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Biostratigraphic analysis of Paleogene lowstand wedge conglomerates of a tectonically active platform margin (Zakynthos Island, Greece)

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ABSTRACT - Paleogene heterometric and polymictic conglomerate deposits were investigated in Zakynthos Island (Ionian Islands, Greece) from different outcrops, along the eastern flank of the anticline crossing the island in a NNW-SSE direction. This structure is formed by the Meso-Cenozoic sedimentary succession of the Pre-Apulian zone. The Paleogene facies sequence of Zakynthos consists of toe of slope accumulations of mainly resedimented material produced by gravity flows during repeated falls of relative sea-level below the shelf edge, with subsequent erosion of the exposed Cretaceous-Paleogene sequences. The lithoclasts are scattered within different sedimentary wedges of coarse detrital material; their study provided information on the stratigraphy and depositional environments of the eroded Cretaceous-Paleogene succession. The fossil assemblage content of the conglomerate clasts is interpreted in the frame of a carbonate ramp model. The lack, elsewhere in the island, of in situ sequences corresponding in age and facies to the sampled lithoclasts and the occurrence of different sedimentary facies sequences suggest a differential tectono-sedimentary evolution of the depositional substratum during the Late Cretaceous and the Paleogene. Considering the eastward transition to the Ionian basin, an eastern source of the clasts can be excluded, whereas in Cephalonia Island in the Lixouri peninsula a stratigraphic record with characters similar to those of the Zakynthos conglomerate clasts has been documented. The systematic investigation of the well-preserved Paleogene larger foraminiferal assemblages led to the recognition of 42 different taxa (34 of specific rank). Several taxa are rare in coeval deposits from the Mediterranean Tethys and some are as yet undescribed. A comparison with coeval assemblages from the Mediterranean Tethys is attempted, in order to outline stratigraphic and biogeographic relationships.

KEY WORDS: larger foraminifers, biostratigraphy, facies, Paleogene, Pre–Apulian platform, Ionian Islands, Greece

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INTRODUCTION

The aim of this work is the biostratigraphic analysis and the systematic investigation of the Paleogene larger foraminiferal assemblages from Zakynthos. The Paleogene sequence is characterized by various conglomerate bodies within toe of slope-proximal basin sedimentary complexes, mainly deposited as lowstand wedges along a tectonically active platform margin connecting a persistent Cretaceous isolated carbonate platform with a basinal area. According to the sedimentary model of the Pre-Apulian domain proposed by Accordi and Carbone (1992) and Accordi et al. (1999), in western Cephalonia (Lixouri peninsula) conditions of persistent low-energy carbonate shelf characterized Paleocene–early Ypresian times in both a western and eastern sector, followed by Lutetian-Chattian large hiatuses and several phases of incipient drowning. In Zakynthos larger hiatuses exist from Paleocene to middle Eocene p.p., whereas from the Lutetian to the Chattian a discontinuous toe-of-slope carbonate sequence is set up. A final Chattian-Aquitanian drowning phase affected both the islands.

The larger foraminiferal assemblages of the conglomerate clasts have been investigated from a systematic, biostratigraphic and paleogeographic point of view. In addition, the paleoenvironmental analysis of the assemblages allowed us to interpret them in a carbonate ramp model framework. A comparison with coeval assemblages of western Cephalonia and other areas of the Mediterranean Tethys has been attempted in order to assess stratigraphic and biogeographic affinities.

Previous studies

The earliest geological reference to the geology of Zakynthos is by Herodotus (c. 440 BC), who reported the occurrence of bitumen near the village of Keri (southern Zakynthos). Strickland (1840) drew a geological map of Zakynthos, distinguishing four units: Apennine Limestone (compared with the Chalk of England), Older Tertiary Beds, Newer Tertiary Beds and Alluvium. Fuchs (1877) provided an improved geological map and recorded the occurrence of nummulitic limestone from the western part of the island. Partsch (1891) recorded rudist limestone from several localities and assigned them in part to the Eocene, due the co-occurrence of rudist fragments and nummulitids. Issel (1896) recognized 6 units: a) Turonian limestone with *Hippurites*, b) Middle Eocene *Nummulites* limestone, c) Lower and Middle Miocene marl, d) Upper Miocene gypsum, e) Pliocene sediments, and, f) post-Pliocene sediments. Renz (1955), and later Aubouin and Dercourt (1963) and Dercourt (1964) provided the first detailed description of the Mt. Vrachionas succession, ranging from the Santonian to the Pliocene. Aubouin and Dercourt (1963) described the Paleocene-Oligocene succession as represented by

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bioclastic microbreccia limestone interbedded with massive neritic limestone. They recognized, using larger foraminiferal assemblages, a Paleocene-Lower Eocene interval (with *Glomalveolina* sp., *Coskinolina* sp., *Spirolina* sp., *Rhipydionina* sp., *Dendritina* sp. and *Peneroplis* sp.) and a Middle Eocene (Lutetian) interval (with *Alveolina* gr. *levantina, A.* cf. *fragilis*, *A.* gr. *elliptica*, *Nummulites* cf. *aturicus*, *Discocyclina* sp., *Orbitolites* sp., *Assilina* sp., *Gypsina globulus* and reworked *A. distefanoi*), whereas the overlying deposits were referred to the Oligocene, based on the occurrence of the geniculate alga *Subterraniphyllum thomasii* Elliott, 1957. Horstmann (1967) investigated the stratigraphy and micropaleontology of southern Zakynthos. Dermitzakis (1978) described several sections ranging from the Cretaceous to the Lower-Middle Pliocene, focusing on the Miocene. Within the Agios Nikolaos-Lagopodon section, representative of the Mt. Vrachionas succession, eight lithological units are distinguished. Unit 2 is described as 30 meters of Middle-Upper Eocene reefal limestone, breccia and breccious conglomerate with a mixture of Cretaceous (*Orbitoides*, *Lepidorbitoides*) and Paleogene (*Nummulites*, *Discocyclina*, *Chapmanina*) clasts irregularly overlying the well-bedded pelagic limestone of unit 1, considered as Middle Eocene, following Horstmann (1967). Dermitzakis (1978) inferred an Aquitanian age for the marly deposits overlying unit 2, considering the Oligocene marker *S. thomasii* as reworked due the co-occurrence of *Globorotalia kugleri* and *Globigerinoides primordius*. Using foraminiferal biostratigraphy, Mirkou-Peripopolou (1975) investigated the geology of northern Zakynthos, and produced a 1:50.000 geological map, which is as yet the most detailed available for Paleogene deposits, recognizing Paleocene-Eocene neritic-reefal limestone intercalated with sublithographic limestone and Oligocene ruditic limestone and marly limestone. Mirkou-Peripopolou (1975) recognized Upper Paleocene deposits, biostratigraphically characterized by the occurrence of *Glomalveolina* gr. *primaeva*, *Discocyclina seunesi*, *Coskinolina liburnica*, *Broeckinella* sp., *Miscellanea miscella*, and *Globorotalia velascoensis*; Lower Eocene deposits, with *Cuvillierina* sp., *Assilina* sp., *Globorotalia* gr. *formosa-aragonensis*; Middle Eocene deposits, yielding *Chapmanina* cf. *gassinensis*, *Orbitolites* sp., *Fabiania* sp., and *Globorotalia spinulosa*; Upper Eocene deposits, with *Pellatispira madaraszi*, *Spiroclypeus* sp., and *Heterostegina* sp. (*Grzybowskia*). The Oligocene disconformably overlies both the Cretaceous and the Eocene deposits. At the base a reefal limestone with corals, algae and larger foraminifers occurs (lepidocyclinids, *Nummulites* gr. *intermedius-fichteli, Austrotrillina paucialveolata*, *Bullalveolina bulloides*), followed by a level characterized by lepidocyclinids and an upper level with *Lepidocyclina* sp., *Miogypsinoides* sp., and *Spiroclypeus* sp. of Aquitanian age. Underhill (1988) reinterpreted the age and emplacement of the evaporite deposits of SE Zakynthos as the result of diapiric intrusion of Triassic evaporites into the Miocene-Pliocene sediments along the wide evaporite belt running parallel to the strike of the Hellenide thrust faults, which acted as plane of décollement for thrust-sheet emplacement over much of the External Hellenides.

Recently, Kati and Scholle (2008), in a study of the porosity evolution of the Eocene limestones of Zakynthos, recognized resedimented deposits, represented by very coarse-grained reefal debris flow sediments and bioclastic turbidite beds, originated by low-density and subordinately high-density flows. According to the authors, the preserved Eocene limestone comprises exclusively toe of slope-proximal basin facies, consisting of pelagic sediment interbedded with very coarse-grained reefal debris flows and bioclastic turbidites (mostly low-density flows). They also show the presence of lowstand megabreccias interlayered with pelagites-hemipelagites. More recently, Pignatti et al. (2008) illustrated selected Paleocene larger foraminiferal taxa from Zakynthos from samples investigated in greater detail in the present work, with age assignments according to the SBZ zonation (Serra-Kiel et al., 1998) and a comparison with coeval assemblages from the Apulian domain and the Apennines.

Although much geological work has been done on Cephalonia Island (British Petroleum Co. Ltd., 1966, 1971; I.F.P., 1966; Bizon, 1967; Dremel, 1970; Civitelli et al., 1989), very little published evidence existed for the Paleogene and Miocene larger foraminiferal assemblages, with the notable exception of de Mulder (1975), until the detailed investigation of Western Cephalonia by Accordi et al. (1999). They investigated the stratigraphy, micropaleontology and facies distribution of the Lixouri peninsula recognizing 17 main depositional facies in the Late Cretaceous–Early Miocene interval. Facies and hiatuses show structural sectors with different tectono-sedimentary evolution from a Cretaceous rimmed shelf to a homoclinal low-angle ramp, with the occurrence of Lower Eocene (Ilerdian) shallow-water deposits in the Havdata sector (south-eastern Lixouri).

GEOLOGICAL SETTING

Tectonic evolution

The island of Zakynthos is part of the Pre-Apulian zone, the most external isopic zone of the Western Hellenide fold-and-thrust belt (Figs. 1, 2). This zone includes also part of Cephalonia and Lefkas and the small island of Paxos. The geological evolution of the Hellenides is dominated by divergence and convergence of the African and Eurasian plates and related processes like subduction, roll back followed by extension in the Aegean back-arc, and possibly an additional westward Anatolian push. In Mesozoic times, a series of troughs and carbonate platforms developed between the African promontory (Adria) and the internal oceanic part of Neotethys. Subsequently, the oceanic part closed and the different isopic zones were emplaced as well-defined thrust sheets, which migrated progressively towards the foreland. According to Duermeijer et al. (1999), Zakynthos was furthermore subject to a rapid tectonic event between 0.8 Ma and Recent, causing a 22º clockwise rotation of the island. This is probably due to the Late Pleistocene uplift in mainland Greece, related to rebound processes resulting from African slab detachment underneath the Ionian Islands.

The Ionian Islands are limited northward by a prominent tectonic element, the Cephalonia fault, a dextral strike-slip fault truncating the morphological and structural setting of the Pre-Apulian platform, and marking the western termination of the Hellenic subduction zone. It also separates the northern Ionian Islands (Corfu and Paxos), moving slowly northward and northwestward, from the central-southern Ionian Islands, moving rapidly southwestward (Hollenstein et al., 2006). The importance of this line is stressed by structural evidence both offshore and inshore (Morelli et al., 1975; Biju Duval et al., 1977; Auroux et al.,1984; Finetti and Dal Ben, 1986). Structural and paleomagnetic studies evidence a relative tectonic stability only for the area NW of the Cephalonia fault. In contrast, the present relationships of this area with the Hellenide belt, of

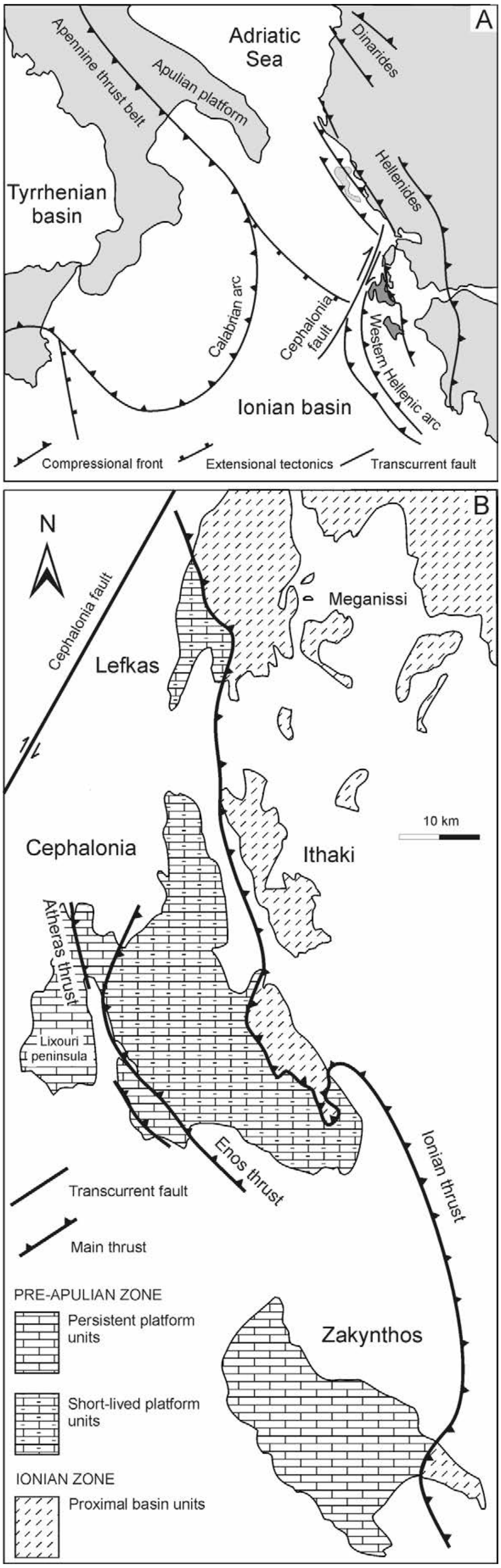

Fig. 1 - Locality maps showing the major structural features of northern Ionian basin (A) and the isopic zone pattern of Western Hellenides (B).

which the Ionian Islands are part, should be characterized, according to Mantovani et al. (1990), by a counterclockwise rotation of the Apulian Platform, in correspondence of the Cephalonia fault, from the Late Miocene up to the Recent. Crustal thinning in the northern Ionian basin, shortening of the Hellenide belt and strong deformation of the Calabrian arc are the consequence of this movement.

Depositional architecture

The distinction between the platform facies of the Pre-Apulian zone and the pelagic facies of the Ionian zone introduced by Renz (1955) has been accepted by several authors (Aubouin, 1959, 1965; Aubouin and Dercourt, 1963; Bernoulli and Laubscher, 1972; Aubouin et al., 1976). Accordingly, the Pre-Apulian zone should be the eastern continuation of the Apulian platform, representing its transition to the Ionian basin by means of an edge-slope facies belt, at present partially covered by the Ionian thrust belt (Sami-Kalamitsi thrust, British Petroleum Co. Ltd., 1971; Jenkins, 1972). New stratigraphical and structural data point to a more complex paleogeographical evolution, starting from a structural setting inherited from the Early Jurassic rifting phase (Harbury and Hall, 1988), in which the role of regional subsidence, local tectonics and sea-level change varies throughout the Cretaceous and Paleogene.

The depositional sequences differ in stratigraphic completeness, sedimentary development and depositional environment, as a result of strong tectonic deformation, with phases of extension (Zelilidis et al., 1998), collision and flexural subsidence, followed by shortening and block rotation (Underhill, 1989; Accordi et al., 1999; Karakitsios and Rigakis, 2007). The oldest outcropping deposits of the succession are well exposed in Lefkas, where Lower Jurassic dolomite, Middle Jurassic chert and bituminous shale, and Upper Jurassic chalky limestone and dolomite, with intercalated rare chert and black shale, have been recorded (Bornovas, 1964; British Petroleum Co. Ltd., 1971).

In Zakynthos, the Lower Cretaceous has been found in a borehole with conglomerates of carbonate and magmatic rocks, whereas in Cephalonia, at the south-eastern termination of the Enos Mount, a Tithonian-Albian succession of limestone and dolomite with calpionellids, radiolarians and planktonic foraminifers testifies to the transition from a deep basin to a proximal basin and deep slope (Esso-Hellenic, 1960; British Petroleum Co. Ltd., 1971; Karakitsios and Rigakis, 2007).

In Late Cretaceous to Paleogene times, major fault systems and west-verging thrust sheets determined the piling up of the sedimentary cover, with the juxtaposition of different tectono-sedimentary units, at present cropping out in the Pre-Apulian sector of the Ionian Islands (Accordi et al., 1999).

Since the Late Cretaceous, the differential effects of sea-level change and tectonics have determined a composite sedimentary architecture linked to the development of different depositional systems. According to Accordi and Carbone (1992), west of the Ionian Thrust there are at least two different tectono-sedimentary units, separated by the Enos thrust: an eastern short-lived carbonate platform and a western persistent rimmed carbonate platform. This last unit crops out in the Lixouri peninsula in western Cephalonia, where the transition from the Late Cretaceous to Paleogene is marked by an evolution of the sedimentary pattern from a rimmed carbonate platform to homoclinal carbonate ramp. In western Cephalonia (Lixouri peninsula) the differential interaction between local tectonic subsidence, eustatic sea-level change and biological controls on the carbonate factory produced a range of Paleocene shallow-water to slope deposits, punctuated by emersion episodes. A hiatus spanning much of the Eocene affects this western sector, whereas in Oligocene-Aquitanian times, an acme in spatial diversification is suggested, possibly related to flexurally subsiding foreland basins, and finally in the late Early Miocene progressive deepening ensued, with the demise of the former carbonate ramp. According to Accordi et al. (1999), the Lixouri peninsula is characterized by the progressive onset of a homoclinal ramp with generally protected medium-low energy environment during the Cretaceous-Paleocene transition. In the middle-late Thanetian a progressive demise of the carbonate sedimentation takes place over wide areas west of the Enos thrust, with the onset of a larger foraminiferal shoal-dominated ramp. Contrary to the Lixouri peninsula, during the Cenozoic Zakynthos was part of a crustal sector where reworked sediment accumulated, originating both from dismantling of uplifted areas of the ancient Cretaceous carbonate platform and from mobilization of loose skeletal material deposited on the ramp. As a result lowstand basin-floor submarine fans and detrital wedges developed in areas of the toe of slope-proximal basin.

BIOSTRATIGRAPHICAL AND CHRONOSTRATIGRAPHICAL FRAMEWORK

The Shallow Benthic Zonation

Larger foraminifers are among the most abundant bioclasts in the investigated Paleogene deposits from Zakynthos. Their occurrence provides important constraints on the age of this resedimented material, according to the Shallow Benthic Zones (SBZ) proposed by Serra-Kiel et al. (1998) for the Paleocene-Eocene and Cahuzac and Poignant (1997) for the Oligocene-Miocene routinely employed for the central-western Tethyan realm. These chronobiozones are correlated with magnetostratigraphy and with other biozonal scales, and in the Paleogene their stratigraphic resolution is comparable with that of the planktonic foraminifers and nannoplankton. Thus, the Shallow Benthic Zonation is the standard in present-day larger foraminiferal biostratigraphy.

After over a decade since the establishment of the SBZ, a considerable amount of further data is now available, and advances in zonal definition, subdivision into subzones (Less et al., 2008), the correlation of some unresolved boundaries with magnetostratigraphy and changes linked to the redefinition of some Early Paleogene GSSPs have already been proposed or can be postulated for the next years.

One example of changes in respect to Serra-Kiel et al. (1998) is the GSSP for the Paleocene-Eocene boundary. This GSSP, after the seven different concepts outlined by Berggren and Aubry (1996), and the four working hypothesis of Aubry (2000), has been defined in correspondence of the base of a Carbon Isotopic Excursion (CIE) in the type section of Dababya (Egypt; Dupuis et al., 2003). The CIE is well marked, has a short vertical distribution, is recorded at a global level and is strictly related with a remarkable rise of the ocean temperature first known as IETM (Initial Eocene Thermal Maximum) and now as PETM (Paleocene-Eocene Thermal Maximum). The PETM/CIE has been dated first at roughly 57.33 Ma (Kennett and Stott, 1991), later at about 55 Ma (Katz et al., 2001; Scheibner et al., 2003; Moran et al., 2006). The event is well constrained from the point of view of the plankton and nannofossil biostratigraphy.

The Larger Foraminifera Turnover (LFT) is a prominent evolutionary event, well described by Hottinger (1997a, 1998) as the passage from a condition of diversification of moderate K-strategists at a generic level to the diversification of species belonging to a restricted number of successful genera (e.g., *Alveolina* and *Nummulites*) with a considerable increase of the test size and adult dimorphism. The LFT corresponds to the SBZ 4/5 boundary and a major worldwide transgression (TA 2.1-TA; 2.2 Pignatti, 1991). The collaborators in IGCP project 286 (International Geological Correlation Programme) recommended to fix the Paleocene-Eocene boundary in shallow water carbonate deposits at the level of the LFT. Hottinger and Schaub (1961) used this event to define the Ilerdian stage. According to the correlation of Serra-Kiel et al. (1998) and Hottinger (1997a, 1998) the LFT seems not to be correlated with the Paleocene-Eocene boundary. The sections of Campo (Molina et al., 2003) in Spain and Galala in Egypt (Scheibner et al., 2005 and Scheibner and Speijer, 2008; 2009) have been recently (re)investigated in order to provide evidences of the correlation between the P/E boundary (and therefore the CIE) and the LFT. In particular, the section of Galala seems to confirm that the LFT, the P/E boundary and the SBZ 4/5 boundary coincide.

Scheibner and Speijer (2008) recognized three different stages which characterized the evolution of the Tethyan carbonate platforms during the Paleocene-Lower Eocene. The first stage is constrained between the most prominent eustatic sea level fall of the Paleocene, coinciding roughly with the SBZ 3/4 boundary. The second stage coincides with SBZ 4 and the third with SBZ 5. Therefore, the P/E boundary coincides with the stage 2/3 transition. The authors focus on the major climatic perturbation (PETM) as driving force for the facies shift, taking into account the paleolatitudes. In the Ionian Islands the first stage is represented by coralgal and larger foraminiferal biodedtrital deposits, the third stage (well-documented on Cephalonia in the Lixouri peninsula) by larger foraminiferal shoals, in which alveolinids dominate, whereas the second stage is poorly represented or absent.

In the present work this correlation of the P/E boundary with the SBZ 4/5 boundary is adopted, pending the necessity of further investigations. A revision of the stratigraphic distribution of several taxa and the introduction of additional markers are additional further goals.

Larger foraminifers as a tool in facies interpretation

The biostratigraphic value of larger foraminifers has been recognized since the middle of the 19th century, whereas their use as a tool for interpreting depth and depositional environment has been fully developed only in the last decades.

The iterative development of larger foraminifers in neritic sediments is a constant feature since Late Paleozoic times. They almost represent an ecosystem of their own (comparatively independent from the remaining ecosystem): with a few exceptions, they do not appear to play a particular role in the food chain of invertebrates and fish and may represent the end member of a food chain, feeding on bacteria, diatoms or pellets produced by planktonic organisms (Hottinger, 1997b). It is thus reasonable to use foraminifers as ecological indicators taking into account competition with ostracods for similar food resources in the environment.

The models developed by Arni (1965) for the Sirte basin and by Luterbacher (1970) for the Tremp basin are early models of paleoecological interpretation of Paleogene larger foraminifers. Hottinger (1974) developed a more detailed model for the ecological distribution of alveolinids, orbitolitids, nummulitids and discocyclinids from the Late Paleocene-Middle Eocene timespan.

The three classical complementary approaches to the paleoecological interpretation of microfossil assemblages are well illustrated by Luterbacher (1984): direct comparison with recent forms, morphofunctional analysis, and comparison with the distribution of microfossils in ancient facies models.

As stressed by Hottinger (1997b), the neritic carbonate production constitutes itself a depth signal, with the depth range corresponding to the photic zone, due to the occurrence of photosymbiotic organisms and truncated towards depth by rising clines of nutrient concentration. The direct comparison with recent forms through taxonomic relatedness is not possible for the taxa older than the mid-Miocene biological revolution. In this case, the assemblages should be investigated on the base of morphological elements in the test reflecting vital functions related to the depth of habitat.

The occurrence of light-dependent symbionts (as in larger foraminifers) is the first trait of dependence in test morphology and it is reflected in exoskeletal and endoskeletal structures for the storage and movement of the symbionts to regulate the irradiation of sunlight (e.g., in porcelaneous tests) and in the egg-holder structures and/or lateral chamberlets of the lamellar-perforated forms (Hottinger, 1997b).

Test thickness in lenticular and discoidal test as well as the elongation of fusiform test depends from turbulence (and therefore from the depth) when are related with wall thickness. The ratio of microspheric/macrospheric specimens in dimorphic species, considering the relation between sexual reproduction (therefore the occurrence of microspheric forms) and the optimum of environmental conditions in the depth gradient where stress is lowest and density of population highest, is another depth-dependent trait.

The depth signal may be truncated at a certain depth by a thermocline located shallower than the euphotic depth limit or by a nutricline of nutrients concentrations. Turbid waters may compress the photic zone to very shallow depths or suppress it. The comparison with the distribution of microfossils in recent and ancient facies models is essential because the depth signal should not contradict empirical evidence. Moreover, it is necessary to take into account the maturation grade of the communities (Hottinger, 1997a, 1997b; McGowran and Li, 2002). Depth signals are most reliable in mature communities, characterized by stable, equilibrated generic composition through time with the dominance of K-strategists.

The research of depth-dependent morphological characters is important also for its implications on biostratigraphy, concerning the difficulties that can arise when a single morphological character is considered of taxonomic value but is interdependent at a certain level with other characters and with the environment. Pécheux (1995) provided evidence of how light controls on the one hand the growth rate, the fecundity and the phenotypic involute-evolute morphology through symbiosis. On the other hand, abundance, determined by interspecific competition (and possibly by incumbency), controls the size of the embryo and of the adult and indirectly other morphological features, such as chamber irregularity and the distribution of large and small, previously overlooked, microspheric specimens.

In the frame of a detailed analysis of the morphological characters considered in nummulitid taxonomy, Racey (1992) suggests to reweight each one on the base of the grade of light-dependence, taking into account their interdependence (ontogenetic factors).

In the present work the main reference for depth distribution of larger foraminifera is Hottinger (1997b), which integrates models proposed e.g. by Henson (1950), Arnaud-Vanneau (1979, 1986), Arnaud-Vanneau and Darsac (1984), Caus and Serra-Kiel (1984), Reiss and Hottinger (1984), Hottinger et al. (1989), and Hohenegger (1994).

The nature of the investigated material constrains the type of the information available. The stratigraphic relationships cannot be investigated, whereas the evolutionary trends of the succession can be roughly reconstructed by means of the biostratigraphic and paleoenvironmental interpretation of each clast.

The sedimentary model adopted in this work takes into account the genetic approach of Pomar (2001), which stresses the variability of depositional profiles in carbonate platforms as a function of the type of sediment that was produced (basically, grain size), the locus of sediment production, and the hydraulic energy.

Oligophotic gravel-producing biota, such as some larger foraminifers and red algae, generate distally steepened ramps. In this case, the fine-grained skeletal components are produced in the shallow euphotic zone and may aggrade until they reach the shelf-equilibrium profile. Subsequently, storms and currents move them down-shelf and off shore. In the oligophotic zone the produced gravel-sized skeletons are accumulated in situ, being moved only by episodic events such as storms. In this zone the sedimentation rate is determined by in situ accumulation and by finer-grained sediment from the shallow euphotic zone. The result is a distally steepened ramp with the slope angle depending from the fabric of the sediment and the storm/current intensity and frequency.

In contrast, mud-dominated carbonate production, in either euphotic or oligophotic zones, generates homoclinal ramps.

Pomar (2001) stresses the role of *Nummulites* in the coarse-grained skeletal carbonate production in the mesophotic zone with a distally steepened ramp profile as expected result. Whereas the importance of *Nummulites* shoals and "banks" in the sedimentary models of Paleogene ramps has been investigated in a number of works (e.g. Arni, 1965; Racey 1988, 1995, 2001 and references therein), the role of alveolinids has been rather neglected, despite the common occurrence of shoals dominated by *Alveolina* especially in Late Ypresian times. Buxton and Pedley (1989) indicate the occurrence of abundant *Alveolina* specimens in their 4th ramp biofacies (shallow subtidal ramp, protected embayment). Hottinger (1974, 1997b) and Luterbacher (1984) point out this distinction between *Nummulites* and *Alveolina*, defining a shallower range for alveolinids with an overlap of the depth distribution of alveolinids and nummulitids.

KEY-OUTCROP DESCRIPTION

The outcropping successions consist mainly of skeletal grainstone-rudstone with reworked larger foraminifers, alternating with layers of microbioclastic mudstone with planktonic fauna. Episodes of conglomerate with heterometric clasts of Cretaceous-Cenozoic limestone are frequently found as channelized bodies or layers (Fig. 3). The same lithic material of these conglomerates is also scattered into the muddy and skeletal layers. Frequent changes in skeletal and lithoclastic composition testify to deposition at the toe of slope in different ages and with different sedimentary patterns. The reworked fossil assemblages testify to the existence of different environments of a carbonate ramp, and the heterogeneity of lithoclasts suggests the dismantling of stratigraphic successions of different age and lithology. The occurrence of clasts of pelagic mudstone in these toe of slope deposits suggests periods of strong relative sea level fall, probably due to tectonic uplift.

Facies analysis of the Paleogene outcrops in the various sectors of the island indicates variable thicknesses and different facies sequences (Fig. 4), suggesting a differential tectono-sedimentary evolution of the depositional substratum.

Northern sector

The Cretaceous bedrock in this sector of the island shows an inner carbonate platform facies sequence; only in some outcrops west of Anafonitria village, Maastrichtian skeletal grainstone facies with rudist (*Plagioptychus* sp., *Sabinia* sp.), coral and orbitoid remains are found (Fig. 5 A). Along the NW coastal cliff, near the monastery of Anafonitria, this facies overlies a well-bedded lagoonal limestone sequence characterized by framestone with radiolitids in living position (*Biradiolites angulosus* d'Orbigny), still showing their opercular valves. Near Ormos Vroma rudstone and floatstone with lithoclasts and rudist remains overlie thick layers of well-packed skeletal grainstone with orbitoids and rudist fragments. The Upper Cretaceous inner platform sequence widely crops out along the road Anafonitria-Maries-Exo Chora (Fig. 5 B, D), with layers rich in radiolitids (*Biradiolites angulosissimus* Toucas and *Rajka spinosa* Milovanović), a Campanian-Maastrichtian species considered by Pons and Vicens (1986) as junior synonym of *Biradiolites chaperi* Douvillé). On the NE side of the island, the Cretaceous sequence is well exposed in wide quarries near Katastari, where inner platform facies alternate with grainstone rich in echinoid remains, typical of open shelf environment. The overlying Cenozoic toe of slope-proximal basin sequence widely crops out in the area between Koriti and Skinaria, where several conglomerate episodes characterize the stratigraphic succession. Two main conglomeratic episodes are recognizable: a lower one, time-transgressive, Lutetian-Priabonian p.p. in age and an upper one, Rupelian p.p.-Aquitanian. At places a transgressive pelagic mudstone sequence of Lutetian p.p.-Priabonian age separates the two conglomerate sequences. The relationships between the limestone of the Cretaceous platform and the Tertiary toe of slope sequence are shown in Section A of Fig. 4.

Central sector

The Upper Cretaceous succession in the Ag. Leon-Gyri-Ag. Pantes-Langadakia area is similar to that of the N sector. A Turonian-Campanian p.p. inner carbonate platform sequence shows laminated dolomites at the bottom, followed by radiolitid-rich muddy layers (*Sauvagesia*) and rare packstone-grainstone with small hippuritids (*Hippurites socialis* Douvillé) and hydrozoans (Fig. 5 C). A sharp change in the Cretaceous facies sequence is manifest in this central sector, between the villages of Agia Marina and Agii Pantes, and marks the southward transition to a biodetrital deeper-water Campanian p.p.-Maastrichtian sequence of skeletal rudstone-grainstone, polygenic conglomerate and microbioclastic pelagic mudstone with *Contusotruncana fornicata* (Plummer, 1931) and *Globotruncana linneiana* (d'Orbigny, 1839).

The Cenozoic deposits in this sector show a marked areal variability, with time-transgressive facies sequences characterized by conglomeratic episodes of different age. A Gyri-Ag. Pantes-Langadakia succession was recognized (Section B of Fig. 4), where the Cretaceous platform sequence is overlain by toe of slope deposits with episodes of Lutetian-Priabonian p.p. lowstand wedge conglomerates. Transgressive microbioclastic mudstone of proximal basin follows, Chattian p.p.-Burdigalian in age. Different stratigraphic evidences were found in the Macherado and Kiliomeno areas (Sections C, D, of Fig. 4): in the Macherado area skeletal Cretaceous limestone is overlain by Lutetian p.p.-Bartonian pelagites, followed by Rupelian p.p.-Aquitanian p.p. lithobioclastic debris flow with lowstand wedge conglomerates. In the Kiliomeno area skeletal Cretaceous limestones are overlain by older Lutetian-Priabonian p.p. debris flow.

Further to the south also the Agalas-Lithakia section (Section E of Fig. 4) shows Lutetian-Priabonian p.p. toe of slope deposits with lowstand wedge conglomerate transgressive on the Upper Cretaceous skeletal rudstone with rudists and orbitoids. Contrary to the above-mentioned central areas, here Lutetian p.p.-Priabonian pelagic mudstones with skeletal blankets of proximal basin is interposed at places between the underlying toe of slope deposits and the overlying Chattian p.p.-Burdigalian micro-bioclastic mudstone.

Near Pantokratoras the upper part of the sequence shows calcarenite layers and conglomerate levels with clasts originated from a dismantled coral reef, rich in colonial corals, corallinacean algae, gastropods and rare well-preserved nautiloid shells (Fig. 6 D).

Southern sector

In this sector the Cenozoic toe of slope-proximal basin sequence, spanning from Lutetian to Burdigalian, is more continuous and thicker than those of the previous sectors. This sequence consists of well-bedded calcarenites with variable grain size and concentrations of larger foraminifers often showing orientation by traction current (Fig. 6 A, B). Along the road from Limni Keri to the Akros Keri lighthouse a thick succession of Cretaceous-Eocene limestone crops out. The lower part of the sequence forms the cliffs of the southernmost coast of the island, between Keri and Agalas, and consists of chalky-like well-bedded limestone with rare globotruncanids, indicative of deep-water slope-proximal basin environments. The chalky sequence is followed upsection by a Campanian-Maastrichtian sequence consisting of skeletal grainstone-rudstone with orbitoids and rudists (*Sabinia* sp.), overlain by a rhythmic succession of light brown calcarenite alternating with more or less marly layers. The faunal assemblage of these layers consists of rare smaller benthic foraminifers which did not allow any age attribution. A Cenozoic sequence of calcarenite follows, alternating with polymictic conglomerate layers (Fig. 6 C), showing clasts with *Austrotrillina*, *Borelis*, *Amphistegina*, *Praerhapydionina delicata*, *Microcodium*, as well as reworked Eocene

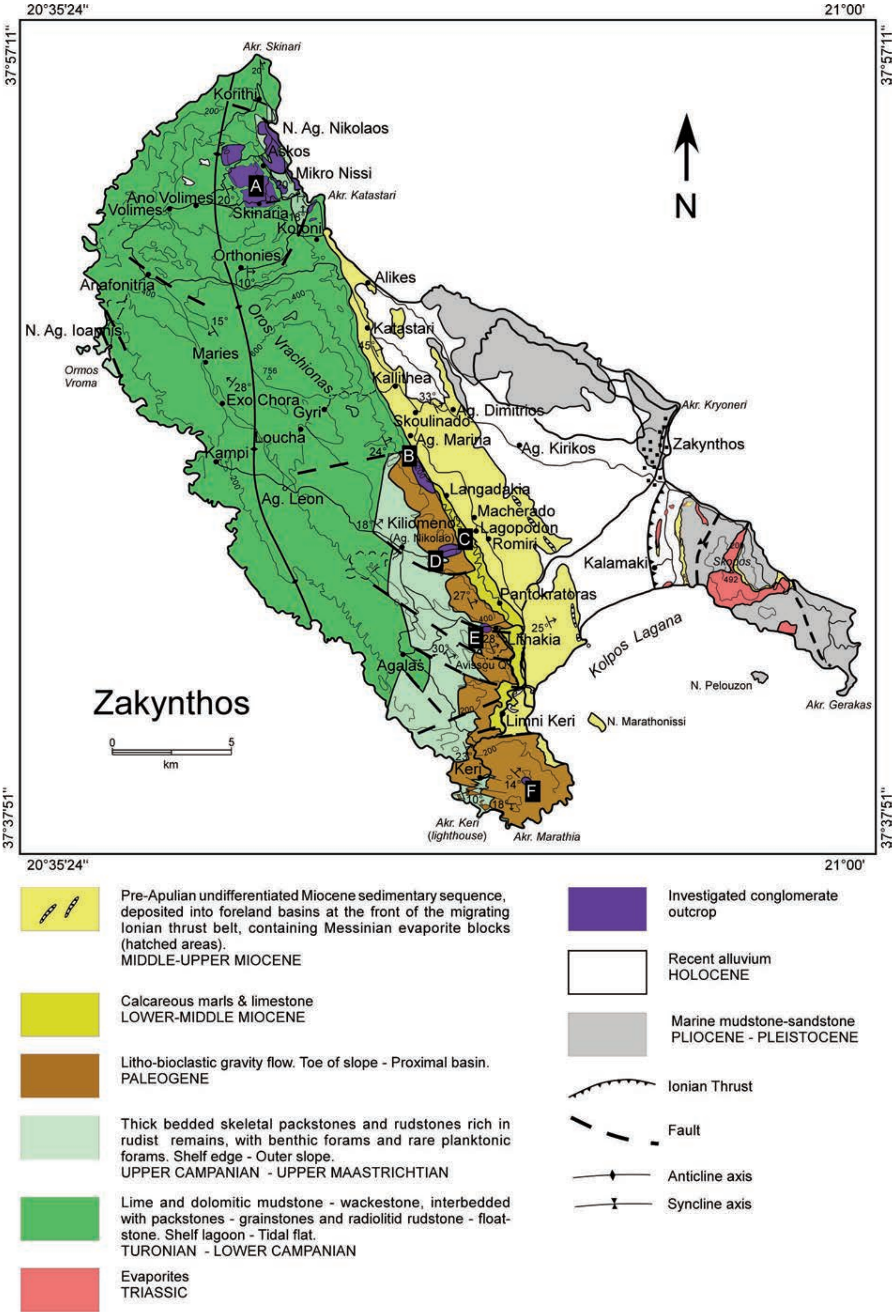

Fig. 2 - Schematic geological map of Zakynthos, based on I.G.M.E. (1980; fieldwork carried on in the early 1960's) and the map by Accordi and Carbone (1992), modified integrating original (Pre-Apulian domain) and literature data. Ionian domain redrawn after Underhill (1988, 1989), and Zelilidis et al. (1998). Pre-Apulian domain redrawn considering Horstmann (1967), Mirkou-Peripopolou (1974), and Dermitzakis (1975).

