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Chrono-biostratigraphic analysis of the Lower Pleistocene paleotsunami deposits overlying the Late Pliocene Erosional Surface (LPES) at the Manavgat Subbasin (SW Türkiye) based on new nannofossil and fossil ascidian spicule data

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ÖZ

Doğu Akdeniz kenar havzalarında yer alan Antalya Havzası'nın doğu kesimini oluşturan Manavgat Alt Havzası'ndaki Geç Pliyosen regresyonu ve erozyonu dönemi sonrasında oluşan bir aşınma yüzeyi tespit edilmiştir. Bu hiyatüs, olasılıkla Akdeniz'in tabanında meydana gelen ve kıyı düzlüğünde hızlı ve kısa süreli deniz taşkınlarına neden olan depremlerin sonucu oluşan Alt Pleistosen paleotsunami çökelleri tarafından örtülmektedir. 10 inceleme noktasından alınan kayaç örneklerinin sedimantolojik ve biyostratigrafik incelemesi, bu yeni hızlı transgresif istifin kanıtlarını sağlamıştır. Alt Pleyistosen paleotsunamit zonu bölgede, 2-3 m kalınlıkta uzanıma sahiptir. Çamurlu bir matris içinde kumdan blok boyutuna kadar değişen tanelerden oluşan kötü boylanmış kırıntılı çökellerden oluşur. Çamurlu matris, farklı ortamsal, sedimantolojik ve stratigrafik kökenleri temsil eden çeşitli makro ve mikro fosil verilerini içermektedir. Kumdan blok boyutuna kadar olan bileşenler, havza dışı sedimanter istiflerden yeniden çökeltilmiş farklı yaşta marn, kumtaşı, çakıltaşı ve kireçtaşı parçalarından ve havza içinden taşınan çökelimle eşyaşlı resif bloğu veya kayaç parçalarından oluşur. Tespit edilen kalkerli nannofosil verileri, Miyosen yaşlı olarak bilinen Karpuzçay Formasyonu'nda iki farklı yaşta tortul istifi ortaya çıkarmıştır: (1) Altta Erken Pliyosen yaşlı kırıntılı şelf çökelleri "Karpuzçay Formasyonu" ve (2) "Manavgat Formasyonu Tsunami Üyesi"nin paleotsunami çökelleriyle başlayan sığ denizel ve kıyısal kırıntılı çökelleri içeren, Erken Pleyistosen yaşlı "Manavgat Formasyonu". Karpuzçay Formasyonunun mavi-gri marnları, NN15 - Reticulofenestra pseudoumbilica zonunun (geç Erken Pliyosen) %45-60 oranında çökelimle eşyaşlı nannofosil topluluğuna sahiptir, Manavgat Formasyonunun gri-kahverengi çamurtaşları ise NN19a - Gephyrocapsa caribbeanica Astzonunun (Erken Pleistosen) %5-15 oranında çökelimle eşyaşlı nannofosil verilerini içerir. Manavgat Formasyonu Tsunami Üyesi tortullarına ait nannofosil verileri, tsunami olayının 1,81 My ile 1,60 My (Gelasian-Calabrian geçişi) arasında meydana geldiğini göstermektedir.

Anahtar Kelimeler: Ascidian spikülü, Erken Pleistosen, Manavgat Alt-havzası, nannofosil, tsunami tortulları

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ABSTRACT

In the Manavgat Subbasin, which is the eastern part of the Antalya Basin located at the Eastern Mediterranean marginal basins, an erosional surface that formed after the late Pliocene regression and erosion period was determined. This hiatus is overlain by Lower Pleistocene paleotsunami deposits that are probably the result of earthquakes below the Mediterranean that caused rapid and short-lived sea flooding of the coastal plain. Sedimentologic and biostratigraphic examination of rock samples, taken from 10 locations, provided evidences of this new regressive succession. The lower Pleistocene paleotsunamite zone extends in 2-3 m. thickness at the region. It consists of poorly sorted clastic sediments which are composed of sand to boulder-sized grains within a muddy matrix. The muddy matrix contains various macro- and microfossils data representing different environmental, sedimentological and stratigraphic origins. The sand to boulder components are composed of different aged marl, sandstone, conglomerate, and limestone fragments, which were reworked from extrabasinal sedimentary successions and coeval reef block or boulders that were removed from the intrabasin. Detected calcareous nannofossil data have brought out two different aged sedimentary sequences in the Karpuzçay Formation known as Miocene aged: (1) Early Pliocene aged clastic shelf deposits "Karpuzçay Formation" below and (2) Early Pleistocene aged "Manavgat Formation" contains shallow marine and coastal clastic deposits that begun with the paleotsunami deposits of "Manavgat Formation Tsunamite Member". The blue-grey marls of the Karpuzçay Formation have 45-60% synsedimentary nannofossil assemblage of NN15 - Reticulofenestra pseudoumbilica zone (late Early Pliocene), grey-brown mudstones of the Manavgat Formation include 5-15% synsedimentary nannofossil data NN19a - Gephyrocapsa caribbeanica subzone (Early Pleistocene). The nannofossil data of Manavgat Formation Tsunami Member deposits suggest that the tsunami event occurred between 1.81 Ma and 1,60Ma (Gelasian-Calabrian transition).

Keywords: *Ascidian spicule, Early Pleistocene, Manavgat subbasin, nannofossil, tsunami deposits*

1. INTRODUCTION

In this study, the presence of an unexplored angular unconformity within the Karpuzçay Formation which was defined by Akay et al. (1985) in the Manavgat Subbasin (Antalya) of south-western Turkey is discussed. Although previously described as Aksuçay Formation (Akbulut, 1977), Manavgat break (Monod, 1977), Beşkonak Formation (Eroskay, 1968) after then marine sedimentary rock units comprising shale-sandstone-conglomerate alternation with rare volcanic tuff interbeds were redefined as Karpuzçay Formation limited biostratigraphic data by Akay et al (1985). According to these previous researchers, this sedimentation period was assumed between Upper Oligocene and Upper Tortonian. Most researchers such as Monod, O., 1977; Poisson, 1977; Akay et al.,1985); Şenel (1997), Flecker et al. (1998), Robertson (1998), Karabıyıkoğlu et al. (2000), Robertson et al. (2003), Flecker et al. (2005), Karabıyıkoğlu et al. (2005), Çiner et al. (2008) reiterated that Karpuzçay Formation represents to be a continuous, regressive Miocene deposition. First, Sagular (2009) indicated that marine clastic sedimentary rocks, including tsunami deposits of the Karpuzçay Formation, represent the Plio-Quaternary sedimentation based on the nannofossil and didemnid records in the study of the Manavgat region. However, the author neither separates the different sedimentary parts of these sediments into the Pliocene and Pleistocene sequences, nor did also perform a detailed biostratigraphic study. The necessity of dividing Karpuzçay formation into two different formations (Karpuzçay Formation-1 and Karpuzçay Formation-2) was firstly proposed by Sagular et al. (2016). In Sagular and Yavuzlar (2017), tsunami deposits within the Karpuzçay Formation as Karpuzçay Fm-2 Tsunamite Member in detail. The authors revealed an erosional surface that formed after the late Pliocene regression in the Manavgat Subbasin. They described that this unconformable surface was covered by lower Pleistocene paleotsunami deposits probably occurred by rapid and short-lived sea overflows on the coastal plains because of earthquakes at the base of the Mediterranean. According to Herman et al. (2015), these earthquakes have continued as significant rates of moderate level seismicity at the southern edge of the Anatolian Block laid the east-west trending Cyprian Arc, representing the convergent boundary between the Anatolian and the African Plate for 50 million years. Sedimentary formations similar to those described in this study, where mud and megablocks are deposited together, where deep and shallow marine sediments and fossils are present coexistent, are described in detail as earthquake tsunami deposits by different researchers such as Dawson and Stewart (2007), Fujiwara and Kamataki (2007), Kortekaas and Dawson (2007), Morton et al. (2007). In this study, we have been dealt with the nannofossil contents of the shallow marine sediments which occurred with a new rapid transgression initiated by an earthquake and tsunami event at the Eastern Mediterranean in the early Pleistocene.

2. MATERIAL AND METHODS

In the study, comparative biostratigraphic proofs were obtained from many different micro- or macrofossil data such as nannofossils, ascidian spicules, planktic and benthic foraminifers, molluscs, reefal fragments or the others (i.e. honey bee remnant) in the 47 rock samples collected from 10 investigation spots. Biostratigraphic data of tsunami levels were obtained from nannofossils and ascidian spicules in smear slides conventionally prepared to Perch-Nielsen (1985a), Bown and Young (1998) and thin sections prepared to Sagular (2003) method were examined under the polarised light microscopes. By means of the tip of a sterile needle is made scrapping from the fresh fracture surface of the sample onto a microscope slide. Scraped sample solution made with one or two pure water drops is dried on a hotplate. The slide is covered with a coverslip having a drop of Canada balsam heated on the hotplate. Then prepared smear slide is examined by means of Nikon and Leica polarizing research microscopes, under 1000x or more magnifications. In thin sections prepared from carbonate-rich sediments may be enabled to search of nannofossils but need to be used thin section preparation methods as explained by Bown and Young (1998), Sagular (2003). Thin sections allow making a distinction between synsedimentary and reworked fossil records in thin-grained limestone or arenites. Applied imaging techniques under five transmitted light types such as normal light (NL), polarized light (PL), phase contrast (CL), polarized light with gypsum plate (GL), and with quartz plate (QL) were taken from Martini (1971), Perch-Nielsen (1985a), Bown and Young (1998), Sagular (2003). The semiquantitative abundance of synsedimentary or reworked calcareous nannofossils was estimated as the number and proportion of species for 200 field of views in the smear slides in accordance with Bown and Young (1998), and Sagular (2003). However, in the fine-grained calcareous clasts and calcareous matrix/cement of the thin sections were merely sought out the existence of the mainly reworked nannofossil species in accordance with Sagular (2003). Nannofossils species and biozones referred to Martini (1971), Okada and Bukry (1980), Perch-Nielsen (1985a, 1985b), Young et al (2017). In addition, for the identification and dating of the ascidian spicules were utilized by Varol and Houghton (1996) and Sagular et al (2018).

3. GEOLOGICAL SETTINGS

In the study area 5 geologic units were defined: (1) Oymapınar Limestone which is consist of yellow-cream colored reefal or sparritic limestones was named after Oymapınar village on the edge of Manavgat River (Monod, 1977), (2) Geceleme Formation which comprises cream-brown marls interbedded/alternated calcarenite/limestone (Akay et al, 1985), (3) Karpuzçay Formation which is composed of blue-green-grey marl and limestone or marl-claystone-sandstone-conglomerate alternations (lower part of the formation identified by Akay et al, 1985), (4) Manavgat Formation which includes grey-brown mudstone-sandstone alternations and upper deltaic coarse clastics (upper part of Karpuzçay Formation and completely Taşlık Formation identified by Akay et al., 1985; new suggestion in this study), (5) Upper Quaternary deltaic, coastal and terrestrial deposits (Fig. 1). Oymapınar Limestone, Geceleme and Karpuzçay Formations referred in the study were dealt for the Aksu, Köprüçay and Manavgat Basins by Akay et al. (1985), Akay and Uysal (1985). Except Sagular (2009), ages of these same kind marine sediments, including also tsunami deposits in the study area, in the Aksu, Köprüçay, and Manavgat basins, were reported as Miocene in former studies (Gutnic et al., 1979; Akay et al., 1985; Flecker et al., 1998; Robertson, 1998; Karabıyıkoğlu et al., 2000; Robertson et al., 2003; Flecker et al., 2005; Karabiyikoglu et al., 2005; Çiner et al, 2008). Sagular (2009), in the study of the Manavgat region, based on the nannofossils and didemnid records, determined that marine clastic sedimentary rocks involving tsunami deposits of the Karpuzçay Formation represent the Plio-Quaternary sedimentation. However, the author did not separate the different sedimentary parts of these sediments into the Pliocene and Pleistocene sequences, nor did also perform a detailed biostratigraphic study.

Akay et al. (1985) defined the marine sedimentary rock units theoretically or based on less and relative biostratigraphic data as Neogene-Quaternary sedimentary successions. Authors described that the Antalya Miocene basin in the west of Middle Taurus lies between the Beydağları and Anamas-Akseki platforms; the basin consists of the Aksu Formation which includes terrigenous conglomerate-siltstone, marine conglomerate-sandstone, and reef limestone lenses; the Oymapınar Limestone of mainly reef limestone;

the Çakallar Formation consisting of limestone breccia and packstone alternated with clayey limestone; the Geceleme Formation of limy claystone-sandstone alternation; and the Karpuzçay Formation which is composed of shale-sandstone-conglomerate alternation with occasional volcanic tuff interbeds.

According to the authors, this sedimentation period was from Upper Oligocene to Upper Tortonian. And they introduced that the Taşlık Formation consisting of clayey limestone-limestone-blocky conglomerate (some are gypsum) deposited locally in Lower Messinian. Although they could not accurately prove nannofossil zones between NN7 and NN11, in their study, they argued that all standard Miocene nannofossil biozones from NN1 to NN11 exist in the Antalya Basin. Afterwards many researchers such as Flecker et al. (1998), Glover and Robertson (1998a,1998b), Robertson (1998), Karabıyıkoğlu et al. (2000), Poisson et al. (2003), Robertson et al. (2003), Deynoux et al. (2005), Flecker et al. (2005), Karabıyıkoğlu et al. (2005), Çiner et al. (2008) also asserted that are present the same stratigraphic structure in their numerous regional geologic, tectonics, sequence stratigraphic or sedimantologic studies in the Manavgat Basin, based on the stratigraphic findings and interpretations of Akay et al. (1985).

Tsunami deposits were identified as F11: Massive pebbly mudstone by Karabıyıkoğlu et al. (2005) or were described as F10: massive pebbly mudstone facies by Çiner et al. (2008) within the Karpuzçay Formation. However, these sedimentary levels belonging to the Karpuzçay Fm were accepted as tsunamite in the studies of Flecker et al. (2005), Sagular (2009).

As referred to in this study, in the other study of the authors (Sagular and Yavuzlar, 2017) tsunami deposits have been proposed to be named as Manavgat Formation Tsunamite Member. In addition, the upper part of the (formerly-named by Akay et. al, 1985) Karpuzçay Formation, which includes tsunamite level in its below, has been renamed as Manavgat Formation.

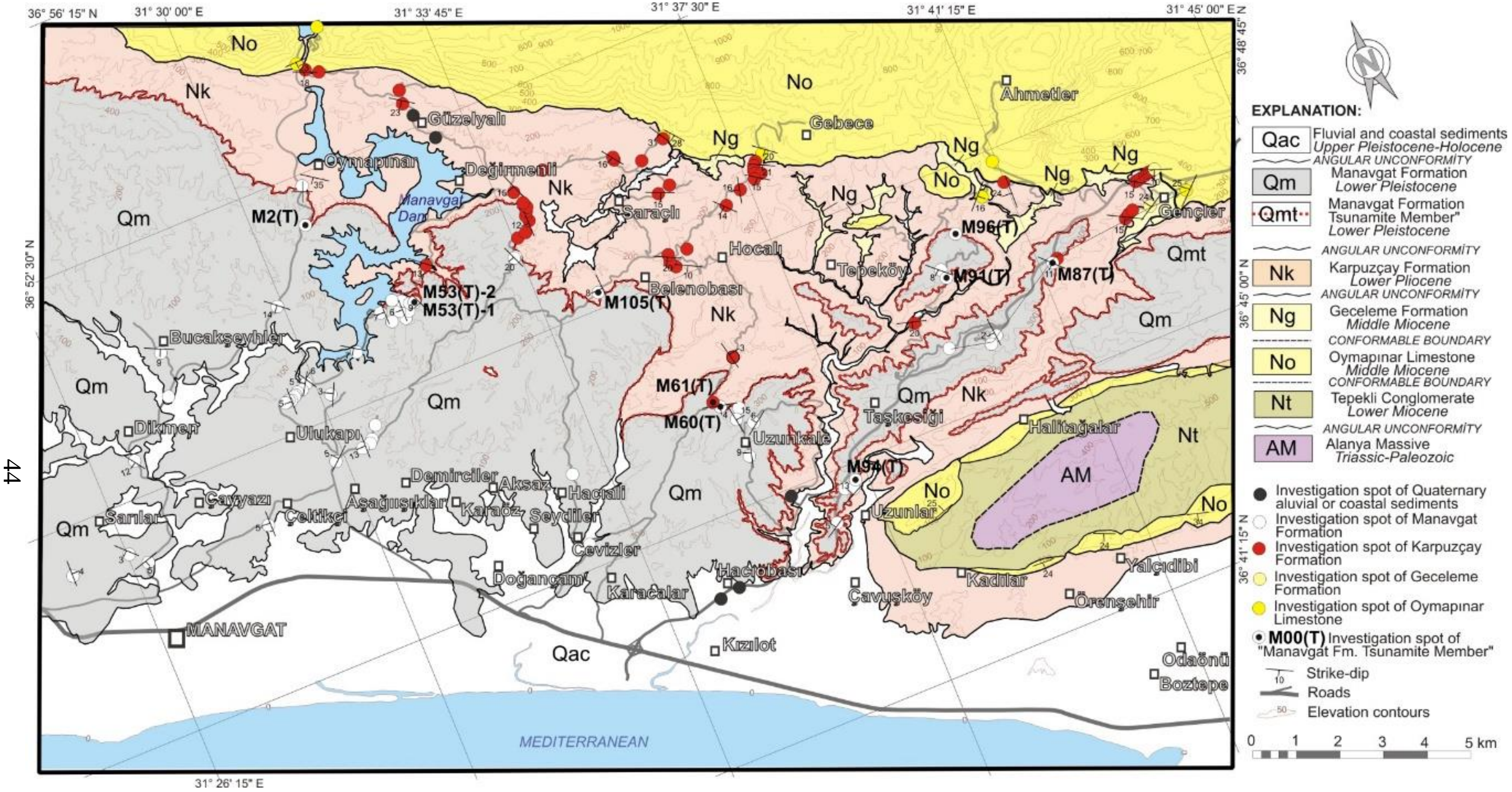


Figure 1. Geological map of the Neogene–Quaternary sedimentary successions prepared in the study area located at the Antalya-Manavgat Subbasin (SW Turkey).

Şekil 1. Antalya-Manavgat Alt Havzasında (GB Türkiye) yer alan çalışma alanında hazırlanan Neojen-Kuvaterner tortul istiflere ait jeolojik harita.

Four stratigraphic sequences are placed in the Manavgat Subbasin (Fig. 2): (1) At the bottom, two conformable successions, comprising Oymapınar Formation (Langhian) and Geceleme Formation (Langhian-Serravalian), involve in the first sequence. Oymapınar formation comprises yellow-cream colored, fossiliferous, thick-stratified, sparritic limestones deposited in carbonate shelf or slope of neritic environment. Geceleme Formation consists of alternations of cream-light brown limestone/calcarenite and light brown marls occurred in outher (carbonate) shelf. (2) The second sequence is the Karpuzçay Formation including Early Pliocene aged clastic and carbonate facies sediments. At the bottom, overlaying the Geceleme Formation with angular unconformity, Karpuzçay Formation begins the alternations of red-green limestone-calcarenites and blue-green marls, representing clastic to carbonate shelf environments and Pliocene transgression in the northeast coasts of the Eastern Mediterranean. Upwards, it presents blue-green siltstone/marls alternated with red-brown sandstones belonging to offshore transition and clastic shelf and a regressive character. In the regressive upper levels, green-grey mudstones alternated with common burrows-having, wavy/lenticular cross-bedded, red-brown sandstones represent a transition between offshore shelf and lower shore-face. In the top levels of the sequence, the formation consists of highly burrowed, wavy/flaser cross-bedded, green-grey mudstones with coal lenses alternated with red-brown sandstones regressively deposited in upper delta / tidal and coastal flat in the subbasin. It is observed that the sequence which had begun with transgressive character then it ended in regressive.

The maximum thickness of the unit was measured approximately 750 meters in the study area. (3) Third sequence begins with the tsunami deposits (Manavgat Formation Tsunamite Member) taken in place bottom levels of the Manavgat Formation and overlays angular-unconformably the Late Pliocene Erosional Surface in the Manavgat Subbasin. Tsunamite zone includes multigenetic pebbly mud matrix involving recrystallized limestone boulders/blocks/cobbles (Mesozoic aged), conglomerate-sandstone blocks/cobbles (Neogene aged), marl blocks (Early Miocene or Early Pliocene aged), reef boulders/cobbles and muddy rip-up clasts (cobble-pebble sized). Sedimentary formations similar to those defined in this study, where mud and megablocks, deep and shallow marine fossils and clastics are deposited together, being poorly sorted, irregular successions, were described in detail as earthquake tsunami deposits by Dawson and Stewart (2007), Fujiwara and Kamataki (2007), Kortekaas and Dawson (2007), Morton et al. (2007).

