix et al. (2007). It defines the homonymous zone (*E. rigoi* Zone, between the *E. quadrata* Zone and the *N. halstattensis* Zone- *E. triangularis* Zone), and it occurs from the Early Norian to the Alunian. The species is widespread throughout the entire Tethys (Moix et al., 2007).

The stratigraphic position of *E. rigoi* and its zone (above *E. quadrata* Zone), and its wide distribution through all the Tethys, make this conodont a suitable species as candidate to indicate the base of the Norian. At Pizzo Mondello, *E. rigoi* has been found 1.50m above *Gonionotites maurolicoi*.

- ***Metapolygnathus echinatus* (Hayashi, 1968)**: the species was regarded as an early growth stage of *M. communisti* and referred to *Carnepigondolella pseudoechinata* by Kozur (1990). Orchard (1991, a) refers *Metapolygnathus echinatus* as a very important index species of his *Metapolygnathus communisti* Zone and interpretes this species as “the end member in the lineage *M. lindae*- *M. samueli*”. Subsequently, Orchard (1991, b) reviewed *Metapolygnathus echinatus* and included it in *Metapolygnathus pseudoechinatus* (Kozur) a “short-ranging species in the Carnian-Norian boundary interval”. According to Orchard (1991, b), *M. pseudoechinatus* (= *M. echinatus*) is characterized “by a long blade up to two thirds total unit length, and a short subquadrate platform that bears small, usually sharp marginal denticles, particularly on the anterior part.”

At Pizzo Mondello section, *Metapolygnathus echinatus* is associated with *M. parvus*, *M. communisti* and abundant *Carnepigondolella pseudodiebeli*. Our specimens present a shorter blade and platform in respect to those specimens described by Orchard (1991, b). *M. echinatus* occurs 8m above *Gonionotites maurolicoi* and 7m below a Norian radiolarian assemblage (A9a). Thus this species seems to be a good proxy for the Carnian/Norian boundary in agreement with Orchard and Kozur proposals at Albuquerque (2007).

Conclusions

On the basis of the new bio-chronostratigraphic studies, the following points can be emphasized.

1) The Pizzo Mondello succession yields ammonoids.

The record is fully consistent with the faunas described by Gemmellaro (1904) and spans from the Late Carnian *Discotropites plinii* Zone to the Early Norian *Guembelites jandiaunus* Zone.

2) The succession also provides very good Halobiids. Six out of the seven identified species (*H. lenticularis*, *H. superba*, *H. austriaca*, *H. simplex*, *H. radiata*, and *H. styriaca*) occur also in North America with the same distribution. This provides a very good tool for correlations. *H. mediterranea* is documented only from the Tethyan realm. *H. radiata* spans from Late Carnian to earliest Norian, while *H. styriaca* is traditionally considered Early Norian in age.

3) The conodont studies allow to recognize two main events (Fig. 4):

- the first one is represented by the FO of *Metapolygnathus primitius*, *Epigondolella quadrata* and *E. orchardi* in FNP88A where *Halobia radiata* is also present.

- the second one is represented by the FO of *Metapolygnathus echinatus* and *M. parvus* in NA36, 8m above *Gonionotites maurolicoi* and 7m below a Norian radiolarian assemblage (A9a).

At present, we consider the second event, in accordance also with Orchard and Kozur (Albuquerque meeting, May, 2007) and Orchard (2007b), as more suitable to define the base of the Norian Stage.

4) The studies on radiolarian assemblages show that most species cross the C-N boundary, but a few species could have their FAD in the Early Norian as for example *Kahl-erosphaera kemerensis adentata* Tekin, *Podobursa akayi* Tekin, *Senella triassica* Tekin, or *Monocapnuhosphaera inflata* Tekin. We do hope to have many more data when all the new samples will be processed and studied.

In summary, Pizzo Mondello section not only provides a very good magnetostratigraphic and chemostratigraphic records as well described in literature (Bellanca et al., 1995; Muttoni et al. 2001; 2004), but also the best integrated bio-chronostratigraphic record across the Carnian/Norian boundary of the Tethyan realm. Further investigations are necessary to better calibrate the conodont events with ammonoids, halobiids and radiolarians. A high resolution sampling for all the fossil groups of the intervals PM19 to PM22 and PM26 to PM33 of the section is scheduled for spring 2008. New paleomagnetic and chemostratigraphic high resolution samplings will also be done, in order to increase the calibration of the conodont events with the magnetostratigraphic scale and stable isotope curves and to select possible proxys (PM4n boundary $\delta^{13}C$ shift).