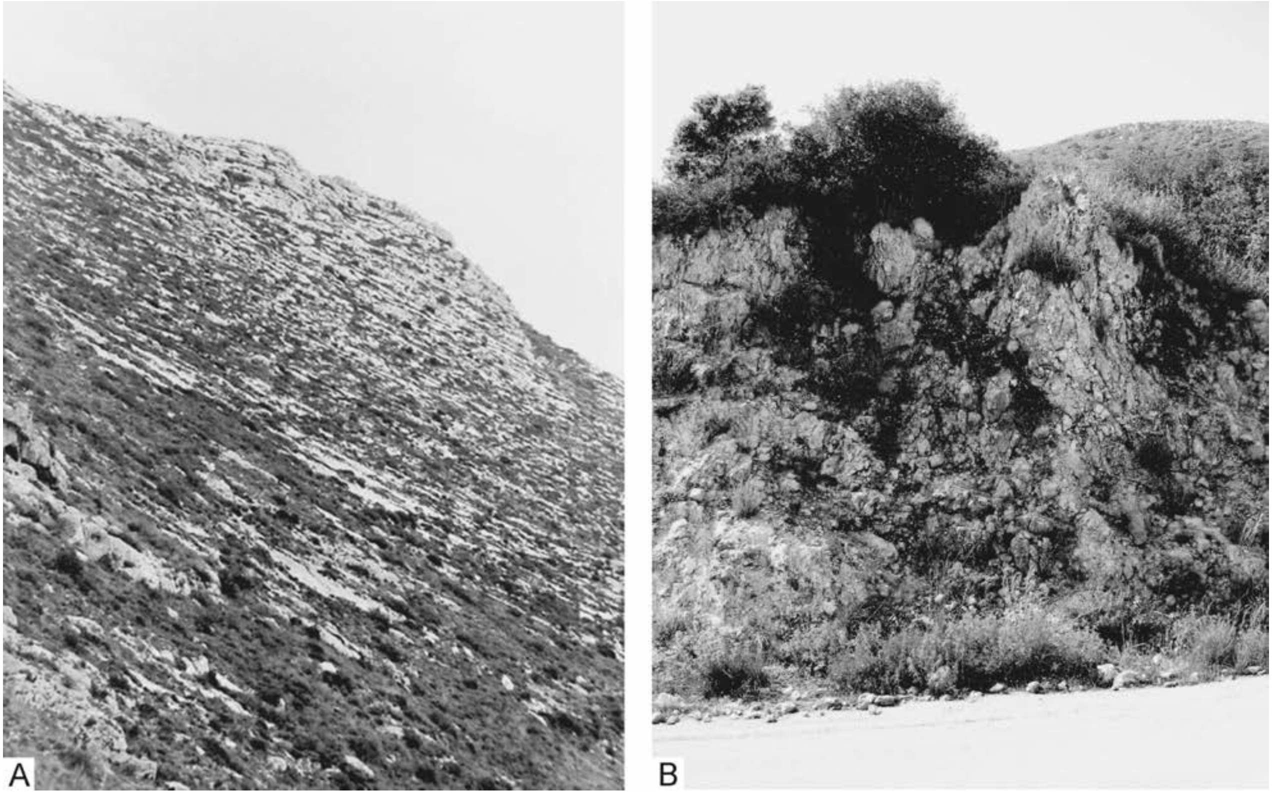

Fig. 3 - Some features of lowstand wedge conglomerate outcrops. (A) A sheet lobe breccia, at the top of thin-bedded turbidites of toe of slope, evidenced by the prominent morphology. Langadakia. (B) Typical texture of a toe of slope lowstand wedge conglomerate, cropping out at Kiliomeno.

nummulitids. Near Akros Marathia a different conglomerate succession crops out, showing, from the bottom, layers with rudist fragments and orbitoids, strongly dolomitized layers, layers rich in corals and gastropods and finally alveolinid and nummulitid layers.

The section shown in Section F of Fig. 4 is a synthesis of different facies sequences from different areas of this sector, frequently complicated by the presence of faults; it is thus difficult to estimate the thickness of the successions.

KEY – SECTIONS CLASTS ANALYSIS

The investigated clasts from the conglomerates of Zakynthos provide important evidence on the Paleogene sedimentary environments of the Ionian Islands. These clasts represent the only evidence for deposits largely eroded elsewhere in the area and yield well-preserved larger foraminiferal assemblages, that are highly informative both from the biostratigraphic and paleoenvironmental point of view. This dual aspect of larger foraminifers is the key of investigation at the base of the present work.

Each clast from the investigated conglomerate outcrops can be interpreted as a snapshot of a specific moment and environment in the sedimentary history of the Ionian Islands. The high resolution of these photographs is at the scale of the Shallow Benthics Zonation: the larger foraminiferal assemblages are interpreted on the base of their ecological meaning and distributed within the carbonate ramp models of Figs. 7, 8, 9, 10 along with other selected organogenous and inorganic components relevant for paleoenvironmental analysis with the support of structural/textural feature interpretation. The high number of the investigated clasts (Fig. 11) allows obtaining a reliable overview of the depositional intervals and environment. A description of the age and texture of the microfacies represented in the clasts from each outcrop is given below. When the SBZ age assignment is inapplicable (Cretaceous clasts, clasts yielding planktonic foraminiferal assemblages) or the biostratigraphic resolution is too low (Paleogene and Oligocene clasts with reworked, poorly-preserved assemblages), the age of the clast is indicated with a letter as in Fig. 4.

Section A: Koriti-Skinaria

In the NE sector of the island, post-Oligocene conglomeratic deposits yielding mainly Oligocene clasts widely crop out disconformably overlying Upper Cretaceous inner platform limestone. The collected samples are from the outcrops located at N 37°53.166‘ E 20°41.884’ (N-W of the village of Skinaria) and N 37°52.815’ E 20°42.705’ (near the village of Skinaria), on the road to Ano Volimes. The mean thickness of the deposits is about 5 m.

Different shallow-water Oligocene assemblages and microfacies yielding mainly porcellanaceous taxa were recorded.

B (Upper Cretaceous)

- Biodetrital grainstone with *Orbitoides* sp., *Siderolites calcitrapoides* Lamarck, 1801, rare miliolids and abundant rudist fragments (mainly radiolitids) (Pl. A, Fig. 3) - Shelf edge.

SBZ 2 (Selandian p.p.)

- Packstone-grainstone with *Haymanella paleocenica, Kayseriella decastroi, Paraspirolina* sp., *Pseudocuvillierina sireli*,

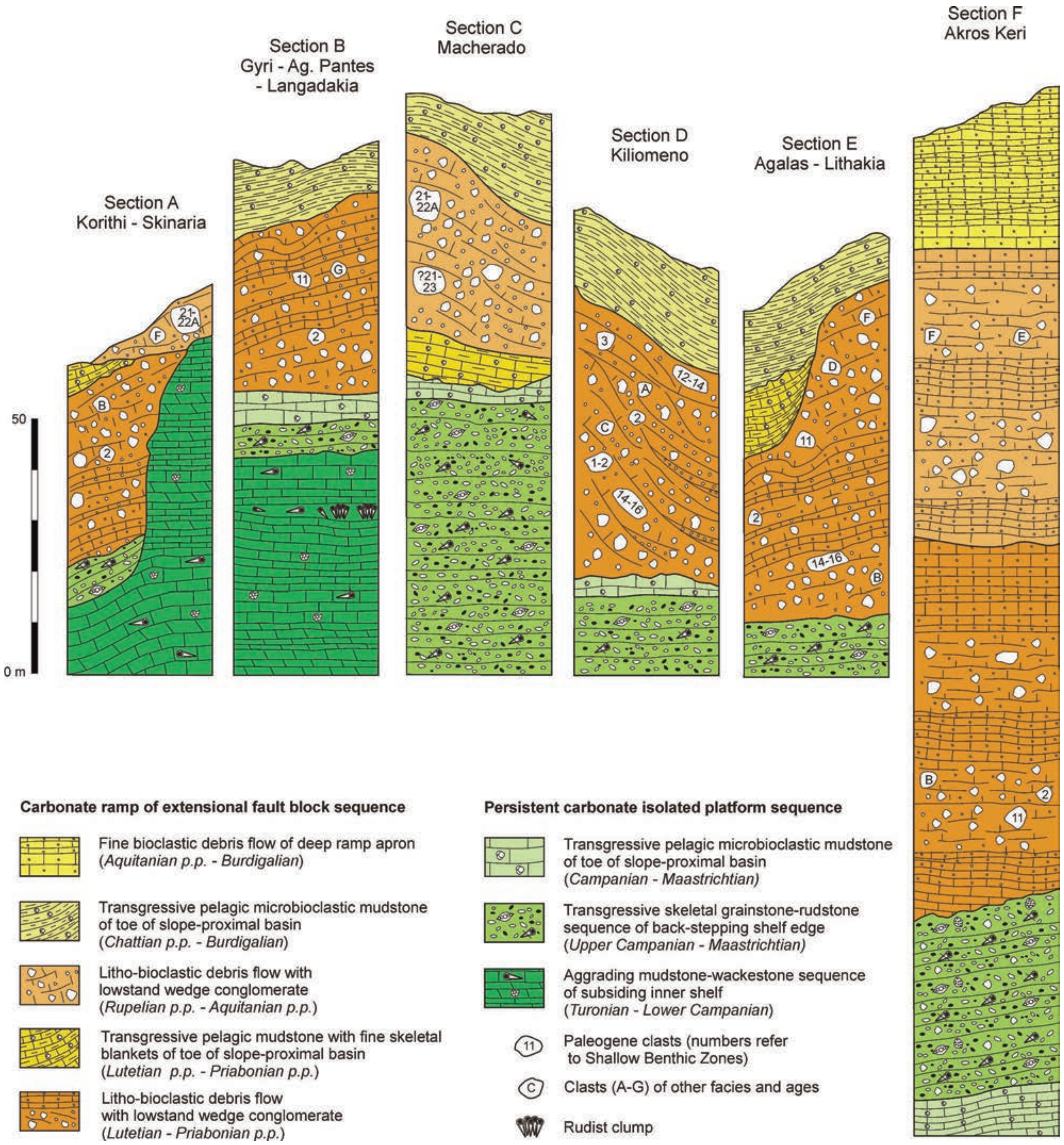

Fig. 4 - Generalized stratigraphy of the main structural sectors of Zakynthos Island illustrating the relative position of conglomerate deposits in the stratigraphic record. When the SBZ age assignment is inapplicable or very broad, the inferred age of the clast is indicated with a letter. A: Maastrichtian; B: Upper Cretaceous; C: Lower Ypresian; D: Middle Eocene; E: Upper Eocene; F: Oligocene.

Stomatorbina binkhorsti, textulariids, miliolids, small rotaliids, multi-layered *Polystrata alba* rhodoliths (suggesting medium to high energy environments), dasyclads, coral fragments, bivalves, moldic porosity (by dissolution of bivalve shells) and vuggy porosity partially filled with blocky calcite cement - Inner ramp, open marine.

SBZ 21-22A (Rupelian)

- Mudstone-wackestone with *Bullalveolina bulloides*, *Austrotrillina* cf. *paucialveolata,* miliolids, peneroplids, corallinacean fragments and abundant articulated *Microcodium*, suggesting minor reworking - Inner ramp, protected shallow subtidal (Pl. E, Fig. 1).
- Packstone-grainstone with *B. bulloides*, *Austrotrillina* cf. *paucialveolata*, *Sphaerogypsina globulus*, miliolids, peneroplids and corallinacean fragments (Pl. E, Fig. 2) - Inner ramp, open marine.
- Biodetrital wackestone-packstone with *B. bulloides*, *Penarchaias glynnjonesi*, *Amphistegina* sp.; larger foraminiferal and skeletal remains are often covered by a rim of fibrous cement (Pl. E, Fig. 3) - Inner-middle ramp, open marine.

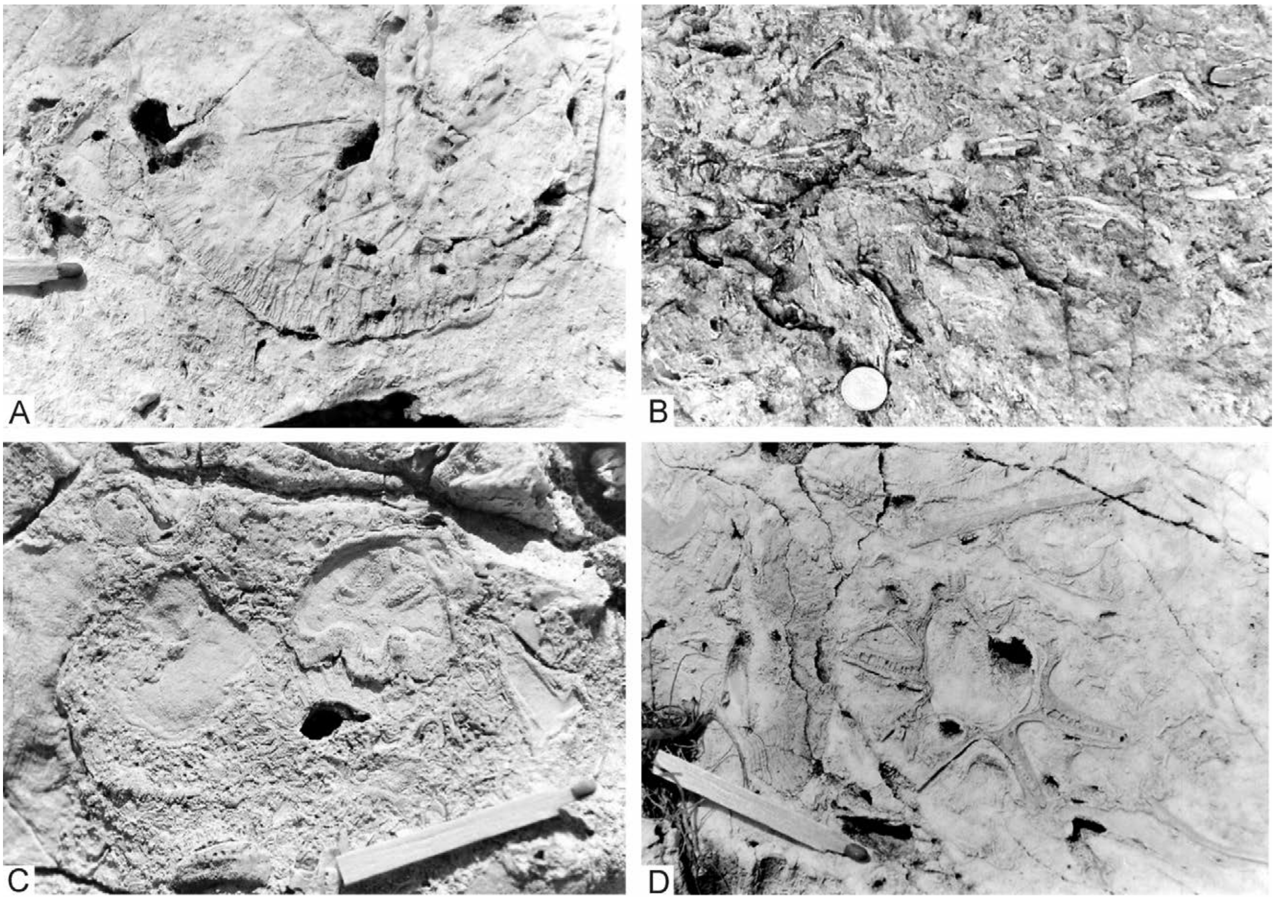

Fig. 5 - Selected textures of Upper Cretaceous carbonate platform bedrock. (A) Fine skeletal packstone showing the caprinid *Plagioptychus* typical of open shelf environment. Monastery of Aghios Georgios Krimnon, Anafonitria. (B) Packed radiolitid shells in an inner-shelf muddy mound. (C) Skeletal packstone-grainstone containing small hippuritid shells. Open shelf environment. Gyri – Kallithea road. (D) Wackestone with scattered skeletal remains, among which *Rajka spinosa* Milovanović. Inner shelf environment. Maries – Exo Chora road.

F (Oligocene)

- Packstone-grainstone with *Operculina* sp.*, Amphistegina* sp.*, Nephrolepidina* sp., rare miliolids and planktonic foraminifers (*Catapsydrax*), *Subterraniphyllum thomasii*, *Microcodium,* corallinales and worm tube fragments. The characters of the fossil assemblage suggest partial reworking - Ramp slope to outer ramp.

Section B: Gyri-Aghia Pantes-Langadakia

Along the eastern side of the Vrachionas Mt., located at N 37°46.709' E 20°46.838' near the village of Aghia Pantes, another conglomerate deposit crops out along the road cut with an exposed thickness of about 10 m, disconformably overlying Turonian-Campanian p.p. deposits.

SBZ 2 (Selandian p.p.)

- Packstone with *Globoflarina sphaeroidea, Helenalveolina rahaghii*, *Plumokathina* sp., miliolids, small rotaliids, textulariids, dasyclads, coral fragments - Inner ramp, restricted to normal marine.

SBZ 11 (middle Cuisian)

- Grainstone with *Somalina* sp., *Orbitolites* sp., *Opertorbitolites* sp., *Glomalveolina* cf. *minutula, Alveolina cremae, A. ruetimeyeri*, *A. levantina*, *Idalina* sp., *Cribrobulimina* sp. It is noteworthy that relatively abundant large *A. levantina* B forms occur together with very small *G.* cf. *minutula*. The tests of the large B forms are bioeroded, probably by sponges (Pl. 7, Fig. 13) - Inner to middle ramp, *Alveolina* shoal (Pl. C, Fig. 4).

G (Oligocene-Aquitanian)

- Grainstone with *Amphistegina* sp., *Heterillina* sp., rare peneroplids, miliolids and planktonic foraminifers, *S. thomasii*, serpulids, gastropods, abundant corallinales fragments. The characters of the fossil assemblage suggest partial reworking - Ramp slope to outer ramp.

Section C: Macherado

The section crops out in a quarry along the Macherado/Romiri-Agalas road (Fig. 12), near the village of Macherado, located at N 37°44,669' E 20°48,520'; the lower part of the section was first described by Dermitzakis (1978). Well-bedded Middle Eocene pelagic limestone with *Hantkenina* sp. is overlain by a conglomerate composed of Oligocene clasts. According to Horstmann (1967) and Dermitzakis (1978) the conglomerate, whose thickness is about 25 m, is followed by Aquitanian marls.

SBZ 21-22A (Rupelian)

- Grainstone with *Bullalveolina bulloides*, *Austrotrillina* cf.

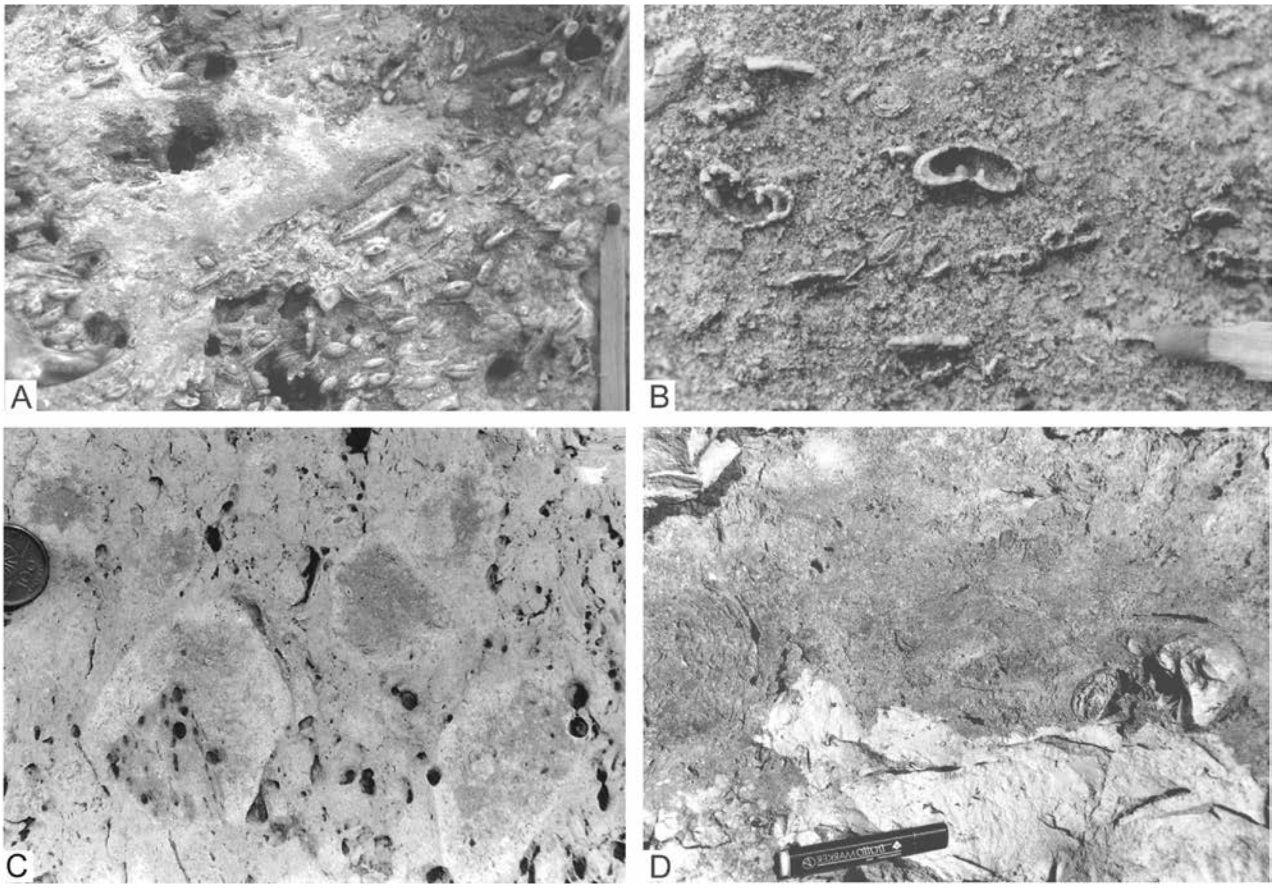

Fig. 6 - Some textures of resedimented material piled at the toe of ramp. (A) Fine-grained calcarenite rich in *Nummulites meneghinii* tests iso-oriented by low density gravity flow. Akros Keri section. (B) Layer of resedimented skeletal material showing whole very small echinoids and nummulitids. Akros Keri section. (C) Conglomerate layer consisting predominantly of small lithoclasts rich in larger foraminifers. Agalas-Litakia section (D) Fine calcarenite, mainly consisting of coral reef remains, showing a whole nautiloid shell. Pantokratoras outcrop.

paucialveolata, *Penarchaias glynnjonesi*, *Borelis* sp., *Amphistegina* sp., corals, abundant corallinales, vuggy porosity partially filled with drusy cement - Inner to middle ramp, sandy shoal/bar.

SBZ ?21-23 (?Rupelian-upper Chattian)

- Biodetrital wackestone-packstone with intraclasts, *B.* cf. *bulloides*, *Borelis inflata*, *Austrotrillina* sp., *Operculina* sp., *Amphistegina* sp., rare planktonic foraminifers, *Discocyclina* spp., miliolids, bryozoans, corals, gastropods and corallinales fragments. This sediment is indicative of at least two reworking phases, the former testified to by the occurrence of Eocene taxa, the latter by the mixing of pene-contemporaneous taxa from different environments - Outer ramp, proximal to colonized hard bottoms (Pl. E, Fig. 4).

Section D: Kiliomeno

The outcrop is along the Macherado/Romiri-Agalas road, located at N 37°44.603' E 20°47.795' (2.2 km east of the Kiliomeno village), consisting of a 15 m thick heterometric conglomerate of uncertain age (?Oligocene-Miocene), disconformably overlying well-bedded Maastrichtian pelagic limestone.

Most of the clasts, up to 0.4 m in diameter, are shallow-water limestone rich in larger foraminifers, ranging in age from the Maastrichtian to the Lutetian; rare Lower Ypresian pelagic limestone clasts also occur. Clasts yielding SBZ 3 assemblages largely prevail. No clasts yielding Ypresian larger foraminifers were found (Pignatti et al., 2008).

A (Maastrichtian)

- Wackestone with abundant *Rhapydionina liburnica (*Stache, 1913), miliolids, bivalves, dasyclads, moldic and fenestral porosity with geopetal filling - Inner platform, low-energy protected lagoon (Pl. A, Fig. 1).
- Grainstone with abundant *Rhapydionina liburnica* and miliolids - Inner platform, protected lagoon (Pl. A, Fig. 2).

SBZ 1-2 (Danian-Selandian p.p.)

- Poorly sorted wackestone-packstone with rare textulariids, miliolids, smaller rotaliids, discorbids, dasyclads, gastropods and *Microcodium* (at places disarticulated)*,* with cavities infilled by vadose silt; occasional moldic porosity - Inner ramp, restricted marine with episodic subaerial exposure (Pl. A, Fig. 4).
- Wackestone with abundant miliolids, ?*Rhabdorites* sp., ?*Pseudocuvillierina* sp., rare smaller rotaliids, discorbiids, dasyclads, and small skeletal remains. Moldic porosity with blocky cement or vadose silt occurs (Pl. B, Fig. 1) - Inner ramp, restricted to normal marine.

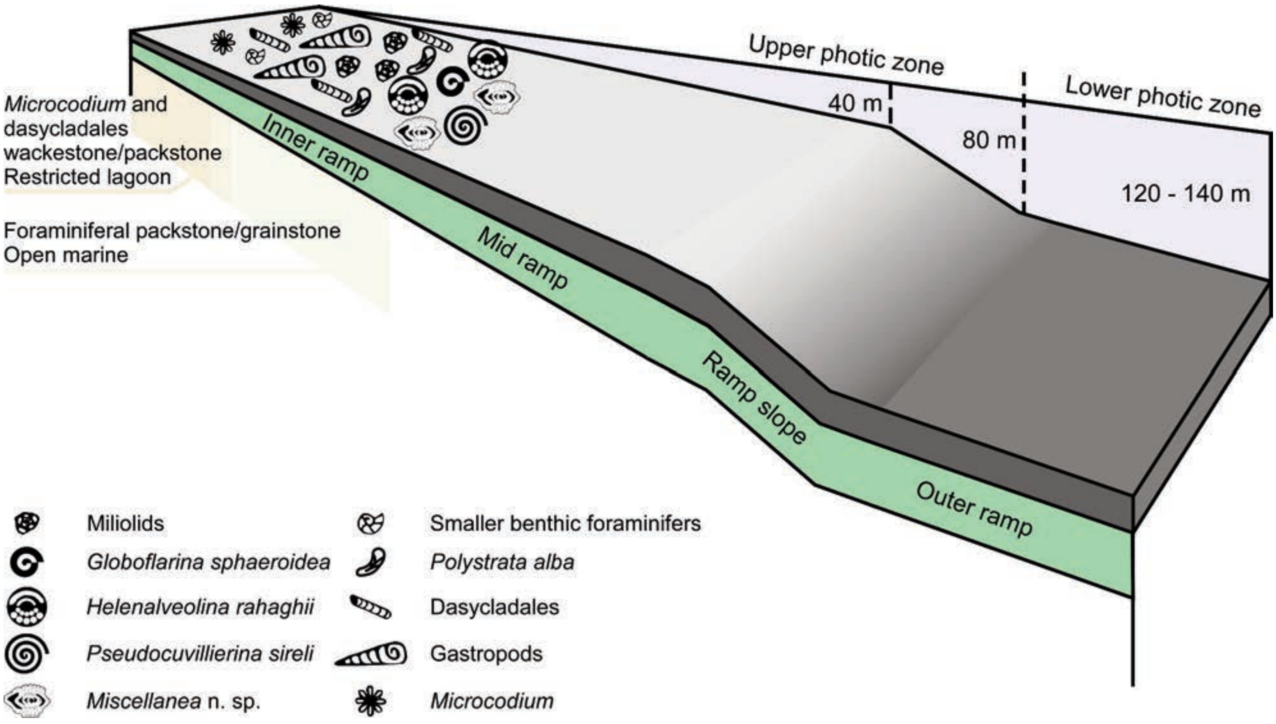

Fig. 7 - Reconstruction of the Danian-Selandian (SBZ 1-2) facies, based on the fossil content of the clasts from the Koriti-Skinaria, Gyri-Aghia Pantes-Langadakia, Kiliomeno, Agalas-Lithakia and Akros Keri conglomerates.

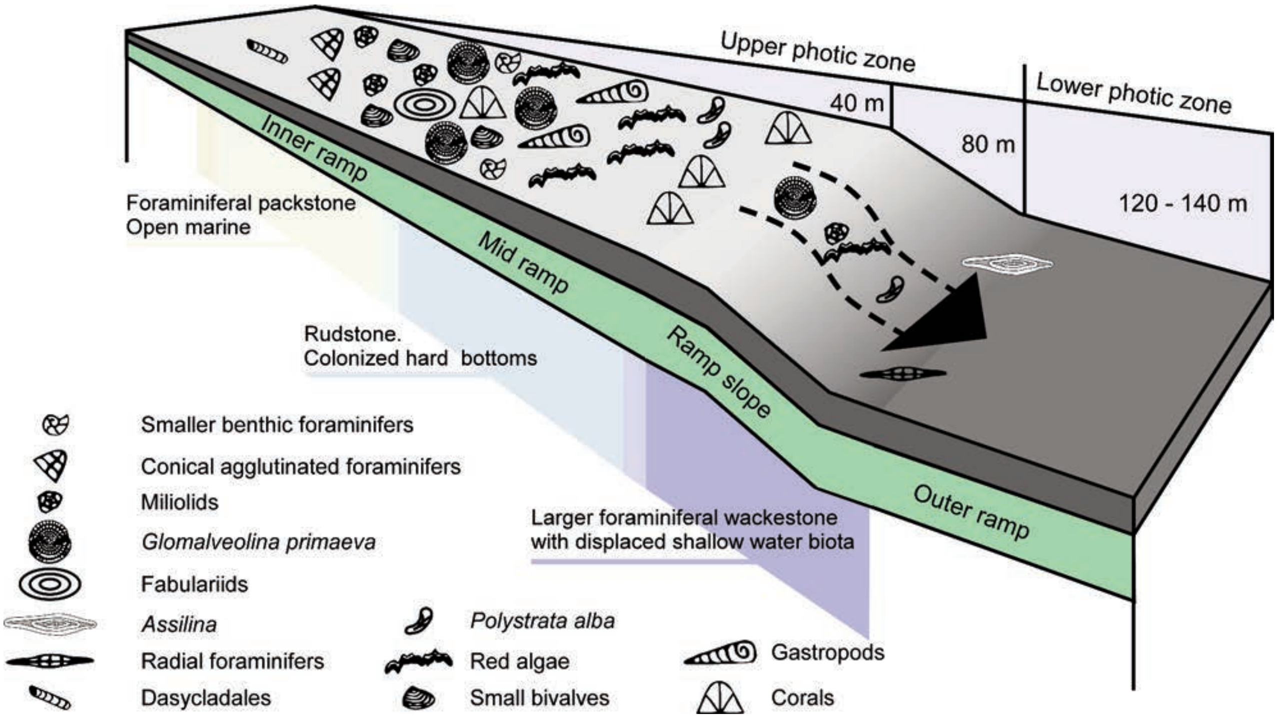

Fig. 8 - Reconstruction of the Selandian p.p.-Thanetian p.p. (SBZ 3) facies, based on the fossil content of the clasts from the Kiliomeno conglomerate.

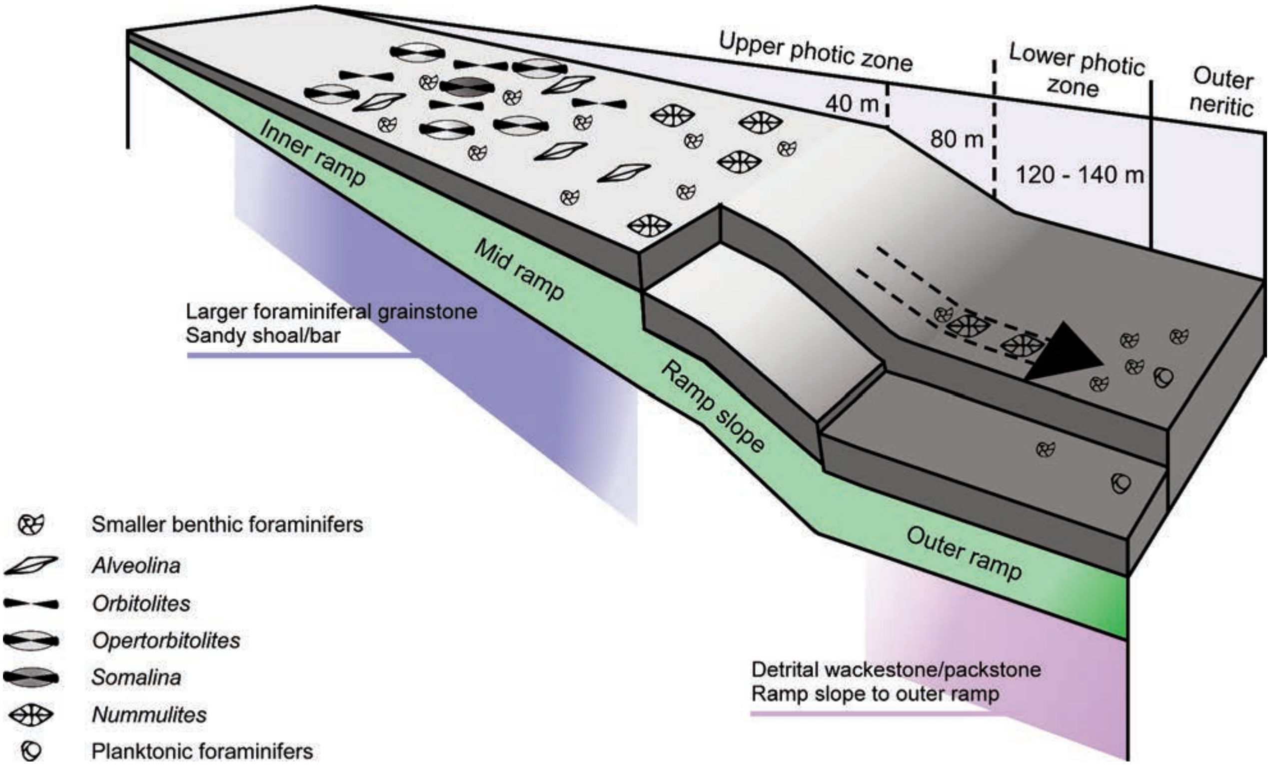

Fig. 9 - Reconstruction of the Eocene facies, based on the fossil content of the clasts from the Gyri-Aghia Pantes-Langadakia, Kiliomeno and Agalas-Lithakia conglomerates.

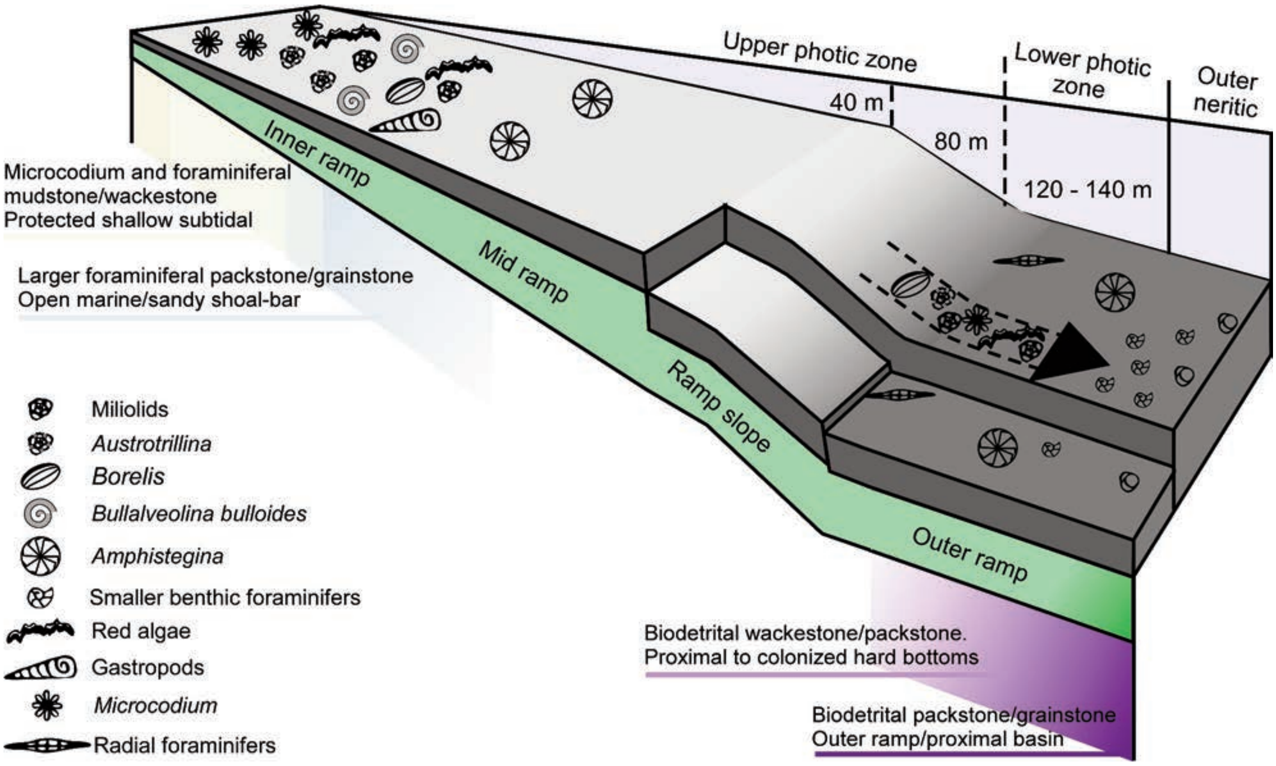

Fig. 10 - Reconstruction of the Oligocene facies, based on the fossil content of the clasts from the Koriti-Skinaria, Gyri-Aghia Pantes-Langadakia, Macherado, Agalas-Lithakia and Akros Keri conglomerates.

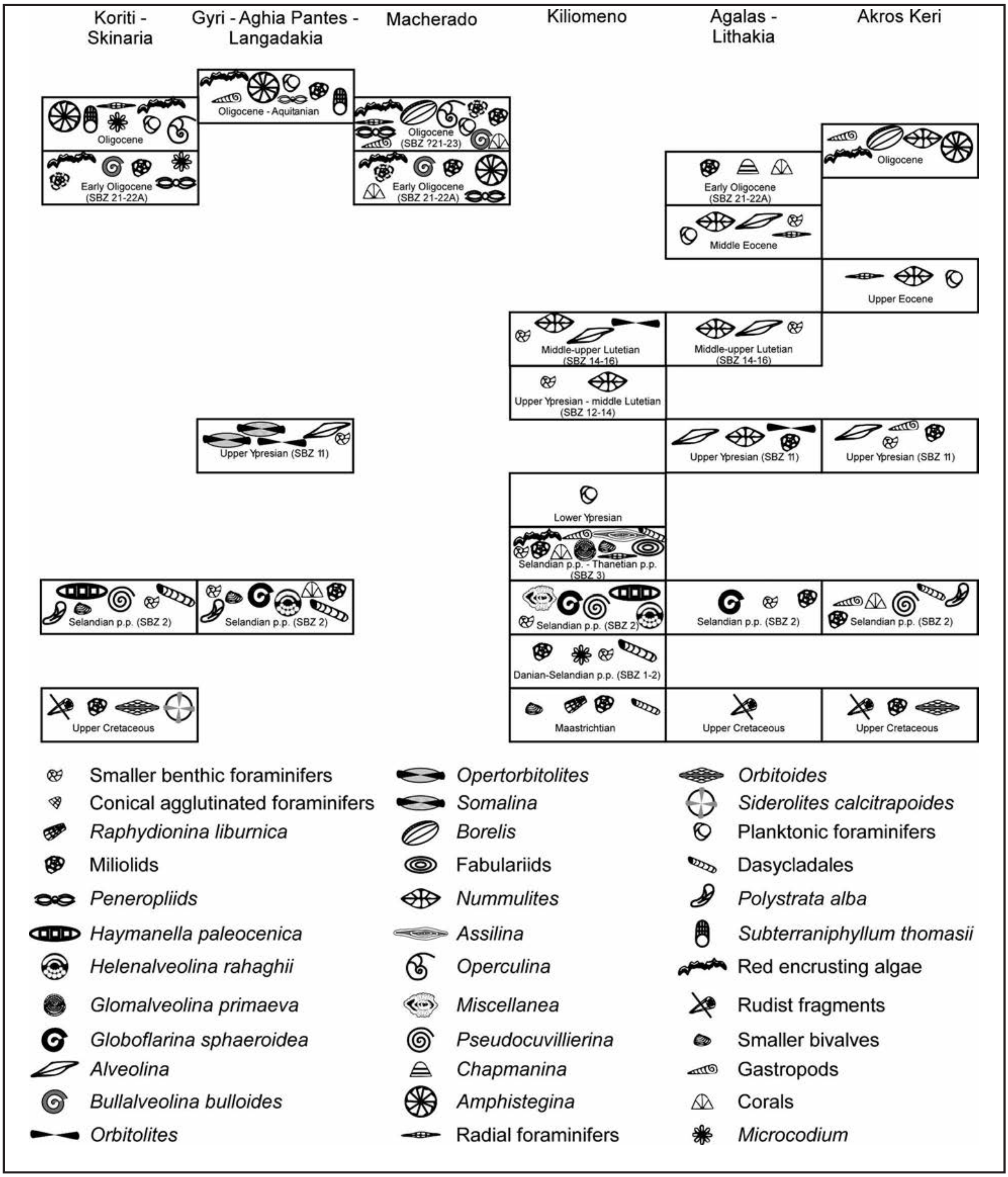

Fig. 11 - Comparative table of the conglomerate outcrops on the basis of the clasts.

SBZ 2 (Selandian p.p.)

- Poorly sorted packstone-grainstone with scarce intraclasts, *Globoflarina sphaeroidea*, *Helenalveolina rahaghii* sensu Drobne et al., 2005 (nom. nud.), *Kayseriella decastroi*, *Haymanella paleocenica, Miscellanea* n. sp., *Pseudocuvillierina sireli*, *Haddonia praeheissigi*, smaller rotaliids (plumokathinas), *Stomatorbina*, textulariids, miliolids, nubeculariids, corallinacean algae and small skeletal remains; the occurrence of detached specimens of *H. praeheissigi,* interpreted as linked to subdued light microhabitats (Matteucci, 1996), suggests a provenance from a pebbly bottom of medium-high energy environment (Pl. B, Fig. 2) - Inner ramp, open marine.