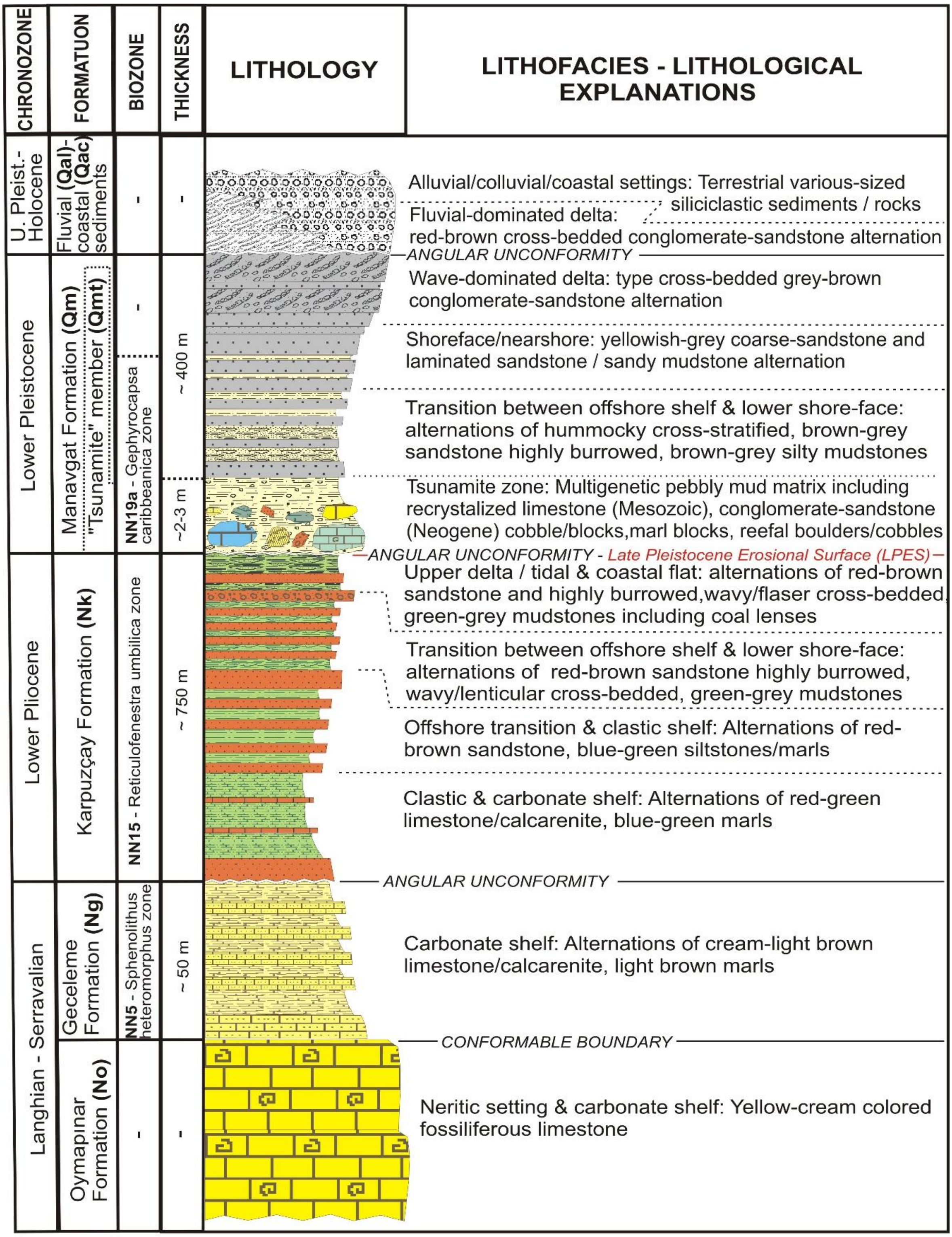


Figure 2. Generalized stratigraphic section taken from the Neogene–Quaternary sedimentary successions in the study area located at the Antalya-Manavgat Subbasin (SW Turkey).

Şekil 2. Antalya-Manavgat Alt Havzasında (GB Türkiye) yer alan çalışma alanındaki Neojen-Kuvaterner sedimanter istiflerden alınan genelleştirilmiş stratigrafik kesit.

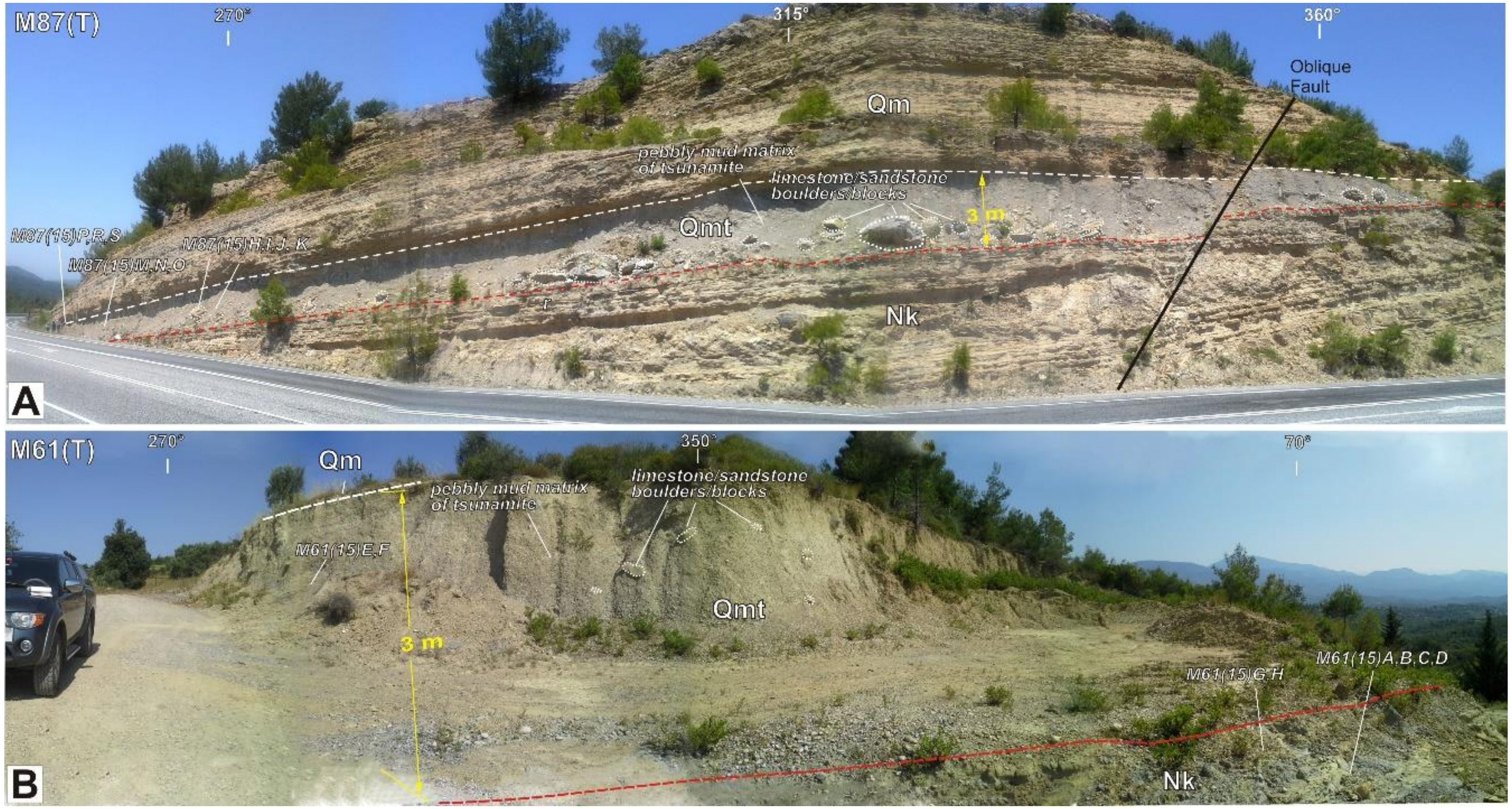


Figure 3. Field images of M61(T) and M87(T) investigation spots include the tsunamite levels between Plio-Quaternary sedimentary successions in the study area in the Manavgat Subbasin (SW Turkey): A–B) Boulderly muddy tsunami deposits (Qmt) in the lower levels of the Manavgat Formation (Qm) covering to the Karpuzçay Formation (Nk) and rock sample places (A: M87(T), B: M61(T), white dashed lines: upper boundary of tsunamite, red dashed lines: tsunamite lower boundary/LPES).

Şekil 3. M61(T) ve M87(T) inceleme noktalarının saha görüntüleri, Manavgat Alt Havzası (GB Türkiye) çalışma alanındaki Pliyo-Kuvaterner sedimanter istifler arasındaki tsunami seviyelerini içermektedir: A–B) Karpuzçay Formasyonunu (Nk) örten Manavgat Formasyonu'nun (Qm) alt seviyelerinde bulunan, bloklu çamurlu tsunami çökelleri (Qmt) ve kayaç örnek yerleri (A: M87(T), B: M61(T), beyaz kesikli çizgiler: tsunamit üst sınırı, kırmızı kesikli çizgiler : tsunami alt sınırı/LPES).stratigrafik referans kesitler.

Among its blocks of resistant rocks such as limestone, conglomerate and sandstone, in the form of boulders, cobbles and pebbles, buried here in the tsunami mud matrix, there are well-preserved cobble-sized blocks of blue-green marl belonging to the lower regular sequence (Karpuzçay Formation) and reefal blocks of boulder or cobble size, coming from synsedimentary (Quaternary) environments. The thickness of the paleotsunamite level was measured about 2-3 meters in the field. As illustrated in detail in the other article of the authors (to be published by Sagular and Yavuzlar-Özer in 2024), example field images of M61(15) and M87(15) observation spots for the tsunamite levels are shown in Figure 3. Upwards, regular sedimentary rock levels of the Manavgat Formation firstly include hummocky cross-stratified, brown-grey sandstones alternated with brown-grey silty mudstones including common burrows of transition between offshore shelf and lower shore-face. In the upper levels, there are yellowish-grey coarse-sandstone and laminated sandstone or sandy mudstone alternations representing shoreface/nearshore conditions. In the uppermost levels, the formation includes wave-dominated delta type cross-bedded grey-brown conglomerate-sandstone alternation. All defined sedimentologic and stratigraphic data indicate that the sedimentation of the formation which started with a short transgressive period, continued in regressive character. (4) Last stratigraphic sequence (Late Pleistocene-Holocene aged) is to be still at the beginning of a new stratigraphic-sedimentologic cycle. In the first levels, the sequence contains fluvial-dominated delta deposits comprising red-brown cross-bedded conglomerate-sandstone alternation. Upwards, terrestrial, various-sized siliciclastic sediments/rocks consisting of mainly sandy/pebbly clastics transitionally deposited in alluvial/colluvial/coastal settings are seen in the study area.

4. FIELD OBSERVATIONS AND STRATIGRAPHIC REFERENCE SECTIONS RELATED THE TSUNAMITE LEVELS

In the study, detailed observations and rock-sampling in the 10 investigation spots at the unconformable boundary between Lower Pliocene aged Karpuzçay Formation (the lower levels of the former Karpuzçay Formation) and Lower Pliocene aged Manavgat Formation (the upper levels of the previously-called Karpuzçay Formation) were made (see Fig. 1). Based on the data obtained from 10 investigation spots, 8 measured stratigraphic reference sections i.e. M2(T), M53(T)-1/M53(T)-2, M60(T)/M61(T) (Fig. 3), M87(T) (Fig. 3),

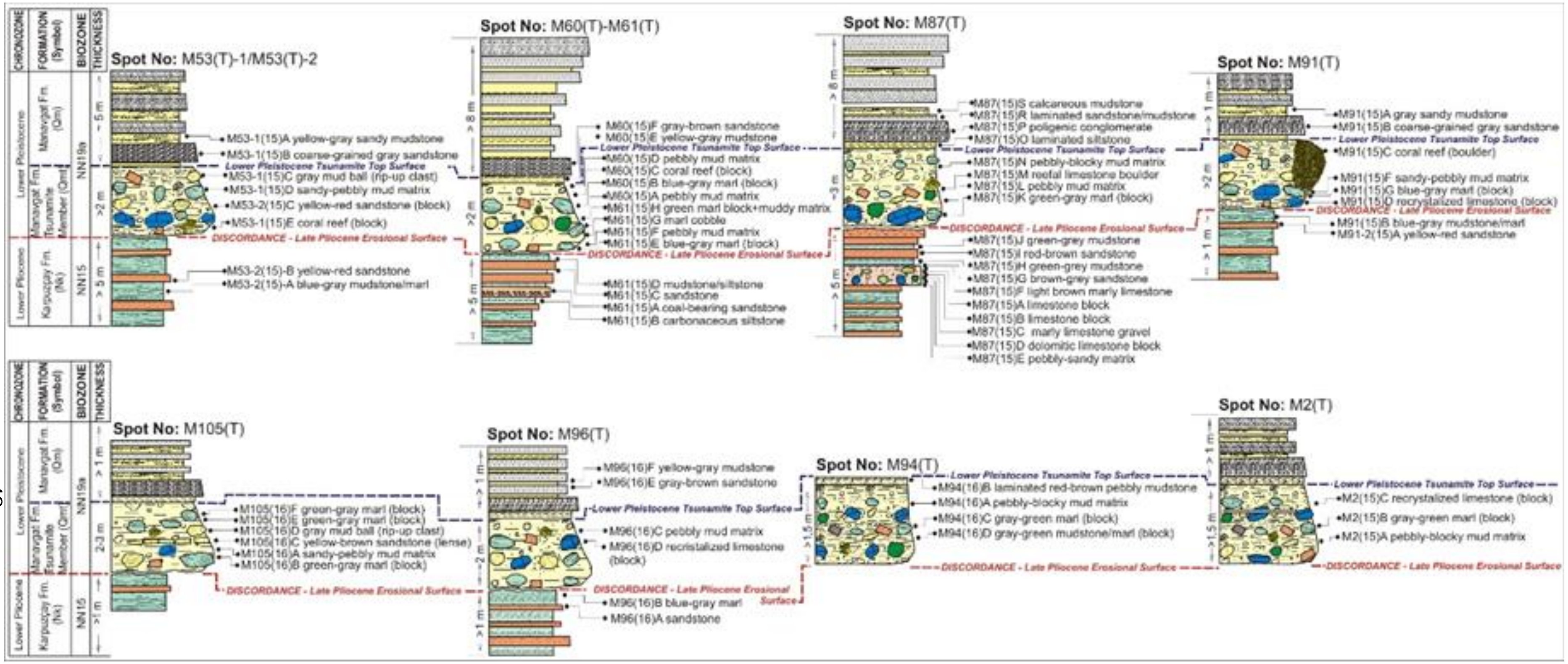


Figure 4. Stratigraphic reference sections of the Manavgat Formation, Manavgat Formation Tsunami Member and Karpuzçay Formation sedimentary rock transitions measured at investigation spots M2(15), M53(15)-1 - M53(15)-2, M60(15) - M61(15), M87(15), M91(15), M94(16), M96(16), M105(16).

Şekil 4. M2(15), M53(15)-1 - M53(15)-2, M60(15) - M61(15), M87(15), M91(15), M94(16), M96(16), M105(16) no.lu inceleme noktalarında ölçülen, Manavgat Formasyonu, Manavgat Formasyonu Tsunami Üyesi ve Karpuzçay Formasyonu tortul kayaç geçişlerine ait stratigrafik referans kesitler.

M91(T), M94(T), M96(T), M105(T) were designed (Fig. 4). Based on the comparison of the 8 stratigraphic reference sections, to observe similar sedimentologic and stratigraphic features in all sections are remarkable.

In the 4 sections (see Fig. 4) designed from the investigation spots M53(T)-1/M53(T)-2, M60(T)/M61(T), M91(T), M96(T) are seen alternations of red-yellow sandstones and blue-grey marls. These units indicate these levels of the Karpuzçay Formation might have been deposited on clastic/carbonate shelf and in regressive character. Above the Late Pliocene Erosional Surface (LPES), this unit is unconformably overlain by approximately 2 m thick tsunami sediments representing the Manavgat Formation and then continues as regular regressive shallow marine clastics of the same formation. North-eastern spots M87(T) and M105(T), south-western spots M53(T)-1 / M53(T)-2, M60 / M61 (15), M91 (15), M96 (16) have the same sequence. But their tsunamite levels reaching up to 3 meters are higher than the others. M2(T) and M94(T) numbered spots expose about 1,5 meters tsunamite zone in the most south-western of the study area. In addition, in a pebbly mud matrix of the tsunami deposits of the north-eastern spots M87(T) and M105(T) include commonly boulder/block-sized reworked rock material whereas in the south-western spots M53(T)-1 / M53(T)-2, M60(T), M61(T), M91(T), M96 (16), there are mainly block/cobble-sized reworked material and in the most south-western spots, usually cobble-sized reworked rock fragments are exhibited. In addition to an increase in the thickness of the tsunami deposits, from the spots of M2(T), M53(T)-1 / M53(T)-2 to M60(T) / M61(T), M94(T), M105(T) and then in the direction of M91 (T), M87 (T), M96 (T), from southwest to northeast, their grain sizes increase is observed.

5. BIOSTRATIGRAPHIC DATA

5.1. Originally Discriminated Nannofossil Data and Fossil Ascidian Spicule Records of the Karpuzçay-Manavgat Formations and Tsunami Deposits

47 various-sized clastic or calcareous rock samples derived from 10 investigation spots are shown in the 8 measured stratigraphic reference sections (see Fig. 4) and they have been examined for nannofossils by smear slides and thin sections under polarizing microscopes.

Quantities and proportions of the originally discriminated nannofossil data are presented in Table 1–5 and some fossil ascidian spicule data are shown in Table 6. 9 blue-grey marl samples derived from the spots such as M53-2, M61, M87, M91, and M96 of the (Early Pliocene) Karpuzçay Formation (see Fig. 4) were determined.

Table 1. Synsedimentary nannofossils including originally classified long-ranged species indicating to the Early Pleistocene sedimentation.

Tablo 1. Erken Pleyistosen çökelimine işaret eden, kökensel olarak sınıflandırılmış uzun menzilli türleri içeren çökelimle eşyaşlı nannofosiller.