The final goal is the presentation of the GSSP proposal for the Norian Stage at Pizzo Mondello.

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Plate 1.

Main lithofacies of the Pizzo Mondello section. C1: thin, plane-bedded layers of limestone and siliceous limestones of facies C in outcrop, m 78 ca. C2: concentration of densely packed thin-shelled bivalves (*Halobia* sp.) of facies C in thin section. Sample FNP 151 (m 80). C3: abundant calcispheres in sample FNP 145 (m 74), facies C, as seen at SEM. B1: dm-scale nodular beds of facies B, outcrop exposure, m 47 ca. B2: wackestone with abundant radiolarian moulds and thin-shelled bivalves, sample 110 (m 51), facies B, thin section. B3: calcispheres are abundant also in facies B; note radiolarian mould filled with large calcite crystals to the right, diameter 50 μm ca. (sample FNP 126, m 62). A1: dm-scale beds with plane to undulate joints and brown chert nodules, outcrop exposure, m 15 ca. A2: wackestone with radiolarian moulds and thin-shelled bivalves, sample FNP 11 (m 29), facies A. Facies A and B are indistinguishable in thin section. A3: calcispheres and fine calcite crystals, sample FNP 11 (m 29), facies A. Calcispheres are usually rarer in facies A. Samples observed at the SEM were etched with 10% HCl for 5 to 10 seconds to highlight crystal boundaries, and coated with graphite.

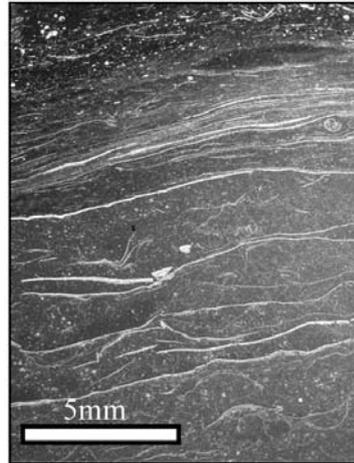
OUTCROPS

THIN-SECTIONS

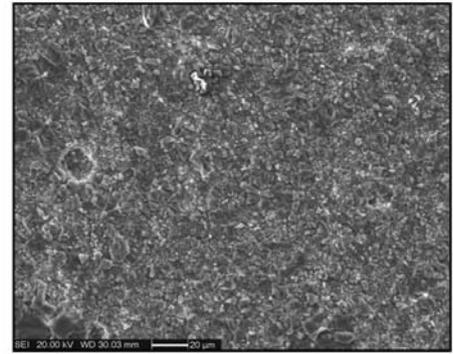
SEM PICTURES



C1



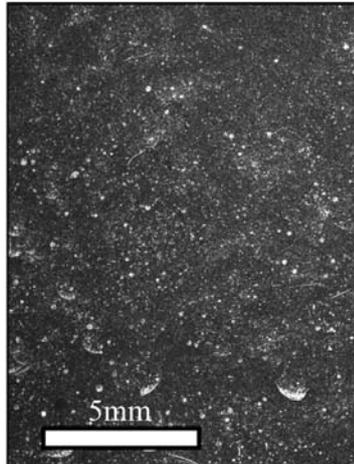
C2



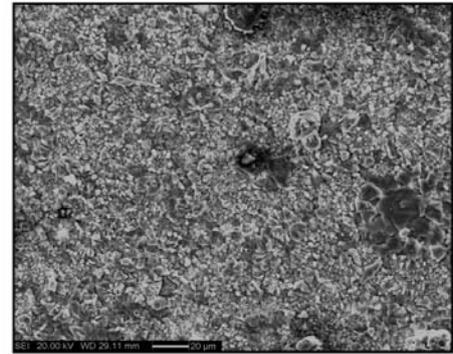
C3



B1



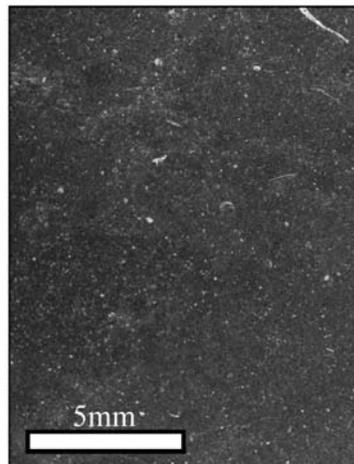
B2



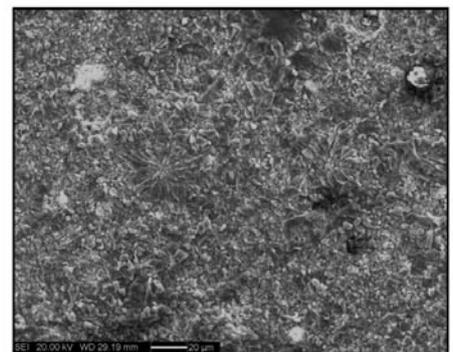
B3



A1



A2



A3

Plate 2

1: *Halobia lenticularis* Gemmellaro; FNP67/68.