SBZ 3 (Thanetian p.p.)

- Packstone with abundant conical agglutinated foraminifers (*Coskinon rajkae*, *Fallotella alavensis*, *F. kochanskae, Cribrobulimina* cf. *carniolica*), *Vania anatolica*,

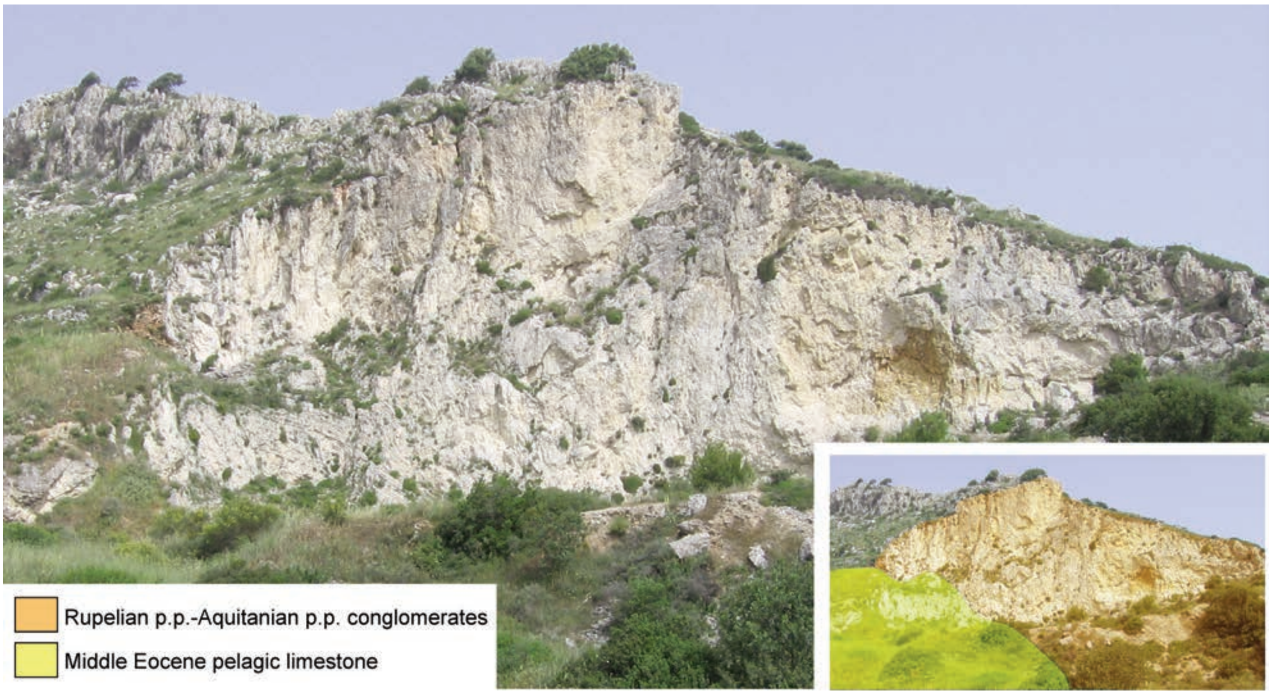

Fig. 12 - Macherado Quarry outcrop.

Glomalveolina primaeva, *Periloculina slovenica*, *Hottingerina anatolica*, *Elazigella altineri*, miliolids, encrusting foraminifers, smaller rotaliids, *Polystrata alba*, dasyclads, corallinacean algae, corals, gastropods and bivalves. Primary, fabric selective, moldic porosity originated by dissolution of bivalve and gastropod shells is associated with secondary, non-fabric selective, vuggy porosity, with the voids partially filled by drusy cement. Occasionally, three generations of porosity occur: a shelter porosity is originated by bivalve shells which successively originates a moldic porosity, and finally secondary dissolution generates vuggy porosity. The secondary porosity and the cements suggest a shallow burial environment. Vuggy porosity with two generations of geopetal fillings by crystal silt suggests meteoric influx (Pl. B, Figs. 3, 4) - Inner ramp, open marine.

- Rudstone with colonial corals, polymorphinids, encrusting foraminifers and *P. alba* fragments (Pl. C, Fig. 1) - Middle ramp, proximal to colonized hard bottoms.

- Wackestone with abundant smaller rotaliids (mainly plumokathinas), *Discocyclina* sp., ?*Assilina* sp., *Ranikothalia* cf. *bermudezi*, echinoid fragments, displaced rare conical agglutinated foraminifers, *G. primaeva* and miliolids. In some instances the foraminifers are covered by a micrite rim. The occurrence of heterolithic bedding suggests an environment with considerable variability of the current flow, in a clast with displaced shallow-water biota and relatively deep microfauna (Pl. C, Fig. 2) - Ramp slope to outer ramp.

C (Lower Ypresian)

Hemipelagic-pelagic mudstone with abundant planktonic foraminifers (*Morozovella* gr. *formosa*) (Pl. C, Fig. 3) - Outer ramp to proximal basin.

SBZ 12-14 Upper Ypresian (Cuisian)-Lutetian p.p.

- Packstone-grainstone with *Nummulites* (*N. cuvillieri*, *N. gizehensis*) specimens and variable percentage of other skeletal remains, peloids and intraclasts (Pl. D, Fig. 1) - Middle ramp, sandy shoal/bar.

SBZ 14-16 Lutetian p.p.

- Packstone-grainstone with *Alveolina* spp. (often as fragments), *Nummulites* spp. and *Orbitolites* sp. (*A. elliptica*, *N. cuvillieri*, *N. gizehensis*), smaller benthic foraminifers, echinoid and *P. alba* fragments. Larger foraminiferal shoals are developed in the inner-middle ramp, with various local lithotypes. *Alveolina* tends to occupy a shallower position, with a partial overlap of the ecological/bathymetric distribution of *Nummulites* (Hottinger, 1974; Luterbacher, 1984). The occurrence of peloids, intraclasts, *Orbitolites* sp. and epiphytic smaller benthic foraminifers suggests the existence of vegetate, protected bottoms (Pl. D Fig. 2) - Inner-middle ramp, sandy shoal.

Section E: Agalas - Lithakia

Along the road Lithakia-Agalas/Kiliomeno, near the village of Lithakia and located at N 37°43’191’ E 20°48’700’ a succession of dolomitized Upper Cretaceous limestone, conglomerate and a well-bedded ?Middle-Upper Eocene pelagic limestone crops out in a quarry (Fig. 13). The conglomerate thickness is about 18 m.

B (Upper Cretaceous)

- Packstone with abundant rudist skeletal remains - Shelf edge to outer slope.

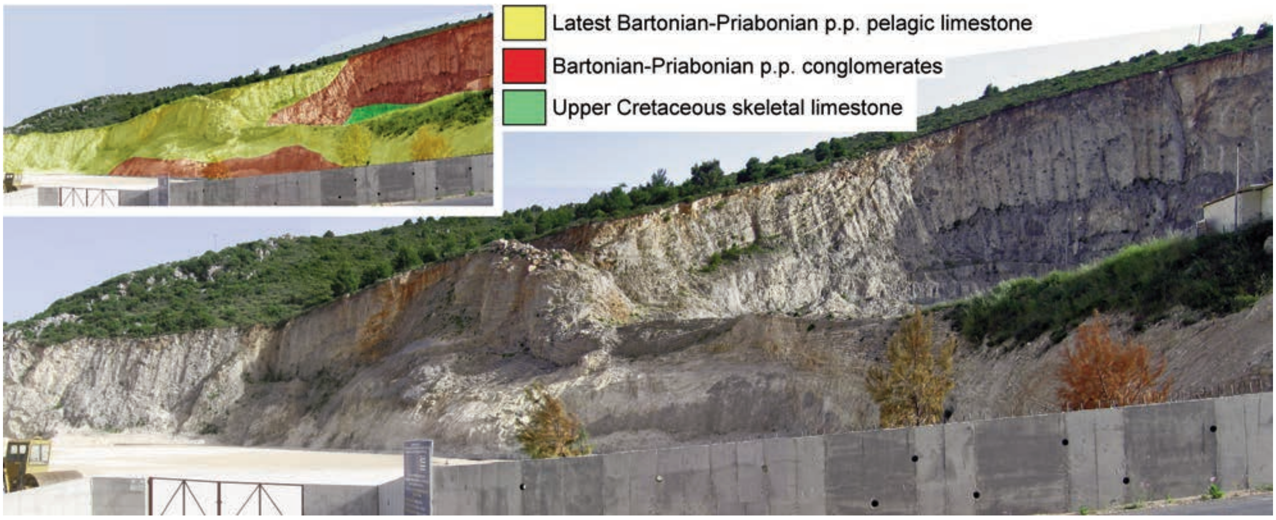

Fig. 13 - Lithakia Quarry outcrop.

SBZ 2 (Selandian p.p.)

- Grainstone with abundant intraclasts, *G. sphaeroidea*, *S. binkhorsti*, miliolids - Inner platform, open marine.

SBZ 11 (middle Cuisian)

- Biodetrital packstone with *Alveolina cremae, A. distefanoi, Orbitolites* sp., *Nummulites biconicus*, *Nummulites* spp., rare miliolids, corallinales and gastropods, vuggy porosity almost totally filled with cryptocrystalline cement and/or blocky calcite cement - Inner to middle ramp, sandy shoal.

SBZ 14-16 (Lutetian p.p.)

- Larger foraminiferal grainstone, with *Alveolina* spp. (mainly *A. elliptica*, often as fragments), *Nummulites* (*N. cuvillieri*, *N. gizehensis*), *Orbitolites* sp., smaller benthic foraminifers, echinoid and *P. alba* fragments (Pl. D, Fig. 3) - Middle ramp, sandy shoal.

D (Middle Eocene)

- *Nummulites* microbreccia with *N*. gr. *discorbinus*, *N*. gr. *perforatus*, *Discocyclina* sp., very rare alveolinids and miliolids, echinoid fragments, planktonic foraminifers scattered in the matrix - Ramp slope to outer ramp.

F (Rupelian)

- Grainstone with *Chapmanina* sp., miliolids, corals, interparticle porosity with grains sometimes covered by a rim of isopachous cement. The pores are sometimes filled of secondary blocky cement - Inner to middle ramp, sandy shoal/bar.

Section F: Akros Keri

Located at N 37°39.724' E 20°49.692', above the village of Keri, a conglomerate deposit crops out, disconformably overlying Upper Cretaceous packstone-wackestone with orbitoids and rudist remains. The investigated outcrop is along the road-cut, exposed for a thickness of about 5 m.

B (Upper Cretaceous)

- Medium-fine grained biodetrital grainstone with *Orbitoides* sp. and abundant iso-oriented rudist skeletal remains - Shelf edge to outer slope.

SBZ 2 (Selandian p.p.)

- Wackestone-packstone with *Pseudocuvillierina sireli*, *Stomatorbina binkhorsti*, *Polystrata alba*, corals, abundant miliolids and dasyclads, reworked orbitoids and rudist skeletal remains - Inner ramp, restricted marine.

SBZ 11 (middle Cuisian)

- Grainstone with abundant *Alveolina cremae*, *Idalina* sp., miliolids, rotaliids, gastropods - Inner to middle ramp, *Alveolina* shoal.

E (Upper Eocene)

- Detrital wackestone-packstone with *Nummulites* sp., *Discocyclina* sp., *Spiroclypeus* sp., planktonic foraminifers, bryozoans and intraclasts (Pl. D, Fig. 4) - Outer ramp to proximal basin.

F (Oligocene)

- Grainstone with *Borelis* sp., *Nummulites* sp., *Amphistegina* sp., ?*Discocyclina* sp., soritiids, miliolids, *Microcodium*, corallinales, echinoid fragments, gastropods, vuggy porosity - Inner to middle ramp, sandy shoal/bar.

REMARKS ON THE ORIGIN AND AGE OF THE CONGLOMERATES AND STRATIGRAPHIC CORRELATIONS

To define the role of the conglomerates in the geological evolution of Zakynthos, two key-issues need to be taken into account: their age and stratigraphic position and the provenance of the clastic material. As concerns the age of the conglomerates, the matrix has been investigated in the attempt to find unreworked microfauna, with negative results (barren matrix). As a consequence, our attention focused in field evidence and only in the case of the conglomerates near Lithakia and Macherado it has been possible to observe on the field their contact with units top and bottom. The Lithakia conglomerate overlies upper Cretaceous skeletal limestone with *Orbitoides* and rudist fragments, yields clasts ranging in age from the upper Cretaceous to the middle-upper Lutetian and is overlain by well-bedded upper Bartonian-Priabonian microbiodetrital pelagic limestone with *Hantkenina* cf. *alabamensis*. Thus the age of the conglomerate is constrained to the Bartonian-Priabonian p.p. The Macherado Quarry conglomerate overlies well-bedded pelagic limestone of Middle Eocene age (Horstmann, 1967; Dermitzakis, 1978), yields clasts of Oligocene age and is overlain by Aquitanian marls (Horstmann, 1967; Dermitzakis, 1978). Thus, the age of the conglomerate is constrained as late Oligocene/early Miocene.

Previous investigations provide little information on the origin, composition and geologic significance of the conglomerate deposits. Dermitzakis (1978) interpreted these deposits as linked to differential vertical movements causing uplift and in part subaerial exposure of the western block and rapid subsidence of the eastern block. The position of the rising block roughly corresponds to the Vrachionas Mt. In this interpretation, uplift was discontinuous in time and intensity, and the resulting heterometric conglomerates are proximal mass-flow deposits. Meulenkamp (1982) suggested that the Mediterranean/Paratethyan realm was affected by major geotectonic events causing a pulsating evolution. In his interpretation of the Hellenic and Calabro-Ionian Arc and the major tectonic events in the area, the Eocene/Oligocene transition corresponds to the shift from a carbonate to a marly-clayey sedimentation in the Ionian domain, whereas the Pre-Apulian domain is characterized by large hiatuses in deposition. The Oligocene-Miocene transition corresponds to the shift from neritic carbonate to deep-water marl-clay sedimentation in the Pre-Apulian domain. According to Meulenkamp (1982), both cases correspond to major tectonic events. Underhill (1989) suggested that the classic subdivision into isopic zones of the external Hellenides, valid for the Mesozoic-Paleocene passive margin units, becomes progressively weaker in Eocene-Oligocene times and is inapplicable for the Neogene units, which belong to a thrust and fold belt.

Accordi and Carbone (1992) stressed the occurrence of slump and gravity flow deposits in the Upper Ypresian-Chattian age platform drowning/collapsing facies sequence suggesting a primary control of tectonics on sedimentation.

In the reconstruction of the external Hellenides by van Hinsenbergen et al. (2005), the latest Eocene-earliest Oligocene corresponds to the onset of underthrusting of Tripolitza and Ionian nappes (Tripolitza nappes below the Pindos nappe and the Ionian nappe below the Tripolitza nappe, respectively). The latest Oligocene-earliest Miocene corresponds to the decoupling of the Tripolitza and Ionian nappes from the underthrusting slab with a peak of metamorphism.

Kati and Scholle (2008) recognized the conglomerate deposits as composed of a large variety of transported and reworked shallow-water carbonate materials. They identify as debris flows the most common resedimented deposits, consisting mainly of numerous reefal block bioclastic lithoclasts, originating from the platform margin and shelf. Thin-to-thick turbidite beds, mostly low-density and minor high-density flows, largely consist of resedimented bioclastic and lithoclastic material originating from the outer shelf and/or upper slope. They also show the presence of megabreccias interlayered with pelagites-hemipelagites.

Therefore, on the basis of the ages of the dated conglomerates (Bartonian-Priabonian p.p. and late Oligocene -early Miocene) and the aforementioned ages of the major tectonic events (latest Eocene-earliest Oligocene and latest Oligocene-earliest Miocene), the origin of the conglomerates seems related to the major tectonic events affecting the Pre-Apulian domain.

Pre-Apulian Zone. The Pre-Apulian domain comprises the central-western area of Zakynthos, Cephalonia, Lefkas in Greece up to the Sazan peninsula in Albania (Fleury, 1980) including the island of Paxos. A regional correlation of the Pre-Apulian deposits is limited by the scarce literature data. Following the detailed investigation of Western Cephalonia by Accordi et al. (1999), a chronostratigraphic correlation of the Late Cretaceous to Early Miocene stratigraphic interval between the Lixouri peninsula in Cephalonia Island and Zakynthos Island (Fig. 14) was carried out. The textural and biotic characters of the Paleocene clasts from the conglomerates of Zakynthos show marked affinities with the Lixouri shallow-water limestone, cropping out in western Cephalonia which can be referred to the same facies with the exception of the Selandian larger foraminiferal packstone-grainstone of Kiliomeno that is lacking in Cephalonia. The lower Ilerdian shallow-water limestone with abundant alveolinids that widely crops out in Lixouri does not occur in the clasts of the Zakynthos conglomerates, whereas the Late Ypresian-Lutetian larger foraminiferal shoal facies of Zakynthos does not occur in Lixouri. The conglomerate cropping out near Poros (south-eastern Cephalonia) is noteworthy, because it yields as yet unrecorded SBZ 2-3 clasts, Upper Bartonian-Priabonian and ?Oligocene clasts, the latter representing distal facies similar to the clasts of the Macherado Quarry outcrop and subordinately of the Askos Skinaria outcrop (Di Carlo, 2010).

The Paleogene deposits of Lefkas belong exclusively to distal facies, with well-bedded pelagic mudstones rich in planktonic foraminifers (Ypresian-Chattian final burial phase and middle Turonian-middle Lutetian foundered platform phase of Accordi and Carbone, 1992). In the frame of the tectono-sedimentary scheme by Accordi et al. (1999), in the Lefkas Island the short-lived platform units (western area) and the proximal basin units of the Ionian zone (central and eastern area) crop out. The Ionian zone is usually described as represented by pelagic facies and therefore clearly distinct from the shallow-water deposits of Zakynthos and western Cephalonia. However, Renz and Reichel (1945) describe their "Adriatische-Ionische" zone roughly corresponding with the Ionian domain as characterized also by shallow-water microfauna. They record Paleocene larger foraminiferal assemblages with *Lituonella roberti* (=*Coskinolina roberti*), *A. primaeva* (=*G. primaeva*), *M. miscella*, *D.* aff. *seunesi*. Particularly interesting is the record of *G. primaeva* from the island of Meganissi, located east of Lefkas (Renz and Reichel, 1945). Here, the Ypresian-Lutetian interval is described as characterized by *Alveolina*, *Orbitolites* cf. *complanatus*, *Discocyclina*, *Nummulites*, *Operculina*, *Carpenteria* and planktonic foraminifers, and the Priabonian by *Pellatispira madaraszi*, *Asterocyclina* and *Baculogypsina*. This island is now private property and could not be accessed.

Apulian platform. In the frame of the Apulian platform, the Paleogene stratigraphic sequence of Monte Saraceno

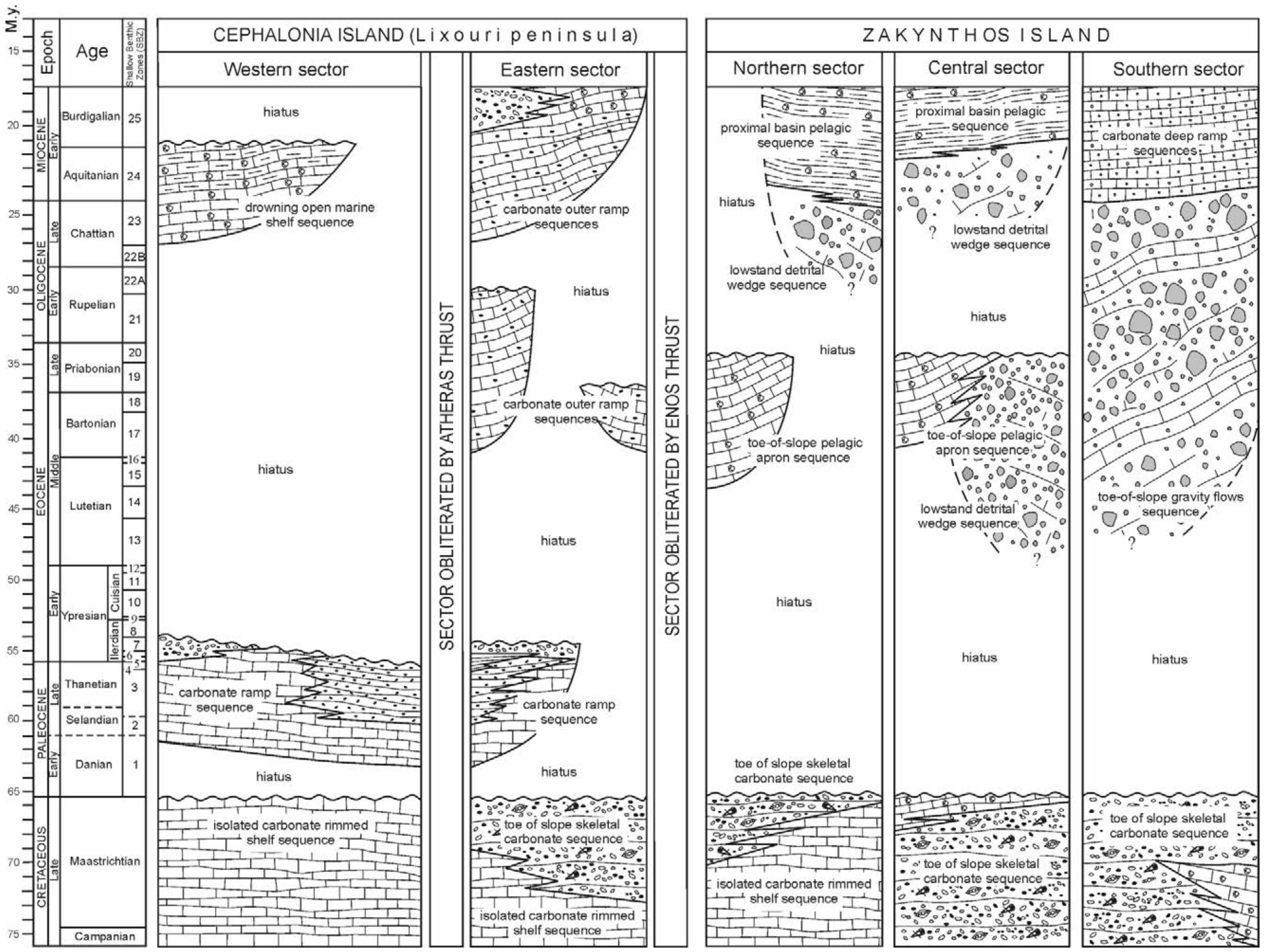

Fig. 14 - Chronostratigraphic chart of the Upper Cretaceous to Lower Miocene stratigraphy of Zakynthos Island compared with that of the Lixouri peninsula in Cephalonia Island.

cropping out in the Gargano promontory comprises in the lower part the Megabreccia del Grottone Fm. (Middle Eocene age; Bosellini et al., 1993a, 1993b), yielding clasts with SBZ 3 larger foraminiferal assemblages (Matteucci et al., 2009a, 2009b) comparable with the coeval Ionian Islands assemblages: *Globoflarina sphaeroidea*, *Glomalveolina primaeva*, *Idalina sinjarica*, *Fallotella alavensis*, *Stomatorbina binkhorsti*, *Discocyclina* sp., *Orbitoclypeus* sp., *Daviesina* sp. and *Kathina* sp. The middle portion is represented by pelagic deposits and the upper portion by turbiditic graded layers with slumpings of middle-upper Lutetian age (*N.* sp. ex gr. *perforatus, N. beaumonti, N. millecaput, N. anomalus, N. garganicus, N. gizehensis*). At the top the Calcari di Monte Saraceno Fm. is characterized by *Nummulites* shoals of upper Lutetian age (*N. beaumonti, N. gizehensis, N. meneghinii, N. puigsecensis, N. variolarius, Orbitoclypeus* sp., *Operculina bericensis*).

The Salento coast is characterized by the well-bedded grainstone of the Torre Tiggiano Limestone, rich in alveolinids and nummulitids. The age of the lower portion of the succession is early Lutetian (SBZ 13), while the upper is Bartonian (Bosellini et al., 1999).

The Maiella platform also belongs to the Apulian domain. A generalized hiatus corresponds to the Danian in wide portions of the platform and transitional areas in the Maiella Mt., Gargano, Tremiti Ids. and the central Apennines. According to Pignatti (1995) the scarcity of Danian shallow-water neritic facies seems to be related with the necessity of a period of biotic recovery of the neritic ecosystems after the K/Pg extinction. For the Iberian area, Baceta et al. (2005) suggest that the biotic recovery of complex reef system is faster than expected with a poor preservation and/or inaccessibility of many early Paleogene successions biasing an accurate estimate of the true recovery time. In the peri-Adriatic platforms, Danian shallow-water deposits (mainly restricted and brackish deposits) and with SBZ 1 (Danian) assemblages with the marker *Bangiana hanseni* are exceedingly rare, known from the Karst region (Northern Italy and Slovenia) and Herzegovina (Drobne et al., 2007).

Strict affinities exist between the SBZ 2-3 larger foraminiferal assemblages of the Ionian Islands and Turkey (e.g. Sirel, 1998), Slovenia (e.g. Drobne and Hottinger, 1971) and Gavrovo-Tripolitza (Fleury, 1980) and subordinately Iran (Rahaghi, 1978; Fleury, 1982). As stressed by Accordi et al. (1999), biogeographical affinities with Maiella Mt. and Gargano are underlined by the common occurrence of *Globoflarina sphaeroidea*. *H. anatolica*, recorded from the Kiliomeno conglomerate (central Zakynthos), occurs both in the peri-Adriatic and NW African-Arabian domain.

In Cuisian (Late Ypresian) times the facies dominated by *Alveolina* reaches its maximum development in the peri-Adriatic platforms. Cuisian *Alveolina* shoals are recorded from the Maiella Mt. by Bally (1954), Pignatti (1990), Vecsei (1991), and Vecsei et al. (1998). Pignatti (1995) stresses the relevance of the lower-middle Cuisian pseudoolitic (grainstone) *Alveolina* facies from the southern Maiella. Lower-middle Cuisian *Alveolina* facies are widespread in the central Mediterranean domain, recorded e.g. from the Gargano promontory (Apulia, Southern Italy; Scotto di Carlo, 1966), northern Fucino (central Italy, Latium-Abruzzi platform; Accordi and Carbone, 1988), Slovenia and the Istrian region (Castellarin and Zucchi, 1966; Drobne, 1977), and Sicily (Checchia-Rispoli, 1905; Montanari, 1965). The occurrence of *Somalina* in the A. Pantes deposits provides further evidence of a link among the Apulian-Pre-Apulian domain, the NW African-Arabian domain and the Middle East domain.

The Middle Eocene of the Maiella Mt. is represented mainly by bioclastic limestone rich in *Nummulites* of the S. Spirito Fm. (Crescenti, 1969). In the southern Maiella are recorded *Alveolina* limestone (Bally, 1954) described by Vecsei et al. (1998; supersequence 4) large scale cross-bedded thick bodies with miliolids, bryozoans, red algae, larger benthic foraminifers (gypsinids, soritids) and encrusting foraminifers. The cosmopolitan *Alveolina elliptica s.l.* forms widely occurs in the Lutetian of Maiella and Gargano as well as in the whole Peri-Adriatic platform system. The well-documented penetration towards Europe through the Apulian domain of the *N. gizehensis* group (Pignatti, 1995; Blondeau et al., 1985; Fleury et al., 1985) is confirmed by the record from the Lutetian of Zakynthos.

Protected shallow-water Oligocene facies are not very common in the Mediterranean Tethys. Pignatti (1995) records larger foraminiferal assemblages from Salento with complex porcelaneous foraminifers (*Austrotrillina* spp., peneroplids, soritids), *Praerhapydionina delicata* and *Planorbulina bronnimanni*. Hottinger (1963) described porcelaneous larger foraminiferal assemblages from southern Spain (Moratella). Analogous facies are described by Sirel (2003) from southern and eastern Turkey.

CONCLUSIONS

Geological considerations

The Paleogene sedimentary sequence of the Pre-Apulian zone was investigated in Zakynthos Island. The facies sequence consists of toe of slope accumulations of resedimented shallow-water material, mainly deposited by gravity flow during repeated falls of relative sea-level below the shelf edge and erosion of the exposed Cretaceous-Paleogene sequences. The clasts are scattered within different sedimentary wedges of coarse litho-bioclastic material, forming deposits of heterometric conglomerate widely cropping out throughout the island; their study provided information on the stratigraphy and depositional environments of the eroded Cretaceous-Paleogene sequences. The facies analysis and biostratigraphic data of the studied sections showed different sedimentary facies sequences, suggesting a differential tectono-sedimentary evolution of the depositional substratum during the Late Cretaceous and the Paleogene.

Both the stratigraphic relationship of Paleogene toe-of-slope-proximal basin bodies with the Upper Cretaceous carbonate platform basement and the variability of the stratigraphic record in the various sectors of the island have evidenced an accumulation of resedimented shallow-water bioclastic material, with intercalated conglomerate episodes linked to relative sea level fall periods.

As the matrix of conglomerates did not provide any data on their age, the stratigraphic range of the conglomerates has been constrained by means of the dating of top and bottom units, with good results especially for the Lithakia and Macherado outcrops.

The Lithakia conglomerate overlies upper Cretaceous skeletal limestone, yields clasts ranging in age from the upper Cretaceous to the middle-upper Lutetian and is overlain by well-bedded upper Bartonian-Priabonian pelagic limestone. Then the age of the conglomerate is constrained into the Bartonian-Priabonian p.p. The Macherado Quarry conglomerate overlies Middle Eocene pelagic limestone, yields clasts of Oligocene age and is overlain by Aquitanian marls. Thus the age of the conglomerate is constrained as late Oligocene/early Miocene.

The dated conglomerate episodes can be related to at least two major tectonic events, known from the literature, affecting the Pre-Apulian domain during the latest Eocene /earliest Oligocene and latest Oligocene/earliest Miocene.

The clast analysis allowed distinguishing a series of microfacies which led to the recognition of depositional environments into a general model of carbonate ramp, whose architecture was influenced by repeated relative sea level changes.

The lack, elsewhere in the island, of *in situ* sequences corresponding in age and facies to the clasts sampled from the Zakynthos conglomeratic deposits, requires further considerations on the source area of the resedimented material. Considering the eastward transition to the Ionian basin, an eastern source can be excluded, whereas in Cephalonia Island a stratigraphic succession with characters similar to those of the Zakynthos conglomerate clasts crops out in the Lixouri peninsula. Thus a west to east transport of the material can be hypothesized and, taking into account the tectonic evidence, the source area had to be generally located in the westernmost unit of the Pre-Apulian zone, of which Lixouri and Zakynthos were part.

Paleontological and biostratigraphical considerations

The systematic investigation of the Paleogene larger foraminiferal assemblages from the conglomerate clasts led to the recognition of 42 different taxa (34 of specific rank).

Several taxa are rare or as yet undescribed. A new species of *Miscellanea* is described from a clast of the Kiliomeno conglomerate along with a well-preserved SBZ 2 (Selandian p.p. - Thanetian p.p.) assemblage (*Kayseriella decastroi, Globoflarina sphaeroidea*, *Helenalveolina rahaghii* nom. nud., *Haymanella paleocenica* and *Pseudocuvillierina sireli*). A taxon closely resembling the porcelaneous genus *Rhabdorites* occurs in SBZ 3 assemblages along with rarely recorded taxa, such as *Glomalveolina primaeva ludwigi*, *Fallotella kochanskae*, *Cribrobulimina* cf. *carniolica*, *Elazigella altineri*. The occurrence of abundant *Somalina* specimens from central-northern Zakynthos along with *Alveolina* markers of upper SBZ 11 (middle Cuisian) suggests a different palebiogeographic distribution of this taxon, up to day restricted to North-Eastern Africa, the Arabian peninsula and the Middle East, and possibly a wider stratigraphic distribution. In the same assemblage, very large microspheric *A. levantina* specimens noteworthy occur.

The biostratigraphic interpretation of the larger foraminiferal assemblages provides an overview of the terms represented by the clasts which can be compared in a regional/ interregional framework.

The investigated clasts of the conglomeratic deposits of Zakynthos are highly informative of the depositional environments of the Ionian Islands during the Paleogene and their fossil content is interpreted in the frame of a carbonate ramp model. Compared with Accordi and Carbone's (1992) general trend of drowning of the Paleogene Zakynthos ramp, a more articulated sedimentary history is suggested. The progressive distalization during the Paleocene is followed in the early-middle Ilerdian by the onset of pelagic sedimentation in Zakynthos and by the *Alveolina* limestone in the Lixouri peninsula. The upper Ilerdian-lower Cuisian range is not represented in either island. Beginning from the middle Cuisian, *Alveolina* and later *Alveolina* and/or *Nummulites* sandy shoals develop in Zakynthos.

The occurrence of the Upper Eocene in Zakynthos is scarcely represented by finely detrital facies, whereas the Oligocene is represented by both distal biodetrital facies and, interestingly, inner ramp (protected marine or shallow subtidal) facies rich in *Bullalveolina bulloides*. Sedimentation in western Cephalonia (Lixouri) starts again in the Bartonian and up to the middle Rupelian, with larger foraminiferal hemipelagic mudstone-wackestone followed by clayey marl and *Austrotrillina* wackestone-packstone of middle Chattian -Aquitanian age.

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APPENDIX

Systematics

On the one hand larger foraminifers possess the features of excellent biostratigraphic markers, due to their complex and distinctive morphology, often even in unoriented thin sections, on the other hand for the same reasons their morphology has first to be adequately assessed in the frame of a systematic description, with the necessity to investigate a more or less large number of differently oriented sections. The necessity to investigate the internal structures of complex larger benthics in order to describe them is an opportunity given by working on thin sections, but at the same time the process involves a not always simple 3d reconstruction of the test from 2d sections.

In the present work a typological approach (Hottinger, 1960 and the "Basle School") to classification has been adopted instead of the biometrical approach (Drooger, 1993 and the "Utrecht School"), due to the assemblages composition (radial foraminifers are scarce and poorly preserved) and hence the typological definition of the biostratigraphic framework. The typological approach is defined by the comparison of a single specimen with the type(s) deemed to represent the taxon and with a background of previous comparisons/classifications from the literature that imply the necessity to evaluate critically a relevant amount of data (Pignatti, 1998).

The suprageneric classification follows Loeblich and Tappan (1987, 1992) and for agglutinated foraminifera Kaminski (2004) and Mikhalevich (2004). A description at generic rank is given for most species, except when deemed irrelevant or linked to broad taxonomic questions which cannot be addressed here.

Fam. Haddoniidae Saidova, 1981
Gen. ***Haddonia*** **Chapman, 1898**
Type species: *Haddonia torresiensis* Chapman, 1898

Wall coarsely agglutinated. Test large, attached; early stage coiled, later uncoiled, rectilinear, irregular or branching. Chambers broad and low, gradually increasing in size. Aperture terminal, slit-shaped, with irregular inner projections.

The recent species *Haddonia torresiensis* occurs in reefal environments of the Indo-Pacific region, where it occupies subdued light microhabitats, developing dense aggregations on pebbly substrates (Matteucci, 1996). In the fossil record, *Haddonia* is rarely recorded as a minor component in *Nummulites*-rich assemblages. A possible explanation is that the *Haddonia* tests tend to be detached and disintegrated after their death in high-energy environments. This inference is supported by a study on recent assemblages from Somalia and Java, where numerous pebbles retain traces of previous rich encrustations (Matteucci, 1996).

Haddonia praeheissigi **Samuel, Köhler and Borza, 1977**
Pl. 1, Fig. 1; Pl. 3, Figs. 1, 2

1968 *Haddonia* sp. – Scheibner, Pl. 6, Fig. 5.
1977 *Haddonia praeheissigi* Samuel, Köhler and Borza, Pl. 48, Figs. 1, 2; Pl. 49, Figs. 1, 2; Pl. 50, Figs. 1, 2.
1995 *Haddonia praeheissigi* Samuel, Köhler and Borza - Moussavian and Vecsei, 219, Fig. 3.
2008 *Haddonia praeheissigi* Samuel, Köhler and Borza – Pignatti et al., Pl. 7, Fig. 5.

Material: four specimens in longitudinal section, one specimen in transversal section.

Samples: x110i, 07199 (central Zakynthos, Kiliomeno conglomerate).

Samuel et al. (1977) described *H. praeheissigi* on the basis of specimens from random thin sections, pointing out the difficulty to verify unambiguously whether the coiling of the early stage is planispiral or trochospiral. They recorded also two specimens with their chambers passing immediately from the proloculus to the uniserial stage and suggested a connection either to alternation of generation or intraspecific variability. Since *Haddonia* is sessile, test morphology is obviously affected by the substrate on which it is attached. The proloculus is large with circular section, the following chambers can be branched and develop an intricate multiserial shape.

The agglutinated material is mainly quartz, with a variable size of the grains (10-140 µm) and calcareous cement (Samuel et al., 1977). A thin, black (as seen under microscope) pseudochitinose layer occurs along the inner side of the chambers, not always preserved due to diagenetic alteration. The test is attached to the substrate directly with the pseudochitinose layer (the agglutinated layer does not occur).

The specimens of *Haddonia* from Zakynthos are up to 2.8 mm in length. The pesudochitinose layer is sometimes clearly visible. The proloculus cannot be investigated. Two specimens occur attached to a clast together with another encrusting foraminifer (an acervulinid).

H. praeheissigi differs from the morphologically similar *H. heissigi* Hagn, 1969 in its smaller size, the absence of a perforated layer and the tendency to build branched tests. The Campanian–Thanetian species *H. praeheissigi* is regarded as the ancestral form of *H. heissigi,* which has been described from the Late Eocene of the Bavarian Limestone Alps.

Paleobiogeographic distribution and stratigraphic range: Campanian-Paleocene of the Carpathian mountains (Považká Bystrica, Slovak Republic; Samuel et al., 1977), Thanetian of Central Italy (Maiella Mt.; Moussavian and Vecsei, 1995). Campanian to Thanetian.

?Fam. Spirocyclinidae Munier-Chalmas, 1877
Gen. ***Vania* Sirel and Gündüz, 1985**
Type species: *Vania anatolica* Sirel and Gündüz, 1985

Wall imperforate, finely agglutinated. Test discoidal-flabelliform, biconcave, bilaterally symmetrical, margin slightly rounded. Very small proloculus followed by a planispiral, evolute coiling stage with few undivided chambers, later chambers spreading and successively flabelliform, reniform and finally annular. The septa are simple. A subepidermal network occurs along the lateral wall, consisting of radially arranged main beams, intercalated secondary beams and short rafters parallel to the septa. Aperture consisting of two alternating rows of pores on the periphery.

Remarks: *Vania* differs from *Pseudobroeckinella* Deloffre and Hamaoui, 1969 by its intercalated secondary beams and in having a flabelliform stage. In *Broeckina* Munier-Chalmas, 1882 the subepidermal network is incomplete and does not reach the floor, whereas in *Vania* it is complete and always continuous through the whole chamber. In addition, *Broeckina* has a porcelaneous wall. *Broeckinella* Henson, 1948 has only one row of apertures and no annular chambers.

Vania differs from the coeval taxon *Saudia* Henson, 1948 by the absence of pillars. *Qataria* and *Dohaia* Henson, 1948 have a planispiral and later cyclical chambers arrangement instead of the four growth stages of *Vania. Cyclopsinella* Galloway, 1933 has a subepidermal network of anastomosing pillars. *Thomasella* Sirel, 1998 has a labyrinthic median zone with numerous pillars.

The genus is tentatively referred to the Spirocyclinidae, following Kaminski (2004); in contrast, it is excluded from the Lituolida by Mikhalevich (2004), who assigns it to the Loftusiacea.