TSUNAMITE SPOTS - ROCK SAMPLE NUMBERS

CHRONOZONE	NANNOFOSSIL SPECIES	M2(15)		M53-1/M53-2(15)						M60(15)					M61(15)						
		M2(15)A (Tm)	M2(15)B (Bl)	M53-1(15)A	M53-1(15)B (Ts)	M53-1(15)C (Int)	M53-1(15)D (Tm)	M53-2(15)A	M53-2(15)C (Ts)	M60(15)A (Tm)	M60(15)B (Bl)	M60(15)D (Tm)	M60(15)E	M60(15)F (Ts)	M61(15)B	M61(15)C (Ts)	M61(15)D	M61(15)E (Bl)	M61(15)F (Tm)	M61(15)G (Bl)	M61(15)H (Bl)
LOWER PLEISTOCENE	*Calcidiscus leptoporus* (Murray & Blackman)			7																	
	Ceratolithus cristatus HET coccolithomorpha (Lecal-Schlauder)					1															
	Coccolithus pelagicus (Wallich)			10			1			1		3	1						2		
	Coronosphaera mediterranea (Lohmann)	1		1																	
	Gephyrocapsa caribbeanica Boudreaux & Hay			41			4			2		10							4		
	Gephyrocapsa lumina Bukry	2										2							2		
	small *Gepyrocapsa* spp.	8					1			1			1						1		
	Helicosphaera carteri (Wallich)			6								1							2		
	Helicosphaera hyalina Gaarder																				
	Helicosphaera pavimentum																				
	Helicosphaera wallichii (Lohmann)																				
	Oolithotus fragilis (Lohmann)	2										2									
	Pontosphaera sp. Lohmann																		1		
	Pontosphaera japonica (Takayama)																				
	Pontosphaera scutellum Kamptner					1													1		
	Pseudoemiliana lacunosa (Kamptner)									2			2								
	Pseudoemiliana lovata (Kamptner)			1								1							1		
	Reticulofenestra producta (Kamptner)	1		3						1		6							1		
	Rhabdosphaera clavigera Murray & Blackman			4			1														
	Scyphosphaera apsteinii Lohmann			1																	
	Scyphosphaera expansa Bukry & Percival			1																	
	Scyphosphaera porosa Kamptner			1																	
	Syracosphaera pulchra Lohmann			3																	
	Umbellosphaera tenuis (Kamptner)																				
	Umbilicosphaera foliosa Kamptner						1					3	2						2		
	Umbilicosphaera sibogae (Weber-van Bosse)																		2		
	Leonella granifera (Fütterer)																				
	Pernambugia tuberosa (Kamptner)			2																	
	Synsedimentary nannofossil quantities in original rocks	4		44		2	4			4		14	2						8		
	Total synsedimentary nannofossil quantities in original rocks	14		81		0	8			7		26	6						19		
	"Synsedimentary" nannofossil (%) ratios in original rocks	2		47		0	7			6		29	3						15		
	Total "synsedimentary" nannofossil (%) ratios in original rocks	2		37		0	6			4		19	3						8		

NANNOFOSSIL SPECIES	M87(15)											M91(15)				M94(16)				M96(16)			M105(16)				
	M87(15)A (Bl)	M87(15)C (Bl)	M87(15)E (Cm)	M87(15)F (Bl)	M87(15)H	M87(15)I	M87(15)L (Tm)	M87(15)N (Tm)	M87(15)O (Tm)	M87(15)R	M87(15)S	M91(15)B	M91(15)E (Int)	M91(15)F (Tm)	M91(15)G (Bl)	M94(16)A (Tm)	M94(16)B	M94(16)C (Bl)	M94(16)D (Bl)	M96(16)B	M96(16)C (Tm)	M96(16)F	M105(16)A (Tm)	M105(16)B (Bl)	M105(16)D (Bl)	M105(16)E (Bl)	M105(16)F (Bl)
Calcidiscus leptoporus (Murray & Blackman)										2	1											3	2				
Ceratolithus cristatus HET coccolithomorpha (Lecal-Schlauder)																8	3					10					
Coccolithus pelagicus (Wallich)								4		1	1					3	8				4	4	3				
Coronosphaera mediterranea (Lohmann)																2	2				1	3	1				
Gephyrocapsa caribbeanica Boudreaux & Hay							1	1	2	1	1		2			1	3				1						
Gephyrocapsa lumina Bukry											1					1	1				2						
small *Gepyrocapsa* spp.							3	1	23	5	2										1		8				
Helicosphaera carteri (Wallich)								3		1						3	5				1	2	2				
Helicosphaera hyalina Gaarder										1											1						
Helicosphaera pavimentum											1																
Helicosphaera wallichii (Lohmann)																1	2					3	1				
Oolithotus fragilis (Lohmann)									2		1			1		1											
Pontosphaera sp. Lohmann																1											
Pontosphaera japonica (Takayama)																	1										
Pontosphaera scutellum Kamptner																											
Pseudoemiliana lacunosa (Kamptner)																	6					1					
Pseudoemiliana lovata (Kamptner)										1							1				4	3	1				
Reticulofenestra producta (Kamptner)								4	1	2	1		1			3	6				3	6	4				
Rhabdosphaera clavigera Murray & Blackman																1	3										
Scyphosphaera apsteinii Lohmann											1																
Scyphosphaera expansa Bukry & Percival																											
Scyphosphaera porosa Kamptner																											
Syracosphaera pulchra Lohmann																	2										
Umbellosphaera tenuis (Kamptner)																					1		1				
Umbilicosphaera foliosa Kamptner																	7				1	25	5				
Umbilicosphaera sibogae (Weber-van Bosse)														1		1	18					6	2				
Leonella granifera (Fütterer)											1						6				2	2	10				
Pernambugia tuberosa (Kamptner)																											
Synsedimentary nannofossil quantities in original rocks							1	1	4	2	8		2	1		13	20				7	13	11				
Total synsedimentary nannofossil quantities in original rocks							4	13	28	14	9		3	2		26	73				21	65	40				
"Synsedimentary" nannofossil (%) ratios in original rocks							1	0	3	3	14		4	1		3	14				1	9	4				
Total "synsedimentary" nannofossil (%) ratios in original rocks							1	1	1	2	9		3	3		3	13				1	6	3				

EXPLANATIONS:

Manavgat Formation (Lower Pleistocene) ***clastics above the "Tsunamite":***	**M..(15)A**	Marl/mudstone rock samples of the Manavgat formation "smear-slides"
	M..(Ts)	Sandstone rock samples of the Manavgat Formation "thin-sections"
Manavgat Formation Tsunamite Member *(Lower Pleistocene) - tsunami deposits:*	**M..(Tm)**	Pebbly/cobbly/blocky mud matrix sample of the tsunamite
	M..(Int)	Intrabasinal mud ball sample within the tsunamite "Rip-up mudclasts"
	M..(Bl)	Extrabasinal rock samples marl/mudstone blocks within the tsunamite "reworked sedimentary rock clas
Karpuzçay Formation (Lower Pliocene) - *clastics below the "Tsunamite":*	**M..(15)A**	Marl/mudstone rock samples of the Karpuzçay Formation "smear-slides"
	M..(Cm)	Sandy/muddy matrix of conglomerate samples within the Karpuzçay Formation "smear-slides"
	M..(Ts)	Sandstone/limestone rock samples of the Karpuzçay formation "thin-sections"

A,B,C,D,E	**nannofossil name / quantity:**	Indexed nannofossil species directly representing any defined chronostratigraphic range
[DE]	**nannofossil name / quantity:**	Nannofossil species representing the Pliocene-Pleistocene chronostratigraphic range
[CE]	**nannofossil name / quantity:**	Nannofossil species representing the Miocene-Pleistocene chronostratigraphic range
[BE]	**nannofossil name / quantity:**	Nannofossil species representing the Paleocene-Pleistocene chronostratigraphic range
[CD]	**nannofossil name / quantity:**	Nannofossil species representing the Miocene-Pliocene chronostratigraphic range
[BC]	**nannofossil name / quantity:**	Nannofossil species representing the Paleocene-Miocene chronostratigraphic range

Table 2. Synsedimentary or reworked nannofossils including directly or originally classified long-ranged species of the Early Pliocene sedimentation.

Tablo 2. Erken Pliyosen çökeliminin doğrudan veya kökensel olarak sınıflandırılmış uzun menzilli türlerini içeren eş zamanlı veya yeniden çökeltilmiş nannofosilleri.

CHRONOZONE	NANNOFOSSIL SPECIES	TSUNAMITE SPOTS - ROCK SAMPLE NUMBERS																																														
		M2(15)		M53-1/M53-2(15)						M60(15)					M61(15)							M87(15)											M91(15)				M94(16)				M96(16)			M105(16)				
		M2(15)A (Tm)	M2(15)B (Bl)	M53-1(15)A	M53-1(15)B (Ts)	M53-1(15)C (Int)	M53-1(15)D (Tm)	M53-2(15)A	M53-2(15)C (Ts)	M60(15)A (Tm)	M60(15)B (Bl)	M60(15)D (Tm)	M60(15)E	M60(15)F (Ts)	M61(15)B	M61(15)C (Ts)	M61(15)D	M61(15)E (Bl)	M61(15)F (Tm)	M61(15)G (Bl)	M61(15)H (Bl)	M87(15)A (Bl)	M87(15)C (Bl)	M87(15)E (Cm)	M87(15)F (Bl)	M87(15)H	M87(15)I	M87(15)L (Tm)	M87(15)N (Tm)	M87(15)O (Tm)	M87(15)R	M87(15)S	M91(15)B	M91(15)E (Int)	M91(15)F (Tm)	M91(15)G (Bl)	M94(16)A (Tm)	M94(16)B	M94(16)C (Bl)	M94(16)D (Bl)	M96(16)B	M96(16)C (Tm)	M96(16)F	M105(16)A (Tm)	M105(16)B (Bl)	M105(16)D (Bl)	M105(16)E (Bl)	M105(16)F (Bl)
LOWER PLIOCENE	*Braarudosphaera bigelowii* (Gran & Braarud)												2				2	2		8																												
	Calcidiscus leptoporus (Murray & Blackman)	16	16	5				40		4	2		18		2		6		2	32	2			2		10		13	75	10	51	1			2		8			1	40	80	30	58	1		7	3
	Calcidiscus macintyrei (Bukry & Bramlette)	1	16	2		6	6	6		6					2		4	6	8	28	6			4		65	4	4	75	6	2	1	4		13	2	8			25	8	200			18	80	7	20
	Calcidiscus tropicus Kamptner							4					2		2			4								1	3			1			4							25					18			
	Calciosolenia murrayi Gran						4	2											2									4		27														10				
	Coccolithus pelagicus (Wallich)	2	4	7	X	11	11	32		12	9	4	18		7		13	18	5	52	11			3		35	12	10	69	27	19	2	10		4	9	55	31		230	191	702	49	93	59	159		90
	Coccolithus pliopelagicus Wise						6																				4										8			17	40	1				1		
	Coronosphaera binodata (Kamptner)							4		6								4								5											1											
	Coronosphaera mediterranea (Lohmann)	31		1			2	14		2			2				2	12	2							5			4	18	1	7			2		38	9			5	239	30	19	1	1	7	
	Dictyococcites antarcticus Haq										2	2							4	23						1	10	20	50	17	5	12		9														
	Dictyococcities perplexus (Burns)					4	2	8																2		10	8		4	6	1	2		8			40					480		10	2	240		
	Discoaster asymmetricus Gartner			2				2							2																						8					1						
	Discoaster brouweri Tan																	4								5											24				160		1					
	Discoaster pansus (Bukry & Percival)																2	4								5		2							2		1				11	480		10	1			
	Discoaster pentaradiatus Tan																																				1				80			1				
	Discoaster pliostellulus Browning & Bergen, in Browning et al.							1																																				1				
	Discoaster surculus Martini & Bramlette	1						4											2							5			1	18							16				6						1	
	Discoaster tamalis Kamptner																																				1				40							
	Discoaster variabilis Martini & Bramlette	8		4				16										4								10				6					2		8					80	3	40			1	
	small *Gepyrocapsa* spp.	392	16			2	5			11	4		17		32	X	8	20	1	10	6					185	24	477	474	1611	128	12		8		5	1			17		80		112	1	1	80	40
	Helicosphaera carteri (Wallich)	15		4		6	6	12		8	4	4	4		8		6	7	7	5				2		25	2	5	47	13	20	1	2			2	60	19		129	116	156	30	55	10	200	58	20
	Helicosphaera intermedia Martini						2	5										2										2	4									11		1	5	1		38			1	
	Helicosphaera kamptneri Hay & Mohler in Hay et al.			2				12							10		5	4								10		6		19							24	11		25	91	1	19	20		7	11	1
	Helicosphaera wallichii (Lohmann)																	2	2								4	20		6			6	6	13			9					30	19				
	Helicosphaera selli (Bukry and Bramlette)																	2																			32	11				2		10			11	
	Holodiscolithus macroporus (Deflandre)			2				2										4	2	4																											1	20
	Pontosphaera discopora Schiller	1				2	4	6			2						4			6	6								2	6							8	6		1	5	8		30		1		
	Pontosphaera multipora (Kamptner)	8	8	11		6	8	10		2		6	2		7		2	4		7	3					2	2		4	17	1	2			2		8	11			121	1					7	1
	Pontosphaera japonica (Takayama)					1		2									2	2			2							4	6	1	1	1			2		1					1		2		11	3	
	Pseudoemiliana lacunosa ovata (Kamptner)	5	22	1			4	12		2		1	2		10	X	4	22	3	4	12			2		20	8	4	4	18	26	2					1	5		83		636	30	19	18	240	50	30
	Reticulofenestra haqii Backman							5		3		2	2		2			7		2						25	16	4	4	6	21	3	2	7	2	2	25			630	386	471	32		109	635	58	70
	Reticulofenestra minuta Roth		8			8	12	2			4	11	11				7	5	2	3	2					70	10	40	6	237	82	1					44	7		97		275	31	439	1117	1231	29	79
	Reticulofenestra minutula (Gartner)		22	6		2		4		8	4	10	8		22		8	10		20	18			8		40		5	6	18	6	1					16	14		25	80		2	20	2	240	7	20
	Reticulofenestra producta (Kamptner)	10		2			2	6		15	29	10	4		20		11	5	3	49	10			2		30	29	40	69	69	49	4	11	12	3	4	66	25		24	232	312	59	111	284	714	60	79
	Reticulofenestra pseudoumbilica (Gartner)	4	8	7	X	5	10	26		4	2	5	9		17		26	22	9	23	9					20	2	40	6	27	1	1	5		13	14	25	18		80	386	432	65	115	13	159	38	5
	Rhabdosphaera clavigera Murray & Blackman			4			5	28							2			10		2						5				18					2		31	14		1	3		1			7		1
	Scyphosphaera apsteinii Lohmann																	2		1									4																7		1	
	Scyphosphaera canescens Kamptner																														1																	
	Scyphosphaera intermedia Deflandre																																													1		
	Scyphosphaera recurvata Deflandre																			1									1															2				
	Scyphosphaera pulcherrima Deflandre																			2									1																		1	
	Sphenolithus abies Deflandre in Deflandre & Fert	8	3	6	X	4	2	14		2		4				X		6		2	2			4		45	12	10	125	10	27	1					1	11		25	50	120	50	40	1	7	7	
	Sphenolithus neoabies Bukry & Bramlette	6		2			2	4		2					10	X	8									10		20	50			4			2		80			8	11		19	40		160	7	1
	Sphenaster metula (Wilcoxon)	72	8	6	X	2	6	4		2		4				X	4	6	4							45	4	40	75	6	6	2						11		1	5			11			3	20
	Syracosphaera pulchra Lohmann			3				2									2	2								3		4										9		17				1				
	Umbilicosphaera foliosa Kamptner	2		12			5			4	22	5	48		30			32	6	6	10					25		20		10	1	10			4		8	27		83		239	258	115			30	20
	Umbilicosphaera jafari Müller		4	3		1		18							3		2	2	2	3												2		2			37	7		8	193	80	48		1059	675	7	1
	Umbilicosphaera rotula Kamptner	88	3	6		2	6	48					4		4		6	8		4	2					5		6	50	18	1	2		2			24	11		8	120	80	40	40	1	161	3	1
	Umbilicosphaera sibogae (Weber-van Bosse)	1									12							10	2									2	8	1	1			10	4	16	23	73		267	50	80	61	38	360		1	
	Calciodinellum albatrosianum (Kamptner)									10																		4	1	18	6	7												2				
	Lebessphaera urania Meier, Janofske & Willems			1																																												
	Thoracosphaera heimii Lohmann																2																															
	Pernambugia tuberosa (Kamptner)			2			4	6										8		2						5						1					1			8	15	1		11		7		1
	Synsedimentary nannofossil quantities in original rocks	192	46	33		19	46	257		52	48	18	54		118		50	184	22	130	66			22		519	71	174	492	159	54	49	14	34	65	44	297	75		641	590	1415	134	287	424	819	299	160
	Total synsedimentary nannofossil quantities in original rocks	671	138	101		67	107	352		103	98	68	151		192		136	262	67	312	101			29		726	150	806	1225	2263	655	82	39	64	68	53	733	350		1197	2220	4950	888	1532	3082	4938	498	523
	"Synsedimentary" nannofossil (%) ratios in original rocks	89	43	36		75	77	88		65	92	42	87		95		82	89	41	84	81			79		99	76	93	97	91	70	75	70	71	90	86	75	54		92	95	98	87	91	74	98	95	98
	Total "synsedimentary" nannofossil (%) ratios in original rocks	92	46	46		71	79	85		69	92	51	86		94		86	88	59	74	77			81		99	71	97	98	97	87	79	57	71	86	84	77	64		92	96	98	89	94	73	99	95	98

Table 3. Synsedimentary or reworked nannofossils including directly or originally classified long-ranged species of the Middle Miocene sedimentation.

Tablo 3. Orta Miyosen çökeliminin doğrudan veya kökensel olarak sınıflandırılmış uzun menzilli türlerini içeren çökelimle eşyaşlı veya yeniden çökeltilmiş nannofosilleri.

CHRONOZONE	NANNOFOSSIL SPECIES	TSUNAMITE SPOTS - ROCK SAMPLE NO.																																													
		M2(15)		M53-1/M53-2(15)						M60(15)					M61(15)							M87(15)											M91(15)				M94(16)				M96(16)			M105(16)				
		M2(15)A (Tm)	M2(15)B (Bl)	M53-1(15)A	M53-1(15)B (Ts)	M53-1(15)C (Int)	M53-1(15)D (Tm)	M53-2(15)A	M53-2(15)C (Ts)	M60(15)A (Tm)	M60(15)B (Bl)	M60(15)D (Tm)	M60(15)E	M60(15)F (Ts)	M61(15)B	M61(15)C (Ts)	M61(15)D	M61(15)E (Bl)	M61(15)F (Tm)	M61(15)G (Bl)	M61(15)H (Bl)	M87(15)A (Bl)	M87(15)C (Bl)	M87(15)E (Cm)	M87(15)F (Bl)	M87(15)H	M87(15)I	M87(15)L (Tm)	M87(15)N (Tm)	M87(15)O (Tm)	M87(15)R	M87(15)S	M91(15)B	M91(15)E (Int)	M91(15)F (Tm)	M91(15)G (Bl)	M94(16)A (Tm)	M94(16)B	M94(16)C (Bl)	M94(16)D (Bl)	M96(16)B	M96(16)C (Tm)	M96(16)F	M105(16)A (Tm)	M105(16)B (Bl)	M105(16)D (Bl)	M105(16)E (Bl)	M105(16)F (Bl)
LOWER-MIDDLE MIOCENE	*Braarudosphaera bigelowii* (Gran & Braarud)																		2	5																		3										
	Calcidiscus premacintyrei Theodoridis																																						16									
	Calcidiscus tropicus Kamptner																										1						1							1								
	Coccolithus miopelagicus Bukry			2				14										2										5																				
	Coccolithus pelagicus (Wallich)			3	X	3	3		X	7	1	3	2		1		2	2		22	6			1			3		2		6	1	7		1		15	18		8	7	13	1	4	21	1		1
	Cyclicargolithus abisectus (Müller)			10		6	4	6		4		2	4		4		4	6		6	4			4	1			2	2	1		1	6										2					
	Cyclicargolithus floridanus (Roth & Hay)	8	56	2			2	4		4	2		2		2			2	2	6	8				1	1	4		5	10	12	1			1		24		24		5	18				4	1	
	Dictyococcites antarcticus Haq											2								9					5		2			1	1	2		3														
	Dictyococcites bisectus (Hay, Mohler and Wide)																							2	2																	1	1					
	Dictyococcities hesslandii (Haq)		31																								6																					
	Dictyococcities scripsae Bukry & Percival																								2												1		12	1								
	Discoaster druggii Bramlette & Wilcoxon							2												2																	1											
	Discoaster minutus Hojjatzadeh																																									1	1					
	Discoaster premicros de Kaenel & Bergen, in de Kaenel et al.																																												1			
	Helicosphaera ampliaperta Bramlette & Wilcoxon																														1																	
	Helicosphaera carteri (Wallich)	1		2		2		2				1					1	1	1								1				6		1				17	11	2	4	4	3	1	3	3		2	
	Helicosphaera intermedia Martini																																					6						2				
	Helicosphaera recta (Haq)							1																																								
	Helicosphaera stalis Theodoridis					2												2																				23				1					1	
	Helicosphaera walbersdorfensis Muller																																					17	2	17						1		
	Micrantholithus flos Deflandre																	2																											44			
	Pontosphaera desuetoidea Bartol																																						1					4	80	7		1
	Pontosphaera multipora (Kamptner)			5		2		2				4			1					3	1									1								6			4					5		
	Reticulofenestra haqii Backman		18					1		1		2						1							2		4				6		1	3			7		2	20	14	9	1		39		2	1
	Reticulofenestra gelida (Geitzenauer)																																				8										7	
	Reticulofenestra lockeri Muller																			2																												
	Reticulofenestra minuta Roth					2	6	2				7	1				1	1		1			1		2		2			18	25	1					12	4	16	3		5	1	21	403	9	1	1
	Reticulofenestra producta (Kamptner)			1						9	3	6						1		21	2				3		7		2	6	16	1	7	5	1		19	14	96	1	8	6	2	5	106	5		1
	Reticulofenestra pseudoumbilica (Gartner)		18	3		1		4				3	1		3		6	2	1	9	5		1							2			3				7	11		3	14	8	2	5	5	1	2	
	Scyphosphaera apsteinii Lohmann	1																																					1						3			
	Scyphosphaera brevis Varol																																				8					1						
	Scyphosphaera lagena Kamptner																																									1						
	Scyphosphaera recurvata Deflandre																								1																				3			
	Scyphosphaera tubifera Kamptner																																				16					1						
	Sphenolithus belemnos Bramlette and Wilcoxon																														1			2			1										1	
	Sphenolithus compactus Backman	8	1							2																													1									
	Sphenolithus conicus Bukry			2												X	2								1	1	3					2		2						1	5				13	1	1	
	Sphenolithus disbelemnos Fornaciari and Rio							2																					2		1																	
	Sphenolithus dissimilis Bukry and Percival																										8		2			2		2													1	
	Sphenolithus heteromorphus Deflandre																	2																			24		2		11			10	9			
	Sphenolithus moriformis (Brönnimann & Stradner)	24	23	8		6		9		12	2	10	8			X		5		9	2				12	1	6	3	2		6	2	3	6	1		24	6	42		3		33		2	5		
	Thoracosphaera heimii (Lohmann)																				1																1										1	
	Lebessphaera urania Meier, Janofske & Willems																																											1				
	Triquetrorhabdulus carinatus Martini		1																																													
	Umbilicosphaera jafarii Müller		4	1		1		2							1					1																	11	4	72		7	2	2		381	5		
	Zygrhablithus bijugatus (Deflandre in Deflandre & Fert)	1																									2		1											1								
	Synsedimentary nannofossil quantities in original rocks	16	58	16		8	8	32		24	4	12	6		6		6	16	4	14	15		2	6	32	2	15	7	14	11	15	8	6	12	2		84	43	289	20	21	24	4	14	153	13	12	1
	Total synsedimentary nannofossil quantities in original rocks	43	153	39		25	17	58		41	8	40	18		12		16	29	6	96	29		2	7	32	3	49	10	18	39	81	13	29	23	4		196	123	289	60	92	70	47	55	1116	44	22	5
	"Synsedimentary" nannofossil (%) ratios in original rocks	8	55	17		25	13	12		34	8	29	10		5		10	9	7	9	17		100	21	100	1	16	4	3	7	21	14	30	25	3		21	31	100	3	3	2	3	5	26	2	4	1
	Total "synsedimentary" nannofossil (%) ratios in original rocks	6	51	18		29	13	13		27	8	30	10		6		4	10	5	23	21		100	19	100	1	22	1	1	2	11	3	43	26	5		21	22	100	5	4	1	5	3	27	1	4	1

Table 4. Synsedimentary or reworked nannofossils including directly of originally classified long-ranged species of the Middle Eocene sedimentation.