2: *Halobia radiata* Gemmellaro; FNP95.

3: *Halobia styriaca* Mojsisovics; NA45.

4: *Halobia mediterranea* Gemmellaro; FNP170.2.

5: *Discotropites plinii* (Mojsisovics), lateral view; PMAM17.

6 a-b: *Gonionotites maurolico* Gemmellaro, a) oral view, b) lateral view; PMAM7.

7: *Dimorphites* sp., specimen from debris (FNPdet2), lateral view.

Bar scale always 1 cm. All specimens whitened with Ammonium Chloride, except for fig. 5.

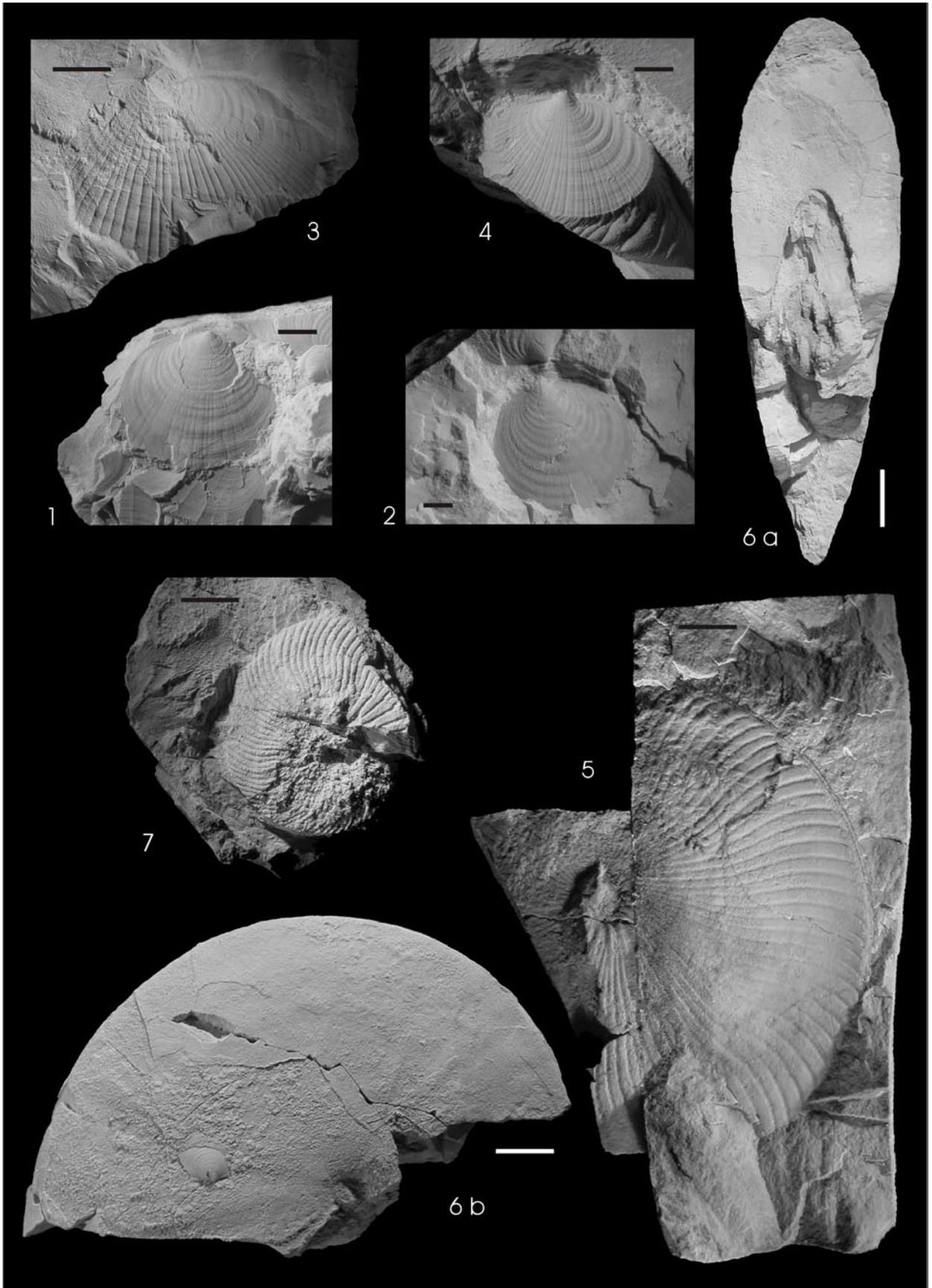


Plate 3

1a-b: *Norigondolella* sp., NA16.

2a-b: *Metapolygnathus oertlii* (Kozur), NA16.

3a-b: *Metapolygnathus communisti* B Krystyn, NA22.

4a-b: *Carnepigondolella pseudodiebeli* (Kozur), NA22.

5a-b: *Carnepigondolella samueli* (Orchard), PM19.

6a-b: *Carnepigondolella zoeae* (Orchard), PM19.

7a-b: *Epigondolella orchardi* (Kozur), juvenile specimen, FNP88A.

8a-b: *Epigondolella quadrata* Orchard, FNP88A.

9a-b: *Epigondolella quadrata* Orchard, juvenile specimen, NA30.

10a-b: *Metapolygnathus primitius* (Mosher), NA34.

11a-b: *Epigondolella orchardi* (Kozur), NA33.

12a-b: *Epigondolella rigoi* Kozur, NA33.

a= upper view, b= lateral view, c= lower view.

All the bars are 200 μ m.