Vania anatolica Sirel and Gündüz, 1985

Pl. 3, Figs. 3-7A, 8

1960b "Meandropsinidae" – Hottinger, Pl. 1, Fig. 2.
1967 *Broeckinella arabica* Henson – Hottinger, Figs. 34, 35, Pl. 2, Figs. 2-4.
1971 *Broeckinella arabica* Henson – Drobne and Hottinger, Figs. 3a-d, Fig. 3b; Pl. 1, Figs. 1-4; Pl. 2, Figs. 1, 2.
1974 *Broeckinella arabica* Henson – Drobne, Pl. 12, Fig. 2.
1976b *Broeckinella arabica* Henson – Sirel, Pl. 1, Fig. 13.
1978 *Broeckinella arabica* Henson – Rahaghi, Pl. 1, Figs. 1, 2.
1980 *Broeckinella arabica* Henson – Hottinger and Drobne, 200.
1983 *Broeckinella* aff. *arabica* Henson – Sirel et al., Pl. 3, Figs., 1, 2, 4.
1984 *Broeckinella arabica* Henson – Drobne, Pl. 7, Fig. C1-2; Pl. 8, Fig. C1-2.
1985 *Vania anatolica* Sirel and Gündüz, Pl. 1, Figs. 1-3; Pl. 2, Figs. 1-6; Pl. 3, Figs. 1-8.
1987 *Broeckinella arabica* Henson – Bandel and Kuss, Pl. 6, Fig. 5.
1987 *Broeckinella arabica* Henson – Drobne et al., text Fig. 3.
1988 *Broeckinella arabica* Henson – Drobne et al., 160.
1989 *Broeckinella arabica* Henson – Kuss and Leppig, text Fig. 5k.
1996 *Vania arabica* (Henson) – Jurkovšek et al., Pl. 20, Fig. 4.
1998 *Vania anatolica* Sirel and Gündüz – Sirel, Pl. 6, Fig. 10-15.
1999 *Vania anatolica* Sirel and Gündüz – Accordi et al., Pl. 14, Figs. 5, 7.
2001 *Vania anatolica* Sirel and Gündüz – Özcan et al., Pl. 4, Fig. 14.
cf. 2004 *Vania anatolica* Sirel and Gündüz – Belkhodja and Bignot, Pl. 2, Fig. 14.
2008 *Vania anatolica* Sirel and Gündüz – Pignatti et al., Pl. 7, Figs. 3, 4.

Material: four specimens in subaxial sections, one specimen in subequatorial section, two specimens in oblique section.

Samples: x110a, x110h, x110j, x110c, x110b, x110i (central Zakynthos, Kiliomeno conglomerate).

The specimens described by Sirel and Gündüz (1985) and Sirel (1998) reach a maximum diameter of 6.5 mm, a maximum thickness of 372 µm (margin) and 98 µm (centre). The equatorial diameter of the proloculus ranges from 86 to 225 µm (Sirel, 1998). The interior of the chambers in the adult ontogenetic stage is subdivided by vertical and horizontal partitions producing a subepidermal network and interseptal pillars are absent.

Paleobiogeographic distribution and stratigraphic range: western Cephalonia (Ionian Islands; Accordi et al., 1999), central Turkey, with *Glomalveolina primaeva* (Reichel, 1936) and *M.* "*juliettae*" (Sirel, 1998), Dinarides (Drobne and Hottinger, 1971), Iran (Rahaghi, 1978), Egypt, with *F. kochanskae*, *G. primaeva* and *M. meandrina* (Bandel and Kuss, 1987), or *G. dachelensis*, *G. telemetensis*, *G.* cf. *lepidula*, *H. lukasi*, *O. azilensis*, *D. simplex*, *F. kochanskae persica*, and *Orbitolites* sp.

Fam. Pfenderinidae Smout, 1954
Gen. ***Coskinon* Hottinger and Drobne, 1980**
Type species: *Coskinon rajkae* (Hottinger and Drobne, 1980)

Coskinon rajkae (Hottinger and Drobne, 1980)

Pl. 3, Figs. 10, 11, 13; Pl. 5, Fig. 25A

1971 *Lituonella* sp. 1 – Drobne and Hottinger, 230.
1972 *Dictyoconus alavensis* (Mangin, 1958) – Samuel et al., Pl. 14, Fig. 3.
1973 *Coskinolina liburnica* Stache - Bignot, Pl. 2, Figs. 8, 9.
1978 *Lituonella* n. sp. – Slišković et al., 126.
1980 *Coskinolina* (*Coskinon*) *rajkae* Hottinger and Drobne, text Fig. 2; Pl. 2, Figs. 2-4; Pl. 12, Figs. 1-28.
1984 *Coskinon rajkae* (Hottinger and Drobne) – Drobne, Pl. 7, Fig. C1-2; Pl. 8, Fig. C1-2.
1987 *Coskinolina* (*Coskinon*) *rajkae* Hottinger and Drobne – Drobne et al., Pl. 1, Fig. 3.
1988 *Coskinon rajkae* (Hottinger and Drobne) – Drobne et al., Pl. 23, Fig. 1; Pl. 26, Figs. 7, 8.
1989 *Coskinon rajkae* (Hottinger and Drobne) – Drobne et al., Pl., 3, Figs. 1, 2.
1998 *Coskinolina* (*Coskinon*) *rajkae* Hottinger and Drobne – Sirel, Pl., 9, Figs. 6-10.
1999 *Coskinon rajkae* (Hottinger and Drobne) – Accordi et al., Pl. 12, Figs. 1, 4, 11.
cf. 2001 *Coskinon rajkae* (Hottinger and Drobne) – Özgen and Akyazi, Pl. 1, Figs. 9-11.
2002 *Coskinon rajkae* (Hottinger and Drobne) – Caffau et al., Fig. 4.2, 7.
2008 *Coskinon rajkae* (Hottinger and Drobne) – Pignatti et al., Pl. 7, Figs. 6, 9b.

Material: four specimens in axial/subaxial section, many specimens in oblique section.

Samples: x110a, x110b, x110f, x110h, x110j, x110i, x110l (central Zakynthos, Kiliomeno conglomerate).

Wall imperforated, agglutinated. High conical test with axial length one and a half times the diameter of the cone (Hottinger and Drobne, 1980). Apertural face convex in the early growth stage, fairly convex or flat in the adult stage. The megalosphere is followed by about 10 chambers following a low-trochospiral arrangement, with 3-4 chambers per whorl. The successive uniserial growth stage is characterized by 7-9 (Hottinger and Drobne, 1980) or 6-7 (Sirel, 1980) chambers per 1 mm of axial cone length. Dimorphism restricted to the early ontogenetic stage: the spiral growth stage is longer in the microspheric specimens. The axial plane intercepts (cuts or passes) 4-6 pillars in correspondence of 1.3 of axial length of the test. The pillars (endoskeleton) appear later in ontogeny, in the uniserial growth stage.

The specimens from Kiliomeno (central Zakynthos) have 6-8 pillars at a cone axial length of 1.1 mm and 7-9 chambers per mm of axial length.

Remarks: *Coskinon rajkae* differs from *Coskinolina floridana* (Cole, 1941) by its smaller size, its plain or faintly convex apertural face in the adult stage and its longer juvenile stadium. *C. rajkae* differs from all the other species of *Coskinolina* by its smaller size and its juvenile stage without endoskeletal pillars (Hottinger and Drobne, 1980).

Paleobiogeographic distribution and stratigraphic range: Váh Valley (West Carpathians; Samuel et al., 1972), Western Cephalonia (Ionian Islands, Accordi et al., 1999), Golež and Barka (south-west Slovenia) Podveležje (Herzegovina) and Majevica (Bosnia) (Hottinger and Drobne, 1988), usually with *Fallotella alavensis*. Eastern Turkey, with *Elazigella altineri* Sirel, 1998, *Hottingerina anatolica* Sirel, 1998 (Özgen and Akyazi, 2001).

C. rajkae is a well known SBZ 3 marker (Selandian p.p.-Thanetian p.p.).

Fam. **Orbitolinidae Martin, 1890**

Gen. ***Fallotella* Mangin, 1954**

Type species: *Fallotella alavensis* Mangin, 1954

Wall agglutinated. Test conical with apical proloculus. Early stage with very reduced low trochospiral coiling. Exoskeleton consisting in regularly spaced radial beams perpendicular to the septa and intercalated secondary partitions. The aperture consists of few large pores at the basal surface of the cone. *Fallotella* can be distinguished from *Coskinolina* by the occurrence of secondary radial partitions and from *Dictyoconus* by lacking transverse septula (Mangin, 1954).

***Fallotella alavensis* Mangin, 1954**

Pl. 3, Figs. 14-22

1954 *Fallotella alavensis* Mangin, text Figs. 1-3; Pl. 3, Figs. 1-6.
1972 *Dictyoconus alavensis* (Mangin) – Samuel, Borza and Köhler, Pl. 14, Figs. 1, 2, 4 *non* Fig. 3; Pl. 15, Fig. 1.
1973 *Coskinolina liburnica* Stache – Bignot, Pl. 2, Figs. 1-7, 10, 11 *non* 8, 9; Pl. 3, Figs. 1-12.
1974 *Coskinolina alavensis* – Drobne, Pl. 1, Fig. 13; Pl. 12, Fig. 2.
1980 *Fallotella alavensis* Mangin – Hottinger and Drobne, text Fig. 2; Pl. 2, Figs. 1-3; Pl. 14, Figs. 1-27.
1984 *Fallotella alavensis* Mangin – Drobne, Pl. 7, Fig. d1-3.
1987 *Fallotella alavensis* Mangin – Drobne et al., Pl. 1, Fig. 3.
1995 *Fallotella alavensis* Mangin – Pignatti, 369.
1999 *Fallotella alavensis* Mangin – Accordi et al., Pl. 13 Figs. 7, 8.
2001 *Fallotella alavensis* Mangin – Özgen and Akyazi, Pl. 1, Figs. 4-6.
2002 *Fallotella alavensis* Mangin – Caffau et al., Fig. 4.2, 7.
2008 *Fallotella alavensis* Mangin – Pignatti et al., Pl. 5, Fig. 2; Pl. 7, Figs. 2, 7a.

Material: four specimens in basal/nearly basal section, four specimens in nearly axial section, many specimens in oblique/tangential section.

Samples: x110a, x110b, x110f, x110h, x110j, x110i, x110l (central Zakynthos, Kiliomeno conglomerate).

High conical test, often with subcylindrical adult growth stage. Dimorphism restricted to the early growth stage. The megalosphere is in apical position and followed by a hemispheric to reniform deuteroconch. The successive 6-9 chambers have a low-trochospiral arrangement. A uniserial growth stage follows, with 7-11 (Hottinger and Drobne, 1980) chambers per 1 mm of axial cone length. At a cone diameter of 1.15 mm there are 7-10 radial partitions (beams) per quadrant. Intercalated secondary vertical partitions occur in the distal part of the chambers. Horizontal partitions (rafters) do not occur. The endoskeleton consists of pillars. The axial plane cuts or passes 6-8 pillars at a test height of 1.25 mm. The exoskeleton appears in the later spiral stage, whereas the endoskeleton appears in the third or fourth chamber (Hottinger and Drobne, 1980). The microspheric generation is poorly known.

The specimens from Kiliomeno (central Zakynthos) have 4-5 radial partitions per quadrant at a cone diameter of 1.4 mm (n=3), with 7-10 chamber per 1 mm of axial cone length (n=3).

Paleobiogeographic distribution and stratigraphic range: from the Zagros mountains to the north-western Pyrenees across the Mediterranean region. Typical SBZ 3 marker with *G. primaeva* and *C. rajkae*.

***Fallotella kochanskae* Hottinger and Drobne, 1980**

Pl. 3, Figs. 24, 25

1980 *Fallotella* (*Fallotella*) *kochanskae* Hottinger and Drobne, text Fig. 2; Pl. 2, Fig. 4; Pl. 15, Figs. 1-14.
1987 *Fallotella kochanskae* Hottinger and Drobne – Bandel and Kuss, Pl. 6, Fig. 6.
2001 *Fallotella kochanskae* Hottinger and Drobne – Özgen and Akyazi, Pl. 1, Figs. 1-3.
2008 *Fallotella kochanskae* Hottinger and Drobne – Pignatti et al., Pl. 7, Fig. 1.

Material: one specimen in subaxial section and one in oblique basal section.

Samples: x110f (central Zakynthos, Kiliomeno conglomerate).

Test narrow conical to low conical, with a basal diameter to axial cone length ratio of 1.2-1.8 (Hottinger and Drobne, 1980). Base of the cone convex in the early growth stage, flat or nearly flat in the adult growth stage. Exoskeleton consisting of 7-8 alternating main partitions per quadrant at 1-1.8 mm of cone axial length; 10-14 chambers in 1 mm of axial length.

The endoskeleton appears early in ontogeny and is composed of pillars with alternate position respect to adjacent in chambers. The axial plane intercepts (cuts or passes) 7-10 pillars in a cone with a diameter of 1.5 mm. The proloculus is followed by two or more semiannular to annular chambers with an endoskeleton (Hottinger and Drobne, 1980).

Early growth stage and microspheric generation not yet adequately known.

The two specimens from the Kiliomeno conglomerate occur in subaxial and oblique basal sections. The subaxial section intercepts up to 7 pillars while 10 pillars can be counted in the oblique basal section (estimated diameter: 1.6 mm). 10 chambers per 1 mm of axial length.

Remarks: the spacing of the structural elements in *F. alavensis* is much wider.

Paleobiogeographic distribution and stratigraphic range: taxon originally described from the SBZ 3 *(G. primaeva* zone) of the Golež section (Istrian region, Slovenia) and from Iran, with *G. dachelensis* (*F. kochanskae persica*). Successively *F. kochanskae* has been recorded also from the Galala Mts. with *V. anatolica* and *G. primaeva* (Eastern Desert, Egypt; Bandel and Kuss, 1987).

Fam. Valvulinidae Berthelin, 1880
Gen. ***Cribrobulimina* Cushman, 1927**
Type species: *Valvulina mixta* Parker and Jones, 1865

***Cribrobulimina* cf. *carniolica* Hottinger and Drobne, 1980**

Pl. 3, Figs. 9, 12

1980 *Cribrobulimina carniolica* Hottinger and Drobne, text Fig. 2; Pl. 2, Figs 1, 3; Pl. 3, Figs. 1-11.
1988 *Cribrobulimina carniolica* Hottinger and Drobne – Drobne et al., Pl. 26, Figs. 10, 11.
2001 *Cribrobulimina carniolica* Hottinger and Drobne – Özgen and Akyazi, Pl. 1, Figs. 7, 8.

Material: two specimens in subaxial section.

Samples: x110l (central Zakynthos, Kiliomeno conglomerate).

Wall agglutinated, chambers simple, undivided, inflated with sutures depressed. Large megalosphere (0.25-0.35) followed by a spiral chamber with one interiomarginal foramen with a valvulinid tooth. The marginal aperture may already occur in late chambers of this growth stage: the apertural face of the chamber covers the umbilicus with a simple, flattened wall coarsely perforated by large foramina. In the adult, the chambers are trochospirally arranged, with 6-7 chambers per whorl (Hottinger and Drobne, 1980).

Paleobiogeographic distribution and stratigraphic range: Padriciano (northern Italy; Özgen and Akyazi, 2001), Sopada, Golež and Barka section, Slovenia (Hottinger and Drobne, 1980; Özgen and Akyazi, 2001), Majevica (Bosnia, Hottinger and Drobne, 1980). SBZ 3 (Selandian p.p.-Thanetian p.p.).

***Cribrobulimina* sp.**

Pl. 7, Figs. 1, 2

Material: two specimens in nearly axial section.

Samples: 08279 (central-northern Zakynthos, A. Pantes conglomerate).

Remarks**:** the specimens occur in a clast of the central Zakynthos conglomerate with *Somalina* sp., *Idalina* sp., *O.* cf. *complanatus*, *Opertorbitolites*, *Glomalveolina* cf. *minutula*, *Alveolina cremae*, *A. ruetimeyeri*, *A. levantina*, and *Nummulites* sp., and their age is thus Cuisian (SBZ 11).

The only coeval *Cribrobulimina* record in literature are the specimens figured by Hottinger and Drobne (1980) that occur in the late Cuisian-early Lutetian of Molat and Silba Islands (Croatia).

Fam. Spiroloculinidae Wiesner, 1920
Gen. ***Elazigella* Sirel, 1998**
Type species: *Elazigella altineri* Sirel, 1998

***Elazigella altineri* Sirel, 1998**

Pl. 5, Figs. 18, 19

1998 *Elazigella altineri* Sirel, Pl. 23, Figs. 1-18.
1999 *Elazigella altineri* Sirel – Sirel, Pl. 7, Figs., 1-18.

Material: four specimens in axial/subaxial section.

Samples: x110a (central Zakynthos, Kiliomeno conglomerate).

Wall calcareous imperforate, porcelaneous. Proloculus spherical, followed by long and low chambers planispirally arranged. Later chambers overlapping the early chambers, producing a thin umbonal region. The small proloculus is followed by five whorls or more, with at least three chambers per whorl. The single basal triangular aperture has a narrow tooth. The specimens described by Sirel (1998, 1999) reach a maximum diameter and thickness of 1.8 mm and 0.18 mm (microspheric form), 1.6 mm and 0.22 mm (megalospheric form), whereas the diameter of the small proloculus is about 40 µm.

The few specimens from Zakynthos are all megalospheric; they have a diameter and a thickness of respectively about 0.9 mm and 0.2 mm. The only one measurable proloculus has an internal diameter of 45 µm.

Remarks: *Elazigella* differs from *Spiroloculina* d'Orbigny, 1826 by having a triangular aperture with a narrow tooth, a lenticular test with a umbonal thickening on both sides, from *Vidalina* Schlumberger, 1900 and *Eoophtalmidium* Langer, 1868 on the basis of the tooth. Its assignment to the family Spiroloculinidae is confirmed in the recent reclassification of the Quinqueloculinoidea by Mikhalevich (2005).

Paleobiogeographic distribution and stratigraphic range: *Elazigella* has been recorded as yet only from central Turkey, in assemblages with *Glomalveolina primaeva* (Reichel, 1936), *Vania anatolica* Sirel and Gündüz, 1985, *Hottingerina anatolica* Sirel, 1998, *Miscellanea* cf. *yvettae* Leppig, 1988 (Thanetian limestone of Elmadilağ), with *G. primaeva, H. anatolica, "Miscellanea juliettae"* Leppig, 1988*, Haymanella paleocenica* Sirel, 1998, *Pseudocuvillierina* sp., *Broeckinella* sp. and *C. rajkae* (Thanetian limestone of Harabekayiş; Sirel, 1998, 1999).

Fam. Hauerinidae Schwager, 1876

Kayseriella Sirel, 1998

Type species: *Kayseriella decastroi* Sirel, 1998

Kayseriella decastroi **Sirel, 1998**

Pl. 1, Fig. 2

1998 *Kayseriella decastroi* Sirel, Pl. 16, Figs. 19-23; Pl. 20, Figs. 1-11; Pl. 22, Figs. 1-15.
1999 *Kayseriella decastroi* Sirel – Sirel, Pl. 1, Figs. 1-11; Pl. 2, Figs. 1-12; Pl. 3, 1-15.
cf. 2008 *Kayseriella decastroi* Sirel – Inan and Inan, Pl. 1, Figs. F, G.

Material: one specimen in axial section.

Sample: 07199 (central Zakynthos, Kiliomeno conglomerate).

Porcelaneous test, biumbilicate. Early chambers with quinqueloculine (microspheric forms) or pseudotriloculine (megalospheric forms) arrangement, later planispiral and then rectilinear, uncoiled. Single basal aperture with a tooth in the planispiral stage, terminal aperture in the uniserial stage. The coiled stage can reach a diameter of 1.2 mm (both A and B forms), the specimens with uniserial stage can reach a length of 2.1 mm. The diameter of the proloculus is 0.120-0.180 mm (Sirel, 1999).

The specimen from Zakynthos has an internal diameter of the proloculus of 75 µm and 14 chambers at a diameter of 0.85 mm of planispiral coiling stage. The foramen in the planispiral stage seems to be provided with a peristomal lip distally directed as in *G. sphaeroidea* and not with a tooth as described by Sirel (1999). Moreover, the proloculus is clearly not followed by a triloculine stage. The specimen from Zakynthos can be compared with the specimen of Pl. 1 Fig. 2 in Sirel (1999). The axial section of the specimen illustrated by Sirel (1999) in Pl. 3, Fig. 1 (upper left) shows how the first chamber communicates with the proloculus by an aperture which is axially directed, therefore not observable in a equatorial section. Successively, the coiling axis progressively becomes orthogonal to the direction of the proloculus-first chamber aperture axis.

Remarks: *Scandonea* De Castro, 1971 has thin subepidermal partitions in the uniserial stage and a cribrate aperture in both the planispiral and uncoiled stage.

Dargenioella De Castro, 1898 has a wall with three layers, a different coiling mode and does not have uniserial chambers in the uncoiled stage (Sirel, 1999).

Paleobiogeographic distribution and stratigraphic range: Selandian of central and north-eastern Turkey, with *Ankaraella trochoidea* Sirel, 1998, *Pseudocuvillierina sireli*, *Idalina sinjarica* Grimsdale, 1952, *Laffitteina bibensis* Marie, 1926, *L. erki* (Sirel, 1969); considered as endemic in the eastern Pontids SBZ 2 deposits (Inan and Inan, 2008). *K. decastroi* has been described by Sirel (1998; 1999) from the Danian of central Turkey (Peyamli hill, Kayseri) with *L. mengaudi* (Astre, 1923).

Gen. ***Idalina*** **Munier-Chalmas and Schlumberger, 1885**

Type species: *Idalina antiqua* Munier-Chalmas and Schlumberger, 1885

A trematophore occurs in the adult stage. The apertural axis is fixed throughout ontogeny.

Megalospheric forms with a miliolid bottle-neck followed by a plurilocular or bilocular chamber cycle.

Microspheric forms with a quinqueloculine chamber arrangement in the early growth stage, reduced successively to triloculine and biloculine cycles. Penultimate or ultimate chambers in both generations embracing more than half of the preexisting shell, appearing monolocular in section of appropriate orientation. The basal layer is thickened, sometimes with faint ribs, that never reach the chamber roof (Hottinger et al., 1989).

Idalina sinjarica **Grimsdale, 1952**

Pl. 4, Figs. 1-19

1952 *Idalina sinjarica* Grimsdale, Pl. 20, Figs. 11-14.
1972 *Idalina sinjarica* Grimsdale – Bignot, Pl. 24, Fig. 1; Pl. 28, Figs. 1, 2.
1974 *Idalina sinjarica* Grimsdale – Drobne, text Fig. 8c-d; Pl. 1, Figs. 1, 2, 4-13; Pl. 12, Figs. 1, 2; Pl. 13, Fig. 2; Pl. 14, Fig. 1.
1975 *Idalina sinjarica* Grimsdale – Drobne, Pls. 8, 9.
1984 *Idalina sinjarica* Grimsdale – Drobne, Pl. 7, Figs. f1-3.
1988 *Idalina sinjarica* Grimsdale – Drobne et al., Pl. 22, Fig. 1.
1992 *Idalina* aff. *sinjarica* Grimsdale – Yalçin and Inan, Pl. 2, Figs. 2-4.
1995 *Idalina sinjarica* Grimsdale – Pignatti, 369.
1998 *Idalina sinjarica* Grimsdale – Sirel, Pl. 17, Figs. 1-23.
1999 *Idalina sinjarica* Grimsdale – Accordi et al., Pl. 15, Fig 5.
2001 *Idalina sinjarica* Grimsdale - Özgen and Akyazi, Pl. 1, Figs. 12, 13.
2008 *Idalina sinjarica* Grimsdale – Pignatti et al., Pl. 3, Fig. 5; Pl. 7, Fig. 11.

Material: nine specimens in axial section, eleven specimens in equatorial/subequatorial section, many specimens in oblique section.

Samples: x110a, x110b, x110f, x110h, x110j, x110i, x110l, 07064, 07069, 07072, 07173 (central Zakynthos, Kiliomeno conglomerate).

The megalospheric specimens described by Drobne (1974) reach up to 1.9 mm (axial section) and 2.4 mm (equatorial section) with 6 or 7 whorls. The proloculus diameter range from 100 to 125 µm.

Microspheric specimens with 4-6 whorls in the triloculine stage (diameter of the long axis: 1.2–1.25 mm). The successive two whorls belong to the biloculine stage. Axial diameter 2.2 mm.

In the specimens described by Sirel (1998) the proloculus is much larger, with a mean internal diameter of 200 µm.

The internal proloculus diameter of the A form specimens from Zakynthos ranges from 167 to 195 µm with a mean of 174 µm (n=7). In one specimen (axial section) the plurilocular stage reaches a maximum diameter of 0.92 mm, total diameter 1.28 mm. Only few specimens reach the biloculine growth stage.

Remarks: *I. sinjarica* differs from *I. antiqua* (Senonian) in possessing a much thick basal layer, from *I. berthelini* Schlumberger, 1905 (Middle Eocene) in lacking striate ornamentation. *I. causae* has much lower chambers and thicker wall.

Paleobiogeographic distribution and stratigraphic range: *I. sinjarica* was first described by Grimsdale (1952) from the Sinjar Fm. (northern Iraq) with *Glomalveolina primaeva*, *Miscellanea miscella, M. stampi* (Davies, 1927)*, Saudia layirinthica* Grimsdale, 1952. *I. sinjarica* is recorded from

Slovenia with *Glomalveolina primaeva* or *Alveolina solida* Hottinger, 1960 and *Alveolina pasticillata* Schwager, 1883 (Drobne, 1974, 1975), Herzegovina (Bignot and Cadet, 1971; Hottinger and Drobne, 1980), Pyrenees (Drobne et al., 2002), central and southern Turkey (Yalçin and Inan, 1992; Sirel, 1998; Özgen and Akyazi, 2001), north-eastern Italy (Padriciano; Özgen and Akyazi, 2001) and central Italy (Maiella Mt.; Pignatti, 1995; Pignatti et al., 2008). SBZ 3-5.

***Idalina* sp.**

Pl. 7, Figs. 3, 4

Material: four specimens.

Samples: 08279 (central-northern Zakynthos, A. Pantes conglomerate).

Remarks: Several *Idalina* specimens occur in a middle Cuisian (SBZ 11) larger foraminiferal assemblage with *O.* cf. *complanatus*, *Opertorbitolites* sp., *Somalina* sp., *Glomalveolina* cf. *minutula*, *Alveolina cremae*, *A. ruetimeyeri*, *A. levantina* and *Nummulites* sp. from a clast from Agia Pantes, Zakynthos.

Drobne (1988) and Drobne et al. (2002) record *Idalina* specimens from SBZ 11 deposits of Dalmatia, with *Periloculina dalmatina* and *Fabularia* sp. 3 *sensu* Drobne et al. (2002).

Fam. Austrotrillinidae Loeblich and Tappan, 1986
Gen. ***Austrotrillina* Parr, 1942**
Type species: *Trillina howchini* Schlumberger, 1893

***Austrotrillina* cf. *paucialveolata* Grimsdale emend. Adams, 1968**

Pl. 9, Figs. 3-5

1937 *Trillina howchini* Schlumberger – Silvestri (*part.*), Pl. 5, Fig. 2.
1952 *Austrotrillina paucialveolata* Grimsdale, Pl. 20, Figs. 7-10.
1956 *Austrotrillina paucialveolata* Grimsdale – van Bellen, Pl. 3, Fig. A; Pl. 6, Fig. B.
1963 *Austrotrillina howchini* (Schlumberger) – Hottinger, Pl. 1, Figs 1, 2.
1964 *Austrotrillina paucialveolata* Grimsdale – Dizer, Pl. 2, Figs. 1, 2.
1968 *Austrotrillina paucialveolata* Grimsdale – Adams, Pl. 3, Figs. 1-6.
non 1980 *Austrotrillina paucialveolata* Grimsdale – Rahaghi, Pl. 7, Figs. 6-9; Pl. 28, Fig. 3.
non 1984 *Austrotrillina paucialveolata* Grimsdale – Rahaghi, Pl. 2, Fig. 8.

Material: three specimens in transversal section (two centered).

Samples: 07082, 07086 (northern Zakynthos, Askos-Skinaria conglomerate).

Megalospheric forms with up to 16 chambers, following a triloculine arrangement. Proloculus (internal diameter 0.08-0.13 mm) followed by a tubular second chamber. The alveoles are simple and appear late (in last four to six chambers) in ontogeny. The basal layer may be thickened, especially in the early whorls. The specimens described by Grimsdale (1952) have poorly preserved and irregularly spaced alveoles and probably include both A and B forms (Adams, 1968). The microspheric forms are poorly known.

Few specimens occurring in clasts from the north Zakynthos (Askos) conglomerate can be compared with *A. paucialveolata*. In the specimens of Pl. 9, Fig. 3 the basal layer is thickened and faint beams appear in the last two chambers. In the specimens of Pl. 9, Fig. 4 partially eroded by *Microcodium*, the basal layer is not thickened but the beams are well developed.

Remarks: Hottinger (2007) described the new ?Middle-Upper Eocene species *A. eocenica* as larger (roughly twice, with a megalosphere of 0.08-0.1 mm) and with a thicker basal layer than *A. paucialveolata*. *A. asmariensis* differs from *A. paucialveolata* in having a smaller chamber lumen and simple, closely spaced alveoles (Bassi et al., 2007).

Paleobiogeographic distribution and stratigraphic range: Peribetic lower Oligocene (Southern Spain) with *Bullalveolina bulloides* and *Praerhapydionina delicata* (Hottinger, 1963, 2007). Lower-middle Oligocene of Iraq, Iran, Spain, Turkey (Adams, 1968).

Fam. Fabulariidae Ehrenberg, 1839, emend. Drobne, 1984
Gen. ***Periloculina* Munier-Chalmas and Schlumberger, 1885**
Type species: *Periloculina zitteli* Munier-Chalmas and Schlumberger, 1885

***Periloculina slovenica* Drobne, 1974**

Pl. 4, Figs. 20-27, 29-33

1965 *Periloculina* – Cita, Pl. 63, Fig. 1.
1972 *Lacazinella* n. sp. – Bignot, Pl. 24, Fig. 2.
1974 *Periloculina slovenica* Drobne, text Fig. 12c, d; Pl. 11, Figs. 1-10; Pl. 12, Fig. 1.
1977 *Periloculina slovenica* Drobne – Khan, Pl. 2, Fig. 2.
1984 *Periloculina slovenica* Drobne – Drobne, Pl. 1, Figs. a-e; Pl. 2, Figs. a-k; Pl. 3, Figs. a-f; Pl. 4, 1-15; Pl. 5, Figs 1-7; Pl. 6, Figs. 1-9; Pl. 7, Figs. a1-2; Pl. 8, Figs. a1-2.
cf. 2001 *Periloculina slovenica* Drobne – Özgen and Akyazi, Pl. 1, Fig. 14.
2002 *Periloculina slovenica* Drobne – Drobne et al., text Fig. 1(a-e), Fig. 5(1-3).

Material: seven specimens in equatorial section (five A forms and two B forms), many specimens in oblique section.

Samples: x110a, x110b, x110f, x110h, x110j, x110i, x110l, 07173 (central Zakynthos, Kiliomeno conglomerate).

Wall porcelaneous, test ovoid, elongated in the direction of the apertural axis. Megalospheric specimens with spherical proloculus ranging in diameter from 150 to 450 µm, mean 260 µm (Drobne, 1984). The proloculus is enveloped by 3 chambers forming one cycle. Additional triloculine cycle can occur, with the cycle number inversely proportional to the proloculus size. Three or three and half whorls of biloculine chambers arrangement follows. The adult stage is monoloculine with 2 to 4 chambers.

Roughly parallel ribs are generated by thickening of the basal layer which covers the chambers floor. Randomly, the ribs reach the chamber roof. Therefore, the chamber lumen is irregularly divided.

Microspheric form with quinqueloculine arrangement of the chambers in the early growth stage, followed by a triloculine, biloculine and then by a uniloculine stage. The spiral step is somewhat irregular in the biloculine and triloculine stage and is lower in the early growth stages than in the adult stage.

The aperture develops gradually during growth, from a simple tooth to a trematophore, which is often positioned out of the pole. The test of the microspheric generation is more spherical throughout the growth stage (Drobne, 1984).

Two equatorial sections of microspheric forms were found in two clasts from the Kiliomeno conglomerate. The equatorial diameter is 4.29 mm and 4.09 mm, the axial diameter is 3.60 mm and 3.50 mm. Both specimens have 7 chambers in the unilocular stage.

The mean proloculus internal diameter (A forms) is 0.16 (n=6) measured in axial section. Almost all the investigated specimens are juvenile and do not reach the uniloculine growth stage.

Paleobiogeographic distribution and stratigraphic range: Bosnia (Drobne, 1984; Drobne et al., 1988), Slovenia (Pavlovec and Pleničar, 1981), Van area, Eastern Turkey (Sirel, 1988), SBZ 3.

? *Periloculina*

Pl. 4, Fig. 28

A centered section of a megalospheric specimen dubitatively referred to *Periloculina* occurs in a SBZ 3 clast of the Kiliomeno conglomerate. The specimen is characterized by an unusual growth pattern of small-sized terminal chambers arranged irregularly after the normal early growth stage (proloculus enveloped by cycles of chambers). The large proloculus has an internal diameter of 0.239 mm. Triloculine stage diameter: 0.68 mm. At a test diameter of 1.3 mm the biloculine stage changes in the terminal unusual pattern.

Fam. Rhapydioninidae Keijzer, 1945

Gen. ***Rhapydionina* Stache, 1913**

Type species: *Peneroplis liburnica* Stache, 1889

***Rhapydionina liburnica* (Stache, 1889)**

Pl. A, Figs. 1, 2

1889 *Peneroplis liburnica* Stache, Pl. 5a, Fig. 20.

1976a *Rhapydionina liburnica* (Stache) – Sirel, Pl. 1, Figs. 1-8; Pl. 2, Figs. 1-6.

1988 *Rhapydionina liburnica* (Stache) – Drobne et al., Pl. 24, Figs. 8-10.

1995 *Rhapydionina liburnica* (Stache) – Chiocchini et al., Pl. 26, Figs. 1-9.

1999 *Rhapydionina liburnica* (Stache) – Accordi et al., Pl. 1, Fig. c; Pl. 9, Figs. 3, 6.

2007 *Rhapydionina liburnica* (Stache) – Tewari et al., text Fig. 3a.

Material: many specimens in random section.

Samples: x1103, 07047, 07048 (central Zakynthos, Kiliomeno conglomerate).

Wall porcelaneous, test free, dimorphic. Megalospheric form with early chambers planispirally arranged. Later chambers are uniserially arranged. An enrolled flexostyle follows after the proloculus. The uniserial stage is conical or cylindrical with up to 11 chambers. planispiral stage with 4-5 chambers (Sirel, 1976a). The specimens from Zakynthos have a proloculus with an internal diameter of 70 µm and 124 µm and up to 5 chambers both in the uniserial and planispiral stage.

Microspheric form with a tiny proloculus directly followed by an uniserial, flabelliform and flattened adult stage.

Both generations present the peripheral region of the chambers subdivided by vertical radial partitions aligned from chamber to chamber that may occur even in the planispiral stage of the megalospheric specimens. Cribrate aperture at the end of the chamber in the uniserial stage.

Paleobiogeographic distribution and stratigraphic range: Maastrichtian of Turkey (Hadim region; Sirel, 1976a), Istrian region (Stache, 1889), Latium, Italy (Chiocchini et al., 1995), Slovenia (Doleja Vas; Drobne et al., 1988), Greece (Western Cephalonia, Accordi et al., 1999). *R. liburnica* occurs in the deposits of Zakynthos with miliolids and nubeculariids.

? ***Rhabdorites* sp.**

Pl. 5, Figs. 21-24, 25B, 26, 27

Remarks: Several specimens of an as yet formally not described porcelaneous, spiroliniform taxon with subdivided chambers occur in the SBZ 3 clasts of the Kiliomeno conglomerate. The early chambers are planispirally arranged, later becoming uniserial. Up to 6 chambers in the uniserial stage, radially subdivided by very thin and short vertical partitions, aligned from a chamber to the successive. The aperture is round, situated in central position at the end of the chambers of the uniserial stage. The vertical partitions are much shorter and the septa more curved if compared with *Rhabdorites*.

Fam. Alveolinidae Ehrenberg, 1839

Wall porcelaneous, test subspherical to axially elongated. Megalospheric nepiont consisting of a single spherical chamber with a flexostyle. Microspheric and undifferentiated nepionts with small spherical proloculus followed by a streptospiral coiling stage. Chambers divided into one or more rows of chamberlets by septula alternating from a chamber to the successive. The chamberlets are connected by a passage running parallel and just beneath the septum (preseptal passage). A second passage running after the septum and parallel to the preseptal passage may occur (postseptal passage). In *Subalveolina* and *Bullalveolina* the postseptal passage is replaced by one or more regular rows of "alveoli". Usually, the numerous apertures are simple, round and arranged in one or more rows parallel to the chamber suture, rarely a single large slit-like aperture occurs (e.g. in *Cisalveolina*).

Gen. ***Bullalveolina* Reichel, 1936**

Type species: *Alveolina bulloides* d'Orbigny, 1839

***Bullalveolina bulloides* (d'Orbigny, 1839)**

Pl. 9, Figs. 8, 9B-C, 11-25

1826 *Alveolina bulloides* d'Orbigny, p. 306, nom. nud.

1839 *Alveolina bulloides* d'Orbigny, p. 70.

1843 *Alveolina bulloides* d'Orbigny – Guérin – Menéville, Figs. 11, 11a, 12a, 12a-b.

1852 *Alveolina bulloides* d'Orbigny – d'Orbigny in Fornasini, 1904; Pl. 4, Fig. 11.

1937 *Bullalveolina bulloides* (d'Orbigny) – Reichel, text Fig. 13(4-6;17-19); Pl. 11, Fig. 5.

1974 *Bullalveolina bulloides* (d'Orbigny) – Hottinger, Pl. 105, Figs. 3, 6-9.

1995 *Bullalveolina bulloides* (d'Orbigny) – Pignatti, Pl. 8, Fig. 7.

1998 *Bullalveolina bulloides* (d'Orbigny) – Poignant, Pl. 3, Fig. 17.

Material: six specimens in equatorial section, six specimens in axial/subaxial section, many specimens in tangential section.

Samples: 07082, 07086, 07138, 07139 (northern Zakynthos, Askos-Skinaria conglomerate).

The specimens described by Hottinger (1974) have alternating septula. Test subspherical, with a diameter of 0.5-

0.8 mm. Proloculus diameter about 35 µm. Proloculus followed by 3-4 streptospiral whorls (2 chambers per whorl). 2, exceptionally 3 alternating rows of alveoles develop in the posterior (proximal) part of the chambers in the outer whorls. Dimorphism absent. According to Reichel (1937), the preseptal space is large, wider in correspondence of the base.

The two specimens from sample 07086 (Kiliomeno conglomerate) have a proloculus with an internal diameter of 50 µm (axial section) and 40 µm (equatorial section). The test diameter at the 5th whorl is 0.77 mm (axial section) and 0.86 mm (equatorial section). The two specimens from sample 07139 have a test diameter at the 5th whorl of 0.88 mm (axial section) and 0.95 (equatorial section). The equatorial section of Pl. 9 Fig. 25 illustrates the occurrence of two alternating rows of alveoles, each one communicating with the preseptal space through a distinct secondary intercameral foramen.

Remarks: According to Sirel (1982) the differences between *Praebullalveolina* and *Bullalveolina* are:

- the number of apertures. One row of main apertures alternating with secondary apertures in *Praebullalveolina*, whereas *Bullalveolina* has three rows of apertures in the apertural face;

- the number of the secondary intercameral foramina. In *Praebullalveolina* only one secondary intercameral foramen connects the preseptal passages with one or two rows of alveoles, whereas in *Bullalveolina* the two or three rows of alveoles communicate by two or more secondary intercameral foramina;

- the higher number of chamberlets per chamber and the more delicate internal structure of *Praebullalveolina*.

Considering the scarcity and the preservation of the available material of *B. bulloides* and the difficulty to determine the number of aperture rows, the more reliable character to distinguish the two taxa is the number of intercameral foramina.

Paleobiogeographic distribution and stratigraphic range: Early Oligocene of Western Aquitaine (France), central and southern Apennines (Italy) and Crete (Greece) (Hottinger, 1974); SBZ 21-22A (Cahuzac and Poignant, 1997).

Gen. ***Glomalveolina*** **Hottinger, 1960**

Type species: *Alveolina dachelensis* Schwager, 1883

Test globular to slightly ovate (elongation index up to 2.1; Hottinger, 1974), without flosculinization. Dimorphism absent or very slight and restricted to the early growth stage. Both generations with tiny proloculus followed by early streptospiral coiling, adult planispiral. Septula alternating. According to Loeblich and Tappan (1964; 1987), the correct author of the taxon following the ICZN is Hottinger (1962) who designated *A. dachelensis* as type species of *Glomalveolina*, because the type indicated by Reichel (1936), *Alveolina ovulum* Stache (sic), is a *nomen nudum*. Moreover, Loeblich and Tappan (1964, 1987) adopt for the work of Hottinger a date of publication (1962) different from the date stated in the work (1960). As far as we are aware, there is no evidence that 1960 is not the correct year of publication, therefore the date specification in the work is here adopted (ICZN 1999, article 21.1).