Tablo 4. Orta Eosen çökeliminin kökensel olarak sınıflandırılmış uzun menzilli türlerini doğrudan içeren çökelimle eşyaşlı veya yeniden çökeltilmiş nannofosilleri.

TSUNAMITE SPOTS - ROCK SAMPLE NUMBERS

CHRONOZONE	NANNOFOSSIL SPECIES	M2(15)		M53-1/M53-2(15)						M60(15)					M61(15)						
		M2(15)A (Tm)	M2(15)B (Bl)	M53-1(15)A	M53-1(15)B (Ts)	M53-1(15)C (Int)	M53-1(15)D (Tm)	M53-2(15)A	M53-2(15)C (Ts)	M60(15)A (Tm)	M60(15)B (Bl)	M60(15)D (Tm)	M60(15)E	M60(15)F (Ts)	M61(15)B	M61(15)C (Ts)	M61(15)D	M61(15)E (Bl)	M61(15)F (Tm)	M61(15)G (Bl)	M61(15)H (Bl)
UPPER PALEOCENE-MIDDLE EOCENE	*Braarudosphaera bigelowii* (Gran & Braarud)																			1	
	Chiasmolithus solitus (Bramlette and Sullivan)																				
	Coccolithus pelagicus (Wallich)		5				1		X				1				1		5	6	
	Cruciplacolithus latipons Romein																				
	Dictyococcites hesslandii (Haq)		1																		
	Dictyococcites scripsae Bukry & Percival																				
	Discoaster backmanii Agnini et al.												1								
	Discoaster deflandrei Bramlette & Riedel																	2			
	Discoaster multiradiatus Bramlette & Riedel																				
	Ericsonia formosa (Kamptner)																	2			
	Ericsonia ovalis Black												2				2				
	Ericsonia subpertusa Hay & Mohler																				
	Pontosphaera cf. *pectinata* (Bramlette & Sullivan)		1				2	4										1	6	2	
	Pseudotriquetrorhabdulus inversus (Bukry & Bramlette)		1																		
	Reticulofenestra dictyoda (Deflandre in Deflandre & Fert)																		6	2	
	Reticulofenestra hillae Bukry & Percival																				
	Reticulofenestra reticulata (Gartner & Smith)																				
	Reticulofenestra stavensis (Levin & Joerger)																				
	Sphenolithus moriformis (Brönnimann & Stradner)		1					1					2					1	2	3	
	Toweius callosus Perch-Nielsen																2				
	Toweius magnicrassus (Bukry)																				
	Zygrhablithus bijugatus (Deflandre in Deflandre & Fert)		1																		
	Synsedimentary nannofossil quantities in original rocks		2				2	4					2				4	5	17	11	
	Total synsedimentary nannofossil quantities in original rocks		9				3	5					6				5	6	19	14	
	"Synsedimentary" nannofossil (%) ratios in original rocks		2				3	1					3				7	2	32	7	
	Total "synsedimentary" nannofossil (%) ratios in original rocks		3				2	1					3				3	2	17	3	

NANNOFOSSIL SPECIES	M87(15)											M91(15)				M94(16)				M96(16)			M105(16)				
	M87(15)A (Bl)	M87(15)C (Bl)	M87(15)E (Cm)	M87(15)F (Bl)	M87(15)H	M87(15)I	M87(15)L (Tm)	M87(15)N (Tm)	M87(15)O (Tm)	M87(15)R	M87(15)S	M91(15)B	M91(15)E (Int)	M91(15)F (Tm)	M91(15)G (Bl)	M94(16)A (Tm)	M94(16)B	M94(16)C (Bl)	M94(16)D (Bl)	M96(16)B	M96(16)C (Tm)	M96(16)F	M105(16)A (Tm)	M105(16)B (Bl)	M105(16)D (Bl)	M105(16)E (Bl)	M105(16)F (Bl)
Braarudosphaera bigelowii (Gran & Braarud)																											
Chiasmolithus solitus (Bramlette and Sullivan)																									1	1	
Coccolithus pelagicus (Wallich)						1				1							1		12	2	1						1
Cruciplacolithus latipons Romein																	3										
Dictyococcites hesslandii (Haq)																											
Dictyococcites scripsae Bukry & Percival						2																					
Discoaster backmanii Agnini et al.																											
Discoaster deflandrei Bramlette & Riedel										1				3						5					1		
Discoaster multiradiatus Bramlette & Riedel										1																	
Ericsonia formosa (Kamptner)																			8								
Ericsonia ovalis Black					1		2																				
Ericsonia subpertusa Hay & Mohler						4																					
Pontosphaera cf. *pectinata* (Bramlette & Sullivan)							4																				
Pseudotriquetrorhabdulus inversus (Bukry & Bramlette)																											
Reticulofenestra dictyoda (Deflandre in Deflandre & Fert)																											1
Reticulofenestra hillae Bukry & Percival																										1	
Reticulofenestra reticulata (Gartner & Smith)																			17		1						
Reticulofenestra stavensis (Levin & Joerger)																						1					1
Sphenolithus moriformis (Brönnimann & Stradner)	2					2	2							1											2		
Toweius callosus Perch-Nielsen																											
Toweius magnicrassus (Bukry)																			8								
Zygrhablithus bijugatus (Deflandre in Deflandre & Fert)						1								1													
Synsedimentary nannofossil quantities in original rocks	3				1	4	6			2				4			3		33	5	1	1			2	2	2
Total synsedimentary nannofossil quantities in original rocks	3				1	10	8			3				5			4		45	7	2	1			4	2	3
"Synsedimentary" nannofossil (%) ratios in original rocks	100				0	4	3			3				6			2		5	1	0	1			0	0	1
Total "synsedimentary" nannofossil (%) ratios in original rocks	100				0	5	1			0				6			1		4	0	0	0			0	0	1

Table 5. Synsedimentary or reworked nannofossils including directly of originally classified long-ranged species of the Cretaceous sedimentation.

Tablo 5. Kretase çökeliminin kökensel olarak sınıflandırılmış uzun menzilli türlerini doğrudan içeren çökelimle eşyaşlı veya yeniden çökeltilmiş nannofosilleri.

TSUNAMITE SPOTS - ROCK SAMPLE NUMBERS

CHRONOZONE	NANNOFOSSIL SPECIES	M2(15)		M53-1/M53-2(15)						M60(15)					M61(15)						
		M2(15)A (Tm)	M2(15)B (Bl)	M53-1(15)A	M53-1(15)B (Ts)	M53-1(15)C (Int)	M53-1(15)D (Tm)	M53-2(15)A	M53-2(15)C (Ts)	M60(15)A (Tm)	M60(15)B (Bl)	M60(15)D (Tm)	M60(15)E	M60(15)F (Ts)	M61(15)B	M61(15)C (Ts)	M61(15)D	M61(15)E (Bl)	M61(15)F (Tm)	M61(15)G (Bl)	M61(15)H (Bl)
UPPER CRETACEOUS-DANIAN	*Calculites obscurus* (Deflandre)																				
	Cervisiella operculata (Bramlette & Martini 1964)																				
	Cervisiella saxea (Stradner)	1																			2
	Cribrosphaerella ehrenbergii (Arkhangelsky)																				
	Eiffellithus eximius (Stover)																		1		
	Eiffellithus gorkae Reinhardt	1																			
	Eiffellithus turriseiffelii (Deflandre)																				
	Lithraphidites quadratus Bramlette & Martini																				
	Placozygus fibuliformis (Reinhardt)																				
	Retecapsa crenulata (Bramlette & Martini)																		1		
	Watznaueria barnesiae (Black in Black & Barnes)													X			1		1		
	Zeugrhabdotus sigmoides (Bramlette & Sullivan)																				
	Synsedimentary nannofossil quantities in original rocks	2															1		3		2
	Total synsedimentary nannofossil quantities in original rocks	2															1		3		2
	"Synsedimentary" nannofossil (%) ratios in original rocks	1															2		6		2
	Total "synsedimentary" nannofossil (%) ratios in original rocks	0															1		3		2

NANNOFOSSIL SPECIES	M87(15)											M91(15)				M94(16)				M96(16)			M105(16)				
	M87(15)A (Bl)	M87(15)C (Bl)	M87(15)E (Cm)	M87(15)F (Bl)	M87(15)H	M87(15)I	M87(15)L (Tm)	M87(15)N (Tm)	M87(15)O (Tm)	M87(15)R	M87(15)S	M91(15)B	M91(15)E (Int)	M91(15)F (Tm)	M91(15)G (Bl)	M94(16)A (Tm)	M94(16)B	M94(16)C (Bl)	M94(16)D (Bl)	M96(16)B	M96(16)C (Tm)	M96(16)F	M105(16)A (Tm)	M105(16)B (Bl)	M105(16)D (Bl)	M105(16)E (Bl)	M105(16)F (Bl)
Calculites obscurus (Deflandre)										1																	
Cervisiella operculata (Bramlette & Martini 1964)																							1				
Cervisiella saxea (Stradner)																				3		1	1	1		1	
Cribrosphaerella ehrenbergii (Arkhangelsky)																							1				
Eiffellithus eximius (Stover)																											
Eiffellithus gorkae Reinhardt																											
Eiffellithus turriseiffelii (Deflandre)																1											
Lithraphidites quadratus Bramlette & Martini																						1					
Placozygus fibuliformis (Reinhardt)										1																	
Retecapsa crenulata (Bramlette & Martini)																											
Watznaueria barnesiae (Black in Black & Barnes)						4		1		2																	1
Zeugrhabdotus sigmoides (Bramlette & Sullivan)																								1			
Synsedimentary nannofossil quantities in original rocks						4		1		4						1				3		2	3	2		1	1
Total synsedimentary nannofossil quantities in original rocks						4		1		4						1				3		2	3	2		1	1
"Synsedimentary" nannofossil (%) ratios in original rocks						4		0		6						1				1		1	1	0		0	0
Total "synsedimentary" nannofossil (%) ratios in original rocks						2		0		1						0				0		0	0	0		0	0

Table 6. Synsedimentary ascidian spicules in the Lower Pliocene and Lower Pleistocene sedimentations.

Tablo 6. Alt Pliyosen ve Alt Pleyistosen çökelimlerindeki eşyaşlı ascidian spiküller

TSUNAMITE SPOTS - ROCK SAMPLE NUMBERS

FOSSIL DIDEMNID ASCIDIAN SPICULES	M2(15)		M53-1/M53-2(15)						M60(15)					M61(15)						
	M2(15)A (Tm)	M2(15)B (Bl)	M53-1(15)A	M53-1(15)B (Ts)	M53-1(15)C (Int)	M53-1(15)D (Tm)	M53-2(15)A	M53-2(15)C (Ts)	M60(15)A (Tm)	M60(15)B (Bl)	M60(15)D (Tm)	M60(15)E	M60(15)F (Ts)	M61(15)B	M61(15)C (Ts)	M61(15)D	M61(15)E (Bl)	M61(15)F (Tm)	M61(15)G (Bl)	M61(15)H (Bl)
undefined " Ascidian spicule"												o								
Bonetia acuta Varol & Houghton																				
Bonetia brevis Varol & Houghton																				
Micrascidites gothicus Sagular in Sagular et al.																				
Micrascidites vulgaris Deflandre, Deflandre-Rigaud				o										o						
Monniotia aciformis	o																			
Monniotia fasciculata Varol & Houghton												o								
Monniotia minutula Sagular in Sagular et al.											o									
Riguadia multiradiata Varol & Houghton									o											

FOSSIL DIDEMNID ASCIDIAN SPICULES	M87(15)											M91(15)				M94(16)				M96(16)			M105(16)				
	M87(15)A (Bl)	M87(15)C (Bl)	M87(15)E (Cm)	M87(15)F (Bl)	M87(15)H	M87(15)I	M87(15)L (Tm)	M87(15)N (Tm)	M87(15)O (Tm)	M87(15)R	M87(15)S	M91(15)B	M91(15)E (Int)	M91(15)F (Tm)	M91(15)G (Bl)	M94(16)A (Tm)	M94(16)B	M94(16)C (Bl)	M94(16)D (Bl)	M96(16)B	M96(16)C (Tm)	M96(16)F	M105(16)A (Tm)	M105(16)B (Bl)	M105(16)D (Int)	M105(16)E (Bl)	M105(16)F (Bl)
undefined " Ascidian spicule"																						o					
Bonetia acuta Varol & Houghton																o											
Bonetia brevis Varol & Houghton																o					o				o		
Micrascidites gothicus Sagular in Sagular et al.																o											
Micrascidites vulgaris Deflandre, Deflandre-Rigaud																o						o					
Monniotia aciformis																											
Monniotia fasciculata Varol & Houghton																											
Monniotia minutula Sagular in Sagular et al.																	o										
Riguadia multiradiata Varol & Houghton																					o						

In these samples (M53-2(15)A, M61(15)B, M61(15)D, M87(15)H, M87(15)I, M91(15)B, and M96(16)B), there are Early Pliocene nannofossil assemblage of NN15 - Reticulofenestra pseudoumbilicus interval zone including synsedimentary data including Calcidiscus spp. [i.e. C. leptoporus (Murray & Blackman), C. macintyrei (Bukry & Bramlette), C. tropicus Kamptner], Calciosolenia murrayi Gran, Coccolithus pliopelagicus Wise, Coronosphaera mediterranea (Lohmann), Discoaster spp. [i.e. D. asymmetricus Gartner, D. brouweri Tan, D. pansus (Bukry & Percival), D. pentaradiatus Tan, D. pliostellulus Browning & Bergen, D. surculus Martini & Bramlette, D. tamalis Kamptner, D. variabilis Martini & Bramlette], Helicosphaera spp. [i.e. H. intermedia Martini, H. kamptneri Hay & Mohler, H. selli (Bukry and Bramlette)], Pseudoemiliana ovata (Kamptner), Reticulofenestra spp. [i.e R. haqii Backman, R. minuta Roth, R. minutula (Gartner), R. pseudoumbilicus (Gartner)], Scyphosphaera spp. (i.e. S. apsteinii Lohmann, S. canescens Kamptner, S. intermedia Deflandre, S. pulcherrima Deflandre), Sphenolithus spp. [i.e. S. abies Deflandre, S. neoabies Bukry & Bramlette, Sphenaster metula (Wilcoxon)], Syracosphaera pulchra Lohmann, Umbilicosphaera spp. [i.e. U. jafarii Müller, U. rotula Kamptner, U. sibogae (Weber-van Bosse)]. In addition, some dinoflagellate cysts such as Calciodinellum albatrosianum (Kamptner) (see Fig 6: 15a-b), Lebessphaera urania Meier, Janofske & Willems were determined.

The resembling data were obtained from the blue-grey marl block/cobbles placed within the tsunamite matrix. Synsedimentary nannofossil quantities show a distribution mainly varying between 46–100% in the samples (see Table 2). The resembling data in 43–98% proportions were obtained from 9 samples of the blue-grey marl blocks/cobbles (M2(15)B, M60(15)B, M61(15)E, M91(15)G, M94(16)D, M105(16)B, M105(16)D, M105(16)E, M105(16)F) participated into the tsunamite matrix (see Table 2).

In addition, in these samples of the Karpuzçay Formation, reworked nannofossil data of Early-Middle Miocene, Eocene, Cretaceous-Paleocene nannofossil assemblages are described. Calcidiscus premacintyrei Theodoridis, Coccolithus miopelagicus Bukry, Cyclicargolithus spp. (i.e. C. abisectus (Müller), C. floridanus (Roth & Hay)), Dictyococcites bisectus (Hay, Mohler and Wide), Discoaster druggii Bramlette & Wilcoxon, Helicosphaera spp. (i.e. H. recta (Haq), H. stalis Theodoridis, H. walbersdorfensis Muller), Scyphosphaera recurvata Deflandre, Sphenolithus spp. (i.e. S. belemnos Bramlette and Wilcoxon, S. compactus Backman, S conicus Bukry, S. dissimilis Bukry and Percival, S. heteromorphus Deflandre, S. moriformis (Brönnimann &

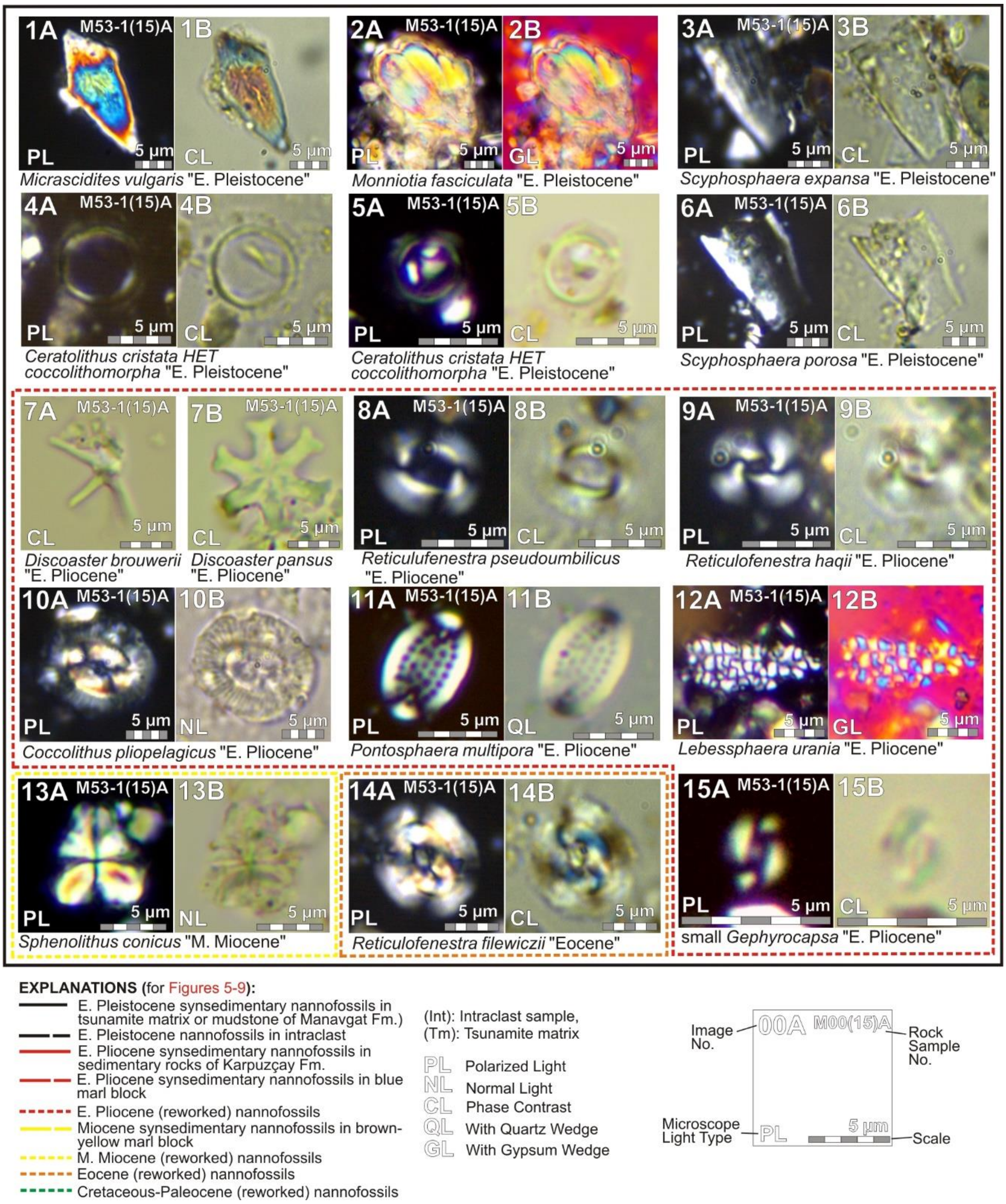


Figure 5. Synsedimentary and reworked nannofossil species in the mudstone sample M53-1(15)A of the Manavgat Formation (regular sedimentary sequence).