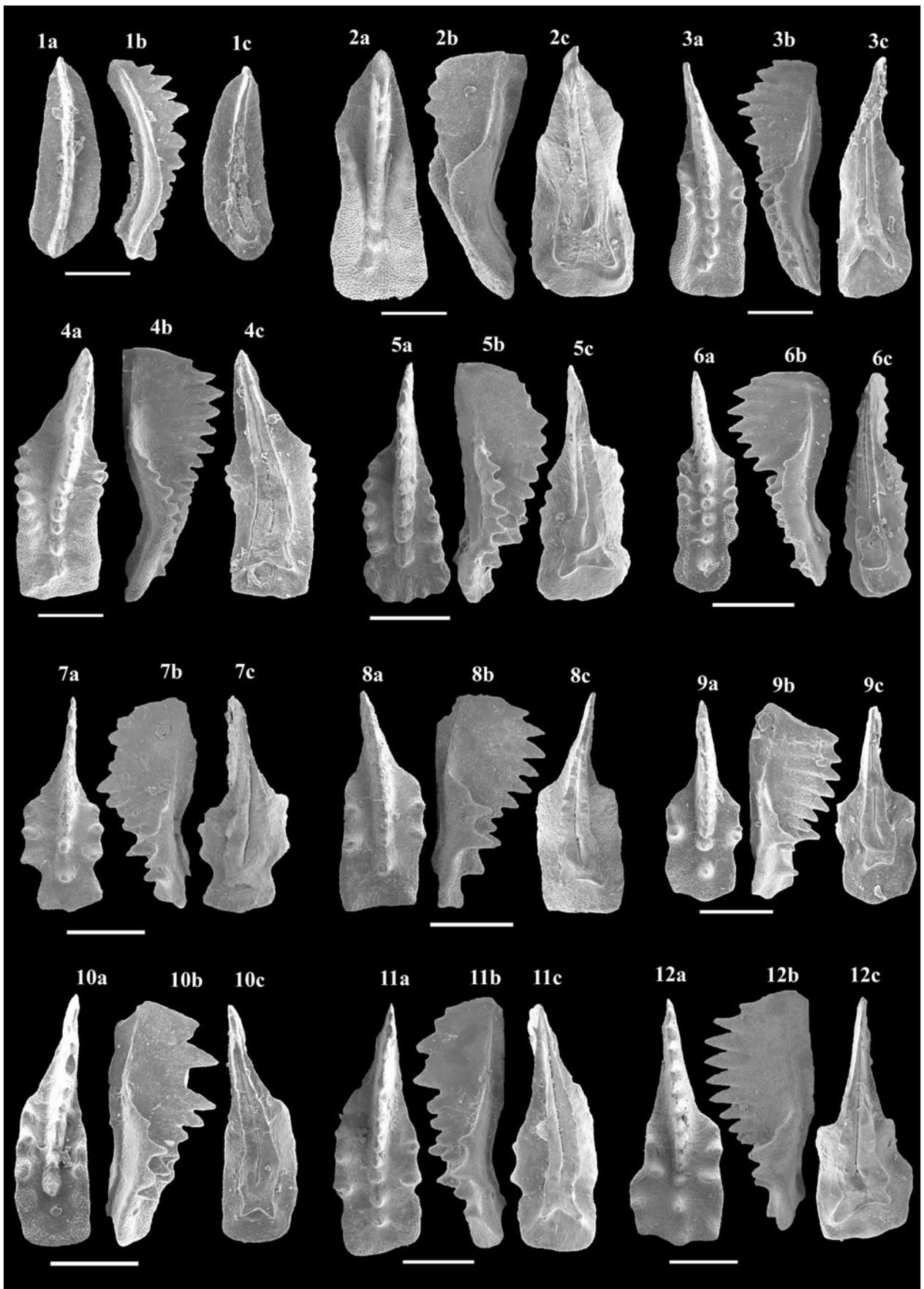


Plate 4

- 1a-b: *Metapolygnathus echinatus* (Hayashi), NA 33.
2a-b: *Metapolygnathus parvus* (Kozur), NA36.
3a-b: *Metapolygnathus parvus* (Kozur), NA 37.
4a-b: *Metapolygnathus echinatus* (Hayashi), NA38.
5a-b: *Epigondolella praetriangularis* (Kozur & Moix), NA37,
6a-b: *Epigondolella rigoi* Kozur, PM28,
7a-b: *Metapolygnathus communisti* Hayashi, PM29.
8a-b: *Epigondolella triangularis* (Budurov), NA42.
9a-b: *Epigondolella triangularis* (Budurov), NA42.
10a-b: *Epigondolella triangularis* (Budurov), NA68.
a= upper view, b= lateral view, c= lower view.
All the bars are 200 μ m.