Glomalveolina primaeva **(Reichel, 1936)**

Pl. 5, Figs. 1-5, 7-13, 14B, 15, 16

1936 *Alveolina primaeva* Reichel, text Fig. 15, Pl. 9, Figs. 4-5.
1936 *Alveolina primaeva ludwigi* Reichel – Reichel, Pl. 9, Figs. 1-3.
1954 *Alveolina ovulum* Stache – Mangin, Pl. 3, Fig. 1b.
1960a *Alveolina* (*Glomalveolina*) *primaeva* Reichel – Hottinger, text Fig. 29, 12-14; Pl. 1, Figs. 3-7.
1960a *Alveolina* (*Glomalveolina*) *primaeva ludwigi* Reichel – Hottinger, text Fig. 29, 9-11; Pl. 1, Figs. 8-10.
1966 *Alveolina* (*Glomalveolina*) *primaeva* Reichel – Köhler, text Figs. 1-3.
1966 *Alveolina* (*Glomalveolina*) *primaeva ludwigi* Reichel – Köhler, text Figs. 4-6.
1968 *Alveolina* (*Glomalveolina*) *primaeva primaeva* Reichel – Samuel and Salaj, Pl. 28, Fig. 7.
1968 *Alveolina* (*Glomalveolina*) *primaeva ludwigi* Reichel – Samuel and Salaj, Pl. 28, Figs 8, 9.
1968 *Alveolina* (*Glomalveolina*) ex. gr. *primaeva* Reichel – Samuel and Salaj, Pl. 28, Fig. 10.
1971 *Glomalveolina primaeva* (Reichel) – Drobne and Hottinger, Pl. 2, Fig. 1.
1972 *Alveolina* (*Glomalveolina*) *primaeva* Reichel – Samuel et al., Pl. 72, Figs. 4, 5.
1974 *Alveolina* (*Glomalveolina*) *primaeva* Reichel – Drobne, Pl. 13, Fig. 1; Pl. 14, Fig. 2.
1976b *Alveolina (Glomalveolina) primaeva* Reichel – Sirel, Pl. 1, Figs. 6-13.
1978 *Alveolina* (*Glomalveolina*) *primaeva* Reichel – Rahaghi, Pl. 6, Figs. 1-10.
1980 *Alveolina* (*Glomalveolina*) *primaeva* Reichel – Rahaghi, Pl. 1, Figs. 13-15.
1982 *Fasciolites* (*Glomalveolina*) *primaeva* (Reichel) – Beckmann et al., Pl. 9, Figs. 1, 2.
1983 *Alveolina (Glomalveolina) primaeva* Reichel – Sirel et al., Pl, 3, Figs. 5-7.
1984 *Alveolina (Glomalveolina) primaeva* Reichel – Drobne, Pl. 7, Fig. b1-3.
1987 *Alveolina (Glomalveolina) primaeva* – Drobne et al., Pl. 1, Fig. 3.
1995 *Glomalveolina primaeva* (Reichel) – Pignatti, Pl. 4, Fig. 2.
1998 *Alveolina* (*Glomalveolina*) *primaeva* Reichel – Sirel, Pl. 29, Figs. 5, 6, 10, 11, 13.
1999 *Glomalveolina primaeva* (Reichel) – Accordi et al., Pl. 15, Figs. 8-9.
2004 *Glomalveolina primaeva* (Reichel) – Belkhodia and Bignot, Pl. 2, Figs. 13, 15.
2008 *Glomalveolina primaeva* (Reichel) – Pignatti et al., Pl. 5, Fig. 5; Pl 6, Figs. 7b, 8a-b.
2008 *Glomalveolina primaeva* (Reichel) – Scheibner and Speijer, Pl. 1, E.
2008 *Glomalveolina primaeva* (Reichel) – Sirel and Açar, Pl. 1, Figs. 1-6.

Material: many specimens both in oriented and oblique section.

Samples: x110a, x110b, x110f, x110h, x110j, x110i, x110l, 07061, 07064, 07067, 07069, 07070, 07072, 07202 (central Zakynthos, Kiliomeno conglomerate).

G. primaeva primaeva (Reichel, 1936): Test spherical, elongation index 0.9-1.1. Early growth stages may be slightly nautiloid. Diameter of the proloculus 50-70 µm (Hottinger, 1974). Köhler (1966) described specimens with a proloculus diameter of 50-110 µm. 5-6 regular whorls at a diameter of 1.45 mm. Equatorial diameter 1.7 mm at the 5th regular whorl (Hottinger, 1960).

G. primaeva ludwigi (Reichel, 1936): Test spherical, slightly nautiloid. Diameter of the proloculus about 50 µm (Hottinger, 1960). Equatorial diameter 1.1 mm at the 5th whorl (Hottinger, 1960). Coiling narrower than in *G. primaeva primaeva*.

Remarks: in the samples from the Kiliomeno conglomerate (Zakynthos), juvenile specimens (mean equatorial diameter: 0.57 mm; n=9) and small-sized forms (mean equatorial diameter: 0.69 mm; n=5) of *G. primaeva* occur. In megalospheric specimens of *G. primaeva* interpreted as adults, equatorial diameter ranges between 0.81 and 1.68 mm (mean=1.14 mm; n=19), the proloculus ranges from 55.7 to 72.6 mm (mean=65.8 mm; n=5).

Paleobiogeographic distribution and stratigraphic range: the species is known from throughout the Mediterranean and Pyrenean Basin, Southern Spain, Peribetic Basin, Italy, Slovenia, Bosnia, Croatia, Sicily, Libya and Egypt. It occurs in the Northern Alpine Basin, Carpathians and Zagros Mt. (Hottinger, 1974). Sirel (1976b, 1998, 2008) recorded *G. primaeva* from several localities of central and eastern Turkey and Accordi et al. (1999) from western Cephalonia.

Remarks on *G. primaeva ludwigi* (Reichel, 1936): A few specimens of *G. primaeva* occurring in the samples from the Kiliomeno conglomerate are characterized by a conspicuous polar depression (in axial section) and a higher number of chambers per whorl (in equatorial section). Following a conservative approach and the original description of Reichel (1936), these specimens are referred to *G. primaeva ludwigi*. *G. primaeva ludwigi* is a taxon rarely recorded from SBZ 3 from Switzerland, the Pyrenees, Slovakia and possibly Oman. The quantitative and qualitative differences between these specimens and *G. primaeva primaeva* (Reichel, 1936) co-occurring in the same assemblages suggest that *G. primaeva ludwigi* may represent a valid subspecific taxon. As stressed by Hottinger (1974), there are no practical reasons to distinguish subspecies of *G. primaeva* for biostratigraphic purposes.

Remarks on the occurrence of small-sized glomalveolinids: the co-occurrence of small-sized glomalveolinids with *G. primaeva* (Fig. 15) can be discussed in the light of the "odd partnership" hypothesis (Hottinger, 1999). The term "odd partnership" indicates the co-occurrence of specimens with identical or closely similar architecture and size differences other than dimorphism. The definition of "closely similar architecture" is linked to a common ancestor and not only to stereotypic features appearing as response to environment, which occur even in many unrelated forms. The larger, by its size and duration of lifetime more exposed partner is called "Don" for Don Quijote, the smaller one "San" for Sancho Panza (in some case, more than two partners may occur). The differences between odd partners are not only in test size, but may affect other morphological elements. Such elements are linked to size, usually at threshold values, differing in value and breadth from genus to genus (Hottinger, 1963). Thus, the smaller megalospheres of the San partners often are undifferentiated and followed by nepionic stages with a simplified nepionic structure lacking for instance an endoskeleton while the Don partners possess an embryonic apparatus in the megalospheric generation with an architecture of its own followed immediately by the full structural differentiation of the adult. The odd partnership is interpreted as a response to seasonal change in the environment and therefore more frequent in shallow water, with the occurrence of "San" partners only in shallower environments or marginal basins.

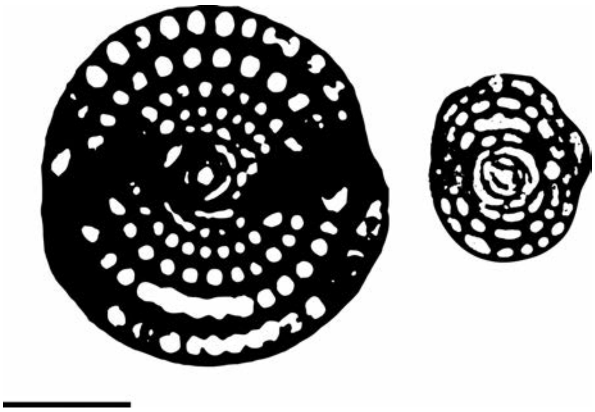


Fig. 15 - A specimen of *G. primaeva* (left) and a small-sized glomalveolinid (right) at a comparable growth stage, from the Kiliomeno conglomerate. Scale bar = 0.5 mm.

Glomalveolina and *Alveolina* are examples of "odd partnership" (e.g. *Alveolina munieri* Hottinger,1960, and *Glomalveolina delicatissima* (Smout, 1954) and testify the development of odd pairs in a period of global community maturation (GMC; Hottinger, 1998, 1999) when the phase of generic dominance is reached and specific diversification begins. This is when dimorphism in dominant species starts to be distinctive in adult shells. Hottinger (1997; 1998) indicated the SBZ 4/5 boundary (i.e., the Paleocene-Eocene boundary) as the starting point of the adult dimorphism and large shell size and SBZ 3 as the starting point of the divergence between the diversity trend of genera and species. Therefore, the question arises about the possible occurrence of odd pairs in SBZ 3. In fact, the normal-sized *Glomalveolina* specimens, with substantially undifferentiated embryo (no adult dimorphism), would be in this case the "Don", the small-sized glomalveolinids, also with undifferentiated embryo, the "San" and the SBZ 3 fauna is characterized by a high diversity of mostly monotypic genera: each population in the community produces different architectures, sometimes very unusual. The embryo differences are common but not strictly necessary to define an "odd partnership" and are linked to the proloculus size: the mode of nepionic growth in odd partners may be similar when starting with comparable proloculus sizes. The embryo of the small glomalveolinids from Zakynthos is tricky to be investigated due to the reduced size of the specimens and the embryo itself: the occurrence of differences between the eventual "odd partners" cannot be easily observed. A working hypothesis could be that there are no reasons for a further simplification of the embryo other than, eventually, a reduced streptospiral coiling stage. The main obstacle to define here a case of "odd partnerships" is represented by the low grade of maturation of the SBZ 3 communities. Further investigations seems possible in the direction suggested by the work of Baceta et al. (2005): the recovery of shallow warm-water complex ecosystems (in the specific case, the reef after the K/Pg) seems to be not slow and long-lasting as regarded by many authors but rapid and punctuated, with the bias of poor preservation and/or inaccessibility of many early Paleogene successions. In this frame, can be observed how a prominent sequence boundary is included in SBZ 3 in the light of the relation between the larger foraminifers turnover (therefore the GMC) and the sea level changes (Pignatti, 1991).

***Glomalveolina* cf. *minutula* (Reichel, 1936)**

Pl. 7, Figs. 5, 7

1936 *Alveolina minutula* Reichel, Pl. 12, Fig. 2A.

1960 *Alveolina* (*Glomalveolina*) *minutula* Reichel – Hottinger,

text Fig. 29 (23); Pl. 1, Figs. 31-33.
1964 *Alveolina* (*Glomalveolina*) *minutula* Reichel – Devoto, Pl. 1, Fig. 8.
non 1966 *Fasciolites* (*Glomalveolina*) *minutulus* (Reichel) – Montanari, Pl. 61, Figs. 3-7; Pl. 62, Figs. 1-7.
1972 *Alveolina* (*Glomalveolina*) *minutula* Reichel – Samuel et al., Pl. 73, Fig. 7.
1974 *Alveolina* (*Glomalveolina*) *minutula* Reichel – Hottinger, Pl. 32, Figs. 1-5.
1977 *Alveolina* (*Glomalveolina*) *minutula* Reichel – Drobne, text Figs. 1k-n.
2006 *Glomalveolina minutula* (Reichel) – Özgen-Erdem et al., text Fig. 5d.
2008 *Glomalveolina minutula* (Reichel) – Sirel and Açar, Pl. 3, Figs. 13-15.

Material: five specimens in axial/subaxial section.

Samples: 08279 (central-northern Zakynthos, A. Pantes conglomerate).

Test spherical, with numerous narrow chamberlets slowly increasing in height (or not increasing in the adult growth stage). Diameter of proloculus 30-65 µm. Index of elongation 0.9-1.1 (Hottinger, 1974).

Remarks: Few *Glomalveolina* specimens occur together with *O.* cf. *complanatus*, *Opertorbitolites*, *Somalina* sp., *Alveolina cremae*, *A. ruetimeyeri*, *A. levantina* and *Nummulites* sp. in a clast of the A. Pantes conglomerate (central Zakynthos). The specimens are tentatively referred to *G. minutula* because of the poor preservation of the outer whorls of the adult growth stage or the occurrence as juvenile specimens.

Moreover, several slightly elongated specimens (elongation index 1.2, n=3) are here also tentatively referred to *G. minutula*. These forms may be interpreted in the light of the rather frequent occurrence of Middle Eocene glomalveolinas related to *G. minutula* with the moderately elongated forms (elongation index 1.4 ca.) that have not yet been adequately described, as stressed by Hottinger (1974). Those forms differ from *G. lepidula* by an extremely narrow spiral and shorter chambers.

Gen. ***Alveolina*** **d'Orbigny, 1826**

Type species: *Oryzaria boscii* Defrance in Bronn, 1825

Test dimorphic, ellipsoidal to fusiform or cylindrical, rarely spherical. Septula alternating, alternating main and intercalar apertures and well-developed pre- and postseptal passages. Irregular supplementary cavities may be present in the basal layer. The basal layer may be thickened axially (elongation) and/or equatorially (flosculinization). Aperture consisting of two rows of openings on the apertural face.

Alveolina cremae **Cecchia-Rispoli, 1905**

Pl. 7, Fig. 11

1905 *Alveolina cremae* Cecchia-Rispoli, Pl. 12, Figs 3-5.
1960 *Alveolina cremae* Checchia-Rispoli – Hottinger, Pl. 10, Figs 8-10; Pl. 11, Figs. 2, 3.
1966 *Alveolina cremae* Checchia-Rispoli – Castellarin and Zucchi, Pl. 9, Fig. 2.
1974 *Alveolina cremae* Checchia-Rispoli – Hottinger, Pl. 86, Figs. 1-5.
1977 *Alveolina* (*Alveolina*) *cremae* Checchia-Rispoli – Drobne, text Figs. 30a-c; Pl. 12, Figs. 15-17, 18-20; Pl. 13, Figs. 1-5.
1992 *Alveolina* (*Alveolina*) *cremae* Checchia-Rispoli – White, Pl. 2, Figs. 8, 9.
1997 *Alveolina cremae* Checchia-Rispoli – Drobne and Trutin, Pl. 2, Fig. 11.
2006 *Alveolina cremae* Checchia-Rispoli – Özgen-Erdem et al., text Fig. 9c.
2008 *Alveolina cremae* Checchia-Rispoli – Sirel and Açar, Pl. 48, Figs 1-6.
2008 *Alveolina cremae* Checchia-Rispoli *elongata* Sirel – Sirel and Açar, Pl. 48, Figs 7-12.

Material: several specimens in axial/subaxial section.

Samples: 07279 (central-northern Zakynthos, A. Pantes conglomerate), 08222, 08242, 08245 (southern Zakynthos, Keri conglomerate).

Megalospheric specimens oval to fusiform, with very large megalosphere (380-550 µm). First 3-4 whorls globular, later 3-5 whorls slightly elongated with the shape of the test becoming fusiform (index of elongation 1.4-2). In senile growth stages the shape of the test is nearly oval.

Microspheric specimens elongated and fusiform up to 3 cm long and with an elongation index of 7 (Hottinger, 1974).

Drobne (1977) distinguished different morphotypes of *A. cremae*:

- fusiform with tight coiled spire, with a proloculus diameter of about 450-750 µm, elongation index of 2.3 (measured at the 5th whorl). The diameter of the B form is 6.0-7.5 mm at the 27th whorl.
- ovoid with loosely coiled spire, proloculus diameter of 350-600 µm and an elongation index of 1.5 at the 7th whorl.
- elongated with loosely coiled spire, ovoid with thickened basal layer in the axial direction, proloculus diameter of ca. 300-500 µm.

The specimens from Zakynthos have a mean proloculus diameter of 363 µm (n=3) and a mean elongation index of 1.4 and 1.9 at the 8th whorl, confirming the co-occurrence of two different morphotypes.

Paleobiogeographic distribution and stratigraphic range: Middle Cuisian of Slovenia, Istria and Croatia (Drobne, 1977; Drobne and Trutin, 1997), central-southern Turkey (Sirel, 2008), Sicily (southern Italy; Checchia-Rispoli, 1905), north-western Turkey (southern Eskişehir, central Anatolia; Özgen-Erdem et al., 2006), Bolca and Opicina (Northern Italy; Hottinger, 1974; Castellarin and Zucchi, 1966). Middle Cuisian, SBZ 11 (*A. dainelli* zone).

Alveolina distefanoi **Checchia-Rispoli, 1905**

Pl. 7, Figs. 6, 10

1905 *Alveolina di-stefanoi* Checchia-Rispoli, Pl. 12, Figs. 8-10.
1965 *Fasciolites distefanoi* (Checchia-Rispoli) – Montanari, Pl. 10, Figs. 6-7.
1966 *Alveolina* (*Alveolina*) *di-stefanoi* Checchia-Rispoli – Scotto di Carlo, Pl. 6, Figs. 4-6.
1974 *Alveolina distefanoi* Checchia-Rispoli – Hottinger, Pl. 83, Fig. 5; Pl. 85, Figs. 7, 8.
1977 *Alveolina (Alveolina) distefanoi* Checchia-Rispoli – Drobne, Pl. 16, Figs. 1-4; text Fig. 34b.
1988 *Alveolina distefanoi* Checchia-Rispoli – Hottinger and Drobne, Pl. 2.

Material: two specimens in axial section.

Samples: 07279 (central-northern Zakynthos, A. Pantes conglomerate).

A form: test fusiform to subcylindrical with slightly thickened basal layer. Elongation index: 2.2-2.6 (Hottinger, 1974), 1.7-1.9 (Montanari, 1965), 2.55-3.6 (Drobne, 1977). The proloculus diameter ranges from 175 to 275 µm (Hottinger, 1974), 150 to 200 µm or 250 µm (respectively for the lower

Cuisian and middle Cuisian specimens; Drobne, 1977). The early ontogenetic stage is 2-4 whorls long, the adult stage is 8-10 whorls long with few, very small secondary passages. The growth of the spire is slow with the exception of the late ontogenetic stage, when is slightly faster (Hottinger, 1974). The specimens from Zakynthos have a proloculus diameter of 138 and 150 µm.

B form: test fusiform and in later stages cylindrical and slightly truncated at the polar end. The early ontogenetic stage has 4-5 regular whorls. The equatorial swelling of the shell is compensated at the end of the elongated growth stage, after a dozen whorls. Supplementary passages are frequent in the axial region of the last elongated whorls (Hottinger, 1974). The chamberlets have a circular outline and are widely spaced, increasing in height in the late ontogenetic stage. The elongation index is 5.0 at the 13th whorl (Drobne, 1977). No microspheric specimens have been found in Zakynthos.

Paleobiogeographic distribution and stratigraphic range: lower and middle Cuisian (SBZ 10, 11) of Slovenia, Istria (Drobne, 1977), Gargano (southern Italy, Scotto di Carlo, 1966), Northern Italy, Slovenia, Greece, Southern Spain (Subbetic Tectonic Units; Hottinger, 1977), and Sicily (Montanari, 1965).

Alveolina ruetimeyeri Hottinger, 1960

Pl. 7, Fig. 8

1960 *Alveolina ruetimeyeri* Hottinger, text Figs. 84, 85; Pl. 9, Figs. 17, 18; Pl. 11, Figs. 13-15; Pl. 14, Figs. 20-22; Pl. 15, Figs. 5, 6.
1965 *Alveolina ruetimeyeri* Hottinger – Dizer, Pl. 3, Figs. 7-10.
1974 *Alveolina ruetimeyeri* Hottinger – Hottinger, Pl. 38, Figs. 1-3.
1977 *Alveolina* (*Alveolina*) *ruetimeyeri* Hottinger – Hottinger, Pl. 17, Figs. 2-5.
1987 *Alveolina ruetimeyeri* Hottinger – Bandel and Kuss, Pl. 6, Fig. 12.
1988 *Alveolina ruetimeyeri* Hottinger – Hottinger and Drobne, Pl. 2.
2005 *Alveolina ruetimeyeri* Hottinger – Özgen-Erdem et al., text Fig. 10i.
2006 *Alveolina ruetimeyeri* Hottinger – Özgen-Erdem et al., text Fig. 9d.
2008 *Alveolina ruetimeyeri* Hottinger – Sirel and Açar, Pl. 64, Figs. 5, 6; Pl. 17, Figs. 1-7.

Material: one specimen in axial section.

Samples: 07279 (central-northern Zakynthos, A. Pantes conglomerate).

A form: elongation index 1.9-2.5. The first 6-7 whorls are strongly elongated; in the later whorls elongation gradually decreases. The basal layer and the septula are relatively thick. The proloculus diameter is 200-250 µm (Hottinger, 1974). The specimens described by Drobne (1977) have a proloculus diameter of 300-400 µm, and an elongation index of 3.3 measured at the 8th whorl and 2.0-2.65 for the successive whorls.

B form: over 2 cm long and with rounded to slightly truncated poles. Elongation Index of 3.5-4.3 (Hottinger, 1974). The specimens described by Drobne (1977) have a mean elongation index of 4.5 measured at the 18th whorl and are up to 16 mm long.

Paleobiogeographic distribution and stratigraphic range: Mediterranean Tethys: Northern Italy, Sicily, Slovenia, Turkey and Southern Spain; very frequent in the marginal basins of the Alps and on the Atlantic Eocene shores (Western Aquitaine, Southern France and Asturian Basin, Northern Spain). *A. ruetimeyeri* is a marker of the *A. oblonga* zone (Hottinger, 1974). Drobne (1977) records *A. ruetimeyeri* from the early Cuisian of the Kozina section (Slovenia), with *A. canavarii,* the middle Cuisian of Žbevnica (Croatia) and Golež (Slovenia), with *A. decastroi*, of Brest-Buzet and Podpican (Croatia) with *A. rectiangula*, *A. levantina* et *A*. ex gr. *cremae*. Early-middle Cuisian, SBZ 10-11.

Alveolina levantina Hottinger, 1960

Pl. 7, Figs. 12, 13; Pl. 8, Fig. 1

1960 *Alveolina levantina* Hottinger, text Fig. 92; Pl. 10, Figs. 11, 13; Pl. 13, Figs. 10, 11; Pl. 14, Figs. 5, 7.
1967 *Alveolina levantina* Hottinger – Colacicchi, text Fig. 40.
1974 *Alveolina levantina* Hottinger – Hottinger, Pl. 49; Pl. 50, Figs. 1, 2; Pl. 51, Figs. 1-3.
1988 *Alveolina levantina* Hottinger – Hottinger and Drobne, Pl. 2.

Material: three specimens in axial/subaxial section.

Samples: 07279 (central-northern Zakynthos, A. Pantes conglomerate).

A form: specimens with moderately fusiform test and rounded poles. There are variants with tight and others with loose coil. The tightly coiled specimens tend to become fusiform and elongated, the loosely coiled specimens have a nearly oval outline in adult stages. The elongation index ranges from 2.5 to 3.5 at the 7th-10th whorl (Hottinger, 1974). Drobne (1977) recognized morphological differences in specimens respectively from the middle Cuisian, the upper Cuisian and near the Cuisian/Lutetian boundary. Test size tends to increase in time. In specimens close to the Lutetian boundary the proloculus is elongated (elongation index 3.5), the axial length is up to 14 mm and the test elongation index is much higher (3.7-5.5) than in the Ypresian forms.

B form: up to 10 cm long. Their equatorial spiral is tighter and the elongated whorls may be twice as numerous. The axial region is crowded with supplementary passages of very large diameter (Hottinger, 1974). The species was originally described by Hottinger (1960) on specimens with B form up to 5 cm of axial length. The specimens described by Drobne (1977) have an index of elongation of 6.4 and an axial diameter of 14 mm measured at the 17th whorl.

The B forms occurring in the clast from the A. Pantes outcrop (central-northern Zakynthos) reach up to 4.4 cm of axial length and 7.8 mm of equatorial diameter. The specimen of Pl. 7 Fig. 13 shows several circular borings due to bioerosion. The supplementary passages are clearly observable.

Paleobiogeographic distribution and stratigraphic range: *A. levantina* has been originally described from the ?lower Lutetian of Dalmatia by Hottinger (1960). Successively, Hottinger (1974) revised its range from *A. stipes* to *A. violae* zone (upper Cuisian-lower Lutetian), Drobne (1977) and Hottinger and Drobne (1988) indicate its range as middle Cuisian-lower Lutetian, and Serra-Kiel et al. (1998) as SBZ 11 p.p.-SBZ 12 (upper part of the middle Cuisian-upper Cuisian). Colacicchi (1967) recorded *A. levantina* from the Cuisian of Colle Sant'Egidio (eastern Marsica, Central Italy). *A. levantina* occurs in a clast of the A. Pantes outcrop (central-northern Zakynthos) with *A. cremae*, *A. ruetimeyeri*, *Orbitolites* cf. *complanatus*, *Opertorbitolites* sp., and *Somalina* sp. (upper SBZ 11). Other records include Southern Italy (Gargano Mt.), Slovenia, Croatia, Herzegovina, Greece, Lebanon, Palestine

(Nablus); it occurs also in Somalia and in the Peribetic Zone of Southern Spain (Hottinger, 1974).

***Alveolina elliptica* (Sowerby, 1840)**

Pl. 8, Figs. 3, 4

1840 *Fasciolites elliptica* Sowerby, Pl. 24, Fig. 17.
1892 *Alveolina javana* Verbeek – Verbeek, Pl. 1, Figs. 4-7.
1940 *A. elliptica nuttalli* Davies – Davies, Pl. 12, Figs. 1-4.
1960 *Alveolina elliptica* (Sowerby) – Hottinger, Pl. 12, Figs. 1-3.
1974 *Alveolina elliptica* (Sowerby) – Hottinger, Pl. 72; Pl. 73, Figs. 1, 2; Pl. 74, Figs. 1-3; Pl. 75, Figs. 1-4; Pl. 76, Figs. 1-6.
1977 *Alveolina elliptica nuttalli* Davies – Drobne, Pl. 10, Figs. 9-11.
1985 *Alveolina elliptica* (Sowerby) – Boukhary, Pl. 4, Fig. 14.
1995 *Alveolina elliptica* cf. *nuttalli* Davies – Pignatti, p. 396; Pl. 5, Fig. 3.
1999 *Alveolina* gr. *elliptica* (Sowerby) – Accordi et al., Pl. 18, Fig. 13.
2007 *Alveolina elliptica* (Sowerby) – Yaseen et al., Pl. 3, Figs. 4-6.

Material: two specimens in axial section, several fragments.

Samples: x110d, 07115 (central Zakynthos, Kiliomeno conglomerate), 08128, 08133 (central Zakynthos, Lithakia Quarry).

The microspheric form is poorly known. Megalospheric form large, oval to subcylindrical. The diameter of the megalosphere range from 150 to 200 μm. The elongation index ranges from 2.5 to 3 at a radius of 1 mm, and from 3.25 to 4 at a radius of 2 mm. The first 1-3 whorls are tightly coiled, the successive 1-5 whorls are very variably coiled, with a basal layer thickened axially and sometimes also equatorially. *A. elliptica nuttalli* Davies, 1940 have a looser spire in the adult growth stage, there are less chamberlets in 1 mm measured in axial section, the diameter of the proloculus reach 250 μm while the index of elongation is 1.5-2.5 at a radius of 1 mm (Hottinger, 1974). The specimens of *A. elliptica nuttalli* from Istria described by Drobne (1977) have a proloculus diameter of 225-300 μm and an elongation index of 1.5-1.7. According to Hottinger (1974) the distinction of species or subspecies in the group of *A. elliptica* is without practical reason.

Paleobiogeographic distribution and stratigraphic range: Indian Ocean margins, from the Persian Gulf to Indonesia, Somalia, and Madagascar. In the Mediterranean area, from Dalmatia,, Istria (Drobne, 1977), Greece (western Cephalonia, Accordi et al., 1999), Northern Italy, and Sicily. According to Hottinger (1974), the localities dated with zonal markers indicate a minimum stratigraphic range of the taxon from the *A. stipes* to *A. munieri* zone (early-middle Lutetian). Hottinger and Drobne (1988) extended the stratigraphic range of the species to the whole Lutetian. In contrast, White (1992) restricted its range to the *A. stipes* zone (middle Lutetian). In the Maiella Mt. and in the Gargano promontory, *A. elliptica* cf. *nuttalli* occurs in the upper Lutetian and even in the lower Bartonian (Pignatti, 1995). Finally, according to Serra-Kiel et al. (1998), *A. elliptica nuttalli* ranges from SBZ ?5 to ?14 and *A. elliptica elliptica* from SBZ 14 to ?18.

Remarks: The remarkable differences in the stratigraphic range recorded in the literature may be symptomatic of an as yet not adequately assessed systematic description. The *A. elliptica* group is an example of extraordinary intraspecific variability of monospecific populations which seems to affect mainly the growth patterns of the test (Hottinger and Drobne, 1988).

Gen. ***Helenalveolina*** **Hottinger, Drobne and Caus, 1989**

Type species: *Helenalveolina tappanae* Hottinger, Drobne and Caus, 1989

Spherical dimorphic alveolinids with streptospiral arrangement of the chambers at least in the early volutions (both generation). Chambers very long. Early chambers undivided, late chambers divided by alternating septula. Preseptal space wide with ribbed floor. Postseptal space short, distal margin of the apertural slit notched.

Remarks: *Cisalveolina* Reichel, 1941 is planispiral in the megalospheric generation throughout growth and there are no notches in the margin of the apertures. *Streptalveolina* Fourcade, Tardy and Vila, 1975 and "*Borelis*" *peybernesi* De Castro, 1983 have one row of tubular apertures, no slit and continuous secondary septa.

The megalospheric generation of *Pseudofabularia* Robinson, 1974 is planispiral through the whole ontogeny.

Helenalveolina can be distinguished from the lacazinids by the absence of pillars in the element subdividing the chambers and by its apertural features, from the fabulariids by the streptospiral coiling and the absence of trematophore (Hottinger et al., 1989).

***Helenalveolina rahaghii* Drobne et al., 2005 (nom. nud.)**

Pl. 1, Figs. 3, 4

1998 *Helenalveolina rahaghii* – Serra-Kiel et al., p. 289.
cf. 2005 *Glomalveolina* gr. *primaeva* (Reichel) – Tentor and Venturini, text Fig. 4.
2005 *Helenalveolina rahaghii* – Drobne et al., Figs. p. 56.

Material: three specimens in axial/subaxial section.

Samples: 07199 (central Zakynthos, Kiliomeno conglomerate).

Multilocular, streptospiral triloculine growth stage followed by adult involute planispiral growth stage. Septula present (Drobne et al., 2005). The specimens from Zakynthos have an internal (i.e., without including the wall) proloculus diameter of 48 μm, an equatorial diameter of 1.14 mm at 2 whorls and 2/3, an axial diameter of 1.65 mm (7 regular whorls). The streptospiral stage with triloculine arrangement of the chambers is composed by 4 whorls with a total diameter of 0.53 mm. In equatorial section the basal layer appears slightly thickened. The basal layer reaches maximum thickness (about 30 μm) in the middle of the chambers, whereas it is thinner in correspondence of the septum. There are 6 chambers in the last whorl.

Paleobiogeographic distribution and stratigraphic range: Since the taxon is a *nomen nudum*, the paleogeographic distribution and the stratigraphic range are not yet adequately assessed. Drobne et al. (2005) record the taxon from deposits of shallow marine environments from SW Slovenia (Dolenja Vas section), Herzegovina and Majevica (Bosnia). SBZ 2, 3 (Serra-Kiel et al., 1998; Drobne et al., 2005).

Fam. Borelidae Schmarda, 1871

Test subspheric, nautiloid or axially elongated, with streptospiral coiling in the early growth stage. Chamberlets aligned and/or alternating from chamber to chamber. Supplementary chamberlets may occur in the upper part of the chamber ("mansardes"). The basal layer may be thickened in the polar region of the test. Apertures with bifid teeth (Fleury and Fourcade, 1990).

Gen. ***Borelis*** **de Montfort, 1808**

Type species: *Borelis melonoides* de Montfort, 1808

Test globular to elongate, with a preseptal passage and septula aligned from chamber to chamber. One row of apertures. In axial section, the septula may be Y-shaped.

Dimorphism weak or absent. First whorls irregularly coiled in both generations (Hottinger, 1974).

Borelis inflata **(Adams, 1965)**

Pl. 9, Figs. 1, 2

1947 *Neoalveolina haueri* (d'Orbigny) – Bursch, text Figs. 7, 8 Pl. 1, Fig. 20; Pl. 2, Figs. 8, 11.
1965 *Neoalveolina inflata* Adams, Pl. 25, d-j.
1974 *Borelis inflata* Adams – Hottinger, Pl. 101, Figs. 1-6.
2003 *Borelis inflata* (Adams) – Sirel, Pl. 11, Figs. 10-13.
2010 *Borelis inflata* (Adams) – Benedetti, Pl. 1 Fig. 6.

Material: two specimens in axial section, three fragmented specimens in oblique section.

Samples: 08107 (central Zakynthos, Macherado Quarry).

Test subspherical, with an elongation index of 0.95-1.56, proloculus subspherical with an internal diameter ranging from 50 to 70 µm, first 3-4 whorls streptospirally coiled around the proloculus (Adams, 1965; Hottinger, 1974). At a diameter of 1 mm, the test shows 8-9 chambers per whorl (Hottinger, 1974).

Paleobiogeographic distribution and stratigraphic range: Oligocene of Indonesia, Central Persia, Crete (Greece), Central Apennines (Italy), Malta and Southern Spain (Hottinger, 1974). SBZ 23, upper Chattian (Cahuzac and Poignant, 1997). SBZ 21-22 of the Saribugday section (Elazig, Turkey; Sirel, 2003). SBZ 21 of Portella Colla (Siciliy, Italy; Benedetti, 2010).

Fam. Peneroplidae Schultze, 1854

Gen. ***Penarchaias*** **Hottinger, 2007**

Type species: *Peneroplis glynnjonesi* Henson, 1950

Peneroplis sensu Henson, 1950 has a planispiral porcelaneous test, multiple apertures and is devoid of an endoskeleton. In this frame Hottinger (2007) considered as *Peneroplis s.s.* forms with an evolute test, a single row of apertures and early, tightly coiled, seminvolute growth stages, with an umbilical depression, stressing that only the mineralized test has this involute tendency, whereas the chamber lumina are evolute and thus have no alar prolongations. Therefore Hottinger (2007) suggested a revision of the genus *Peneroplis*, indicating *Dendritina* as its involute counterpart and establishing the genus *Penarchaias* which includes involute forms characterized by alar prolongations with multiple apertures.

Penarchaias glynnjonesi **(Henson, 1950)**

Pl. 9, Figs. 6, 7, 9A

1950 *Peneroplis glynnjonesi* Henson, Pl. 9, Figs. 8-9.
1963 *Peneroplis glynnjonesi* Henson – Hottinger, Pl. 4, Figs. 3-5.
1982 *Peneroplis* aff. *glynnjonesi* Henson – Sirel and Açar, Pl. 5, Figs. 2-3, ?5, 10-11.
1982 *Dendritina* cf. *glynnjonesi* (Henson) – Bonnefous and Bismuth, Pl. 9, Fig. 5.
1997 *Peneroplis glynnjonesi* ? Henson – Sirel, Pl. 3, Fig. 18.
2004 *Peneroplis* aff. *glynnjonesi* Henson – Sirel, Pl. 35, Figs. 2-3, ?5, 10.
2006 "*Peneroplis*" *glynnjonesi* Henson – Hottinger, Fig. 7c.
2007 *Penarchaias glynnjonesi* (Henson, 1950) – Hottinger, Pl. 1, Fig. 3; Pl. 6, Figs. 2, 10; Pl. 7, Figs. 7, 8; Pl. 8, Figs. 6, 10; Pl. 9, Fig. 6; Pl. 12, Fig. 2; Pl. 13, Fig. 3; Pl. 14, Fig. 13; Pl. 15, Figs. 1-5, 9.

Material: three specimens in oblique section.

Samples: 07151, 07158 (northern Zakynthos, Askos-Skinaria conglomerate).

Wall porcelaneous, surface without ornamentation, lenticular test with involute planispiral chamber arrangement. Five to five and one-half whorls, septa short, highly curved and inclined (Henson, 1950).

Equatorial diameter of 1.4 to 2 mm for the specimens described by Hottinger (2007) and of 2.05 to 2.2 mm for those described by Henson (1950). Dimorphism unknown (Hottinger, 2007).

Paleobiogeographic distribution and stratigraphic range: Henson (1950) described *P. glynnjonesi* from the "lower-middle" Oligocene of southern France, with *Archaias operculiniformis*, *Praeraphydionina delicata*, from the "lower-middle" Oligocene of Iraq (Miliola Limestone, Kirkurk) and from the Upper Eocene of Iran. It has also been recorded from the Upper Eocene of western Turkey (Sirel and Açar, 1982) and the Oligocene of south-eastern Turkey, with *Archaias* (=*Praearchaias*) *diyarbakirensis*, *P. delicata*, *P. huberi*, *A. howchini* and *P.* cf. *thomasi* (Sirel, 1997), and from Tunisia (Bonnefous and Bismuth, 1982). SBZ 17–21, Bartonian to Rupelian (Hottinger, 2007).

Gen. ***Haymanella*** **Sirel, 1998**

Type species: *Haymanella paleocenica* Sirel, 1998

Test porcelaneous, elongated, large, with surficial coarse agglutinated grains. Spherical large megalosphere and small microsphere followed by a second chamber and then by few irregularly coiled periembryonic chambers of the early stage, later chambers becoming uniserial. Sutures straight and depressed, aperture terminal and radiate (Sirel, 1999).

The genus was originally included in the family Lituolidae de Blainville, 1827 by Sirel (1998; 1999). Later, Hottinger (2007) recognized the porcelaneous nature of the test, similar to that in agglutinating miliolids such as *Agglutinella* El-Nakhal, 1983, *Schlumbergerina* Munier-Chalmas, 1882 and *Siphonaperta* Vella, 1957. The taxonomic rank of the agglutinated test in miliolids has not been yet adequately assessed, and this resulted in an artificial distinction at subfamily level in Loeblich and Tappan's (1987) classification. Following the conservative approach of Hottinger (2007) in peneroplid taxonomy, agglutination is here considered as a character of generic rank.

Adhaerentia Plummer, 1938 (Danian of Alabama) differs from *Haymanella* in having biserially arranged early chambers. The Cretaceous genus *Acruliammina* Loeblich and Tappan, 1946 has a different aperture. *Haplophragmium* Reuss, 1860 has a rounded single aperture and a thick alveolate wall. The Cretaceous genus *Cribratina* Sample, 1932 has a subepidermal layer. *Bulbophragmium* Maync, 1952 has thick radiate vertical partitions. *Kolchidina* Morozova, 1967 (Early Paleocene) has planispirally arranged early chambers and a cribrate aperture.

Haymanella paleocenica **Sirel, 1998**

Pl. 1, Figs. 5, 6; Pl. 5, Fig. 17

1998 *Haymanella paleocenica* Sirel, Pl. 2, Figs. 1-18; Pl. 3, Figs.

1-12.
1999 *Haymanella paleocenica* Sirel – Sirel, Pl. 4, Figs. 1-18; Pl. 5, Figs. 1-13.
2008 *Haymanella paleocenica* Sirel – Özgen-Erdem, Pl. 1, Figs. 1, 2.
2008 *Haymanella paleocenica* Sirel – Pignatti et al., Pl. 5, Fig. 1.

Material: 3 megalospheric specimens in longitudinal section.

Samples: 07199, x110c (central Zakynthos, Kiliomeno conglomerate).

The megalospheric specimens described by Sirel (1998) reach a maximum length of 2.2 mm. The large, spherical megalosphere ranges from 0.2 to 0.38 μm. The early coiled stage cannot be easily investigated in the specimens from central Zakynthos, which are 1.45-1.78 mm length.

Remarks: *H. huberi* (Henson, 1950) (Middle-Upper Eocene of the Jahrum Fm., Iran and coeval strata in Oman) differs from *H. paleocenica* for the outline of the foramen, which is stellar with at least six branches of acute peristomal endings whereas in *H. paleocenica* there are only four broad radial or irregular petaloid extensions with rounded ends (Hottinger, 2007).