Şekil 5. Manavgat Formasyonu'na ait M53-1(15)A çamurtaşı örneğindeki çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri (düzenli sedimanter istif).

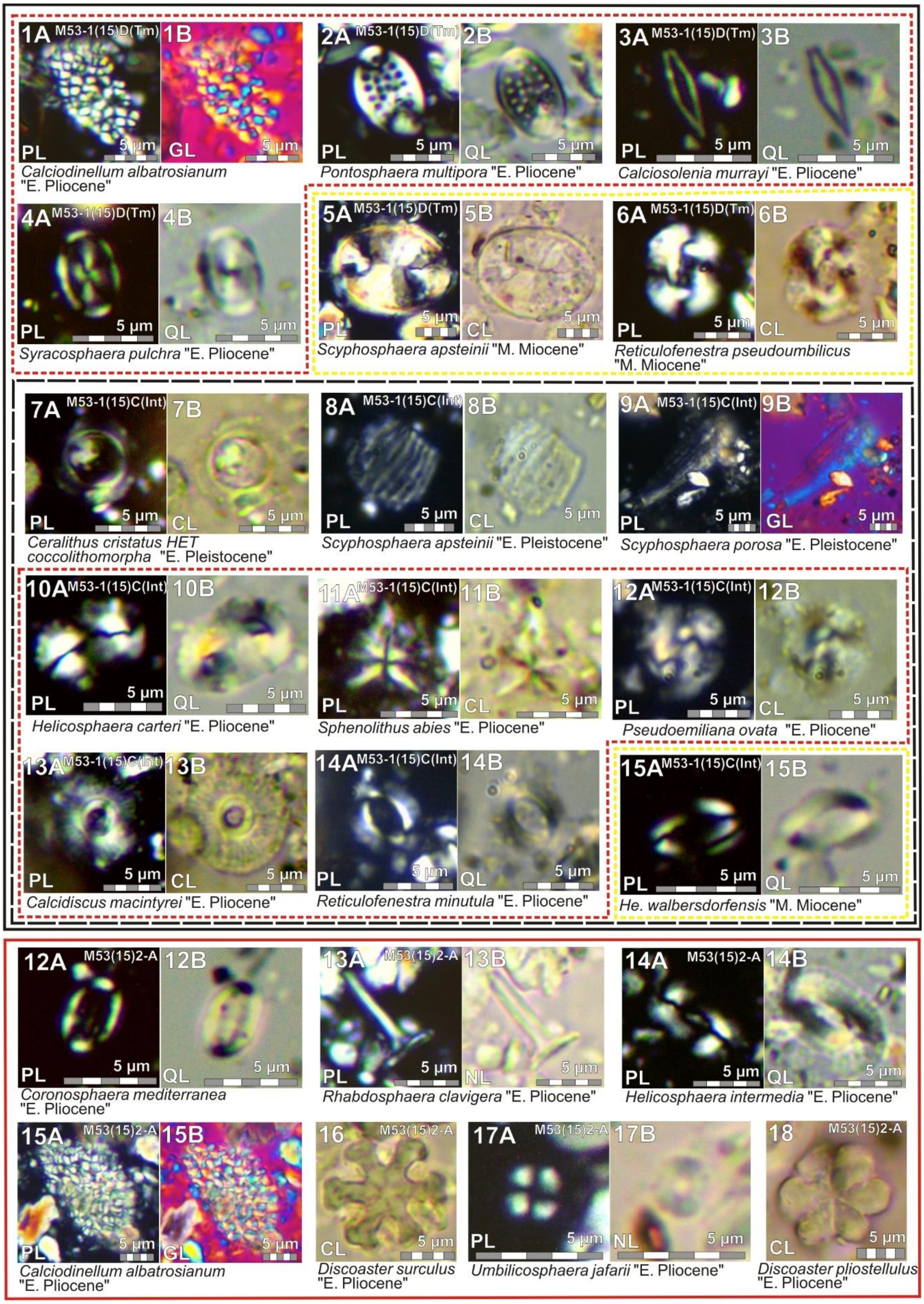


Figure 6. Synsedimentary and reworked nannofossil species in the (pebbly) mud matrix (M53-1(15)D), mud intraclast (M53-1(15)C) samples in the tsunami deposits of the Manavgat Formation and blue marl (M53-2(15)A) of the Karpuzçay Formation (Explanations in Fig. 5).

Şekil 6: Manavgat Formasyonu'nun tsunami çökellerindeki (çakıllı) çamur matriks (M53-1(15)D), çamur intraklast (M53-1(15)C) ve Karpuzçay Formasyonu'nun mavi marn (M53-2(15)A) örneklerindeki çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri (Açıklamalar Şekil 5'te).

Stradner)), Triquetrorhabdulus carinatus Martini, Umbilicosphaera jafarii Müller are nannofossil data reworked from Early-Middle Miocene aged sedimentary rocks such as Middle Miocene aged Geceleme Formation north of the region or the older Lower Miocene rocks around Isparta.

Nannofossil assemblage of the Geceleme Formation indicates NN5 - Sphenolithus heteromorphus zone whereas an Aquitanian-Burdigalian assemblage represents nannofossil data of NN1 to NN3 biozones determined around Isparta (Görmüş et al, 2001; Hepdeniz and Sagular, 2009; Yavuzlar and Sagular, 2018). With a few species and numbers, Chiasmolithus solitus (Bramlette and Sullivan), Coccolithus pelagicus (Wallich), Discoaster deflandrei Bramlette & Riedel, Ericsonia spp. (i.e. E. formosa (Kamptner), E. ovalis Black), Reticulofenestra spp. (i.e. R. dictyoda (Deflandre), R. hillae Bukry & Percival, R. reticulata (Gartner & Smith), R. stavensis (Levin & Joerger)), Sphenolithus moriformis (Brönnimann & Stradner), Toweius spp. (i.e. T. callosus Perch-Nielsen, T. magnicrassus (Bukry)), Zygrhablithus bijugatus (Deflandre) are found as 1-7 % Eocene nannofossil assemblage in blue-grey marl samples of the Karpuzçay Formation.

Besides Upper Cretaceous (reworked) nannofossil data including Watznaueria barnesiae (Black in Black & Barnes), Zeugrhabdotus sigmoides (Bramlette & Sullivan) and dynoflagellate cysts such as Cervisiella saxea (Stradner) are seen in the samples of Karpuzçay Formation or various marl blocks/cobbles in the tsunamite matrix. In addition, there are light brown-cream colored marly limestone, marl cobbles/blocks [samples: M87(15)C(Bl), M87(15)F(Bl), M94(16)C(Bl)] including Lower-Middle Miocene nannofossils (see Table 3) such as Calcidiscus premacintyrei Theodoridis, Cyclicargolithus floridanus (Roth & Hay), Dictyococcites spp. (D. productus (Kamptner), D. scripsae Bukry & Percival), Helicosphaera spp. (i.e. H. carteri (Wallich), H. walbersdorfensis Muller), Reticulofenestra spp. (i.e. R. haqii Backman, R. minuta Roth, R. pseudoumbilica (Gartner)), Scyphosphaera spp. (i.e. S. apsteinii Lohmann, S. recurvata Deflandre), Sphenolithus spp. (i.e. S. compactus Backman, S. conicus Bukry, S. heteromorphus Deflandre, S. moriformis (Brönnimann & Stradner)), Umbilicosphaera jafarii Müller representing NN5 zone. It is concluded that these pebbles/cobbles (rock samples) were

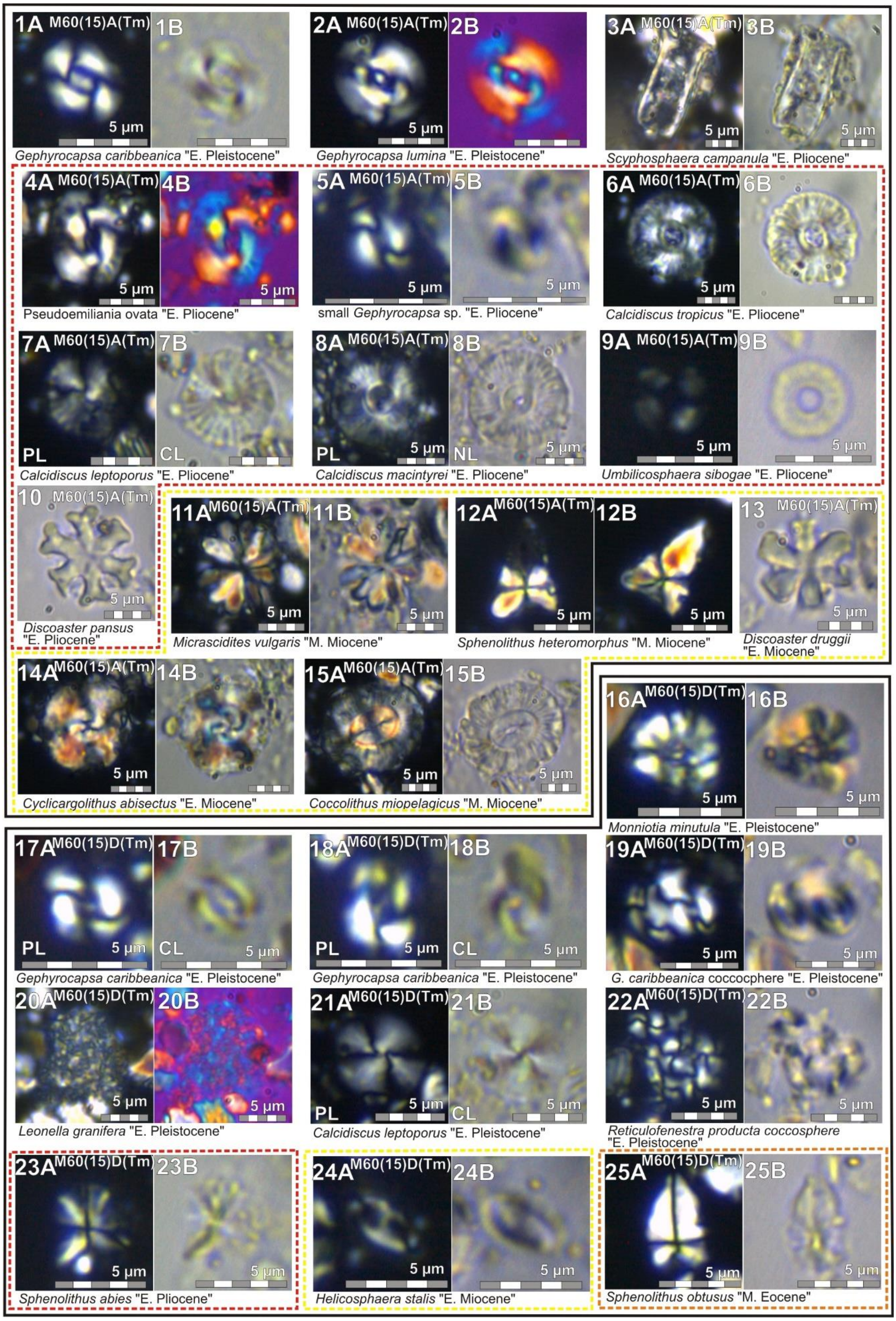

1A M60(15)A(Tm) 1B
Gephyrocapsa caribbeanica "E. Pleistocene"
2A M60(15)A(Tm) 2B
Gephyrocapsa lumina "E. Pleistocene"
3A M60(15)A(Tm) 3B
Scyphosphaera campanula "E. Pliocene"
4A M60(15)A(Tm) 4B
Pseudoemiliania ovata "E. Pliocene"
5A M60(15)A(Tm) 5B
small Gephyrocapsa sp. "E. Pliocene"
6A M60(15)A(Tm) 6B
Calcidiscus tropicus "E. Pliocene"
7A M60(15)A(Tm) 7B PL CL
Calcidiscus leptoporus "E. Pliocene"
8A M60(15)A(Tm) 8B PL NL
Calcidiscus macintyrei "E. Pliocene"
9A M60(15)A(Tm) 9B
Umbilicosphaera sibogae "E. Pliocene"
10 M60(15)A(Tm)
Discoaster pansus "E. Pliocene"
11A M60(15)A(Tm) 11B
Micrascidites vulgaris "M. Miocene"
12A M60(15)A(Tm) 12B
Sphenolithus heteromorphus "M. Miocene"
13 M60(15)A(Tm)
Discoaster druggii "E. Miocene"
14A M60(15)A(Tm) 14B
Cyclicargolithus abisectus "E. Miocene"
15A M60(15)A(Tm) 15B
Coccolithus miopelagicus "M. Miocene"
16A M60(15)D(Tm) 16B
Monniotia minutula "E. Pleistocene"
17A M60(15)D(Tm) 17B PL CL
Gephyrocapsa caribbeanica "E. Pleistocene"
18A M60(15)D(Tm) 18B PL CL
Gephyrocapsa caribbeanica "E. Pleistocene"
19A M60(15)D(Tm) 19B
G. caribbeanica coccocphere "E. Pleistocene"
20A M60(15)D(Tm) 20B
Leonella granifera "E. Pleistocene"
21A M60(15)D(Tm) 21B PL CL
Calcidiscus leptoporus "E. Pleistocene"
22A M60(15)D(Tm) 22B
Reticulofenestra producta coccosphere "E. Pleistocene"
23A M60(15)D(Tm) 23B
Sphenolithus abies "E. Pliocene"
24A M60(15)D(Tm) 24B
Helicosphaera stalis "E. Miocene"
25A M60(15)D(Tm) 25B
Sphenolithus obtusus "M. Eocene"
5 µm

Figure 7. Synsedimentary and reworked nannofossil species in the (pebbly) mud matrix (M60(15)A and M60(15)D) samples in the tsunami deposits of the Manavgat Formation. (Explanations in Fig. 5).

Şekil 7. Manavgat Formasyonu'nun tsunami tortullarındaki (M60(15)A ve M60(15)D) örneklerinin (çakıllı) çamur matrisindeki çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri. (Açıklamalar Şekil 5'te).

probably transported from carbonate rocks of the Geceleme Formation placed at the bottom. As illustrated in Figures 6, 8, 12, 13, Lower Pleistocene nannofossils of the Karpuzçay Formation were determined in a number of the blue-grey marl samples [i.e. M53-2(15)A in Fig. 6, M61(15)B in Fig. 8, M96(16)B in Fig. 12] and in the blue-grey marl cobble/blocks of the tsunamite [i.e. B61(15)E(Bl) and M61(15)G(Bl) in Fig. 8, M105(16)B(Bl) in Fig. 13].

As illustrated in Figure 5–13, reworked Lower Pliocene nannofossils are between 36–87% in the Lower Pleistocene regular (rhythmic shallow marine clastic) sedimentary rock samples of the Manavgat Formation [i.e. M53-1(15)A in Fig. 5; M87(15)O, M87(15)S in Fig. 9; M94(16)B in Fig. 11; M96(16)F in Fig. 12] and are between 71–75% in the gray mudstone intraclast samples [i.e. M53-1(15)C(Int) in Fig. 6] and are between 51–98% in the irregular (tsunamite) sedimentary rock samples [i.e. M53-1(15)D(Tm) in Fig. 6; M60(15)A(Tm), M60(15)D(Tm) in Fig. 7; M94(16)A(Tm) in Fig. 10; M96(16)C(Tm) in Fig. 12; M105(16)A(Tm) in Fig. 13]. In addition, an abundant reworked Lower-Middle Miocene nannofossil (and dinoflagellate cysts) data between 1–55% (see Table 3, Figs. 5-13) including Coccolithus miopelagicus Bukry, Cyclicargolithus spp. [i.e. C. abisectus (Müller), C. floridanus (Roth & Hay)], Dictyococcites bisectus (Hay, Mohler and Wide), Discoaster druggii Bramlette & Wilcoxon, Helicosphaera spp. (i.e. H. stalis Theodoridis, H. walbersdorfensis Müller), Micrantholithus flos Deflandre, Pontosphaera desuetoidea Bartol, Reticulofenestra spp. [i.e. R. haqii Backman, R. gelida (Geitzenauer), R. lockeri Müller, R. minuta Roth, R. pseudoumbilica (Gartner)], Scyphosphaera spp. [i.e. S. apsteinii Lohmann, S. brevis Varol, S. lagena Kamptner, S. recurvata Deflandre, S. tubifera Kamptner], Sphenolithus spp. [i.e. S. belemnos Bramlette and Wilcoxon, S. compactus Backman, S. conicus Bukry, S. disbelemnos Fornaciari and Rio, S. dissimilis Bukry and Percival, S. heteromorphus Deflandre, S. moriformis (Brönnimann & Stradner)], Thoracosphaera heimii (Lohmann), Triquetrorhabdulus carinatus Martini, Umbilicosphaera

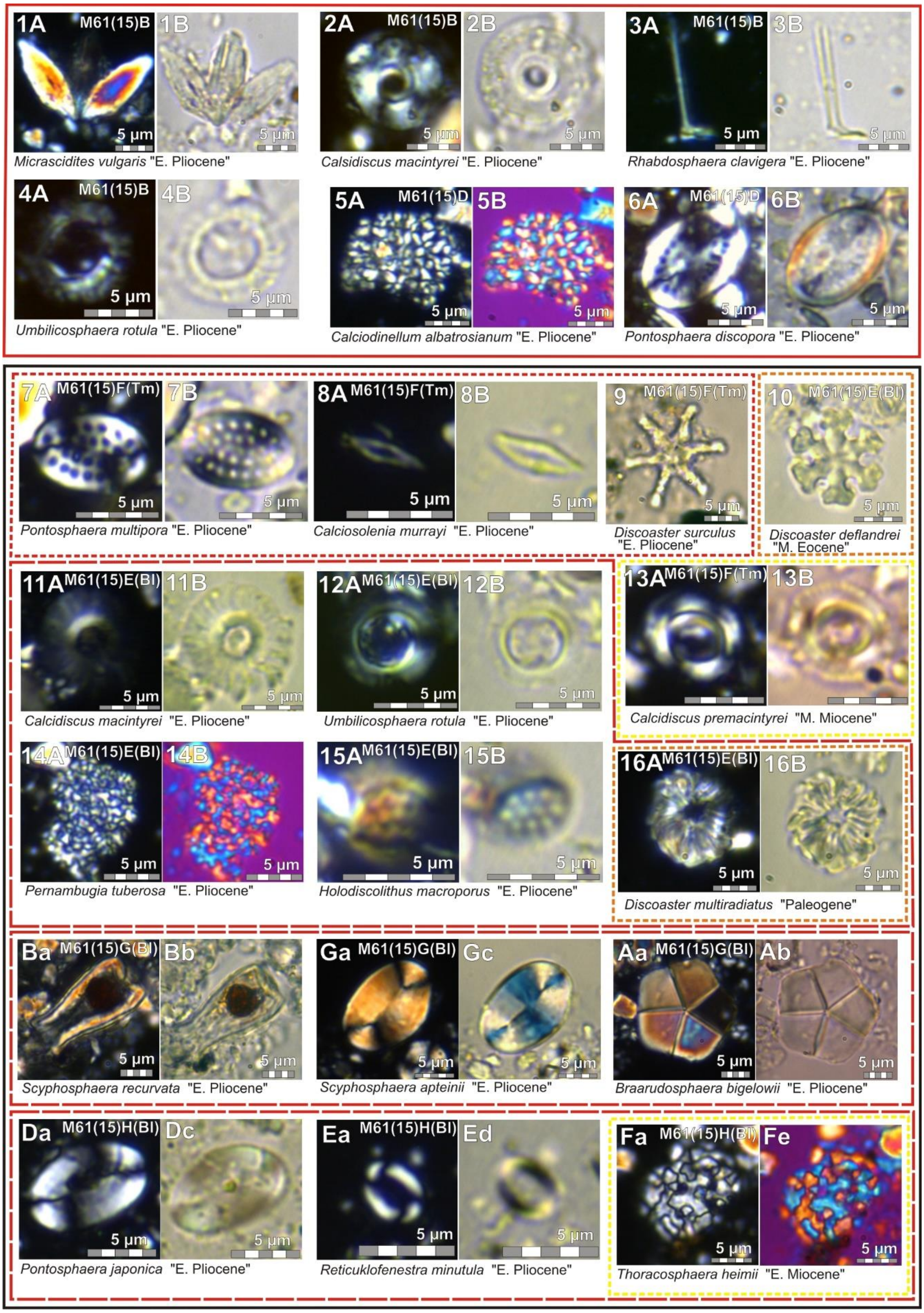


Figure 8. Synsedimentary and reworked nannofossil species in the blue-grey marl (M61(15)B and M61(1)D) samples of the Karpuzçay Formation; (pebbly) mud matrix sample (M61(15)A) and

blue-gray marl blocks (M61(15)E, M61(15)G and M61(15)H) in the tsunami deposits of the Manavgat Formation. (Explanations in Fig. 5).