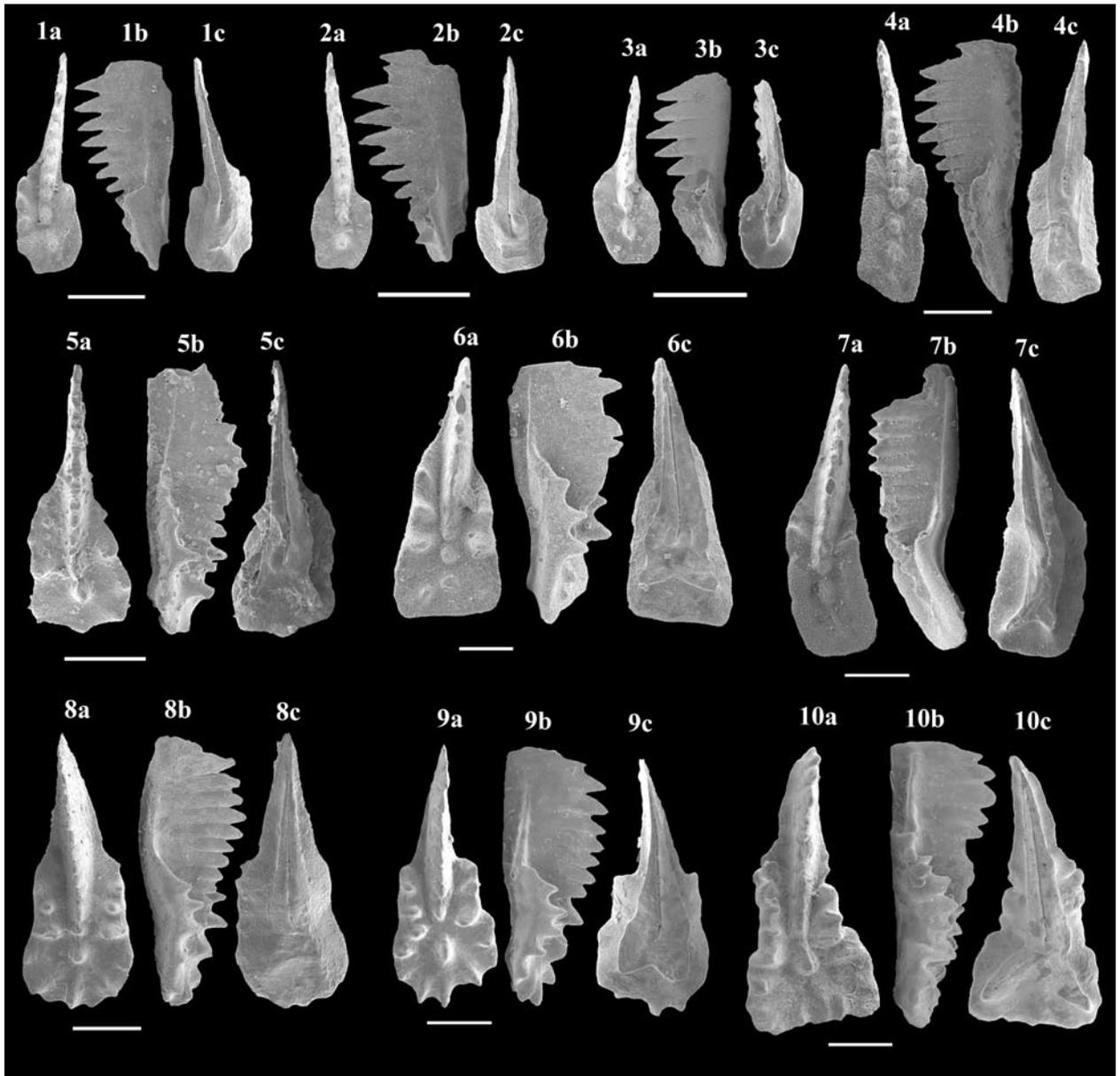


Plate 5

All scale bars equal 100 μ m. Scale A applies to 1-5 and 9-16. Scale B applies to 6 and 7.

Late Carnian:

- 1: *Capnuchosphaera* sp. indet., A7.
- 2: *Triassocampe baldii* Kozur Group, A38.
- 3: ? *Pachus* sp. indet., A7.
- 4: *Xiphotecaella longa* Kozur & Mock, A6.
- 5: *Paronaella* (?) sp., A38.
- 6: *Capnuchosphaera* sp. aff. *C. crassa* Yeh, A38.
- 7: ? *Weverella* sp. A, A38.

Early Norian, sample A11:

- 8: *Pachus multinodosus* Tekin.
- 9: *Pachus multinodosus* Tekin.
- 10: *Corum perornatum* Blome.
- 11: *Corum* sp.
- 12: ? *Castrum* sp. indet.
- 13: *Latium mundum* Blome.

Early Norian, sample A9a:

- 14: *Dumitricasphaera* (?) sp.
- 15: *Entactinosphaera* (?) sp.1 Bragin.
- 16: *Enoplocampe* sp.