Paleobiogeographic distribution and stratigraphic range: Sirel (1998, 1999) described *H. paleocenica* from various localities from Turkey, with *Laffitteina mengaudi* (Astre, 1923) (=*Laffitteina bibensis*, Marie, 1926), *Kolchidina paleocenica* (Cushman, 1947), *Laffitteina* sp., *Valvulina* ? sp., *Thalmannita* sp., *Planorbulina cretae* (Marsson, 1878), *Stomatorbina* (=*Mississippina*) *binkhorsti* (Reuss, 1862), *Ankaraella trochoidea* Sirel, 1998, miliolids and algae (Haymana sections), *L. mengaudi* (Astre, 1923) (=*L. bibensis* Marie, 1926), *Valvulina*? sp., *Rotalia* sp., *Broeckella belgica* Morellet, 1922 (Ordu area, lower part of the Gölköy limestone), *Laffitteina erki* (Sirel, 1969), *Miscellanea*? *primitiva* (Rahaghi, 1983), *Pseudocuvillierina sireli* (Inan, 1988) and *Orduella sphaerica* Sirel, 1998 (Ordu area, upper part of the Gölköy limestone) and in the Yeşilyurt section of Malatya region, with *P. cretae*, *Valvulina*? sp. and algae of Danian age.

H. paleocenica has been recorded from the Selandian (SBZ 2) of the Apulian platform (Gargano), with ?*Dictyoconus* cf. *turriculus* Hottinger and Drobne, 1980, *Sistanites iranicus* Rahaghi, 1983, various small–sized *miscellaneids*, *Stomatorbina binkhorsti* (Reuss, 1862) and *Globoflarina sphaeroidea* (Fleury, 1982) (Pignatti et al., 2008).

Fam. Soritidae, 1839
Gen. ***Globoflarina* Rahaghi, 1983**
Type species: ?*Cyclorbulina sphaeroidea* Fleury, 1982

Wall porcelaneous. Test nautiloid or ovoid, dimorphic. According to Sirel (1998) the proloculus, with a flexostyle, is followed by one whorl and half of chambers with triloculine (megalospheric forms) or quinqueloculine arrangement (microspheric forms), then by three or four planispiral whorls of chambers subdivided in chamberlets by aligned secondary septa in both generations. One row of alveoles communicates with the preseptal space of the preceding chambers by only one secondary intercameral foramen in the septum. The main aperture at the base of the septum.

In the microspheric generation the last ontogenetic stage is represented by uncoiled and flabelliform chambers which are subdivided by thin, incomplete partitions; multiple openings occur between the subepidermal partitions (Fleury, 1982; Rahaghi, 1983; Sirel, 1998).

***Globoflarina sphaeroidea* (Fleury, 1982)**
Pl. 1, Figs. 7-10, 13; Pl. 5, Fig. 28

1982 *Cyclorbulina*? *sphaeroidea* Fleury, Pl. 1, Figs. 1-17; Pl. 2, Figs. 1-10.
1983 *Globoflarina sphaeroidea* (Fleury) – Rahaghi, Pl. 15, Figs. 1-8; Pl. 16., Figs. 1-12; Pl. 17, Figs. 1-12.
1995 *Globoflarina sphaeroidea* (Fleury) – Pignatti, Pl. 1, Figs. 2, 5, 6.
1998 *Globoflarina sphaeroidea* (Fleury) – Sirel, Pl. 32, Figs. 1-8; Pl. 33, 1-9; Pl. 34, 1-11.
1999 *Globoflarina sphaeroidea* (Fleury) – Accordi et al., Pl. 11, Figs. 6, 7.
2005 *Glomalveolina* gr. *primaeva* (Reichel) – Tentor and Venturini, text Fig. 3.
2008 *Globoflarina sphaeroidea* (Fleury) – Pignatti et al., Pl. 3, Figs. 1-3; Pl. 4, Figs. 7, 8; Pl. 5, Figs. 10-12.

Material: one specimen in axial section, one in equatorial section, three specimens in oblique section, several fragments.

Samples: 07199, x110h (central Zakynthos, Kiliomeno conglomerate), 08141 (central Zakynthos, Lithakia Quarry conglomerate).

Megalospheric form: test nautiloid or ovoid, index of elongation 0.75-1.1, mean equatorial diameter 0.75 mm at the 3rd whorl. Up to 5 whorls. The proloculus internal diameter range from 0.1 to 0.17 mm (n=22). The proloculus is followed by a short flexostyle, a peristomal lip distally directed occurs around the aperture (Fleury, 1982). The specimens from Zakynthos have equatorial diameter of 1.72 mm (0.67 mm at the 3rd whorls; n=1) with 17 chambers in the last whorl and axial diameter of 1-1.68 mm at the 5th whorl, 0.73 - 0.86 mm at the 3rd whorl.

Microspheric form: subspherical-ovoidal, involute, early growth stage; late growth stage flabelliform, evolute. The equatorial diameter ranges from 1.35 to 1.75 mm measured at 4 whorls and half, and the coiling is looser than in the megalospheric specimens (Fleury, 1982). Few poorly preserved specimens in oblique section from a clast from the Kiliomeno conglomerate (central Zakynthos) are tentatively interpreted as B forms. These specimens never reach the flabelliform growth stage.

In the specimens described by Sirel (1998) the elongation index is 1.75 (microspheric forms) and at least 1.5 (megalospheric forms), with 19 chambers in the last whorl of the megalospheric specimens (diameter: 1.4 mm).

Remarks: *G. sphaeroidea* differs from *Cisalveolina*, *Subalveolina* and *Praebullalveolina* on the basis of the occurring flabelliform stage with subepidermal partitions and multiple apertures.

Biometrical data on *G. sphaeroidea* may help in distinguishing SBZ 2 from SBZ 3 assemblages yielding this taxon, which is also a potential candidate marker for characterizing, as yet informally, the lower part of SBZ 3. The protoconch diameter of *G. sphaeroidea* from SBZ 2 ranges from 75 to 130 μm in 14 centered equatorial sections from Gargano, Maiella, and Cephalonia; in specimens (n=4) referred to SBZ 3 the diameter ranges from 140 to 175 μm (Pignatti et al., 2008). The only one centered equatorial section of the specimen from Kiliomeno conglomerate measures 122 μm of proloculus diameter and therefore the measure fits with the inferred age. Further investigations in order to provide statistical evidence for the biostratigraphical reliability of these values are needed, due to the possibility that environmental factors affect proloculus size, as demonstrated in extant *Operculina* (Fermont, 1977; Pécheux, 1995).

Paleobiogeographic distribution and stratigraphic range: *G. sphaeroidea* was originally described from the Paleocene of the Dervenachia massif (northern Peloponnese, Greece) by Fleury (1982). Successively, it has been recorded from the Zagros Mts. (Iran; Rahaghi, 1983), southern Turkey (Sirel, 1998) and western Cephalonia (Greece; Accordi et al., 1999). *G. sphaeroidea* has been also recorded from the Maiella Mt. (Central Italy, Pignatti, 1995; Pignatti et al., 2008) and Northern Italy (Tentor and Venturini, 2005). SBZ 2 – lower part of SBZ 3.

Gen. ***Hottingerina*** **Drobne, 1975**

Type species: *Hottingerina lukasi* Drobne, 1975

Wall porcelaneous. Test lenticular, planispiral, involute; beams occur along the whole roof of the chambers. Single aperture, triangular. Test without external ornamentation (Drobne, 1975).

Remarks: *Dendritina* d'Orbigny, 1826 has a dendritic and complexly branched aperture and the surface with numerous striae.

The meandropsinids can be distinguished on the basis of the occurring inner structures (chambers subdivided in secondary chambers) and the multiple apertures.

Reissella Hamaoui, 1963 has endoskeletal structures composed of primary and secondary beams and supplementary apertures.

The early involute ontogenetic stage of *Hottingerina* is similar to the equivalent stage of recent porcelaneous taxa such as *Archaias* de Montfort, *Puteolina* Hofker, *Cyclorbiculina* Silvestri and the Cretaceous genus *Cycledomia* Hamaoui. The differences with the taxa above arise in the adult ontogenetic stage when they become flabelliform or annular (Drobne, 1975).

Hottingerina lukasi **Drobne, 1975**

Pl. 6, Figs. 1-3

1975 *Hottingerina lukasi* Drobne, Pl. 1; Pl. 2, Figs. 1, 2; Pl. 3; Pl. 4, Figs 1-9; Pl. 5, Figs. 1-4; Pl. 6.
1986 *Hottingerina lukasi* Drobne – Kuss, Pl. 33, Fig. 28.
1989 *Hottingerina lukasi* Drobne – Kuss and Leppig, text Fig. 5f.
2008 *Hottingerina lukasi* Drobne – Scheibner and Speijer, Pl. 1, Fig. D.

Material: one specimen in oblique section and one in subaxial section; a subaxial section fragment.

Samples: 07069, 070173 (central Zakynthos, Kiliomeno conglomerate).

Wall porcelaneous. Test surface devoid of ornamentation. Uniserial arrangement of the chambers in the final ontogenetic stage of the microspheric generation. The proloculus is spherical and communicates through a bottleneck with the first regular chamber. Test size is similar in the two generations (Drobne, 1975).

Paleobiogeographic distribution and stratigraphic range: Drobne (1975) described *H. lukasi* from autochthonous or parautochthonous shallow-water assemblages from the Istrian region with *Lacazina blumenthali*, *Pseudolacazina donatae*, *Idalina sinjarica*, *Glomalveolina primaeva* and abundant operculines.

White (1994) recorded *H. lukasi* from northern Oman (Jafnayn Limestone) with *Daviesina persica*, *D. iranica* Rahaghi, 1983, *Lockhartia diversa* Smout, 1954, *Miscellanea meandrina*, *M. primitiva*, *Sakesaria nodulifera* Sander, 1962 and "*Taberina*" *daviesi* Henson, 1950 (Zone 1 *sensu* White, 1994) and *M. iranica*, *M. globularis*, *M. meandrina, A. primaeva ludwigi* (=*Glomalveolina primaeva ludwigi*), *Assilina* cf. *arenensis*, *A. dandotica*, *Lacazina oetzemueri* (=*Pseudolacazina oetzemueri*), *L. diversa* and "*T.*" *daviesi* (Zone 2 *sensu* White, 1994). Zone 1 is identified with the *G. primaeva* Zone while Zone 2 is defined as ranging from the *G. primaeva* Zone to the *A. cucumiformis* or lower *A. ellipsodalis* Zone (White, 1994).

Kuss (1986) recorded *H. lukasi* from the Monastery of St. Anthony (Eastern Desert, Egypt) with *G. dachelensis* (Schwager, 1883).

H. lukasi has been also recorded from the Galala Mts. (Egypt) by Kuss and Leppig (1989), with *M. rhomboidea*, *A. dachelensis*, *G. telemetensis*, *G. levis*, *G.* cf. *lepidula*, *Operculina azilensis*, *S. labyrinthica* and *A. yvettae*, and Scheibner and Speijer (2008).

Hottingerina anatolica **Sirel, 1998**

Pl. 3, Fig. 7B; Pl. 5, Figs. 29-33

1998 *Hottingerina anatolica* Sirel, Pl. 24, Figs. 1-8; Pl. 25, Figs. 1-9.
1999 *Hottingerina anatolica* Sirel – Sirel, Pl. 8 Figs. 1-8, Pl. 9; Figs. 1-9.
1999 *Hottingerina* cf. *anatolica* Sirel – Accordi et al., Pl. 13, Fig. 5.
2008 *Hottingerina anatolica* Sirel - Pignatti et al., Pl. 5, Fig. 7; Pl. 7, Figs. 9a, 10.

Material: 9 specimens in axial/subaxial section.

Samples: x110b, x110c, x110f, x110j, x110h, x110i, 07064 (central Zakynthos, Kiliomeno conglomerate).

Wall porcelaneous. Planispiral coiling with five of four whorls. Short and thin subepidermal partitions occur inside the chambers.

The specimens described by Sirel (1998; 1999) have a proloculus diameter of 88-125 µm.

Two specimens from Zakynthos have a proloculus diameter of 91 µm and 107 µm (axial section).

Remarks: *H. anatolica* differs from *H. lukasi* in having shorter and thinner subepidermal partitions.

Paleobiogeographic distribution and stratigraphic range: *H. anatolica* is described by Sirel (1998) from the Thanetian of the Eastern Turkey, with *V. anatolica*, *C. rajkae*, *G. primaeva, H. paleocenica* and *Miscellanea* "*juliettae*". The taxon is recorded also from Cephalonia (Accordi et al., 1999).

Gen. ***Orbitolites*** **Lamarck, 1801**

Type species: *Orbitolites complanatus* Lamarck, 1801

Orbitolites **cf.** ***complanatus*** **Lamarck, 1801**

Pl. 8, Figs. 2, 5

1801 *Orbitolites complanata* Lamarck, p. 376.
1959 *Orbitolites complanatus* Lamarck – Auboin and Neumann, Pl. 3, Fig. 5.
1961 *Orbitolites complanatus* Lamarck – Lehmann, text Figs. 8, 14, 18, 19, 20; Pl. 1, Figs. 1-4; Pl. 2, Figs. 1-3; Pl. 3, Figs. 1-6.
1965 *Orbitolites complanatus* Lamarck – Montanari, Pl. 15, Figs. 6-8.
2002 *Orbitolites complanatus* Lamarck – Melis et al., text Fig. 5.3.2.

Material: several specimens in subaxial section.

Samples: 07279 (central-northern Zakynthos, A. Pantes conglomerate), x110d, 07048 (central Zakynthos, Kiliomeno conglomerate).

Test large, discoidal, slightly biconcave. Nucleoconch composed of a large proloculus and a reniform deuteroconch. The successive chambers are cyclic and subdivided in chamberlets alternating from cycle to cycle and ogival in equatorial section. The chamberlets belonging to the same cycle are not connected, whereas those belonging to successive cycles are connected through a crosswise oblique stolon system.

The A forms described by Lehmann (1961) have about 50-60 cyclic chambers; the diameter ranges from 4 to 10 mm. Lehmann's (1961) description of the shell architecture of *O. complanatus* is still unsurpassed. A systematic revision of the upper Cuisian-Lutetian forms, usually referred to *Orbitolites complanatus*, is still pending.

O. cf. *complanatus* occurs in a clast of the A. Pantes outcrop (central-northern Zakynthos), with *Cribrobulimina* sp., *Opertorbitolites* sp., *Somalina* sp., *Glomalveolina* cf. *minutula*, *Alveolina cremae*, *A. ruetimeyeri*, *A. levantina* and *Nummulites* sp. See *Somalina* for ecological remarks.

Gen. ***Opertorbitolites*** **Nuttall, 1925**

Type species: *Opertorbitolites douvillei* Nuttall, 1925

***Opertorbitolites* sp.**

Pl. 7, Fig. 9

Material: three specimens in axial/subaxial section.

Samples: 07279 (central-northern Zakynthos, A. Pantes conglomerate), 08245 (southern Zakynthos, Keri conglomerate).

Wall porcelaneous. Test lenticular, similar to *Orbitolites* in shape. Thick closely appressed laminae completely cover the polar region and may produce an umbonal thickening.

Opertorbitolites occurs in a clast of the A. Pantes outcrop (central-northern Zakynthos) with *Cribrobulimina* sp., *Orbitolites* cf. *complanatus*, *Somalina* sp., *Glomalveolina* cf. *minutula*, *Alveolina cremae*, *A. ruetimeyeri*, *A. levantina* and *Nummulites* spp.

Gen. ***Somalina*** **Silvestri, 1939**

Type species: *Somalina stefaninii* Silvestri, 1939

***Somalina* sp.**

Pl. 6, Figs. 7-14

Material: ten specimens in axial/subaxial section, one specimens in a centered oblique section.

Samples: 07279 (central-northern Zakynthos, A. Pantes conglomerate).

Wall porcelaneous. Test discoidal to lenticular, cyclic chambers subdivided into chamberlets as in *Orbitolites,* with a crosswise oblique stolon system and possibly lateral stolons too.

Prominent lateral laminae as in *Opertorbitolites* enclose numerous chamberlet-like cavities, stolons connect the cavities to the main equatorial chamber layer (Loeblich and Tappan, 1987).

The stolons (= lateral canals of Hottinger and Krusat, 1972) begin from the lateral angle of the proximal part of the annular chamber, where the floor is depressed due the occurrence of the suture comprised between the two chamberlets of the previous annular chamber. The stolons radially develop in proximal direction and then they are limited by the laminae. Hottinger and Krusat (1972) formulated two hypotheses about the stolon pattern: the stolons terminate in correspondence of the laminae of the successive annular chambers or communicate outside producing a multiple aperture. The first hypothesis is rejected: the genesis of the lateral cavities would be incomprehensible without the possibility of the protoplasm to flow through the laminae: the canals may be analogues to those developed in some Eocene alveolinids, in which the supplementary cavities perforate the thickened basal layer of the elongated forms and produce supplementary apertures at the poles.

Phylogenetic remarks**:** Hottinger in Hottinger and Krusat (1972) described *Opertorbitolites transitorius* from the late Ilerdian (SBZ 9) of northern Spain as representing a transitional form between *Opertorbitolites* and *Somalina* due to the occurrence of radial canals through the structure of the lateral laminae. The *O. gracilis* – *O. biplanus* lineage is succeeded in the late Ilerdian by *O. transitorius* and successively, in the Eocene, by *Somalina*. The upper limit of *O. transitorius* stratigraphic range is not well known.

Because of the occurrence of partially vacuolate lateral laminae, White (1992) considered *Opertorbitolites transitorius* Hottinger in Hottinger and Krusat, 1972 as *Somalina transitorius* (*recte: S. transitoria*). Moreover, she redefined the group subdivision operated by Lehmann (1961), who divided *O. latimarginalis* as a form with equatorial chambers increasing in size towards the periphery from the forms with low equatorial chambers through the whole test, and then recognized two groups: with biplanar test and only slightly thickened lateral laminae (*O. biplanus* group) or with lenticular test and strongly thickened lateral laminae (*O. douvillei* group). Due to the occurrence of lenticular forms with slightly thickened lateral laminae and forms with strongly thickened lateral laminae but no lenticular test, White (1992) recognized the *O. douvillei* group which includes all the forms with relatively low equatorial chambers and the *O. latimarginalis* group, which includes the forms with chambers increasing in height toward the periphery. White (1992) also suggested her new species *S. hottingeri* (?*A. violae* – *A. stipes* zone, ?Late Ypresian-early Lutetian of Oman) as ancestor of *Somalina s.s.* and interpreted it as derived from the *O. douvillei* group due to the low equatorial chambers, while *S. transitorius* is connected with the *O. latimarginalis* group, due to the equatorial chambers increasing in size. The lower boundary of the *Somalina s.s.* range is thus tentatively defined as occurring in the *A. violae* zone.

The reconstruction of the phylogeny of the group by White (1992) makes the genus *Somalina* polyphyletic: it would have originated a first time (*S. transitorius*) in the late Ilerdian from the *O. latimarginalis* group (*sensu* White, 1992) and later a second time (*S. hottingeri*) in the late Ypresian from the *O. douvillei* group (*sensu* White, 1992).

As concerns the phylogeny proposed by White (1992), there is no reason to assume that vacuolate lateral laminae did not arise independently in different, phylogenetically close groups of orbitolitids as stereotypic feature linked to an environmental response, so the inclusion of *O. transitorius* in *Somalina* on the base of this character is questionable: eventually a new genus may be established.

Paleobiogeographic distribution and stratigraphic range (Fig. 16): Following Hottinger and Krusat (1972) and considering *O. transitorius* as possible ancestor of *Somalina*,

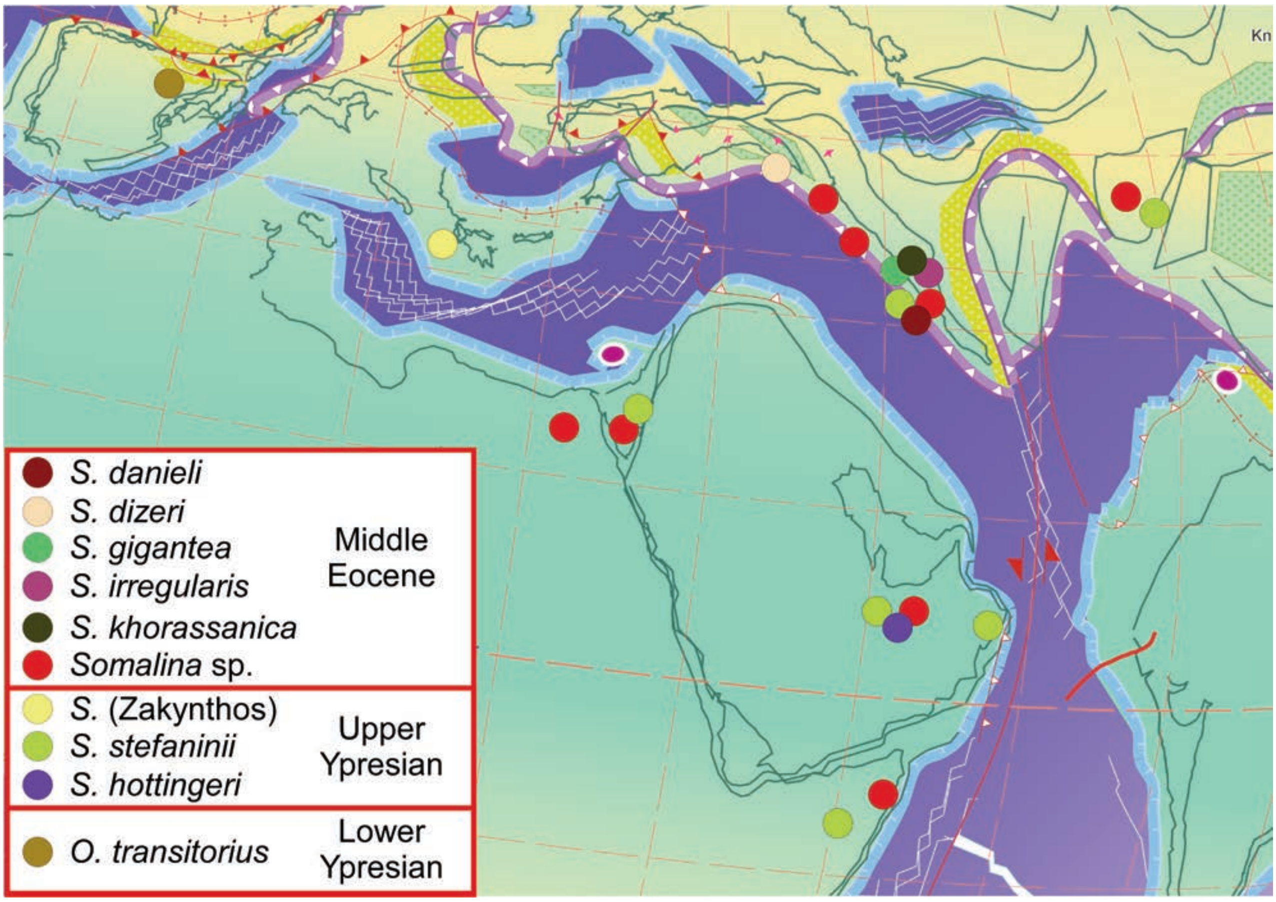


Fig. 16 - Paleobiogeographic distribution of *Somalina*. The range of the genus was previously restricted to the Middle Eocene of North Africa, the African Horn, the Arabian peninsula and the Middle East. The occurrence of *Somalina* from Zakynthos reported here represents the westernmost record of the genus, as the Ilerdian *O. transitorius* from the Pyrenees is not regarded as congeneric. Paleogeographic map adapted from Stampfli and Borel (2004).

the lineage leading to *Somalina* appears first in the western Mediterranean area and successively migrated towards the Middle East. However, the precise age of the earlier records from the Middle East, Northern Africa and Somalia is still poorly known.

In her unpublished Ph.D. thesis Horstmann (1967) recorded *Somalina* from the Ypresian of southern Zakynthos. *Somalina* sp. occurs in a clast of the A. Pantes outcrop (central-northern Zakynthos) with *Cribrobulimina* sp., *O.* cf. *complanatus*, *Opertorbitolites* sp., *Glomalveolina* cf. *minutula*, *Alveolina cremae*, *A. ruetimeyeri*, *A. levantina*, and *Nummulites* spp. Upper SBZ 11 (middle Cuisian).

Fam. Mississippinidae Saidova, 1981
Gen. ***Stomatorbina*** **Dorreen, 1948**
Type species: *Lamarckina torrei* Cushman and Bermúdez, 1937

Stomatorbina binkhorsti **(Reuss, 1862)**
Pl. 1, Fig. 11

1862 *Rosalina binkhorsti* Reuss, Pl. 2, Fig. 3a-c.
1972 *Mississippina binkhorsti* (Reuss) – Samuel et al., Pl. 36, Figs. 1-4.
1979 *Mississippina binkhorsti* (Reuss) – Dieni et al., Pl. 50, Fig. 3.
1991 *Mississippina binkhorsti* (Reuss) – Radoičić, Pl. 6, Figs. 4-7.
1998 *Mississippina? binkhorsti* (Reuss) – Sirel, Pl. 1, Figs. 2-4, 6, 8, 9.
1999 ?*Stomatorbina binkhorsti* (Reuss) – Accordi et al., Pl. 13, Fig. 6.
2001 *Mississippina binkhorsti* (Reuss) – Özgen and Akyazi, Pl. 3, Fig. 4.
2008 *Stomatorbina binkhorsti* (Reuss) – Pignatti et al., Pl. 6, Figs. 1, 2.

Material: one specimen in equatorial section, seven specimens in axial/subaxial section.

Samples: 07199, x110a, x110f, x110j, x110l, x110i, 07070, 07072 (central Zakynthos, Kiliomeno conglomerate).

Wall calcareous, radial, hyaline, with an inner additional granular secondary layer, that appears dark as seen in thin section. Test low trochospiral, unequally biconvex, periphery slightly rounded. The sutures are thick, curved and elevated on the dorsal side, depressed and nearly radial on the umbilical side.

The hyaline layer has been initially interpreted as aragonitic. X-ray analysis has evidenced the calcitic nature of the test (McGowran, 1966).

Remarks: The taxon can be distinguished from *Sistanites iranicus* on the basis of the occurring double-layered wall. Moreover, the ventral side of *S. iranicus* shows a large umbilical opening filled by both horizontal and vertical plates (Sirel, 1998).

Mississippina Howe, 1930 has radial, slightly curved and depressed sutures on both sides.

Paleobiogeographic distribution and stratigraphic range: The oldest records of *S. binkhorsti* are from the upper

Maastrichtian (McGowran, 1966). It is abundant in the Paleocene deposits (SBZ 1- SBZ 4) of the Dinarids (Bosnia), with *Anatoliella ozalpiensis*, *R. perovalis*, *Miscellanea* sp. and dasyclads (Radoičić, 1991), and western Cephalonia, with *C. rajkae*, *F. alavensis*, *G. sphaeroidea*, *S. iranicus*, *G. primaeva*, *I. sinjarica*, *D. seunesi*, *P. cretae*, *Thalmannita* sp., *Hottingerina* sp. and crustal algae (Accordi et al., 1999). Sirel (1998) recorded *S. binkhorsti* from the Danian-Thanetian of central Turkey.

Fam. Cymbaloporidae Ehrenberg, 1839
Gen. **Fabiania Silvestri, 1924**
Type species: *Patella* (*Cymbiola*) *cassis* Oppenheim, 1896

***Fabiania cassis* (Oppenheim, 1896)**
Pl. 8, Fig. 8

1896 *Patella* (*Cymbiola*) *cassis* Oppenheim, Pl. 2, Figs. 2, 3.
1926 *Fabiania cassis* (Oppenheim) – Silvestri, Pl. 1, Figs. 1-6.
1959 *Fabiania* cf. *cassis* (Oppenheim) – Aubouin and Neumann, Pl. 2, 3.
1993 *Fabiania cassis* (Oppenheim) – Sirel and Açar, Pl. 2, Figs. 14, 16, 22.

Material: rare specimens in subaxial section.

Samples: 07179 (central Zakynthos, Kiliomeno conglomerate).

Thick calcareous perforated wall. Test conical to flabelliform with a hollow center and a diameter up to 4 mm. The early stage is characterized by three globose chambers, followed by few chambers of about one-half coil length. Adult chambers added in cyclic series with the interior divided by short horizontal and vertical partitions arising from the outer wall. The chambers are in turn further subdivided by secondary partitions.

Paleobiogeographic distribution and stratigraphic range: Middle-Upper Eocene, Mediterranean region (Spain, France, Italy, Turkey), India and Western Pacific.

Fam. Rotaliidae Ehrenberg, 1839

***"Plumokathina"* sp.**
Pl. C, Fig. 2

Test lenticular, low trochospiral, umblical side with a large umbilical plug and numerous interlocular spaces as plume-shaped deep incisions. *Kathina* has a smaller umbilical plug and reduced interlocular spaces (Peybernès et al., 2000). The genus, as yet a nomen nudum, is being described by Prof. L. Hottinger.

Fam. Nummulitidae de Blainville, 1827
Gen. ***Nummulites* Lamarck, 1801**
Type species: *Camerina laevigata* Bruguière, 1792

***Nummulites gizehensis* (Forskål, 1775)**
Pl. 8, Figs. 9-10

1775 *Nautilus Gizehensis* Forsskål, p. 140.
1840 *Nummulites gyzensis* Ehrenberg, p. 93.
1951 *Nummulites gizehensis* (Forskål) – Said, text Figs. 2-8.
1981 *Nummulites gizehensis* (Forskål) – Schaub, Pl. 36, Figs. 26-52; Pl. 37, Figs. 1-13; tab. 6, Fig. d.
1985 *Nummulites gizehensis* (Forskål) – Blondeau et al., text-Plate, Figs. 5, 6, 10-16.

Material: two specimens in axial section, many specimens in random section, fragments.

Samples: x110d, 07059 (central Zakynthos, Kiliomeno conglomerate).

A form: diameter 3-8 mm, thickness 1-3 mm. Septal filaments radial to convoluted, with or without granules, arranged more or less spirally. Diameter of the megalosphere: 0.6-1.2 mm (equatorial section). The spiral growth is faster in the first 2 or 3 whorls than in the successive whorls. 7 whorls at a radius of 2.5-3.5 mm, 5 whorls with a radius of 2.5-3 mm, 3 whorls with a radius of 2 mm. Chambers with irregular shape and isometric or higher than longer in the early whorls, more regular and isometric or longer than higher in the successive whorls.

B form: diameter 20-40 mm, thickness 3-8 mm. Test flat, surface regular or faintly undulated. In the adult growth stage, the septal filaments are meandriform. The neotype has 34 whorls at a radius of 16.5 (Schaub, 1981). Septa regularly shaped, nearly orthogonal to the chamber floor up to 2/3 of the chambers, then inclined in respect to the chamber roof (Schaub, 1981).

Paleobiogeographic distribution and stratigraphic range: According to Blondeau et al. (1985), the *Nummulites gizehensis* group was originally restricted to Tunisia, Lebanon, Libya and Egypt. The successive dispersal of the group included Algeria, Senegal, New Guinea and toward the east, Iraq and Iran (through Lebanon, Syria, the Negev desert and the Galilee region). To the north, the group reached Northern Italy and Hungary. The Apulian platform and the pre-Apulian region played a key role for the dispersal of this group as well as for several other taxa.

Nummulites gizehensis is a SBZ 14-16 marker.

***Nummulites cuvillieri* Sander, 1962**
Pl. 8, Figs. 6, 7

1962 *Nummulites cuvillieri* Sander, Pl. 1, Figs. 1-13.
1985 *Assilina cuvillieri* (Sander); *non Assilina cuvillieri* Schaub – Boukhary, Pl. 3, Figs. 18-26.

Material: two specimens in axial section.

Samples: x110d (central Zakynthos, Kiliomeno conglomerate).

A form: test lenticular, usually with a depression in the central region. The size and arrangement of the granules are variable. Mean diameter of about 0.08-1 mm, 6-8 sinuous septal filaments per quadrant. The proloculus diameter ranges from 0.05 to 0.075 mm. The height of the chambers increases gradually. According to Sander (1962), the first and second whorl are involute, whereas the third and fourth are partially evolute.

On the basis of this character and the occurrence of granules superimposed on the filaments, Boukhary (1985) referred the species to the genus *Assilina*. Later, Boukhary et al. (1996) and Boukhary and Alsharhan (1998) recorded it as *Nummulites cuvillieri* from the Paleogene of Qatar.

The specimens described by Boukhary have a diameter which ranges from 1.7 to 2.3 mm with a proloculus diameter of 0.5-1 mm, the spiral lamina and the septa are thick, the latter forming an angle of about 20°. Chambers are higher than longer.

B form: diameter/thickness ratio ranging from 2.0 to 2.6, mean thickness of 2.6 mm. 6-8 whorls, 28-32 chambers in the last whorl, with septa slightly inclined at the base (10°-15°). Coarse granules occur over all the test surface. The central depression of the test can be observed in axial section (Boukhary, 1985), and this is an easily recognizable species in rock thin sections.

Paleobiogeographic distribution and stratigraphic range: Middle Eocene of western Qatar (Dukhan Member of the Dammam Fm.; Boukhary, 1985), eastern Saudi Arabia (Hasa Series, Dammam Fm.; Sander, 1962).

Gen. ***Ranikothalia*** **Caudri, 1944**
Type species: *Nummulites nuttalli* Davies, 1927

Ranikothalia **cf.** ***bermudezi*** **(Palmer, 1934)**
Pl. 6, Fig. 6

1934 *Operculina bermudezi* Palmer, Pl. 12, Figs. 3, 6-9.
1957 *Operculinoides bermudezi* (Palmer) – Sachs, Pl. 14, Figs. 1-27.
1962 *Ranikothalia bermudezi* (Palmer) – Hanzawa, Pl. 5, Figs. 1-14.
1969 *Camerina catenula* (Cushman and Jarvis) – Cole, Pl. 17, Figs. 1-4, 6, 8.
1969 *Ranikothalia bermudezi* (Palmer) – Butterlin and Monod, Pl. 2, Figs. 1, 2; Pl. 4, Figs. 1, 2, 5-9.
1979 *Ranikhotalia bermudezi* (Palmer) – Amard and Blondeau, Pl. 1, Figs. 5-7.
1982 *Ranikhotalia* cf. *bermudezi* (Palmer) – Beckmann et al., Pl. 9, Figs. 1, 2.
2007 *Ranikhotalia bermudezi* (Palmer) – Serra-Kiel et al., Pl. 3, Fig. 7; cf. Pl. 3, Fig. 5, 6.

Material: one specimen in nearly axial section.

Sample: 07070 (central Zakynthos, Kiliomeno conglomerate).

Megalospheric forms with 9 chambers in the first whorl, 17-18 in the second and 23 in the third. The mean diameter and thickness are 2.1 mm and 0.8 mm with usually 2 ½-3 whorls. Diameter up to 3.8 mm and thickness up to 1.4 mm. The T/D ratio is 0.25-0.6 (mean: 0.38). Protoconch diameter up to 420 µm. Involute planispiral coiling with the rare exception of the last whorl, which can be semi-evolute and at the same time, with a very thin wall. Well-developed central pillars. Thick marginal cord, with few large radial canals.

Microspheric forms with a diameter of 6-10 mm and thickness of 0.9-1.1 mm. At least 5 whorls. Test planispiral involute in the early whorls, then semi-evolute. Thick marginal cord as in the A form (Butterlin and Monod, 1969).

The specimen in subaxial section from Zakynthos measures 4 mm in diameter (3rd and last whorl) and 0.93 mm in axial thickness.

Remarks: Hottinger (1977) regarded *R. bermudezi* as synonym of *R. sindensis* (Davies, 1927) as well as more or less all the American species of *Ranikhotalia*. In contrast, Butt (1991) regrouped R. *bermudezi* and *R. nuttalli* in the *Nummulites*-like forms with septal filaments and thick marginal cord, stressing the possibility that these taxa are synonym and distinguishing *R. sindensis* as a complanate evolute form without septal filaments, whereas *R. nuttalli* is involute with septal filaments. Butterlin and Monod (1969) distinguished *R. bermudezi* from *R. sindensis* by the less involute coiling and the flatter test of the former and pointed out the affinities between the A form of *R. bermudezi* and *R. thalicus*.

Paleobiogeographic distribution and stratigraphic range: From the Middle East to the Central-Southern America, SBZ 3 (Selandian p.p.-Thanetian p.p.; Serra-Kiel et al., 1998). Butterlin and Monod (1969) and Butterlin (1987) extended the stratigraphic range of *R. bermudezi* up to the Early Eocene. De Mello e Sousa et al. (2003; 2009) recorded the species from the Late Paleocene-Early Eocene (P3-?P6 zone of Berggren et al., 1985) of the Amapà Fm. (Foz Basin, Brazil).

Gen. **?*Assilina***
Pl. 6, Fig. 4, 5

Material: one specimen in axial section.

Sample: 07072 (central Zakynthos, Kiliomeno conglomerate).

An *Assilina*-like form occurs in a clast from the Kiliomeno conglomerate with abundant *G. primaeva*, *S. binkhorsti* and small rotaliids (SBZ 3). The diameter and thickness of the test are 2.71 mm and 0.9 mm (3 whorls). Very short alar prolongations and a thin marginal cord occur. The wall of the last whorl is much thinner. This taxon resembles *Daviesina* (?) sp. indet. B of Beckmann et al. (1992; Pl. 9, Fig. 10) from deposits of the Giglio Mt. (Northern Italy) referred to the lowermost *G. pseudomenardi* zone (P4 zone, Olsson et al., 1999).

Fam. Miscellaneidae Sigal, 1952
Gen. ***Miscellanea*** **Pfender, 1935**
Type species: *Nummulites miscella* d'Archiac and Haime, 1854

Wall hyaline, test with planispiral arrangement of the chamber. Pillars restricted to the central part of the test in the early evolutionary stage and then spread over the lateral test surface.

The chambers communicate through a single intercameral foramen (*Miscellanea*), two or multiple foramina (*Miscellanites*, *Ornatononion*; Hottinger, 2009). Subspherical protoconch followed by a reniform protoconch. A pair of spiral canals run under the umbilical flap which cover the chambers floor. The intraseptal space admit a fan of canal cavities with lateral canal running below the septal sutures. Later canals communicate with the spiral canals. Piles occur on the surface of the test, in central position in the early species and scattered on the lateral test surface in the latter species. Microspheric specimens invaginate the periphery of the test in the last whorl.

Miscellanea cannot be included either into the family Nummulitidae (due the absence of a marginal chord), or in the family Rotaliidae (due the absence of an asymmetric canal system, dorsally closed). Therefore, *Miscellanea* is included in the family Miscellaneidae with *Cuvillierina*, *Pseudocuvillierina*, *Fissoelphidium*, *Laffitteina* and *Thalmannita* by Leppig, 1988. Loeblich and Tappan (1987; 1992) includes *Miscellanea* in the family Pellatispiridae with *Biplanispira*, *Bolkarina* and *Pellatispira* (superfamily Nummulitacea). Following the same approach of Leppig (1988) neither *Miscellanea* nor the family Pellatispiridae can be included in the superfamily Nummulitacea as described by Loeblich and Tappan (1987), due the absence of a marginal chord.

Hottinger (2009) distinguishes two groups of species in the family Miscellaneidae: taxa with a single intercameral foramen and taxa with two or multiple intercameral foramina. The family is assigned to the superfamily Nonionacea due the planispiral involute coiling and the interiomarginal position of the foramina.

The paleobiogeographic distribution of *Miscellanea* and *Miscellanites* is illustrated in Fig. 17.