Şekil 8. Karpuzçay Formasyonu'nun mavi-gri marn (M61(15)B ve M61(1)D) örnekleri; Manavgat Formasyonu'nun tsunami çökellerindeki (çakıllı) çamur matris örneği (M61(15)A) ve mavi-gri marn blokları (M61(15)E, M61(15)G ve M61(15)H) örneklerindeki çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri. (Açıklamalar Şekil 5'te).

jafarii Müller. It was determined that a number of reworked Middle Eocene nannofossil data between 1–32% (see Table 4, Figs. 5–13) in the most of the rock samples of the Karpuzçay and Manavgat Formations. Chiasmolithus solitus (Bramlette and Sullivan), Cruciplacolithus latipons Romein, Dictyococcities hesslandii (Haq), Discoaster spp. (i.e. D. backmanii Agnini et al., D. deflandrei Bramlette & Riedel, D. multiradiatus Bramlette & Riedel), Ericsonia spp. [i.e. E. formosa (Kamptner), E. ovalis Black, E. subpertusa Hay & Mohler], Pontosphaera cf. pectinata (Bramlette & Sullivan), Pseudotriquetrorhabdulus inversus (Bukry & Bramlette), Reticulofenestra spp. [i.e. R. dictyoda (Deflandre in Deflandre & Fert), R. hillae Bukry & Percival, R. reticulata (Gartner & Smith), R. stavensis (Levin & Joerger)], Sphenolithus moriformis (Brönnimann & Stradner), Toweius spp. [i.e. T. callosus Perch-Nielsen, T. magnicrassus (Bukry)], Zygrhablithus bijugatus (Deflandre in Deflandre & Fert) are among of these data. In determinations were come across reworked Upper Cretaceous-Danian nannofossil and dinoflagellate species between 1-32% (see Table 4, Figs. 5–14) in some of the rock samples of the Karpuzçay and Manavgat Formations. Calculites obscurus (Deflandre), Cribrosphaerella ehrenbergii (Arkhangelsky), Eiffellithus spp. [i.e. E. eximius (Stover), E. gorkae Reinhardt, E. turriseiffelii (Deflandre)], Lithraphidites quadratus Bramlette & Martini, Placozygus fibuliformis (Reinhardt), Retecapsa crenulata (Bramlette & Martini), Watznaueria barnesiae (Black in Black & Barnes), Zeugrhabdotus sigmoides (Bramlette & Sullivan), Cervisiella spp. [I.e. C. operculata (Bramlette & Martini), C. saxea (Stradner)] are among these data.

In the whole examined rock samples gathered from the regular sedimentary rock alternations as rhythmic shallow marine clastics [i.e. M53-1(15)A, M60(15)E, M87(15)R, M87(15)S, M94(16)B, M96(16)F] and irregular sedimentary levels “tsunami deposits” [i.e. M2(15)A(Tm), M53-1(15)D(Tm), M60(15)A(Tm), M61(15)F(Tm), M87(15)L(Tm), M87(15)N(Tm), M87(15)O(Tm), M91(15)F(Tm), M94(16)A(Tm), M96(16)C(Tm),

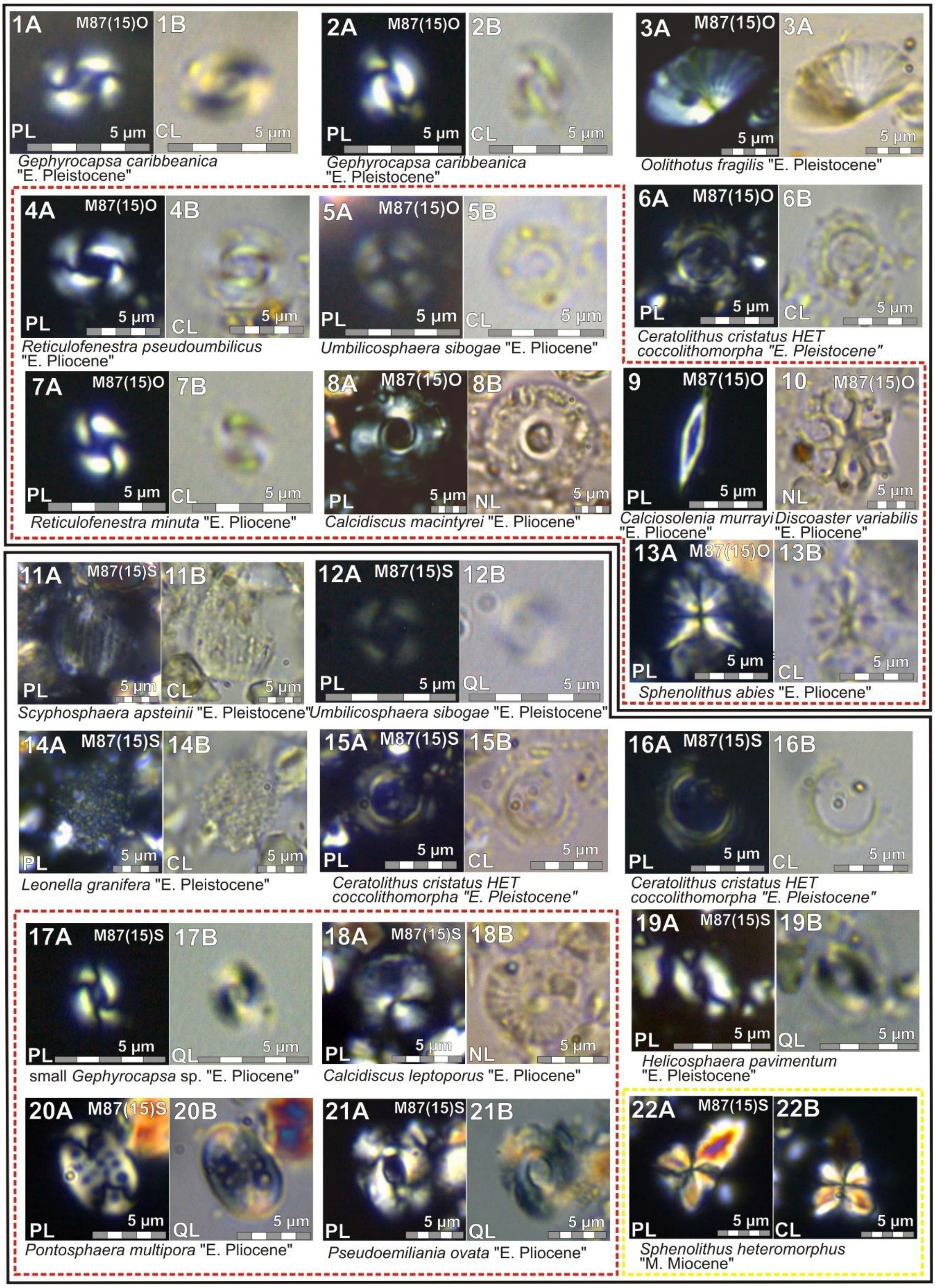


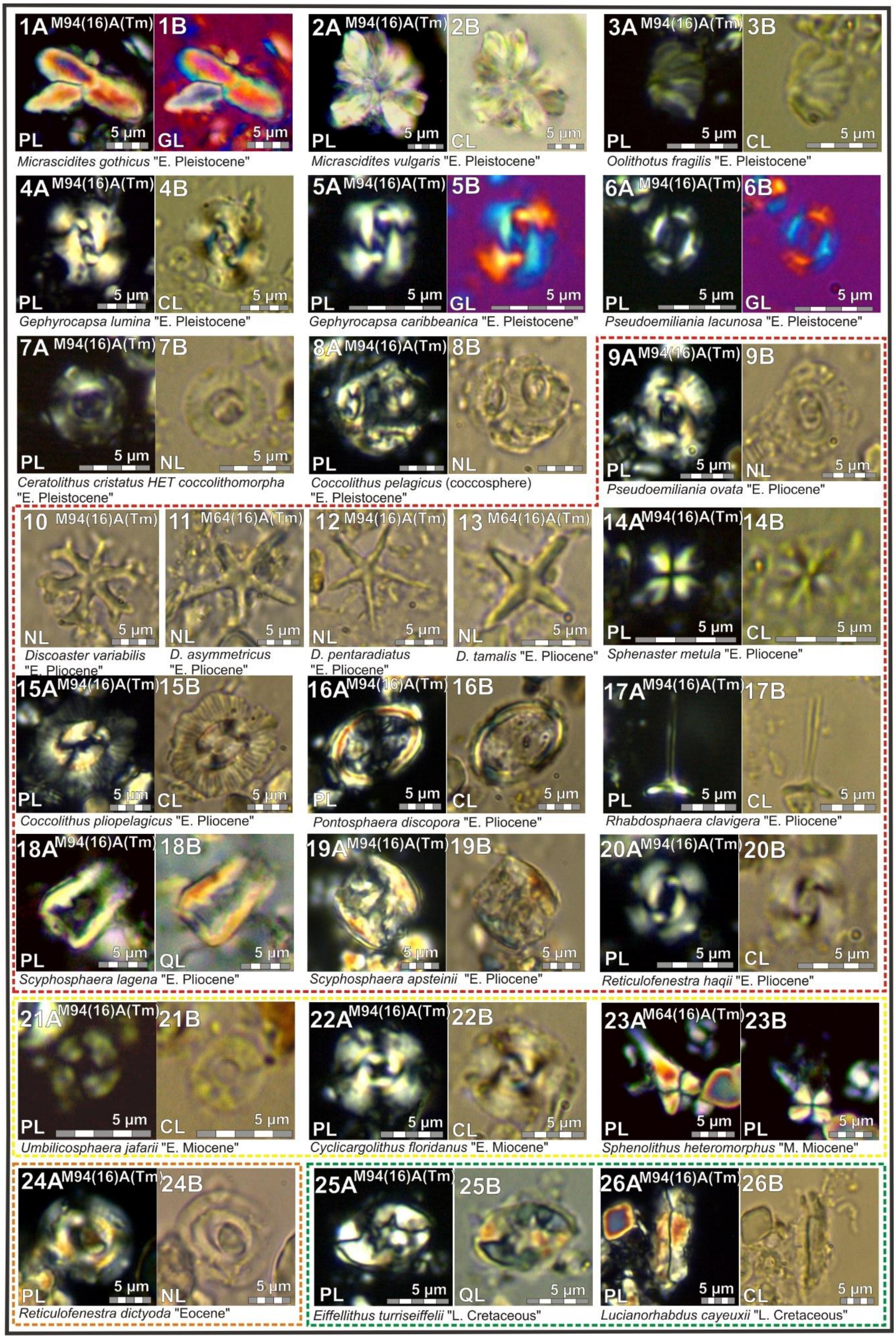
Figure 9. Synsedimentary and reworked nannofossil species in the (pebbly) mud matrix (M87(15)O and M87(15)S) samples in the tsunami deposits of the Manavgat Formation. (Explanations in Fig. 5).

Şekil 9. Manavgat Formasyonu'nun tsunami çökellerinin (çakıllı) çamur matrisindeki (M87(15)O ve M87(15)S) çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri. (Açıklamalar Şekil 5'te).

M105(16)A(Tm)] of the Manavgat Formation, an abundance of reworked nannofossil data are seen to hide absolute synsedimentary data (see Tables 1-5, Figs. 5–14).

As some of them illustrated in Figs. 5–13, Calcidiscus leptoporus (Murray & Blackman), Ceratolithus cristatus HET coccolithomorpha (Lecal-Schlauder), medium Gephyrocapsa spp. (G. caribbeanica Boudreaux & Hay, G. lumina Bukry) and small Gephyrocapsa spp., Helicosphaera spp. (i.e. H. carteri (Wallich), H. hyalina Gaarder, H. pavimentum), Oolithotus fragilis (Lohmann), Pontosphaera spp. [i.e. P. japonica (Takayama), P. scutellum Kamptner], Pseudoemiliana lacunosa (Kamptner), Scyphosphaera spp. (i.e. S. apsteinii Lohmann, S. expansa Bukry & Percival, S. porosa Kamptner), Syracosphaera pulchra Lohmann, Umbellosphaera tenuis (Kamptner), Umbilicosphaera spp. [i.e. U. foliosa Kamptner, U. sibogae (Weber-van Bosse)] are synsedimentary nannofossil data (see Table 1).

They have been seen generally between 3–14% (Fig. 15) in shallow marine mudstone-sandstone alternation of the Manavgat Formation, not exceeding 47% in some extreme samples, as well. In addition in the samples were determined a few dinoflagellate cyst species such as Leonella granifera (Fütterer), Pernambugia tuberosa (Kamptner) (see Table 1). Some samples such as M53-1(15)A, M60(15)E, M87(15)R, M87(15)S, M94(16)B, M96(16)F of regular sedimentary rock levels of the Manavgat Formation include total 53–97% reworked nannofossil data resembling those of the Karpuzçay and Geceleme Formations located at the region. These data comprise 36–87% Lower Pliocene nannofossil assemblage reworked from the Karpuzçay Formation rocks and 3–31% Lower-Middle Miocene assemblage reworked from the Geceleme Formation or the older rocks in and around the Isparta Angle (see Table 1–5, Figs. 5–14). Besides in the same samples, there are also 1–3% Middle Eocene and 1–6% Upper Cretaceous-Danian nannofossils reworked from the Eocene and Cretaceous/Paleogene transition rock sources located at the north of the Isparta Angle. The samples [M2(15)A(Tm), M53-1(15)D(Tm), M60(15)A(Tm), M60(15)D(Tm), M61(15)F(Tm), M87(15)L(Tm), M87(15)N(Tm), M87(15)O(Tm), M91(15)F(Tm), M94(16)A(Tm), M96(16)C(Tm), M105(16)A(Tm)] of pebbly mud matrix of the tsunamite deposits include mainly reworked nannofossil data



1A M94(16)A(Tm) 1B
Micrascidites gothicus "E. Pleistocene"
2A M94(16)A(Tm) 2B
Micrascidites vulgaris "E. Pleistocene"
3A M94(16)A(Tm) 3B
Oolithotus fragilis "E. Pleistocene"
4A M94(16)A(Tm) 4B
Gephyrocapsa lumina "E. Pleistocene"
5A M94(16)A(Tm) 5B
Gephyrocapsa caribbeanica "E. Pleistocene"
6A M94(16)A(Tm) 6B
Pseudoemiliania lacunosa "E. Pleistocene"
7A M94(16)A(Tm) 7B
Ceratolithus cristatus HET coccolithomorpha "E. Pleistocene"
8A M94(16)A(Tm) 8B
Coccolithus pelagicus (coccosphere) "E. Pleistocene"
9A M94(16)A(Tm) 9B
Pseudoemiliania ovata "E. Pliocene"
10 M94(16)A(Tm)
Discoaster variabilis "E. Pliocene"
11 M64(16)A(Tm)
D. asymmetricus "E. Pliocene"
12 M94(16)A(Tm)
D. pentaradiatus "E. Pliocene"
13 M64(16)A(Tm)
D. tamalis "E. Pliocene"
14A M94(16)A(Tm) 14B
Sphenaster metula "E. Pliocene"
15A M94(16)A(Tm) 15B
Coccolithus pliopelagicus "E. Pliocene"
16A M94(16)A(Tm) 16B
Pontosphaera discopora "E. Pliocene"
17A M94(16)A(Tm) 17B
Rhabdosphaera clavigera "E. Pliocene"
18A M94(16)A(Tm) 18B
Scyphosphaera lagena "E. Pliocene"
19A M94(16)A(Tm) 19B
Scyphosphaera apsteinii "E. Pliocene"
20A M94(16)A(Tm) 20B
Reticulofenestra haqii "E. Pliocene"
21A M94(16)A(Tm) 21B
Umbilicosphaera jafarii "E. Miocene"
22A M94(16)A(Tm) 22B
Cyclicargolithus floridanus "E. Miocene"
23A M64(16)A(Tm) 23B
Sphenolithus heteromorphus "M. Miocene"
24A M94(16)A(Tm) 24B
Reticulofenestra dictyoda "Eocene"
25A M94(16)A(Tm) 25B
Eiffellithus turriseiffelii "L. Cretaceous"
26A M94(16)A(Tm) 26B
Lucianorhabdus cayeuxii "L. Cretaceous"
PL
GL
CL
NL
QL
5 µm

Figure 10. Synsedimentary and reworked nannofossil species in the (pebbly) mud matrix (M94(16)A) sample in the tsunami deposits of the Manavgat Formation. (Explanations in Fig. 5)

Şekil 10: Manavgat Formasyonu'nun tsunami çökellerinde (çakıllı) çamur matris (M94(16)A) örneğindeki çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri. (Açıklamalar Şekil 5'te).

derived from the Karpuzçay and Geceleme Formations between 60–96% while synsedimentary fossils are in 4–40% (see Tab. 1–5, Fig. 5–14).

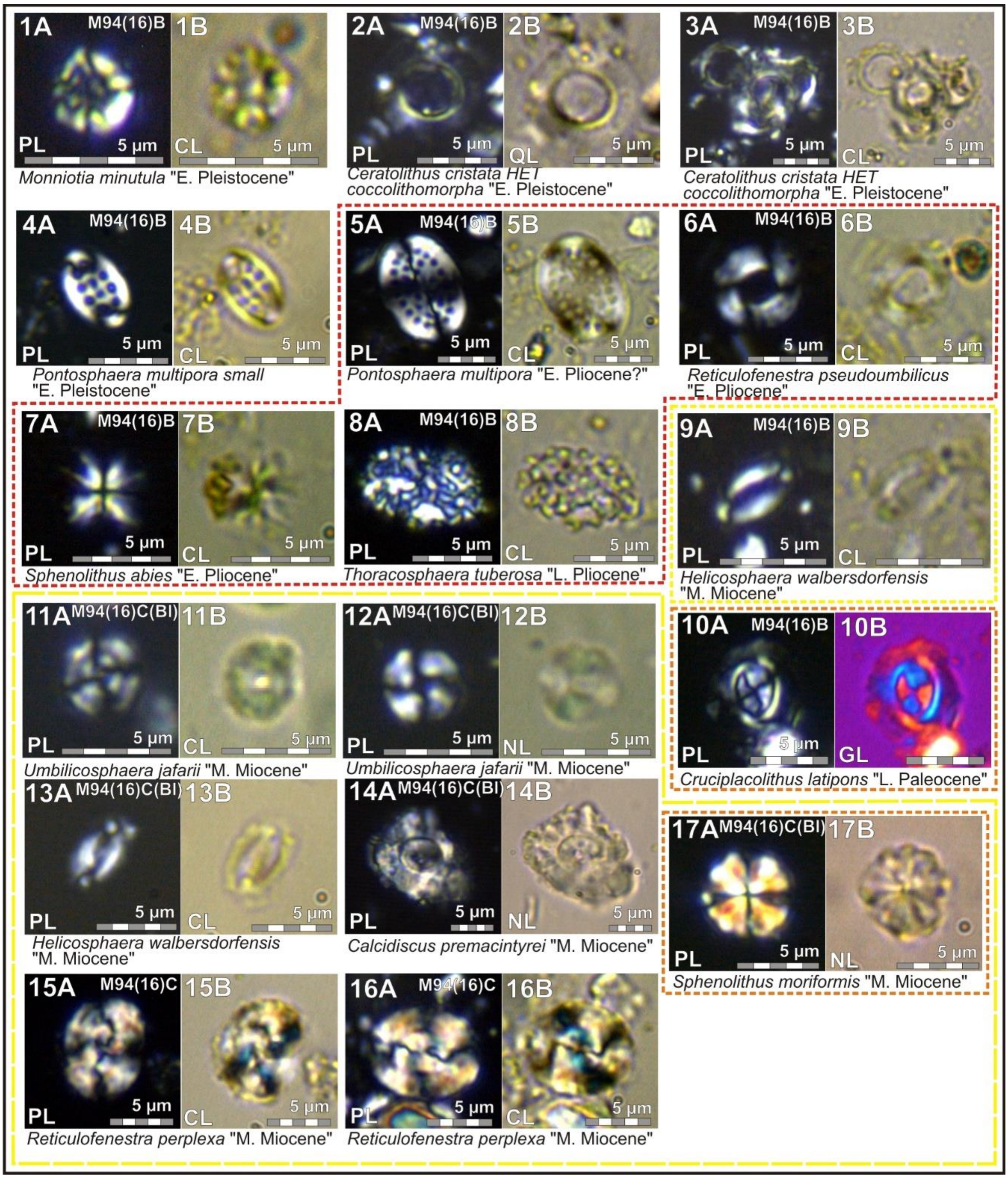


Figure 11. Synsedimentary and reworked nannofossil species in the (pebbly) mud matrix (M94(16)A) sample in the tsunami deposits of the Manavgat Formation) and light brown marl block (M94(16)C) from the carbonate shelf deposits of the Geceleme Formation. (Explanations in Fig. 5).