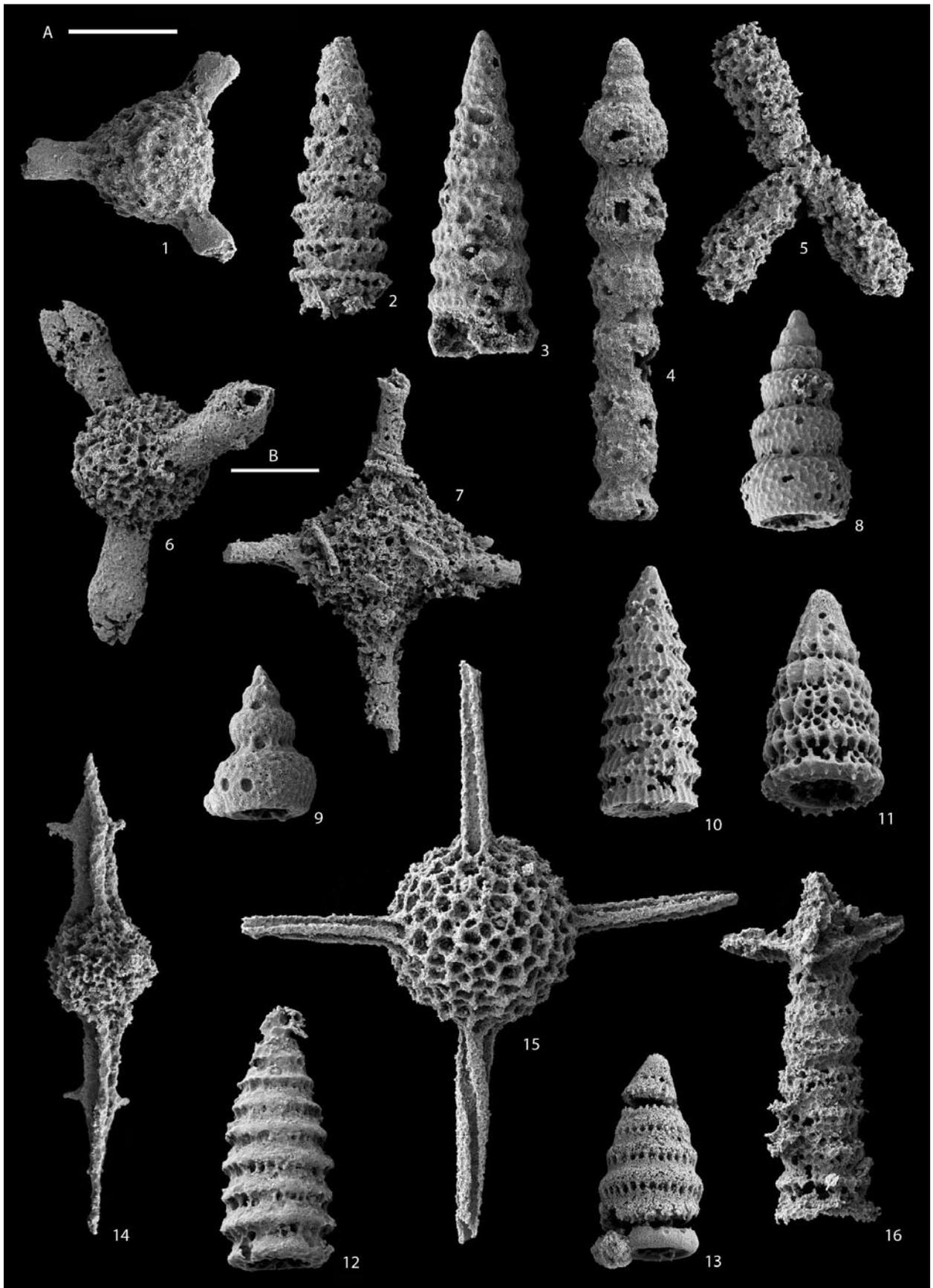


Plate 6

Sample A10a:

- 1: *Kahlerosphaera kemerensis adentata* Tekin.
- 2: *Kahlerosphaera norica* Kozur & Mock.
- 3: *Capnuchosphaera tricornis* De Wever.
- 4: *Capnuchosphaera deweveri* Kozur & Mostler.
- 5: *Capnuchosphaera theloides* De Wever.
- 6: *Vinassaspongius* (?) sp.
- 7: *Capnuchosphaera* sp.cf. *C. lea* De Wever.

Sample A9a:

- 8: *Capnuchosphaera lea* De Wever.
- 9: *Monocapnuchosphaera inflata* Tekin.
- 10: *Capnodoce* sp. cf. *C. anapetes* De Wever.
- 11: *Zhamojdasphaera rigoi* Kozur, Moix & Mostler.
- 12: *Cryptostephanidium* sp.
- 13: *Carinaheliosoma carinata* (Kozur & Mostler).
- 14: *Weverella tetrabrachiata* Kozur & Mostler.
- 15: *Spongortilispinus* sp. aff. *S. turkensis* Kozur, Moix & Mostler.
- 16: *Spongortilispinus tortilis* Kozur & Mostler.