Remarks on *Miscellanea* "*juliettae*": Two taxa, *Miscellanea juliettae pfenderae* and *Miscellanea juliettae villattae* (in the original work also referred to as *Miscellanea juliettae villattea*),

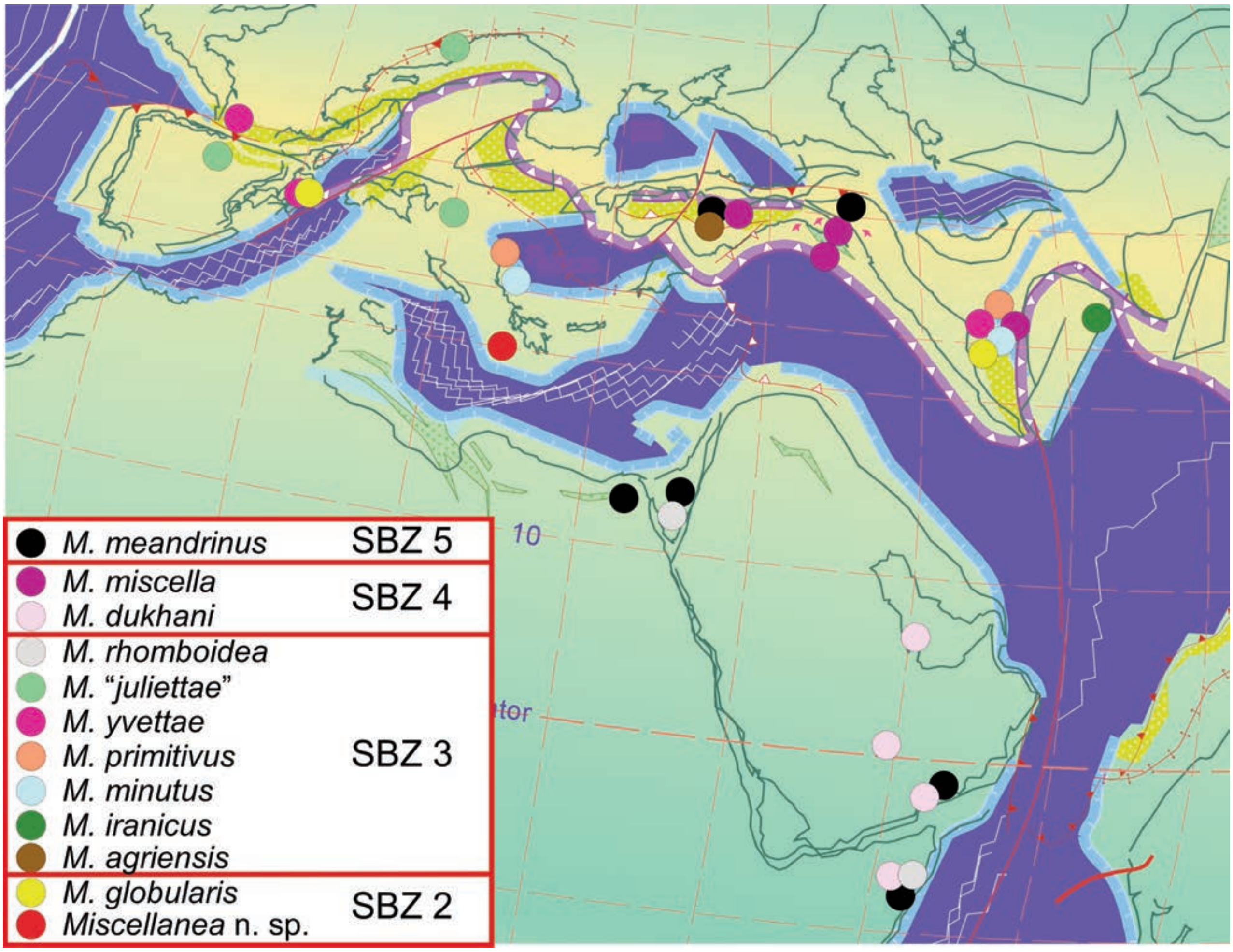


Fig. 17 - Paleobiogeographic distribution of selected miscellaneid species. Some of the taxa here included have been recently reassigned by Hottinger (2009) to his new genus *Miscellanites*. Paleogeographic map adapted from Stampfli and Borel (2002).

are established by Leppig (1988a) as new subspecies by the abbreviation "n. ssp." always after the names.

The first remark concerns the necessity to choose the correct original spelling between *M. juliettae villattae* and *M. juliettae villattea* (art. 32.2.1; ICZN, 1999).

The second remark concerns the status of the name *M. juliettae*. As a matter of fact, it has been introduced in literature for the first time by Leppig (1988a), exclusively as trinomen (as *M. juliettae pfenderae*, *M. juliettae villattae* or *M. juliettae villattea* but never as *M. juliettae* or *M. juliettae juliettae*). Neither *M. juliettae*, nor its nominotypic subspecies *M. juliettae juliettae* have ever been described. Therefore, it is not an available name failing to match ICZN article 13.1 (ICZN, 1999).

In spite of these nomenclatural considerations and of the fact that no author has as yet tried to solve the issue, "*M. juliettae* Leppig, 1988" considered at species rank has been cited several times (e.g., Robador, 1991; Robador et al., 1991; Orue-Extebarria et al., 1996; Sirel, 1997, 1998, 1999; Jauhri, 1997, 1998; Zamagni et al., 2008) and employed as marker of the Tethyan Selandian *p.p.*-Thanetian *p.p.* (*G. primaeva* zone; SBZ 3 *sensu* Serra-Kiel et al., 1998).

The derivation of the names is noteworthy. The taxa are dedicated to Juliette Pfender and Juliette Villatte. Moreover, the author uses always the term "species" when referring to the new taxa in the text, but employs the indication "n. ssp." always after the names *M. juliettae pfenderae, M. juliettae villattae* and *M. juliettae villattea*. In the abstract, Leppig (1988a) explicitly states that "Three new species of Lower Middle Paleocene age are present…" (page 689, the third new species is *M. yvettae*). In another paper published in the same year (Leppig, 1988b), the same specimens of *Miscellanea* used in Leppig (1988a) are figured and indicated as new species (n. sp. 1 and n. sp. 2).

For both taxa, the derivation of the name seems to indicate that it is a species-group name published as separate words that together refer to a single entity (the person to which the species is dedicated) and the evidence from Leppig's (1988a, 1988b) works seems to confirm that the two taxa are of specific rank and not subspecific.

On the other hand, following the Principle of Coordination (art. 46; ICZN, 1999) the two nominal taxa *M. juliettae villattae* and *M. juliettae pfenderae* would be valid, and *M. juliettae / M. juliettae juliettae* invalid. This way, we would have two species (*M. pfenderae* and *M. villattae*) and the name *juliettae* would remain unavailable at any rank. This solution affects substantially the names.

In essence, the main issue is whether *M. juliettae villattae* and *M. juliettae pfenderae* are valid or invalid subspecific names or if they become valid after emendation of spelling.

If they are valid, by the Principle of Coordination we get *M. pfenderae* and *M. villattae*; if they are compound species-group name published as separate words that are deemed to form a single word, we have *M. juliettaepfenderae* and *M. juliettaevillattae*.

For the reasons outlined above, the publication of an emendation of spelling to *Miscellanea juliettaepfenderae* and *Miscellanea juliettaevillattae* following the articles 32.5.2.2. and 11.9.5. (ICZN, 1999) would seem to be opportune, as well as the choice of *Miscellanea juliettaevillattae* upon *Miscellanea juliettaevillattae* acting as First Reviser (article 32.2.1; ICZN, 1999). These issues shall be discussed in a forthcoming paper, and are not formally settled here.

***Miscellanea* n. sp.**

Pl. 2, Figs. 1-16

Material: eighty-three specimens in random section.

Sample: 07199 (central Zakynthos, Kiliomeno conglomerate).

Megalospheric form - Small spherical megalosphere, with a mean internal diameter in axial section of 97.6 µm (n=7). Two specimens in equatorial section have a megalosphere diameter of 99.48 µm and 94.05 µm. The test thickness (axial section) ranges from 0.77 to 1.05 mm, with a mean value of 0.94 mm (n=7). The equatorial diameter ranges from 1.15 mm to 1.62 mm, with a mean value of 1.25 mm (n=7). At least 23 chambers in the last whorl. There are about 3.5 regular whorls. Piles occur on the surface of the central region of the test.

Microspheric form - 1.78 mm (equatorial diameter), 1.11 mm (axial thickness). 33 chambers in the last whorl. There are about 4 regular whorls.

Remarks: The systematics and stratigraphic distribution of the earlier miscellaneids (i.e., those from SBZ 2) are as yet incompletely assessed. *M. globularis* and *M. primitiva,* as well as *M. meandrina* (Carter, 1861), are regarded by Sirel (1997) as only dubitatively referable to the genus *Miscellanea* due to the difficulty to determine the presence of the canal system and indicated as "minimiscellaneids". *M. primitiva* is also referred to as "*Pseudomiscellanea*" *primitiva* (Serra-Kiel et al., 1998; Özgen and Akyazi, 2001; Özcan et al., 2001). *M. globularis* is also referred as *Miscellanites* and considered as the ancestor of "*Miscellanea*" *meandrina* (Peybérnes et al., 2000).

According to Hottinger (2009), *M. miscella*, *M. yvettae*, *M.* "*juliettae*" and *M. dukhani* are *Miscellanea* s.s., *M. primitivus*, *M. iranicus*, *M. meandrinus*, *M. minutus*, *M. globularis* (=*Bolkarina aksarayi*) are to be included in his new genus *Miscellanites*.

In this frame, the specimens from Zakynthos can be included in the genus *Miscellanea* as it is defined up today.

From the whole data collection arise remarkable differences between the investigated specimens from Zakynthos and the species described in literature, as illustrated in Tab. 1.

Comparing the new species with the only miscellaneid described for the Selandian (*M. globularis*) the striking difference of test shape is evident.

The specimens recorded from Mattinata (Gargano; Pignatti et al., 2008) and at determined as *M.* aff. *juliettae*, the specimen figured by Zamparelli (1966) in Pl. 4, Fig. 6 from Rio Arno (Gran Sasso, Central Italy) indicated as *M. miscella*, and specimens from Conca di Cittareale (Rieti, Central Italy) kindly provided by Dr. R.M. Pichezzi (ISPRA) closely resemble *M.* n. sp. but are notably smaller. Further investigations on additional material are needed.

Paleobiogeographic distribution and stratigraphic range: *Miscellanea* n. sp. occurs with *H. praeheissigi*, *K. decastroi, G. sphaeroidea*, *H. rahaghii* nom. nud., *Haymanella paleocenica* Sirel, 1998 and *P. sireli*. Thus, *Miscellanea* n. sp. can be referred to SBZ 2 (Selandian p.p.).

Gen. ***Pseudocuvillierina* Sirel, 1998**

Type species: *Cuvillierina sireli* Inan, 1988

***Pseudocuvillierina sireli* (Inan, 1988)**

Pl. 1, Fig. 12

1988 *Cuvillierina sireli* Inan, Pl. 1, Figs. 1-9; Pl. 2, Figs. 1-8.
1998 *Pseudocuvillierina sireli* (Inan) – Sirel, Pl. 44, Figs. 1-20 (*cum syn*.).
non 1998 *Cuvillierina sireli* Inan – Özgen, Pl. 1, Fig. 10.
2001 *Cuvillierina sireli* Inan – Özgen and Akyazi, Pl. 3, Figs. 5, 6.
2005 *Pseudocuvillierina sireli* (Inan) – Özgen – Erdem et al., text Fig. 11f.
non 2005 *Pseudocuvillierina sireli* (Inan) – Babazadeh, Pl. 1, Figs. 4, 5.
cf. 2006 *Cuvillierina sireli* Inan – Babazadeh, text Fig. 4B.
2006 *Pseudocuvillierina sireli* (Inan) – Cosovic et al., Pl. 1, Fig. 7.

Material: one specimen, subaxial section.

Sample: 07199, (central Zakynthos, Kiliomeno conglomerate).

Wall hyaline, lamellar. Test lenticular, planispiral involute, internally slightly asymmetrical (Leppig, 1988). Thin pillars occur on both the side of the test. Sirel (1998) described specimens with a maximum diameter and thickness 2.06 mm and 0.97 mm, and a megalosphere of about 0.13 mm. The specimens described by Inan (1988) have a diameter ranging from 1.3 mm to 0.5 mm, and are 0.5 to 0.3 mm thick. The diameter of the megalosphere is about 0.025-0.075 mm.

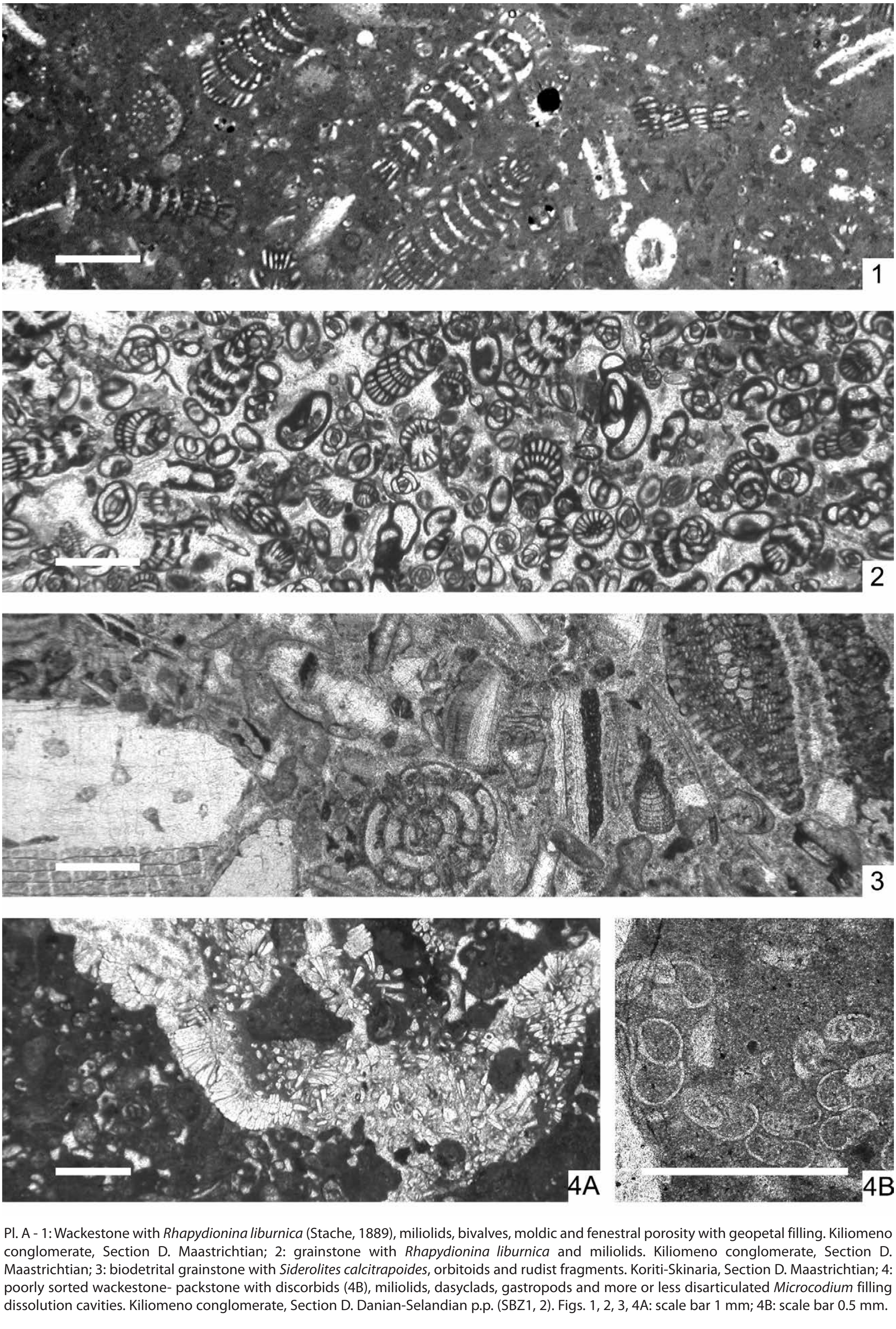
Remarks: *Pseudocuvillierina* differs from *Cuvillierina* Debourle, 1955 because of the occurrence of a spiral canal, well-developed marginal sutural canals and the lack of septal and umbilical flaps. It differs from *Laffitteina* Marie, 1956 in lacking branching interseptal canals that terminate as two alternating rows of openings along the septal sutures on the spiral side and the occurrence of well-developed sutural and marginal canals. It differs from *Miscellanea* Pfender, 1935 by the lack of umbilical and septal flap (Sirel, 1998).

P. sireli differs from *C. vallensis* for its smaller size. Moreover, in *C. vallensis* and *C. sozeri* the height of the spire increases rapidly in the last whorl, whereas in *P. sireli* it is regular (Inan, 1988).

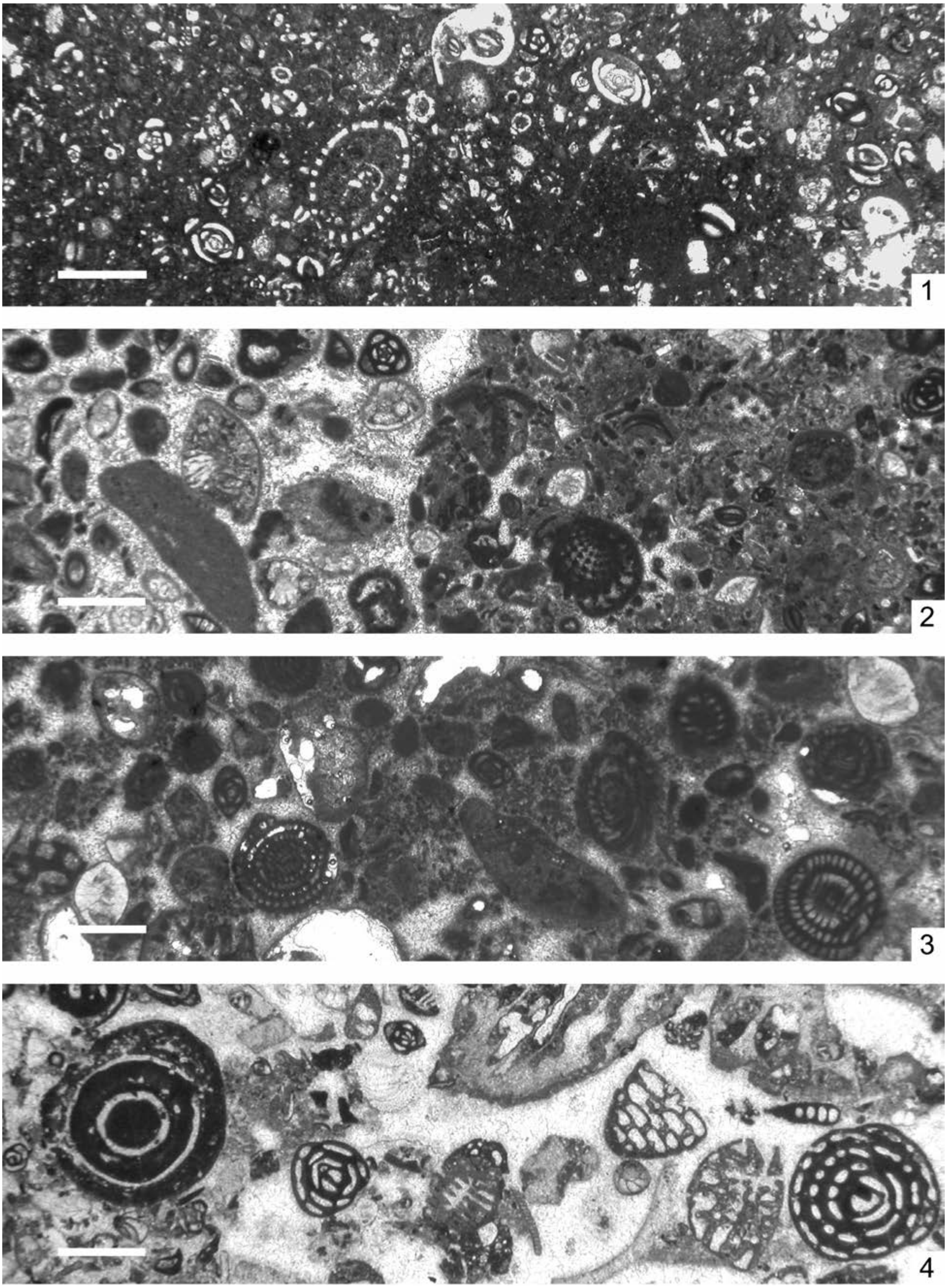
Paleobiogeographic distribution and stratigraphic range: Turkey: central Anatolia, with *I.* aff. *sinjarica*, *P. oeztemueri*, *B. aksarayi*, *O. erki*, *D. danieli*, *R. trochidiformis, P. cretae* and *Keramosphaera* sp. (Inan, 1988); Cide (Sirel, 1998; Özgen and Akyazi, 2001; Özgen-Erdem et al., 2005) and Haymana (Sirel, 1998). Cosovic et al. (2006) recorded *P. sireli* from the matrix of the Tilovica breccias (central Croatia). SBZ 2-?3.

	Form	Diameter equat. (mm)			Diameter axial (mm)			Ratio diam. eq./diam. ax.			Diameter Proloculus (mm)			Number chamb. in the last whorl			Numb. chamb. in the penultimate whorl			Number of whorls
	A/B	Min.	Max	Av.	Min.	Max.	Av.	Min.	Max	Av.	Min.	Max	Av.	Min.	Max	Av.	Min.	Max	Av.	
M. miscella	A	1.5	3.4	2.8	0.9	1.4	1	1.4	2.9	2.4	0.2	0.4	0.27	22	31	26	12	22	16	2.5-3
	B	3	10.1	5	1.1	1.4	1.2	3	4	3.6		0.02		26	40	31	20	32	25	6-7
M. "juliettae pfenderae"	A	0.7	1.8	1.2	0.4	0.9	0.6	1.5	2.2	1.84	0.12	0.25	0.16	10	20	16	10	16	13	2-2.5
	B	1.6	3	2	0.8	1.4	1	1.7	2.2	2		-		19	22	21	13	17	14	4-5
M. "juliettae villattae"	A	0.9	1.9	1.3	0.5	1	0.7	1.5	2.1	1.85	0.12	0.23	0.17	14	20	17	10	13	12	2-2.5
	B	1.5	2.7	2.1	0.9	1.3	1.1	1.6	2.3	2		-		21	27	23	17	20	18	4-5
M. yvettae	A	1.3	2.1	1.7	0.8	1.1	0.9	1.8	2.2	2	0.15	0.27	0.21	18	25	20	12	18	14	2.5-3
	B	1.9	3.2	2.8	1.0	1.6	1.3	1.7	2.1	2		0.02		23	26	25	22	25	23	6
M. primitivus	A	0.9	1.1	1	0.5	0.6	0.6	1.7	2.3	2	0.05	0.1	0.08	13	15	14		10		2.5
	-		-			-			-			-			-			-		-
M. minutus	A	0.9	1.1	1	0.6	0.7	0.7		2.1		0.05	0.1	0.06	13	15	14		10		2.5
	-		-			-			-			-			-			-		-
M. iranicus	A	0.97	1.39	1.69	0.86	0.94	1.08	1.47	1.7	1.91	0.9	0.14	0.23	20	22	24		17		3
	-		-			-			-			-			-			-		-
M. agriensis	A	1.57	1.9	1.73		1.21			1.3		0.28	0.33	0.31		21			18		3-3.5
	B	3.28	3.8	3.53		-			-			-			>25			21		5.5
M. globularis	A	0.5	0.73	0.92	0.52	0.69	0.87	0.97	1.07	1.18	0.03	0.05	0.04		14			13		2
	-		-			-			-			-			-			-		-
Miscellanea n. sp.	A	1.15	1.62	1.25	0.77	1.05	0.94	1.34	1.62	1.5	0.06	0.12	0.1		>23		18	21	19	3.5
	B		1.78			1.11			-			-			33		22	25	24	4

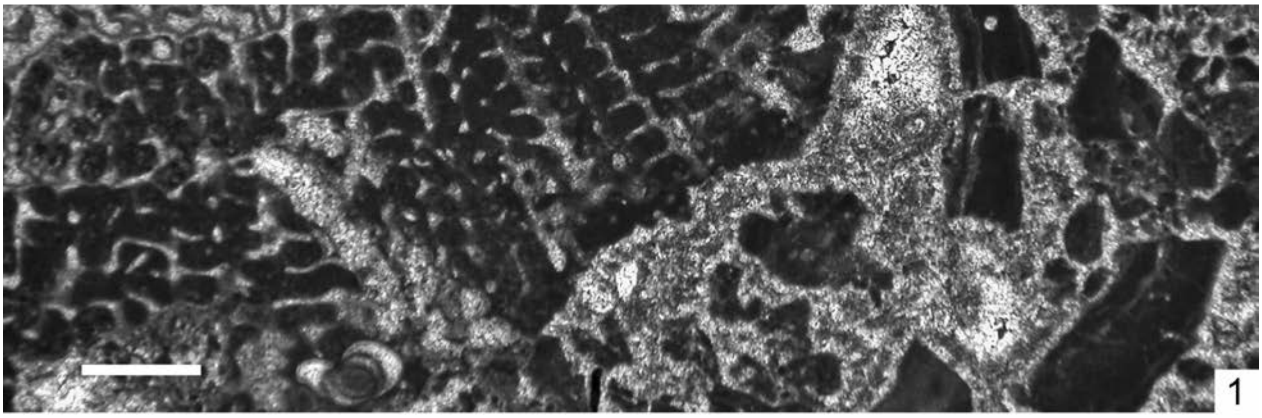
Tab. 1 – Comparative table of several Paleocene *Miscellanea* species on the basis of biometric parameters. Based on Leppig (1988a), integrated with additional species and data. Some of the taxa here included have been recently reassigned by Hottinger (2009) to his new genus *Miscellanites*.

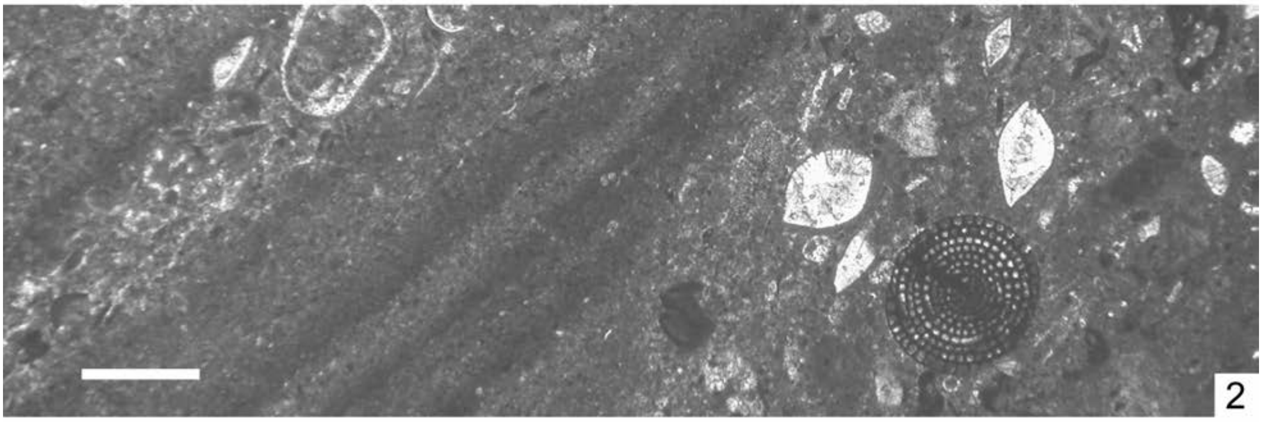


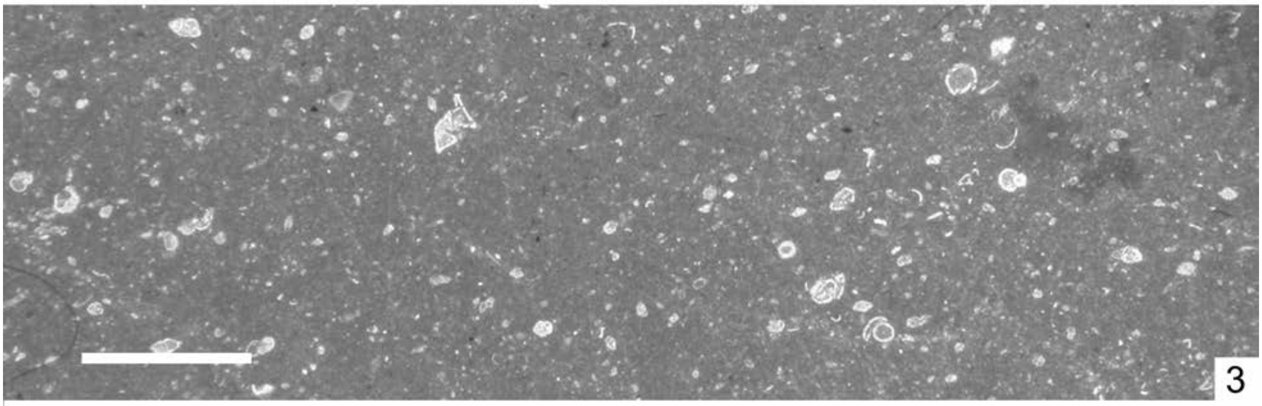
Pl. A - 1: Wackestone with *Rhapydionina liburnica* (Stache, 1889), miliolids, bivalves, moldic and fenestral porosity with geopetal filling. Kiliomeno conglomerate, Section D. Maastrichtian; 2: grainstone with *Rhapydionina liburnica* and miliolids. Kiliomeno conglomerate, Section D. Maastrichtian; 3: biodetrital grainstone with *Siderolites calcitrapoides*, orbitoids and rudist fragments. Koriti-Skinaria, Section D. Maastrichtian; 4: poorly sorted wackestone- packstone with discorbids (4B), miliolids, dasyclads, gastropods and more or less disarticulated *Microcodium* filling dissolution cavities. Kiliomeno conglomerate, Section D. Danian-Selandian p.p. (SBZ1, 2). Figs. 1, 2, 3, 4A: scale bar 1 mm; 4B: scale bar 0.5 mm.

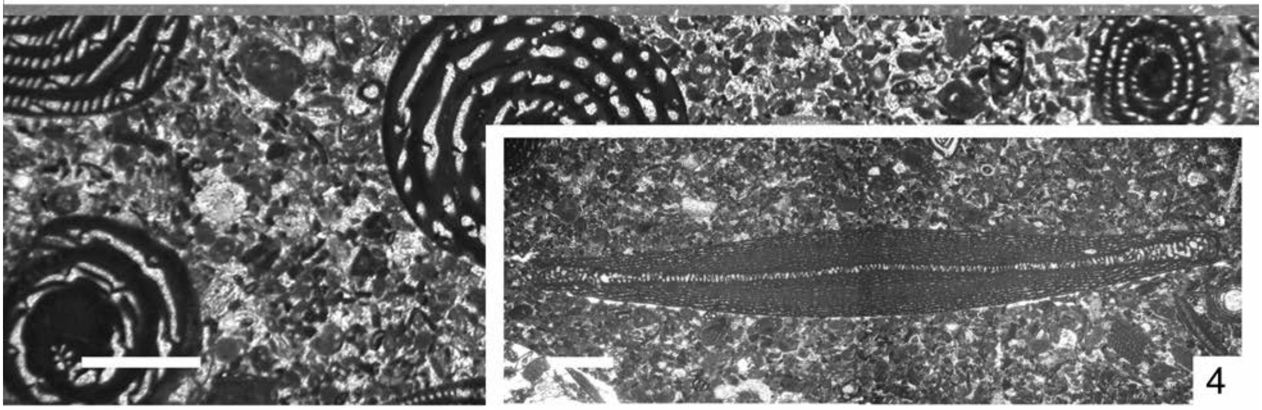


Pl. B - 1: Poorly sorted packstone-wackestone with miliolids and dasyclads. Kiliomeno conglomerate, Section D. Danian - Selandian p.p. (SBZ 1, 2); 2: fairly well sorted packstone-grainstone with scarce intraclasts, *Globoflarina sphaeroidea* (Fleury, 1982), *Miscellanea* n. sp., small rotaliids, miliolids, nubeculariids and small skeletal remains. Kiliomeno conglomerate, Section D. Selandian p.p. (SBZ 2); 3: packstone-grainstone with *Glomalveolina primaeva* (Reichel, 1936), miliolids, small rotaliids, interparticle, vuggy and moldic porosity. Kiliomeno conglomerate, Section D. Selandian p.p. - Thanetian p.p. (SBZ 3); 4: packstone-grainstone with conical agglutinated foraminifera, textulariids, *Idalina sinjarica* Grimsdale, 1952, *Periloculina slovenica* Drobne, 1984, miliolids, corals and vuggy porosity. Kiliomeno conglomerate, Section D. Selandian p.p. - Thanetian p.p. (SBZ 3). Scale bar: 1 mm.

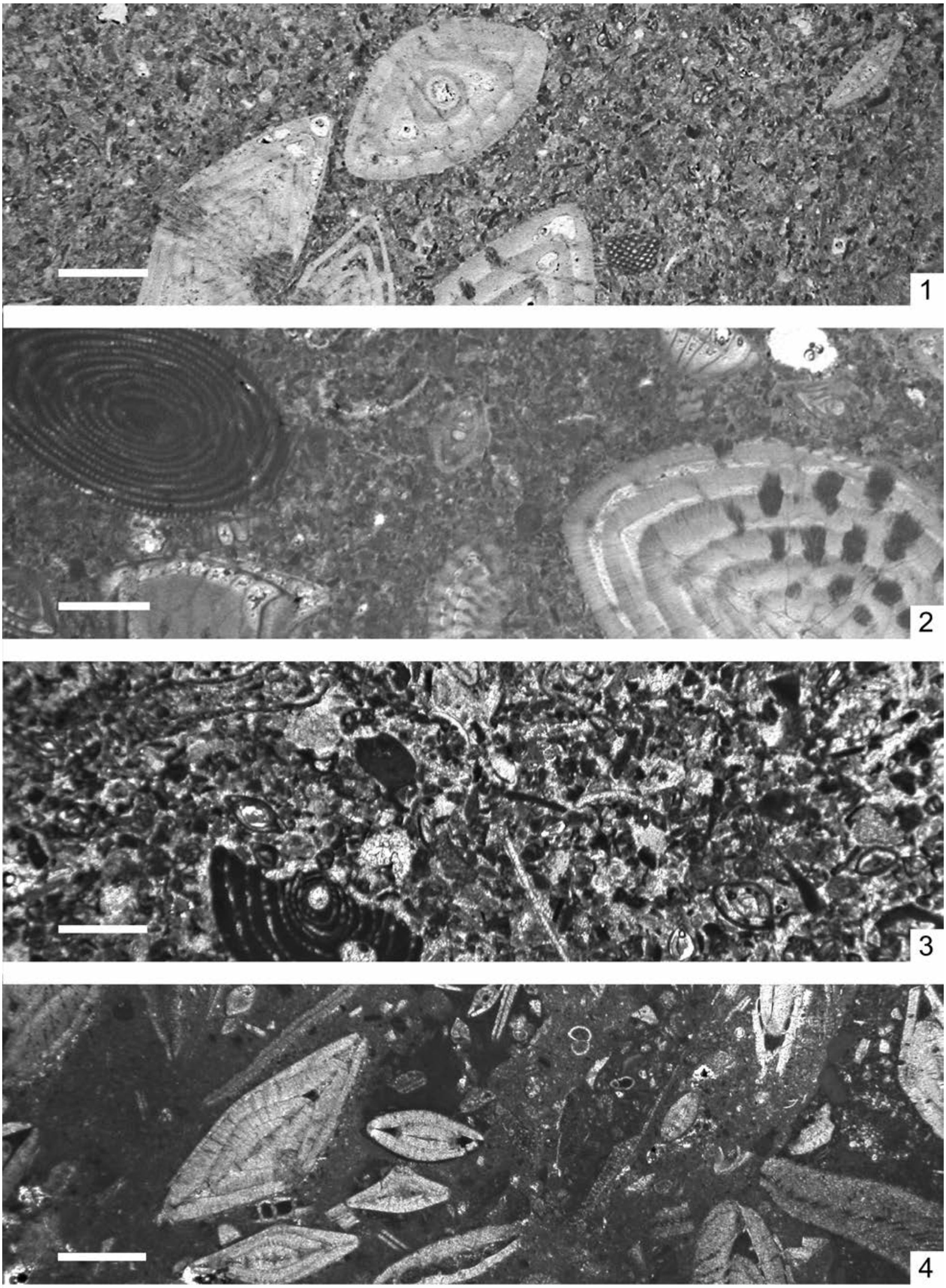




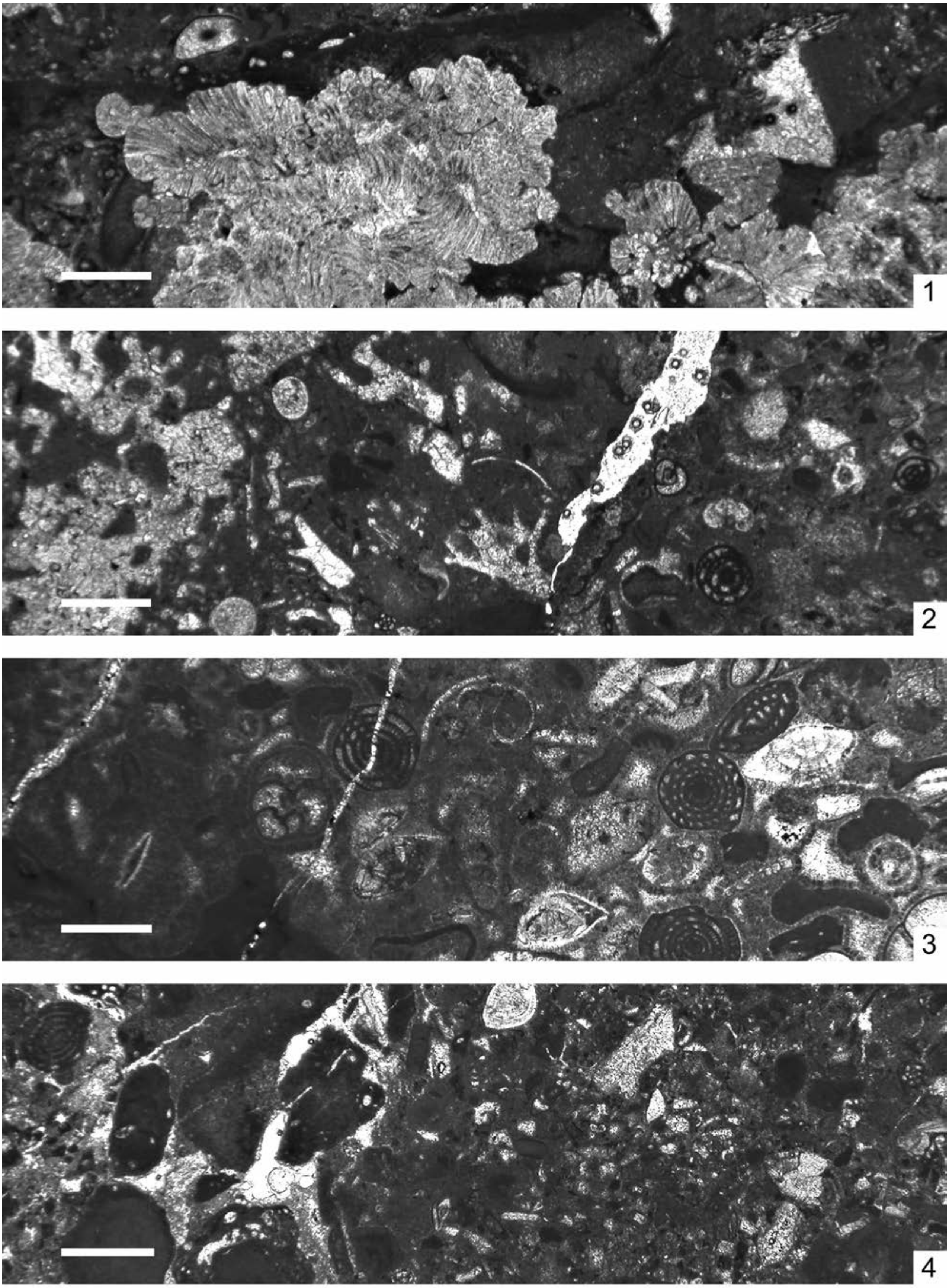




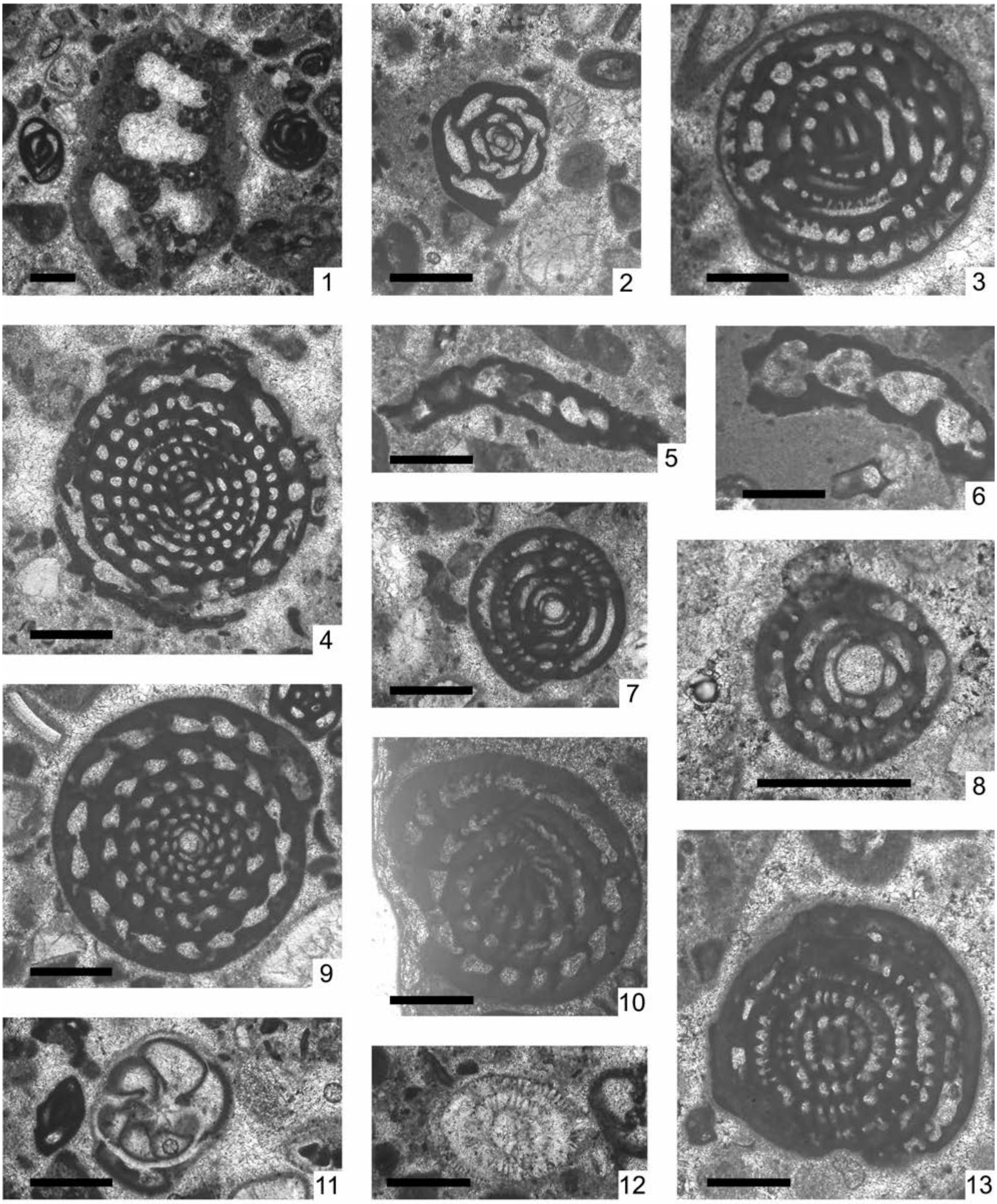
Pl. C - 1: Rudstone with fragmented corals (in the same sample *Polystrata alba* (Pfender) Denizot, 1968 also occurs). Kiliomeno conglomerate, Section D. Selandian p.p. - Thanetian p.p. (SBZ 3); 2: laminated wackestone with *Glomalveolina primaeva* (Reichel, 1936), small rotaliids (mainly plumokathinas), small skeletal remains and heterolithic bedding. Kiliomeno conglomerate, Section D. Selandian p.p. - Thanetian p.p. (SBZ 3); 3: hemipelagic mudstone with planktonic foraminifers (*Morozovella spp.*). Kiliomeno conglomerate, Section D. Lower Ypresian; 4: biodetrital grainstone with *Somalina* sp. and *Alveolina* spp. *Alveolina* shoals, Section B. Aghia Pantes conglomerate. Middle Cuisian (Upper Ypresian, SBZ 11). Scale bar: 1 mm.