Şekil 11. Manavgat Formasyonu'nun tsunami tortullarından (çakıllı) çamur matriks (M94(16)A) örneği ve Geceleme Formasyonu'nun karbonat şelf çökellerinden açık kahverengi marn bloğu (M94(16)C) içindeki çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri. (Açıklamalar Şekil 5'te).

Rarely encountered fossil ascidian spicules such as Micrascidites vulgaris Deflandre, Deflandre-Rigaud were determined in the sample blue-grey marl [M61(15)B] of Karpuzçay Formation (see Tab. 6, Fig. 8). Additionally, more fossil ascidian spicules such as Bonetia acuta Varol & Houghton, Bonetia brevis Varol & Houghton, Micrascidites gothicus Sagular in Sagular et al., Micrascidites vulgaris Deflandre, Deflandre-Rigaud, Monniotia aciformis Varol & Houghton, Monniotia fasciculata Varol & Houghton, Monniotia minutula Sagular in Sagular et al., Riguadia multiradiata Varol & Houghton were recorded in the grey-brown mudstone and yellow-brown sandstone samples [M53-1(15)B(Ts), M60(15)E, M96(16)F] above the tsunamite of the Manavgat Formation and/or pebbly grey-green mud matrix samples [M2(15)A(Tm), M53-1(15)A(Tm), M60(15)A(Tm), M94(16)A(Tm), M96(16)C(Tm)], in addition some muddy rip-up clasts [i.e. M105(16)D(Int)] of the tsunamite matrix (see Tab. 6, Figs. 5, 7, 10, 11).

5.2. Biochronozons of the Karpuzçay and Manavgat Formations Based on Nannofossil Data and Their Stratigraphic-Sedimentologic Origins

In this study, Karpuzçay Formation which was defined a Miocene marine deposition by Monod, O., 1977, Poisson, 1977; Akay et al.,1985), Şenel (1997), Flecker et al. (1998), Robertson (1998), Karabıyıkoğlu et al. (2000), Robertson et al. (2003), Flecker et al. (2005), Karabıyıkoğlu et al. (2005), Çiner et al. (2008) has been divided into two sequences: Lower Pliocene Karpuzçay Formation and Lower Pleistocene Manavgat Formation based on discriminated nannofossils according to their sedimentary-stratigraphic origins (see Tabs. 1–5). There are several origins of nannofossil particules participating in forming of a marine sedimentary rock: 1) "Synsedimentary nannofossils" collapsed as living coccospheres or individual nannoliths spilling out from these

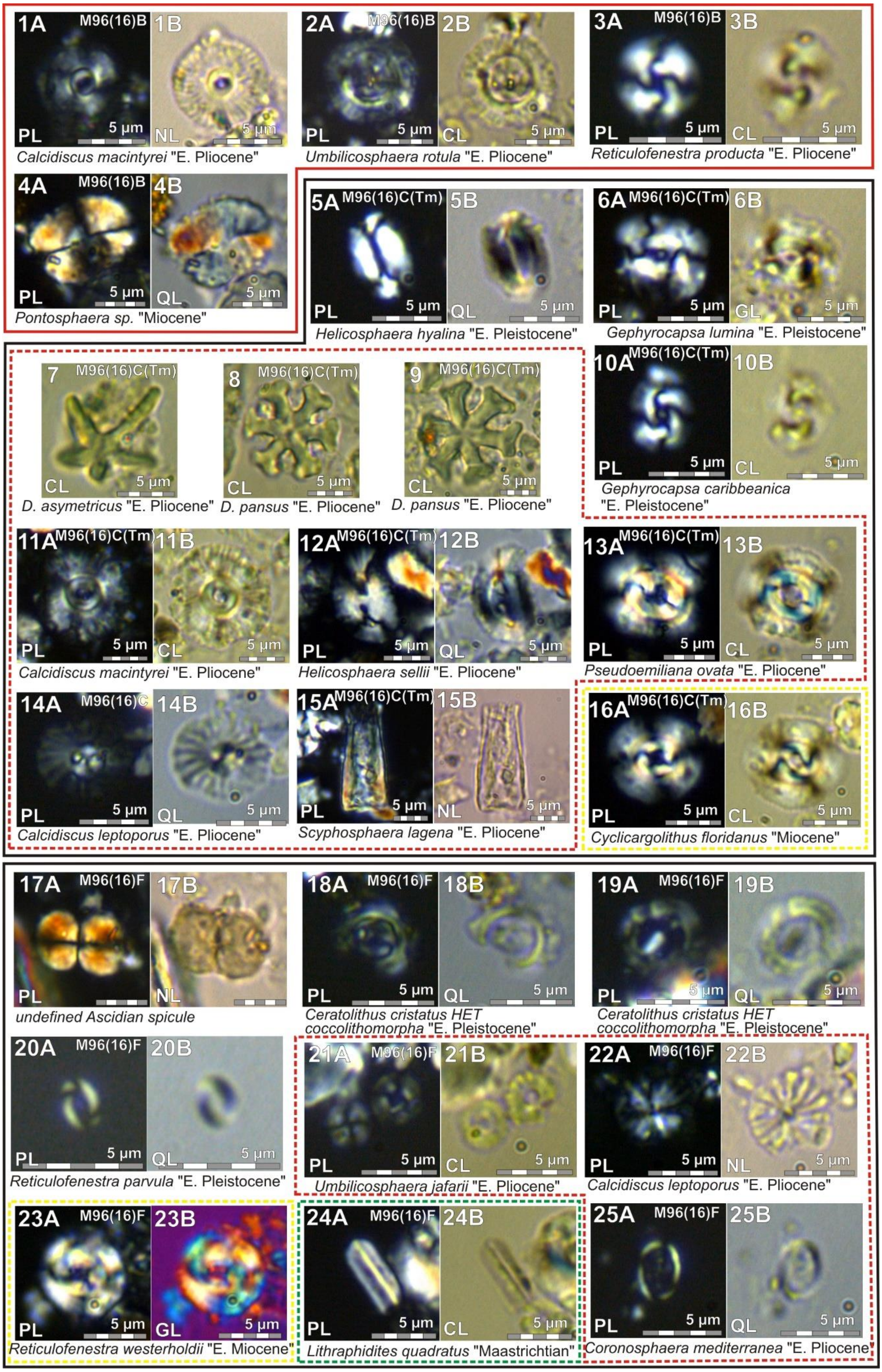

1A M96(16)B 1B PL NL 5 µm
Calcidiscus macintyrei "E. Pliocene"
2A M96(16)B 2B PL CL 5 µm
Umbilicosphaera rotula "E. Pliocene"
3A M96(16)B 3B PL CL 5 µm
Reticulofenestra producta "E. Pliocene"
4A M96(16)B 4B PL QL 5 µm
Pontosphaera sp. "Miocene"
5A M96(16)C(Tm) 5B PL QL 5 µm
Helicosphaera hyalina "E. Pleistocene"
6A M96(16)C(Tm) 6B PL GL 5 µm
Gephyrocapsa lumina "E. Pleistocene"
7 M96(16)C(Tm) CL 5 µm
D. asymetricus "E. Pliocene"
8 M96(16)C(Tm) CL 5 µm
D. pansus "E. Pliocene"
9 M96(16)C(Tm) CL 5 µm
D. pansus "E. Pliocene"
10A M96(16)C(Tm) 10B PL CL 5 µm
Gephyrocapsa caribbeanica "E. Pleistocene"
11A M96(16)C(Tm) 11B PL CL 5 µm
Calcidiscus macintyrei "E. Pliocene"
12A M96(16)C(Tm) 12B PL QL 5 µm
Helicosphaera sellii "E. Pliocene"
13A M96(16)C(Tm) 13B PL CL 5 µm
Pseudoemiliana ovata "E. Pliocene"
14A M96(16)C 14B PL QL 5 µm
Calcidiscus leptoporus "E. Pliocene"
15A M96(16)C(Tm) 15B PL NL 5 µm
Scyphosphaera lagena "E. Pliocene"
16A M96(16)C(Tm) 16B PL CL 5 µm
Cyclicargolithus floridanus "Miocene"
17A M96(16)F 17B PL NL
undefined Ascidian spicule
18A M96(16)F 18B PL QL 5 µm
Ceratolithus cristatus HET coccolithomorpha "E. Pleistocene"
19A M96(16)F 19B PL QL 5 µm
Ceratolithus cristatus HET coccolithomorpha "E. Pleistocene"
20A M96(16)F 20B PL QL 5 µm
Reticulofenestra parvula "E. Pleistocene"
21A M96(16)F 21B PL CL 5 µm
Umbilicosphaera jafarii "E. Pliocene"
22A M96(16)F 22B PL NL 5 µm
Calcidiscus leptoporus "E. Pliocene"
23A M96(16)F 23B PL GL 5 µm
Reticulofenestra westerholdii "E. Miocene"
24A M96(16)F 24B PL CL 5 µm
Lithraphidites quadratus "Maastrichtian"
25A M96(16)F 25B PL QL 5 µm
Coronosphaera mediterranea "E. Pliocene"

Figure 12. Synsedimentary and reworked nannofossil species in blue marl (M96(16)B) of the Karpuzçay Formation, in the (pebbly) mud matrix (M96(16)C) sample of the tsunamite and in the mudstone (M96(16)F) sample collected from regular clastic rocks of the Manavgat Formation (Explanations in Fig. 5).

Şekil 12. Karpuzçay Formasyonu'nun mavi marnında (M96(16)B), tsunamitin (çakıllı) çamur matriksinde (M96(16)C) ve Manavgat Formasyonu'nun düzenli kırıntılı kayaçlarından toplanan çamurtaşı (M96(16)F) örneğinde çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri (Açıklamalar Şekil 5'te).

nannoplanktons, 2) "reworked nannofossils" redeposited nanno-bearing extrabasinal sedimentary rock sequences, 3) "removed nannofossils" translocated close-aged nanno-bearing intrabasinal sediments by means of marine wave&currents, submarine slump&slides, and bottom erosions. In the study related to the disscussive Neogene marine sequences located at the Manavgat Subbasin, “synsedimentary” and “reworked” nannofossil assemblages were discriminated according to sedimentary and stratigraphic origins of various-aged nannofossil assemblages and marine depositions.

Five essential sedimentary sequences and their nannoplankton assemblages were defined in the study: 1) Firstly Upper Cretaceous – Danian carbonates and clastics, having mainly K/Pg transition nannofossil data; 2) Middle Eocene carbonates and clastics, with the same-aged nannofossils; 3) Middle Miocene marine carbonates and clastics of the Geceleme Formation, including nannofossil assemblage of NN5 zone; 4) Lower Pliocene marine carbonates and clastics of (re-defined) Karpuzçay Formation, with nannofossil assemblage of NN15 zone; 5) Lower Pleistocene marine clastics of (first suggested) Manavgat Formation, containing nannofossils representing NN19 zone/CN13b subzone (see Figs. 15–16). Upper Cretaceous-Lutetian nannofossil data determined in the Karpuzçay and Manavgat Formations were probably reworked from the Cretaceous–Paleocene transition sequence on the Antalya Nappes north of Isparta Angle and Lutetian clastic sequence in the Akseki Region (Şenel, 1997), since pre-Miocene sedimentary rocks could not be observed on the ophiolitic basement of the Manavgat Subbasin in the former studies (i.e. Glover and Robertson, 1998) around Isparta Angle. 12 Upper Cretaceous-Danian nannofossils including Eiffellithus spp. [E. gorkae Reinhardt, E. turriseiffelii (Deflandre)], Lithraphidites quadratus Bramlette & Martini, Watznaueria barnesiae (Black in Black & Barnes), Zeugrhabdotus sigmoides (Bramlette & Sullivan) and dinoflagellate cysts such as Cervisiella operculata (Bramlette & Martini), Cervisiella saxea (Stradner) are seen to have

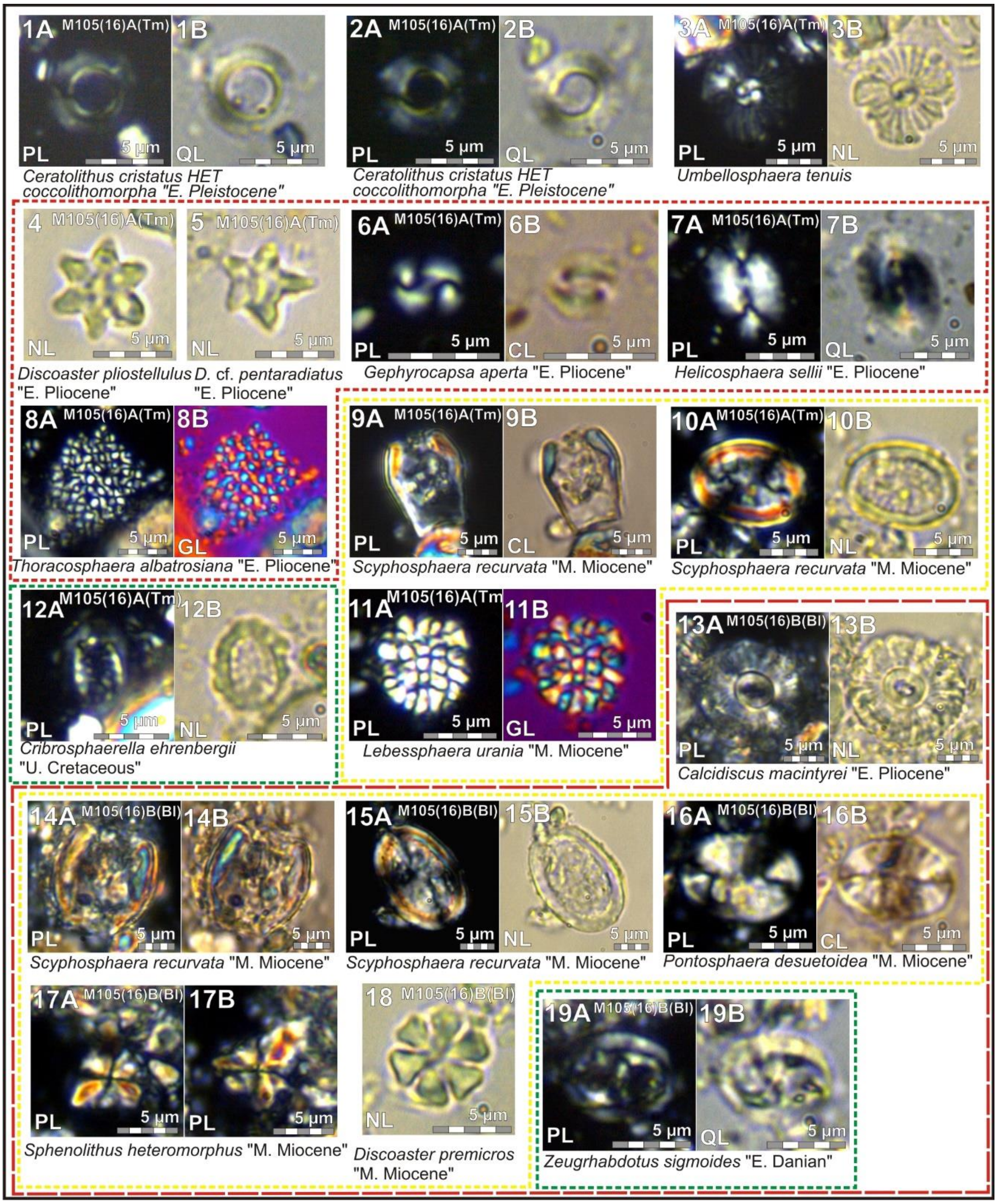
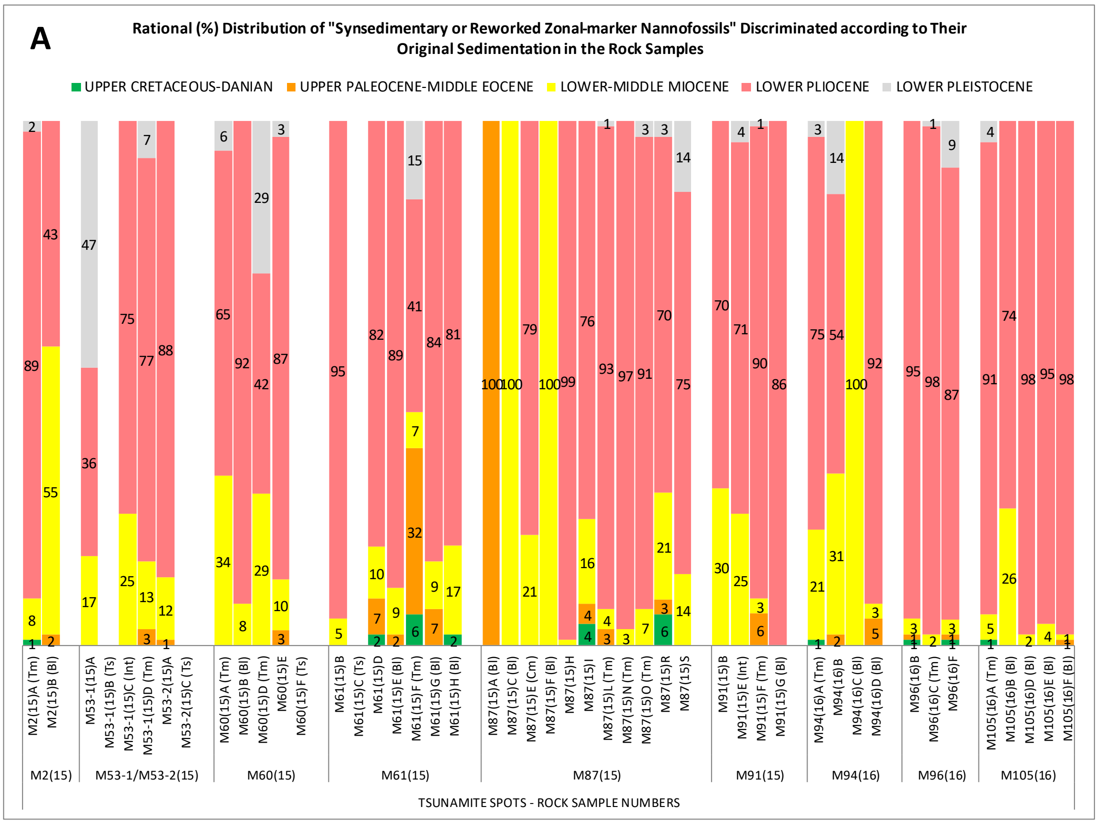


Figure 13. Synsedimentary and reworked nannofossil species in the (pebbly) mud matrix (M105(16)A) sample of tsunami deposits (Manavgat Formation) and blue marl block sample (M105(16)B) reworked from Karpuzçay Formation (Explanations in Fig. 5).

Şekil 13. Tsunami tortullarına (Manavgat Formasyonu) ait (çakıllı) çamur matris (M105(16)A) örneği ve Karpuzçay Formasyonu'ndan yeniden çökeltilmiş mavi marn bloğu örneğindeki (M105(16)B) çökelimle eşyaşlı ve yeniden çökeltilmiş nannofosil türleri (Açıklamalar Şekil 5'te).

participated into Geceleme, Karpuzçay and Manavgat Formation sedimentations as “reworked nannofossil” sedimentary particles (Tables 5, Figure15).