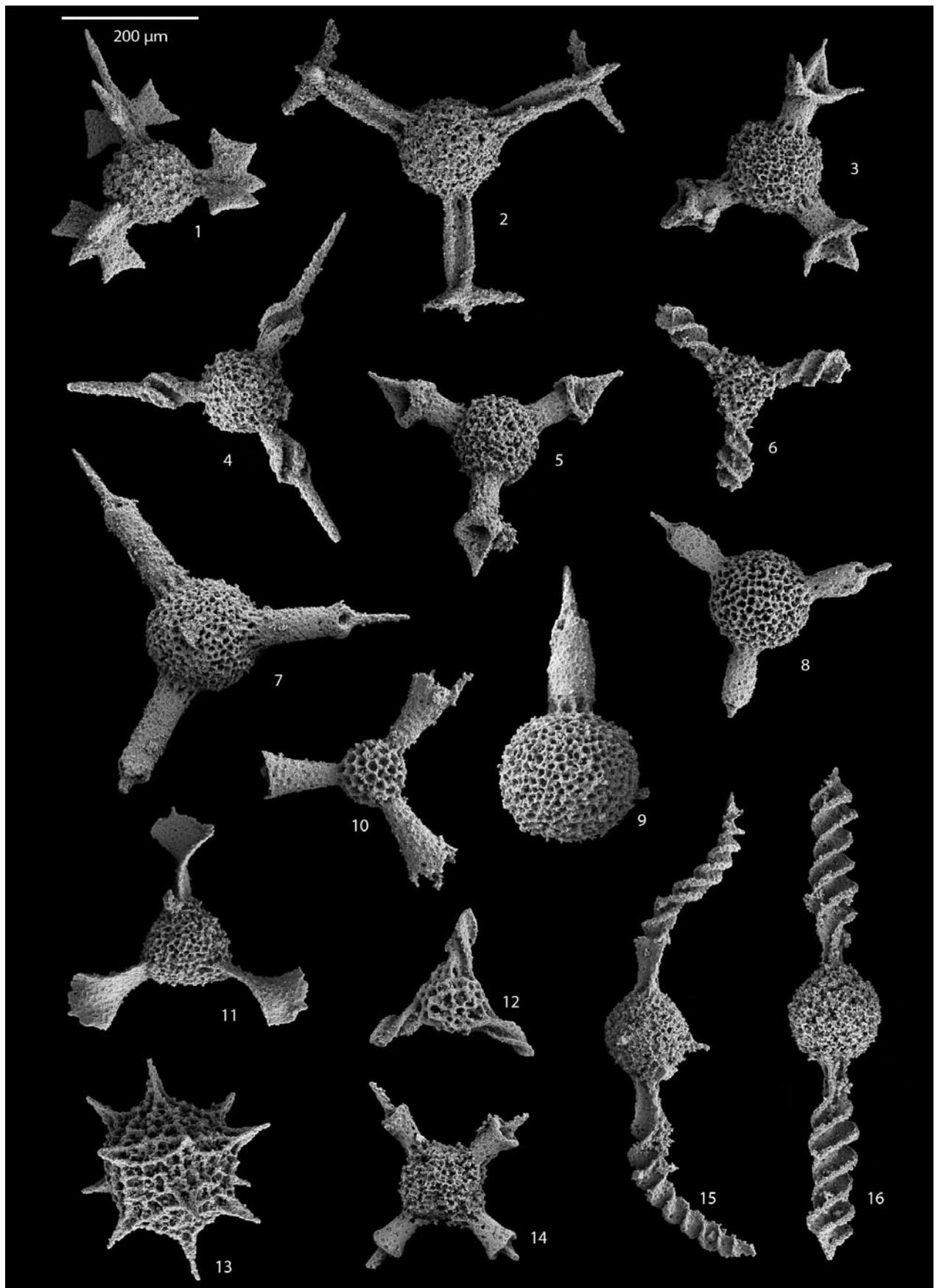


Plate 7

Sample NA 41:

- 1: *Icrioma tetrancistrum* De Wever.
- 2: *Braginastrum curvatus* Tekin.
- 3: *Paronaella* (?) sp. cf. *P. norica* Kozur & Mostler.
- 4: *Capnodoce* sp. cf. *C. longibrachium* Tekin.
- 5: *Karnospongella capricornis* Bragin.
- 6: *Karnospongella multispinosa* Kozur, Moix & Mostler.
- 7: *Acanthocircus* (?) sp. A Pessagno, 1979.
- 8: *Spongotortilispinus carnicus* (Kozur & Mostler).
- 9: *Spongotortilispinus* sp. cf. *S. aequicurvistylus* (Lahm).
- 10: *Spongotortilispinus* sp. cf. *S. turkensis* Kozur, Moix & Mostler.
- 11: *Zhamojdasphaera latispinosa* Kozur & Mostler.
- 12: *Kahlerosphaera* sp. cf. *Eptingium* sp. A De Wever.
- 13: *Bulbocyrtium reticulatum* Kozur & Mostler.
- 14: *Picapora* sp. cf. *P. robusta* Kozur & Mostler.
- 15: *Sanfilippoella* sp. B Carter, 2000.
- 16: *Spinopoulpus noricus* Kozur & Mock.
- 17: *Podobursa akayi* Tekin.
- 18: *Podobursa turriiformis* Tekin.
- 19: *Podobursa* sp. A Tekin, 1999.
- 20: *Senelella triassica* Tekin.
- 21: *Xiphothecaella longa* (Kozur & Mock).
- 22: *Xiphothecaella* sp. cf. *X. rugosa* (Bragin).
- 23: *Xiphothecaella rugosa* (Bragin).
- 24: *Mostlericyrtium sitepesiforme* Tekin.