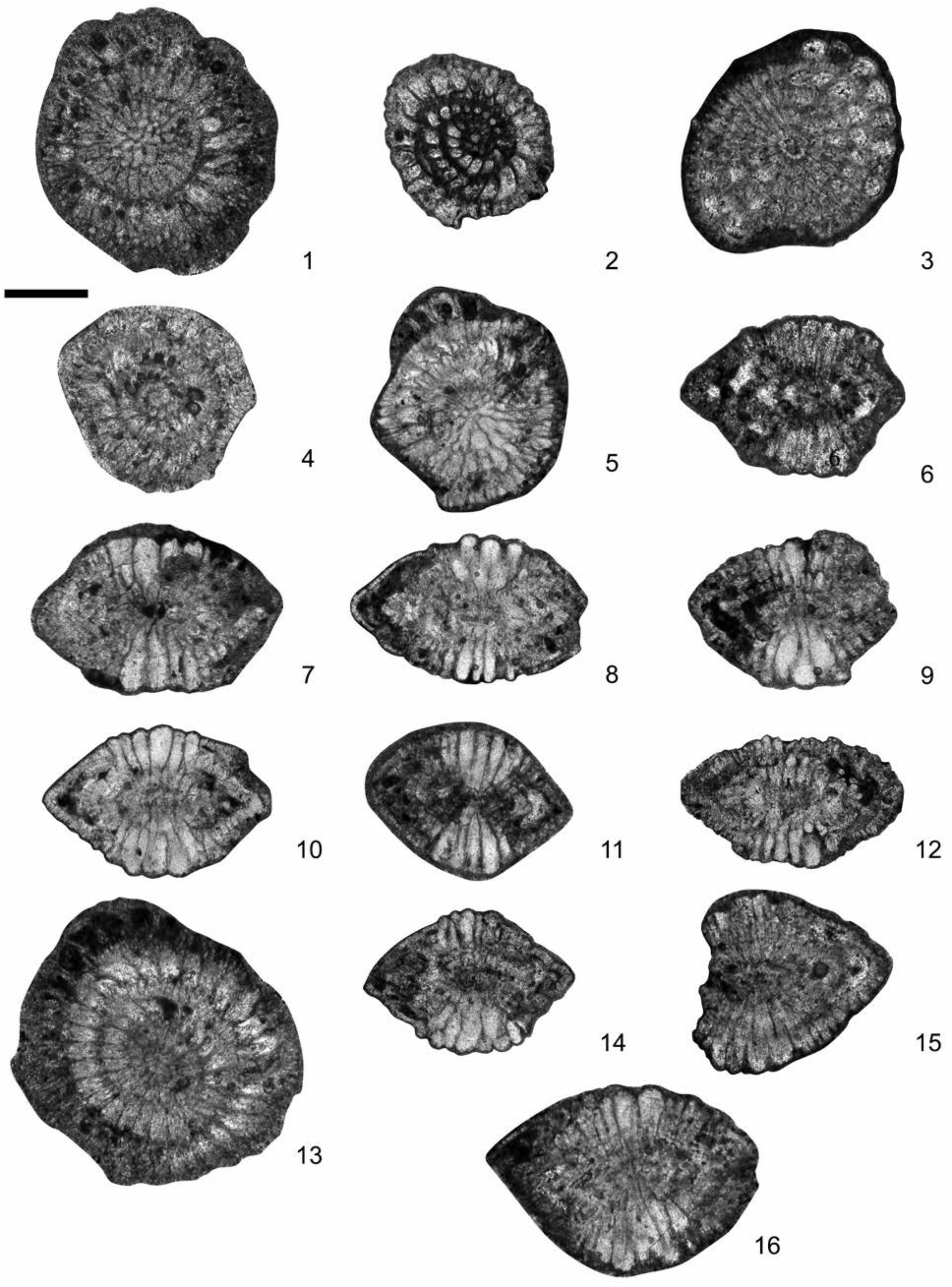
Pl. D - 1: Bioclastic packstone-grainstone with *Nummulites* spp. and a fragment of *Orbitolites*. Kiliomeno conglomerate, Section D. Upper Ypresian - middle Lutetian (SBZ 12-14). 2: bioclastic packstone-grainstone with *Alveolina* spp., *Nummulites* spp and rotaliids. Kiliomeno conglomerate, Section D. Middle-upper Lutetian (SBZ 14-16). 3: bioclastic grainstone with fragmented *Alveolina* spp. specimens. Lithakia Quarry conglomerate, Section E. Lutetian 4: wackestone with intraclasts, *Nummulites* spp., *Discocyclina* spp. and planktonic foraminifera. Keri conglomerate, Section F. Upper Eocene. Scale bar: 1 mm.



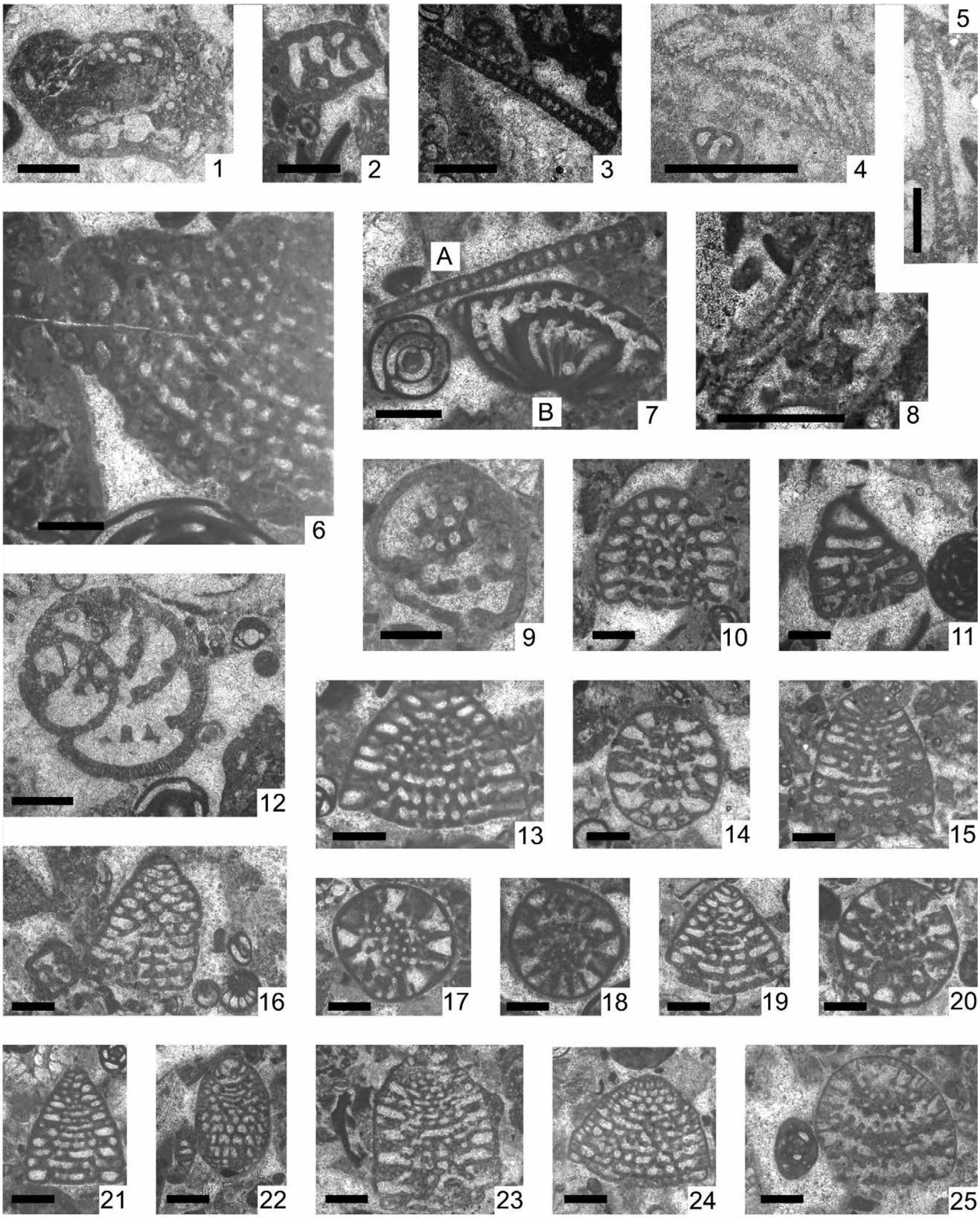
Pl. E - 1: Wackestone with corallinacean algae and abundant *Microcodium*. Askos-Skynaria conglomerate, Section A. Rupelian (SBZ 21 – 22A); 2: biodetrital packstone with *B. bulloides*, miliolids, rotaliids and corals fragments. Askos-Skynaria conglomerate, Section A. SBZ 21-?22A, Rupelian; 3: packstone-wackestone with *B. bulloides*, *P. glynnjonesi*, miliolids, rotaliids and intraclasts. Askos-Skynaria conglomerate, Section A. SBZ 21, Rupelian; 4: biodetrital wackestone-packstone with *B.* cf. *bulloides*, miliolids and *Amphistegina*. Macherado conglomerate, Section C. Oligocene. Scale bar: 1 mm.



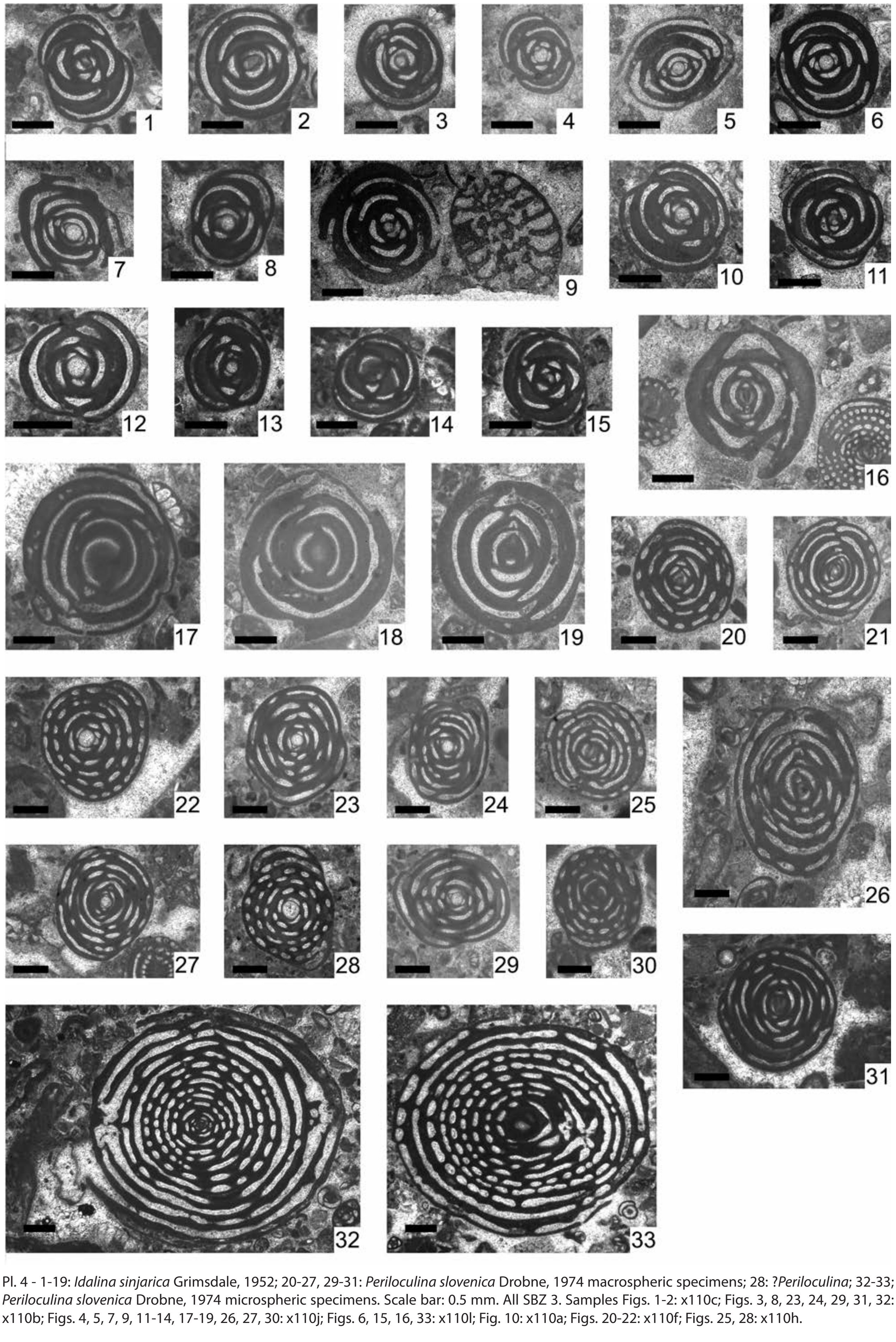
Pl. 1 - 1: *Haddonia praeheissigi* Samuel, Köhler & Borza, 1977; 2: *Kayseriella decastroi* Sirel, 1998; 3, 4: *Helenalveolina rahaghii* Drobne et al., 2005 (nom. nud.); 5, 6: *Haymanella paleocenica* Sirel, 1998; 7-10, 13: *Globoflarina sphaeroidea* (Fleury, 1982); 11: *Stomatorbina binkhorsti* (Reuss, 1862); 12: *Pseudocuvillierina sireli* (Inan, 1988). Scale bar: 0.5 mm. All SBZ 2. Sample Figs. 1-13: 07199.



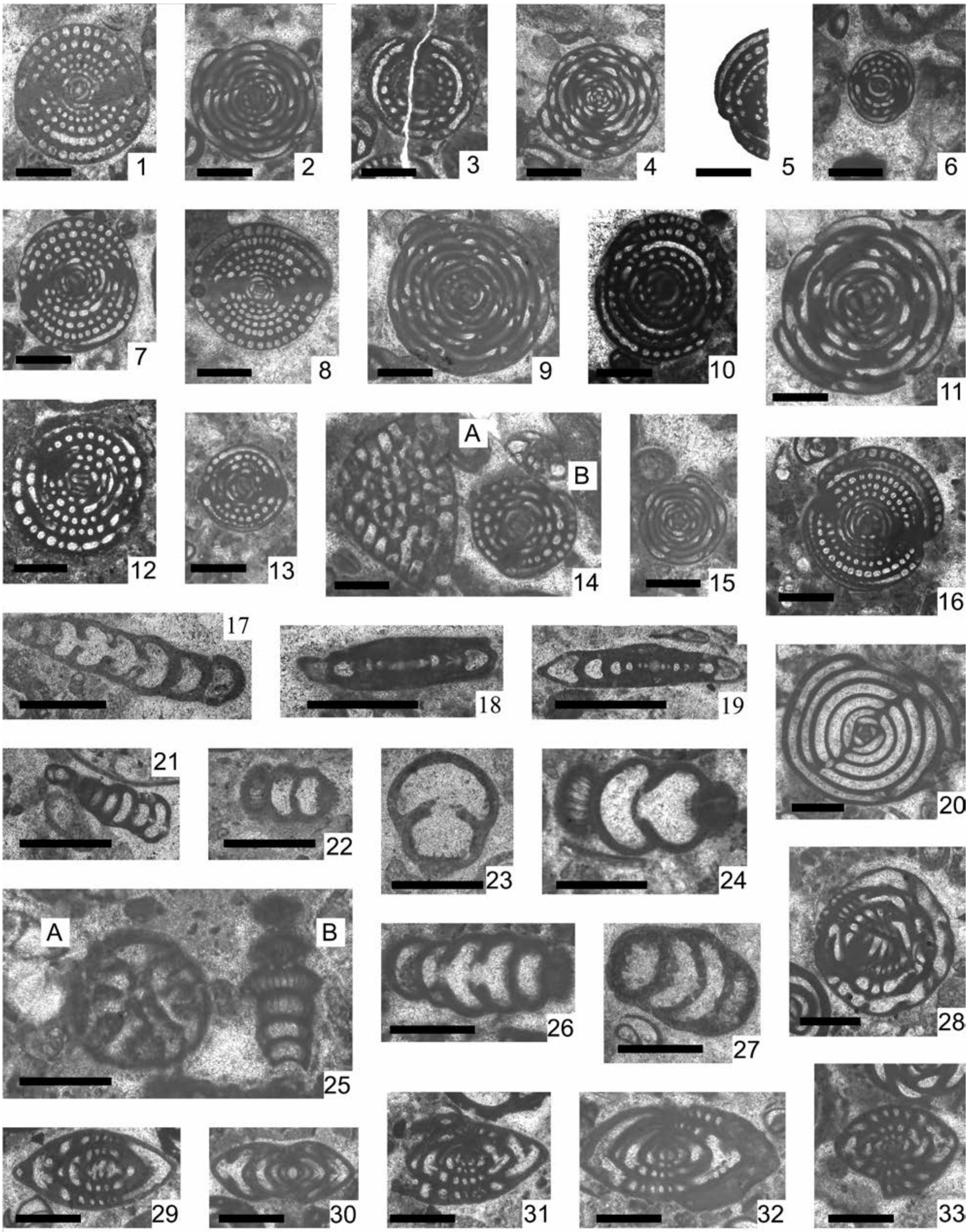
Pl. 2 - 1-16: *Miscellanea* n. sp. Scale bar: 0.5 mm. All SBZ 2. Sample Figs. 1-16: 07199.



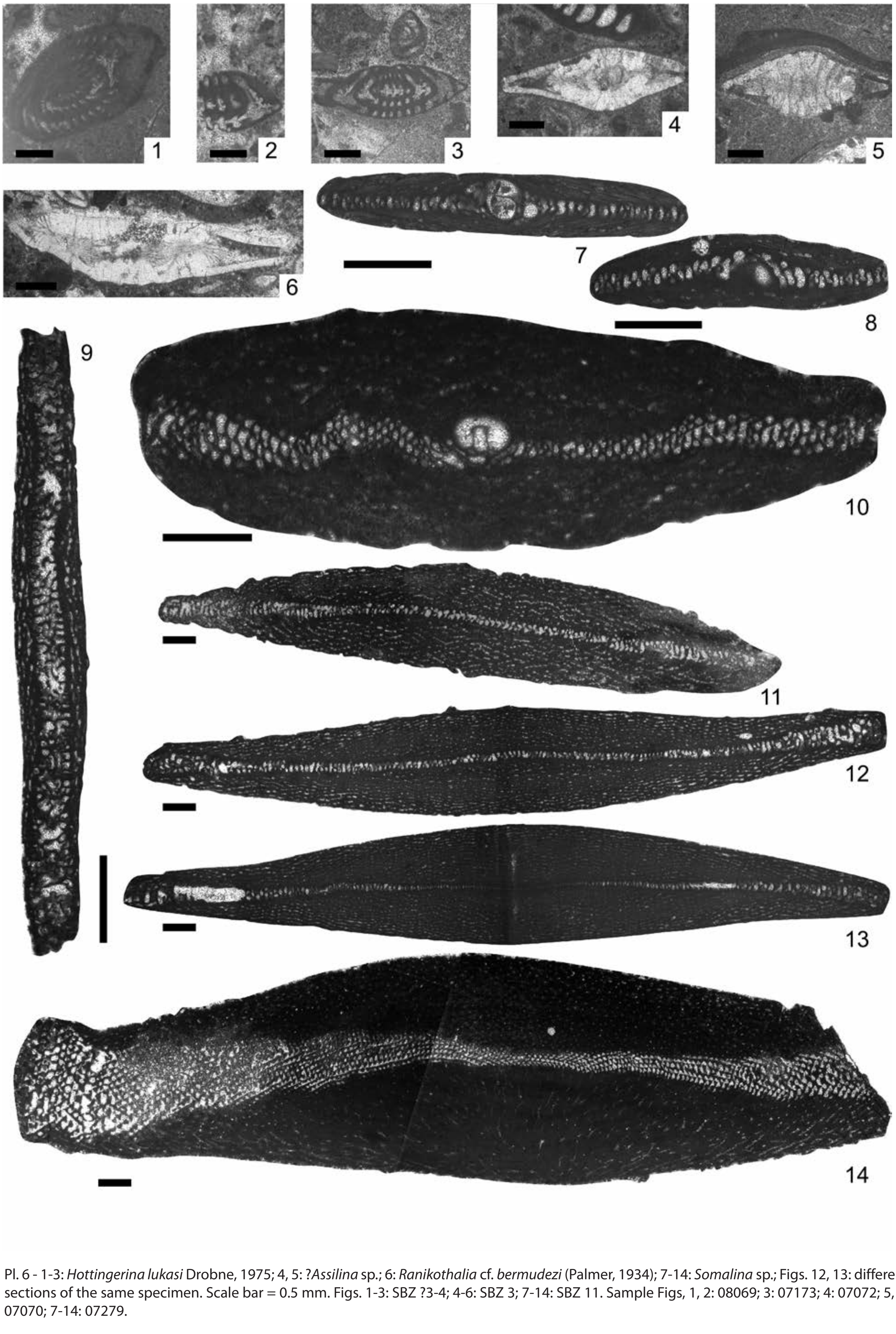
Pl. 3 - 1, 2: *Haddonia praeheissigi* Samuel, Köhler & Borza, 1977; 3-7A, 8: *Vania anatolica* Sirel & Gündüz, 1985; 7B: *Hottingerina anatolica* Sirel, 1998; 9, 12: *Cribrobulimina* cf. *carniolica* Hottinger & Drobne, 1980; 10, 11, 13: *Coskinon rajkae* (Hottinger & Drobne, 1980); 14-22: *Fallotella alavensis* Mangin, 1954; 23: unidentified pfenderinid; 24, 25: *Fallotella kochanskae* (Hottinger & Drobne, 1980). Scale bar: 0.5 mm. All SBZ 3. Samples Figs. 1- 5, 19, 23: x110i; Figs. 8, 11, 16-18, 22: x110j; Fig. 6, 9, 12, 20: x110l; Figs. 7, 10: x110h; Figs. 10, 13, 14, 21: x110b; Fig. 15: x110a; Figs. 24, 25: x110f.



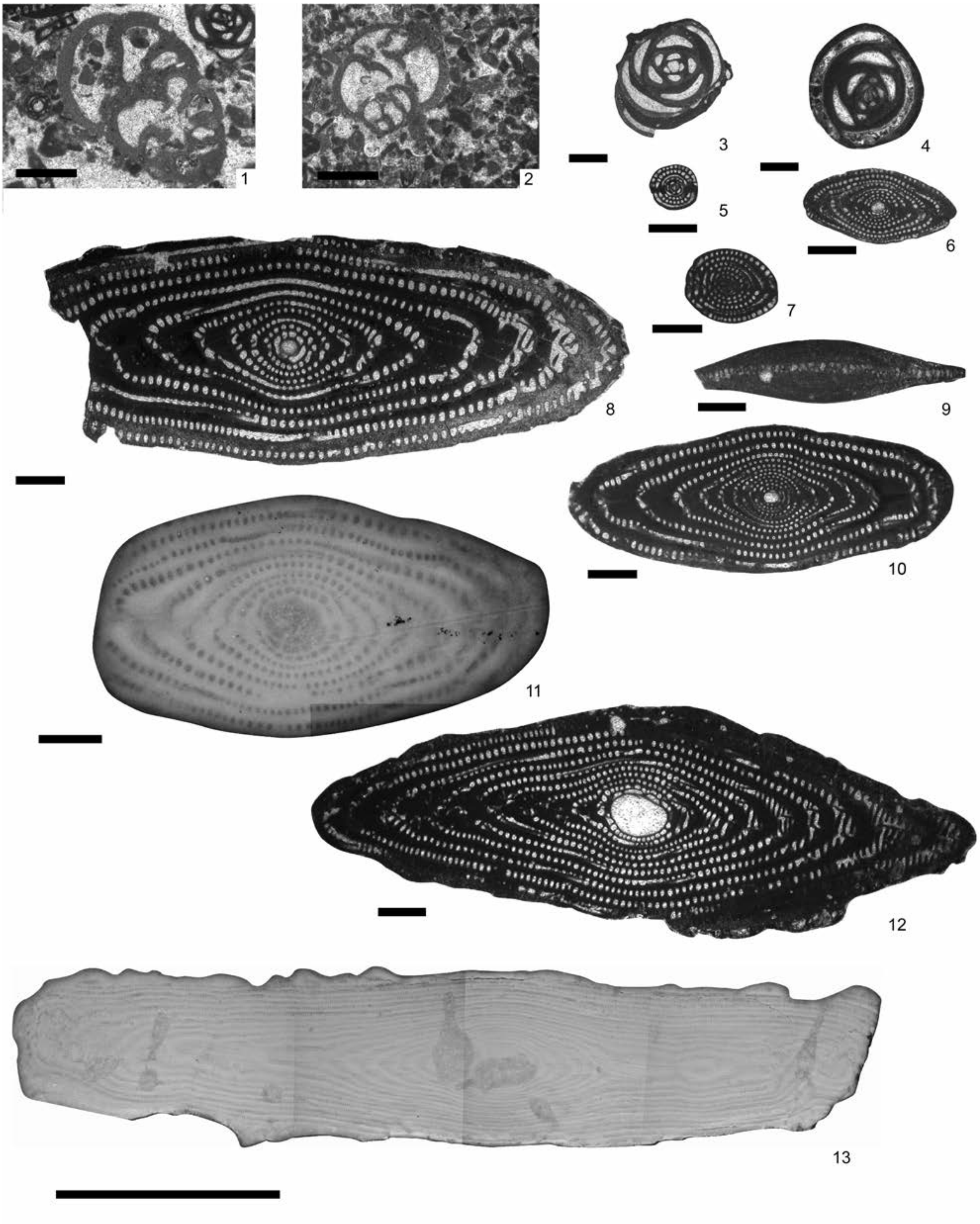
Pl. 4 - 1-19: *Idalina sinjarica* Grimsdale, 1952; 20-27, 29-31: *Periloculina slovenica* Drobne, 1974 macrospheric specimens; 28: ?*Periloculina*; 32-33; *Periloculina slovenica* Drobne, 1974 microspheric specimens. Scale bar: 0.5 mm. All SBZ 3. Samples Figs. 1-2: x110c; Figs. 3, 8, 23, 24, 29, 31, 32: x110b; Figs. 4, 5, 7, 9, 11-14, 17-19, 26, 27, 30: x110j; Figs. 6, 15, 16, 33: x110l; Fig. 10: x110a; Figs. 20-22: x110f; Figs. 25, 28: x110h.



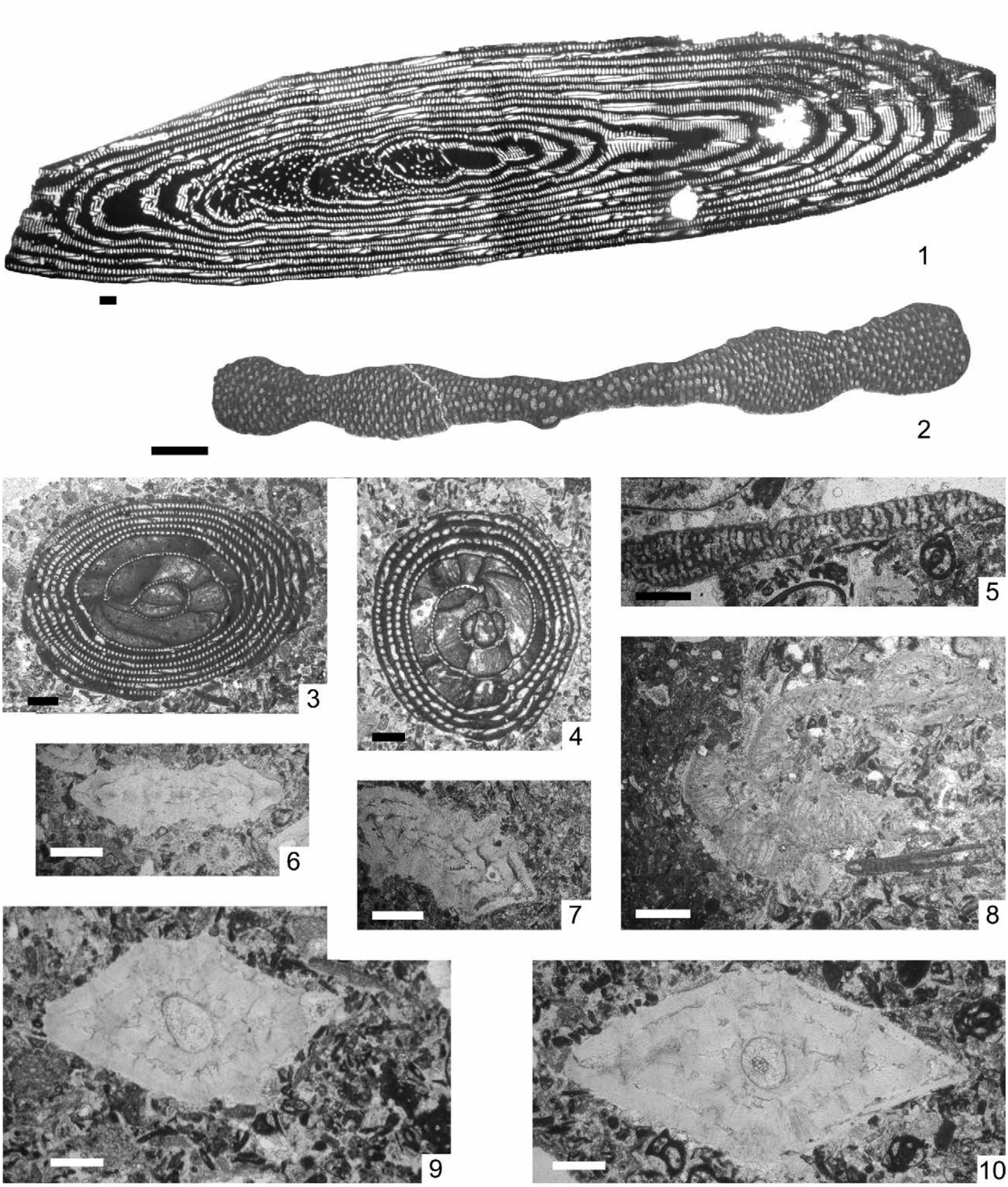
Pl. 5 - 1, 2, 8-11, 15: *Glomalveolina primaeva primaeva* (Reichel, 1936); 3-5, 7, 16: *Glomalveolina primaeva ludwigi* (Reichel, 1936); 6: ?*Helenalveolina*; 12-14: *Glomalveolina primaeva ?primaeva* (Reichel, 1936); 17: *Haymanella paleocenica* Sirel, 1998; 18, 19: *Elazigella altineri* Sirel, 1998; 20: undetermined miliolid; 21-24, 25B, 26, 27: ?*Rhabdorites*; 25A: *Coskinon rajkae* (Hottinger & Drobne, 1980); 28: *Globoflarina sphaeroidea* (Fleury, 1982); 29-33: *Hottingerina anatolica* Sirel, 1998. Scale bar: 0.5 mm. All SBZ 3. Samples Figs. 1, 2, 4-6, 14, 16, 28, 33: x110h; Figs. 3, 7, 21-23, 25-27, 29: x110b; Fig. 8: x110l; Figs. 9-12: x110j; Figs. 13, 15, 17-19, 30-32: x110c; Figs. 20, 24: x110a.



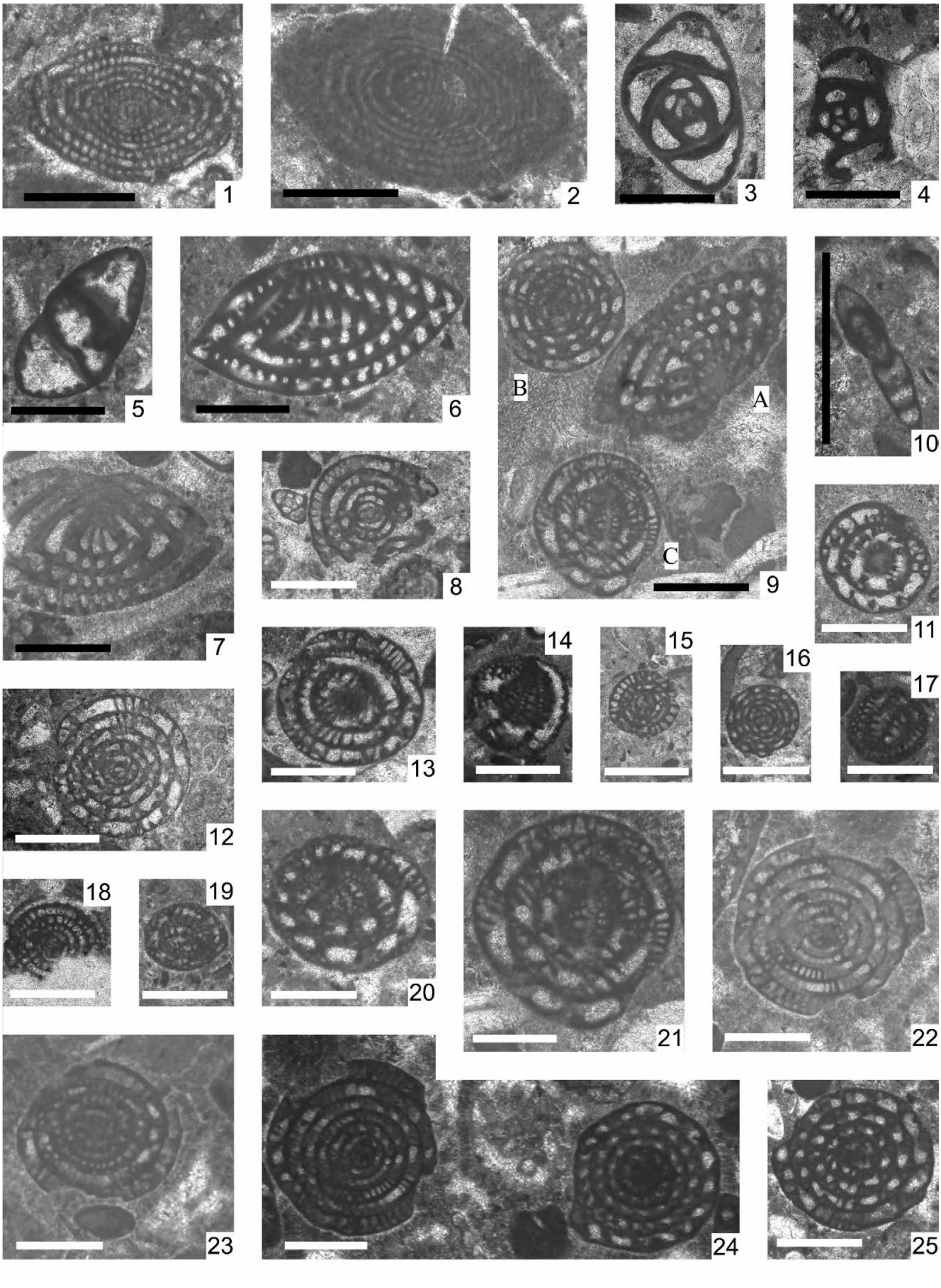
Pl. 6 - 1-3: *Hottingerina lukasi* Drobne, 1975; 4, 5: ?*Assilina* sp.; 6: *Ranikothalia* cf. *bermudezi* (Palmer, 1934); 7-14: *Somalina* sp.; Figs. 12, 13: different sections of the same specimen. Scale bar = 0.5 mm. Figs. 1-3: SBZ ?3-4; 4-6: SBZ 3; 7-14: SBZ 11. Sample Figs, 1, 2: 08069; 3: 07173; 4: 07072; 5, 6: 07070; 7-14: 07279.



Pl. 7 - 1, 2: *Cribrobulimina* sp.; 3, 4: *Idalina* sp.; 5, 7: *Glomalveolina* cf. *minutula* (Reichel, 1936); 6, 10: *Alveolina distefanoi* Checchia-Rispoli, 1905; 8: *Alveolina ruetimeyeri* Hottinger, 1960; 9: *Opertorbitolites* sp.; 11: *Alveolina cremae* Cecchia-Rispoli, 1905; 12, 13: *Alveolina levantina* Hottinger, 1960. 1-12: Scale bar = 0.5 mm; 13: Scale bar = 1 cm. All SBZ 11. Samples Figs. 1-13: 07279.



Pl. 8 - *Alveolina levantina* Hottinger, 1960; 2, 5: *Orbitolites* cf. *complanatus* Lamarck, 1801; 3, 4: *Alveolina elliptica* (Sowerby, 1840); 6, 7: *Nummulites cuvillieri* Sander, 1962; 8: *Fabiania cassis* (Oppenheim, 1896); 9, 10: *Nummulites gizehensis* (Forskål, 1775). Scale bar: 0.5 mm. 1, 2: SBZ 11; 3-10: SBZ 14-16. Samples Figs. 1, 2: 07279; 3-7, 9, 10: x110d; Fig. 8: 07179.



Pl. 9 - 1, 2: *Borelis inflata* (Adams, 1965); 3-5: *Austrotrillina* cf. *paucialveolata* Adams, 1975; 6, 7, 9A: *Penarchaias glynnjonesi* (Henson, 1950); 8, 9B-C, 11-25: *Bullalveolina bulloides* (d'Orbigny, 1839); 10: *Peneroplis* sp. Scale bar: 0.5 mm. 1, 2: SBZ ?21-23; 3-15, 17, 19, 20, 22-24: SBZ 21; 16, 18, 21: SBZ 21-?22A. Samples Figs. 1, 2: 08107; 3, 4: 07086; 5, 10: 07082; 6, 7, 9A-C: 07139; 8, 11-13: 07086; 14, 15, 17, 19, 20: 07082; 9C, 16, 18, 21, 25: 07138; 22-24: 07139.

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