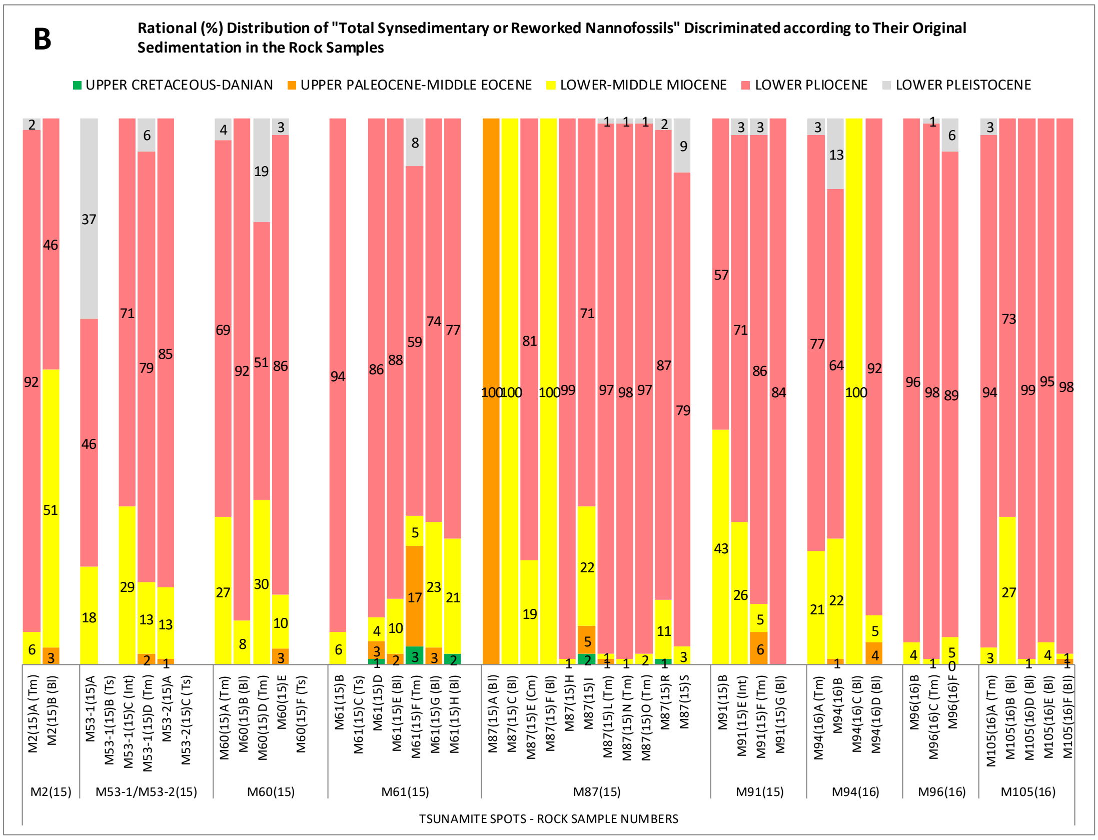


Figure 14. Rational (%) distributions of "synsedimentary or reworked nannofossils" in the Rock Samples of Geceleme, Karpuzçay and Manavgat Formations and tsunami deposits: A) Zonal-marker, B) Total zonal-marker and long-ranged nannofossils discriminated according to their original sedimentations. (fossil quantities are in Tables 1 to 5).

Şekil 14. Geceleme, Karpuzçay ve Manavgat Formasyonları ve tsunami çökellerine ait kayaç örneklerinde "çökelimle eşyaşlı veya yeniden çökeltilmiş nannofosillerin" rasyonel (%) dağılımları: A) Zon-işaretleyici, B) Kökensel çökelimlerine göre ayrılmış toplam zon-işaretleyici ve uzun menzilli nannofosiller. (fosil miktarları Tablo 1 ila 5'te verilmiştir).

Dictyococcites spp. (i.e. D. hesslandii (Haq), D. scripsae Bukry & Percival), Pseudotriquetrorhabdulus inversus (Bukry & Bramlette), Reticulofenestra spp. [i.e. R. dictyoda (Deflandre in Deflandre & Fert), R. hillae Bukry & Percival, R. reticulata (Gartner & Smith), R. stavensis (Levin & Joerger)], Sphenolithus moriformis (Brönnimann & Stradner) are among 22 reworked Middle Eocene nannofossils (see Tab. 4, Fig.15). Upper Cretaceous–Lutetian nannofossils as fine calcareous clastic material repeatedly participated in Early–Middle Miocene, Early Pliocene, and Early Pleistocene sedimentations in addition to synsedimentary and/or other reworked nannofossil data. One Miocene carbonate-clastic succession, Geceleme Formation, supplying reworked nannofossil data into the Early Pliocene and Early Pleistocene sedimentations is located in the study area. Geceleme Formation is represented by NN5 - Sphenolithus heteromorphus zone of Langhian–Serravalian ages and have a nannofossil assemblage including Cyclicargolithus floridanus (Roth & Hay), Discoaster druggii Bramlette & Wilcoxon, Discoaster minutus Hojjatzadeh, Discoaster premicros de Kaenel & Bergen, Helicosphaera spp. [H. ampliaperta Bramlette & Wilcoxon, H. intermedia Martini, H. recta (Haq), H. stalis Theodoridis, H. walbersdorfensis Müller], Micrantholithus flos Deflandre, Pontosphaera desuetoidea Bartol, Reticulofenestra spp. [R. haqii Backman, R. gelida (Geitzenauer), R. minuta Roth], Scyphosphaera spp. [S. brevis Varol, S. lagena Kamptner, S. tubifera Kamptner], Sphenolithus spp. [S. belemnos Bramlette and Wilcoxon, S. compactus Backman, S. conicus Bukry, S. disbelemnos Fornaciari and Rio, S. dissimilis Bukry and Percival, S. heteromorphus Deflandre], Triquetrorhabdulus carinatus Martini, Umbilicosphaera jafarii Müller. These 46 synsedimentary nannofossil species with Miocene in addition to the older (reworked from the Cretaceous–Eocene rocks) nannofossils as extrabasinal sedimentary particles are determined to have been reworked

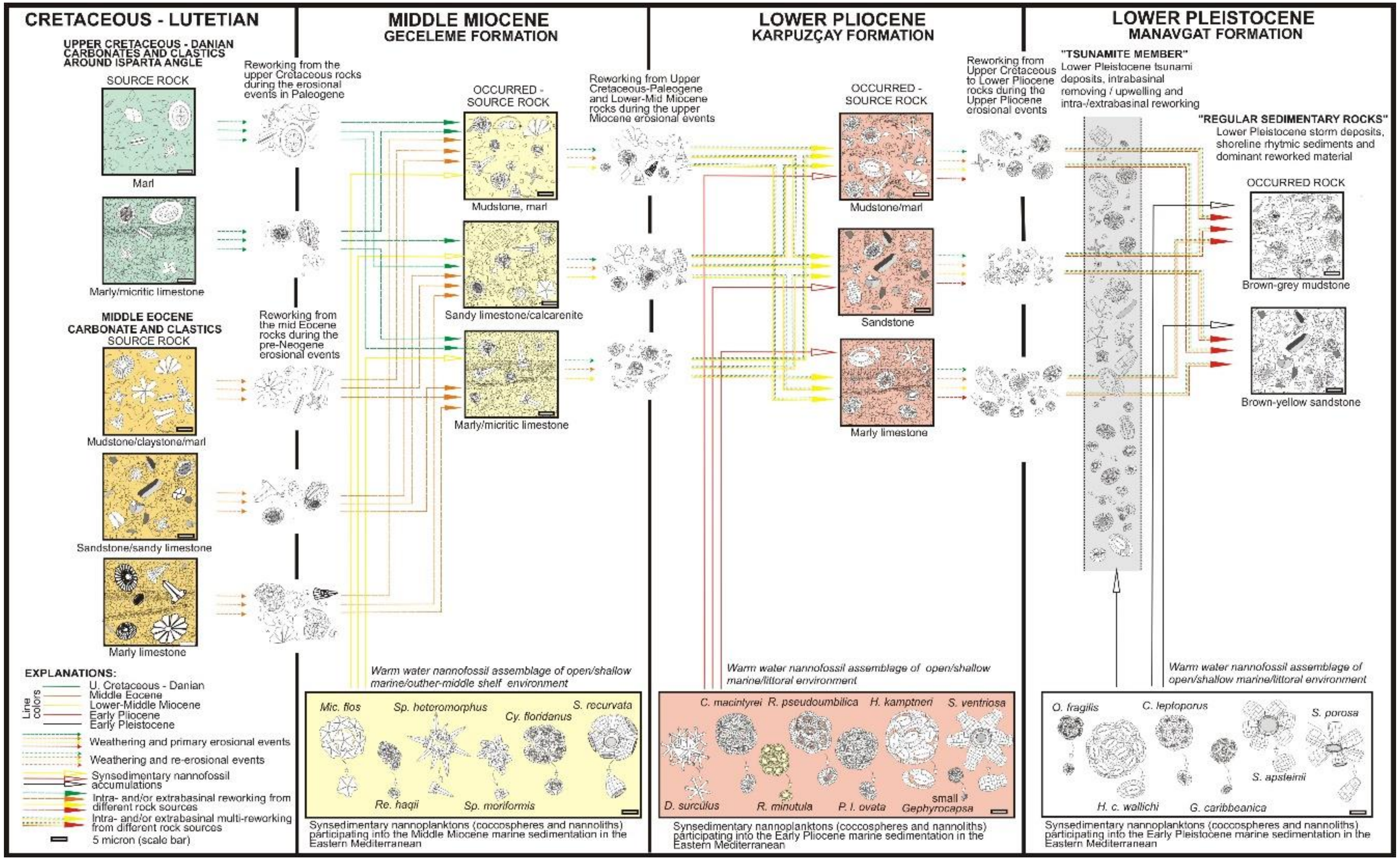


Figure 15. Thematic flow chart explaining sedimentary and stratigraphic origins of different aged nannofossils participating into the rock samples of Geceleme, Karpuzçay and Manavgat Formations and tsunami deposits.

Şekil 15. Geceleme, Karpuzçay ve Manavgat Formasyonları ve tsunami tortullarının kayaç örneklerine katılan farklı yaşlı nannofosillerin sedimanter ve stratigrafik kökenlerini açıklayan konulu akış şeması.

into both Karpuzçay Formation sedimentation (Early Pliocene) and Manavgat Formation (Early Pleistocene) sedimentation (see Tabs. 1–5, Fig.15).

In the rock samples of the Lower Pliocene Karpuzçay Formation were determined 53 synsedimentary nannofossil species including Calcidiscus spp. [C. leptoporus (Murray & Blackman), C. macintyrei (Bukry & Bramlette), C. tropicus Kamptner], Calciosolenia murrayi Gran, Coccolithus pliopelagicus Wise, Coronosphaera spp. [C. binodata (Kamptner), C. mediterranea (Lohmann)], Discoaster spp. [D. asymmetricus Gartner, D. brouweri Tan, D. pansus (Bukry & Percival), D. pentaradiatus Tan, D. pliostellulus Browning & Bergen, D. surculus Martini & Bramlette, D. tamalis Kamptner, D. variabilis Martini & Bramlette], small Gephyrocapsa spp., Helicosphaera spp. [H. carteri (Wallich), H. kamptneri Hay & Mohler, H. wallichii (Lohmann), H. selli (Bukry and Bramlette)], Pontosphaera spp. [P. discopora Schiller, P. multipora (Kamptner), P. japonica (Takayama)], Pseudoemiliana lacunosa ovata (Kamptner), Reticulofenestra spp. [R. minutula (Gartner), R. pseudoumbilica (Gartner)], Rhabdosphaera clavigera Murray & Blackman, Scyphosphaera spp. [S. apsteinii Lohmann, S. canescens Kamptner, S. recurvata Deflandre, S. pulcherrima Deflandre], Sphenolithus spp. [S. abies Deflandre, S. U. neoabies Bukry & Bramlette], Sphenaster metula (Wilcoxon), Syracosphaera pulchra Lohmann, Umbilicosphaera spp. [U. foliosa Kamptner, U. rotula Kamptner, U. sibogae (Weber-van Bosse)] and 3 dinoflagellate cysts are found Calciodinellum albatrosianum (Kamptner), Lebessphaera urania Meier, Janofske & Willems, Pernambugia tuberosa (Kamptner).

All the Pliocene nannofossil assemblage together with the older aged nannofossil data indicating to the Upper Cretaceous-Middle Miocene marine sedimentations are also seen as an abundant reworked nannofossil data participating into the Lower Pleistocene aged Manavgat Formation deposits (see Tabs. 1–5, Fig.15). These data represent NN15 (Martini, 1971) or CN11 (Okada and Bukry, 1980) Reticulofenestra pseudoumbilicus zone of Late Zanclean between ~3,98 and ~3,45 ma. This zone corresponds to CNPL3 – Discoaster asymmetricus / Reticulofenestra pseudoumbilicus concurrent range zone according to Backman et al. (2012) and CNPL4 Discoaster tamalis top zone transition (Fig. 16).

Tsunami deposits and regular sedimentary rocks of the Manavgat Formation include an abundant reworked nannofossil data eroded from the older marine sedimentary rocks of four stratigraphic sequences placed between Upper Cretaceous-Lower Pliocene in addition to the synsedimentary nannofossils such as Calcidiscus leptoporus (Murray & Blackman), Ceratolithus cristatus HET coccolithomorpha (Lecal-Schlauder), middle Gephyrocapsa spp. [G. caribbeanica Boudreaux & Hay, G. lumina Bukry], small Gephyrocapsa spp., Helicosphaera spp. [H. hyalina Gaarder, H. pavimentum Okada & McIntyre], Oolithotus fragilis (Lohmann), Pontosphaera scutellum Kamptner, Pseudoemiliana spp. [P. lacunosa (Kamptner), P. ovata (Kamptner)], Scyphosphaera spp. [S. expansa Bukry & Percival, S. porosa Kamptner, Umbellosphaera tenuis (Kamptner), Umbilicosphaera spp. [U. foliosa Kamptner, U. sibogae (Weber-van Bosse)], Leonella granifera (Fütterer) (Tabs. 1–5, Fig.15). In addition to these Lower Pleistocene nannofossil assemblage within the tsunamite matrix, an abundant Lower Pliocene, and Lower-Middle Miocene, Upper Paleocene–Middle Eocene nannofossil data involve both in the matrix and in the blue marl pebble/cobble/blocks of Karpuzçay, Geceleme Formations or the older sequences.

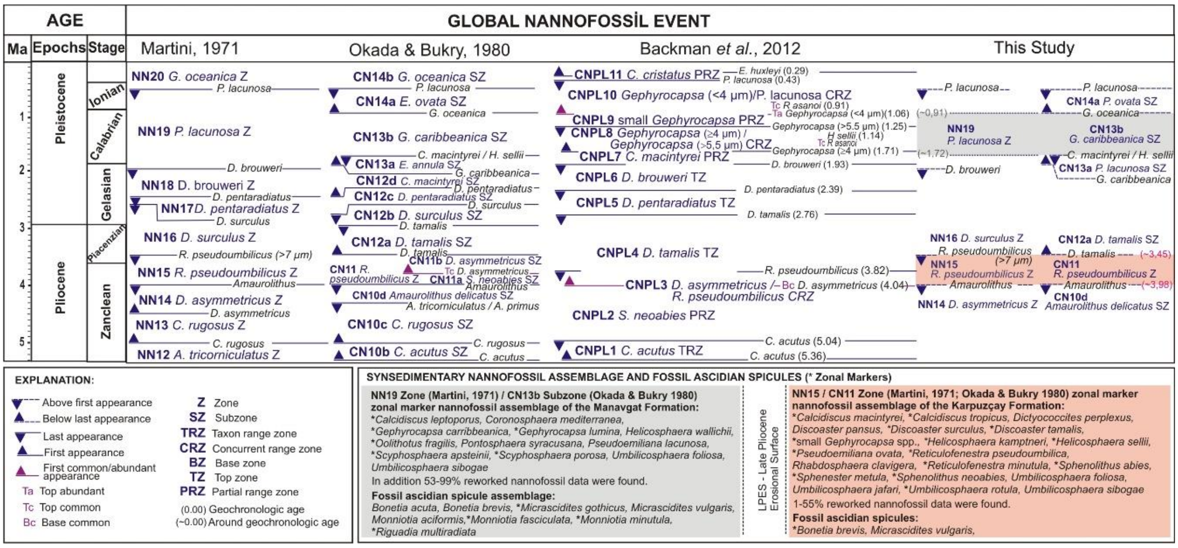


Figure 16. In this study, compared with Martini (1971), Okada and Bukry (1980) and Backman et al. (2012), Early Pliocene and Early Pleistocene nannoplankton zones and chrono-bio events of Karpuzçay and Manavgat (including Tusanami sediments) Formations.

Şekil 16. Bu çalışmada, Martini (1971), Okada ve Bukry (1980) ve Backman ve diğerleri (2012) ile karşılaştırmalı olarak, Karpuzçay ve Manavgat (Tusanami çökelleri dahil) Formasyonlarının Erken Pliyosen ve Erken Pleistosen nannoplankton zonları ve krono-biyostratigrafik olguları.

Although the relative presence of Pliocene nannofossil assemblage as reworked sedimentary material including Calcidiscus macintyrei (Bukry & Bramlette), Discoaster spp. [i.e. D. asymmetricus Gartner, D. brouweri Tan, D. pansus (Bukry & Percival), D. pentaradiatus Tan, D. pliostellulus Browning & Bergen, D. surculus Martini & Bramlette, D. tamalis Kamptner], the most of small Gepyrocapsa spp., Helicosphaera spp. [i.e. H. carteri (Wallich), H. kamptneri Hay & Mohler, H. wallichii (Lohmann), H. selli (Bukry and Bramlette)], Reticulofenestra pseudoumbilica (Gartner), Scyphosphaera spp. [S. apsteinii Lohmann, S. canescens Kamptner, S. intermedia Deflandre, S. recurvata Deflandre, S. pulcherrima Deflandre], Sphenolithus spp. [S. abies Deflandre, S. neoabies Bukry & Bramlette], Sphenaster metula (Wilcoxon), Umbilicosphaera spp. [U. foliosa Kamptner, U. jafarii Müller, U. rotula Kamptner, U. sibogae (Weber-van Bosse)], determined sysedimentary nannofossils such as Calcidiscus leptoporus (Murray & Blackman), Ceratolithus cristatus HET coccolithomorpha (Lecal-Schlauder), Gephyrocapsa spp. [i.e. G. caribbeanica Boudreaux & Hay, G. lumina Bukry], Helicosphaera spp. [i.e. H. hyalina Gaarder, H. pavimentum Okada & McIntyre], Oolithotus fragilis (Lohmann), Scyphosphaera spp. [i.e. S. apsteinii Lohmann, S. expansa Bukry & Percival, S. porosa Kamptner], Umbellosphaera tenuis (Kamptner) correspond into NN19 - Pseudoemiliana lacunosa Zone (Martini, 1971) or CN13b - Gephyrocapsa caribbeanica Subzone (Okada and Bukry, 1980) of Early Pleistocene (Calabrian) between ~1,72 and ~0,91 ma. This zone does not correspond to CNPL8 – Gephyrocapsa ($\geq$4 μm) / Gephyrocapsa (>5.5 μm) Concurrent Range Zone according to Backman et al. (2012) (see Tabs. 1–5, Fig. 16).

6. DISCUSSION AND RESULTS

The Mediterranean region is seismically active due to the convergence of the African Plate with the Eurasian plate and Present day Africa-Eurasia motion ranges from ~4 millimetres per year (mm/yr) in a northwest-southeast direction in the western Mediterranean to ~10 mm/yr (north-south) in the eastern Mediterranean according to Herman et al. (2015). They have stated that the Africa-Eurasia convergence began approximately 50 million years ago and was associated with the closure of the Tethys Sea; the Mediterranean Sea is all that remains of the Tethys. The highest rates of seismicity in the Mediterranean region were described along the Hellenic subduction zone of southern Greece and significant rates of current seismicity and at the southern edge of the Anatolian Block lies the east-west trending Cyprian Arc, which hosts moderate levels of seismicity.

The Cyprian Arc represents the convergent boundary between the Anatolian Block to the north and the Africa Plate to the south and large historical earthquakes have occurred throughout the region spanning the Mediterranean Sea. As being similar to today-cases, a tsunami event must have occurred most likely due to emerging a new earthquake fracturing at the bottom of the Mediterranean Sea in the early Pleistocene due to the Africa-Eurasia convergence. Consequently, a new marine sedimentation which built up shallow marine clastics of the Manavgat Formation was occurred as a result of the Lower Pleistocene tsunami event continuing as a sea-surging up and occupying over the Late Pliocene Erosional Surface (LPES) on the Manavgat coastal plane. In former studies, the originally indiscriminated nannofossil data directly used for chronostratigraphy caused complexity related to stratigraphic description between Neogene and Quaternary sequences. It is concluded that Karpuzçay Formation, which was previously, determined as Burdigalian–Tortonian aged, in fact, was divided into Lower Pliocene and Lower Pleistocene aged two formations belonging to two different marine sedimentations.

Tsunami deposits “Manavgat Formation Tsunamite Member” include a complex nannofossil assemblage supplied from four different original sources: (1) synsedimentary data deposited inner shelf, (2) synsedimentary data upwelling from deep sea bottom, (3) removed data derived from the intrabasin, (4) reworked data derived from the extrabasin. Synsedimentary data consist of Lower Pleistocene nannofossils representing NN19 Zone (Martini, 1971)/CN13b Subzone (Okada and Bukry. 1980) in the pebbly mud matrix or rip-up mud clasts of the tsunamite. As for reworked data, Upper Cretaceous-Lower Pliocene aged nannofossil data should be accepted as stratigraphically misleading old sedimentary particules either eroded from the different sedimentary rocks or coming from the muddy bottom sediments.

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