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Biostratigraphy of some mollusc-bearing middle Miocene localities on the Karaman high plain (Turkey, Konya Province)

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Several samples from the Miocene Tırtar Formation of the Karaman high plain in Turkey have been analysed in respect to nannoplankton and foraminifers. These sandy-clayey shallow marine deposits are famous for their mollusc assemblages, representing a key area for Mediterranean mollusc taxonomy and biostratigraphy. Previous datings based on benthic molluscs were vague, ranging from middle-to late Miocene. The new data clearly acknowledge a Serravallian age of these mollusc-bearing localities, as earlier demonstrated by pteropods.

KEY WORDS: Turkey, Karaman high plain, Miocene, nannoplankton, foraminifers, biostratigraphy, Tırtar Formation

Introduction

A major revision of the benthic gastropod fauna of the Turkish Karaman high plain is currently being prepared based on new collecting campaigns and rich museum and private collections. This Miocene mollusc fauna is highly diverse and excellently preserved. Many of the species bear a close similarity, or are conspecific with species from both the middle Miocene French Atlantic and the middle Miocene Paratethys Sea assemblages. A clear dating of the material is therefore crucial to evaluate biogeographic relations between Atlantic, Paratethys and Mediterranean seas, to constrain stratigraphic ranges of the species and to provide a base for future phylogenetic considerations.

These Miocene Turkish assemblages were already known in the 19th century, when Fischer *in* Tchihatcheff (1866) gave detailed descriptions of several mollusc species from the Karaman area. At the beginning of the 20th century, expeditions by F.X. Schaffer led to geological descriptions and palaeontological lists from various localities around Karaman and Ermenek (Schaffer, 1902; 1903). More or less simultaneously, Toula (1902) published a note on new species from the Karaman high plain, from the collections of Naturalis Biodiversity Center in Leiden (The Netherlands). Later, some contributions by Daus (1915) and Papp (1949) enlarged the inventory until Erünal-Erentöz (1958) presented the first comprehensive milestone paper. Since then, only few additional papers have been devoted to mollusc species from Karaman (R. Janssen, 1993; A.W. Janssen, 1999). However, the importance of these assemblages as a key fauna becomes evident from the numerous papers referring to the Turkish taxa indirectly when describing Miocene to Pliocene molluscs from the circum-Mediterranean region (*e.g.* Steininger, 1963; Davoli, 1982; Lozouet *et al*., 2001; Harzhauser & Kronenberg, 2008; İslamoğlu, 2004; İslamoğlu & Taner, 2003; Landau *et al*., 2004; 2009; Harzhauser & Landau, 2012, and numerous others).

Until now a major drawback has been the vague biostratigraphic dating of the fauna, ranging from middle to late Miocene. This situation goes back to Erünal-Erentöz (1958), who used the now outdated stratigraphic concept of the Helvetian stage (see Harzhauser *et al*. 2003 for discussion). This historical stage comprised parts of the lower Miocene Burdigalian stage and parts of the middle Miocene Langhian and Serravallian stages depending on region and author. Adding further to the confusion, the middle Miocene marine mollusc faunas of the Vienna Basin in

Austria and other Paratethyan assemblages were at that time considered of Tortonian age by all authors, including Erünal-Erentöz (1958), which did not automatically imply a late Miocene age as it does in modern stratigraphy. Therefore, the terms "Miocène moyen" and "Helvétien" as used by Erünal-Erentöz (1958) for the Karaman faunas are ambiguous. The first author to tackle this problem was A.W. Janssen (1999) who suggested a middle to late Serravallian age for the mollusc-bearing localities in the Karaman high plain based on holoplanktonic gastropods. Later, A.W. Janssen (2012) proposed a preliminary pteropod biozonation for the Neogene of the Mediterranean area and identified the pteropod assemblage from the Karaman high plain as Pteropod Zone 19-2. Fortunately, he collected his samples at the same localities, which are treated herein (Seyithasan and Akpınar) providing the possibility of an unambiguous correlation.

In order to achieve our aim - to provide independent age estimates for these deposits to date the mollusc assemblages - an attempt was made to avoid circular reasoning by continuing to use molluscs as biostratigraphic markers. Therefore, new bulk samples were taken in 2012 for analyses of nannolankton and planktonic foraminifers.

Geological setting

All samples were collected from moderately sorted, mollusc-rich clayey-silty sand of the Tırtar Formation (Atabey *et al*., 2000). These sediments have been formerly mapped as Mut Formation (Ulu & Balcı, 2009), named after the town of Mut, located about 45 km south of Karaman (Fig. 1). This formation, however, is mainly restricted to the Mut Basin and covers a time interval from the Burdigalian to early Langhian, related to two 3rd order sea level cycles (Bassant *et al*., 2005).

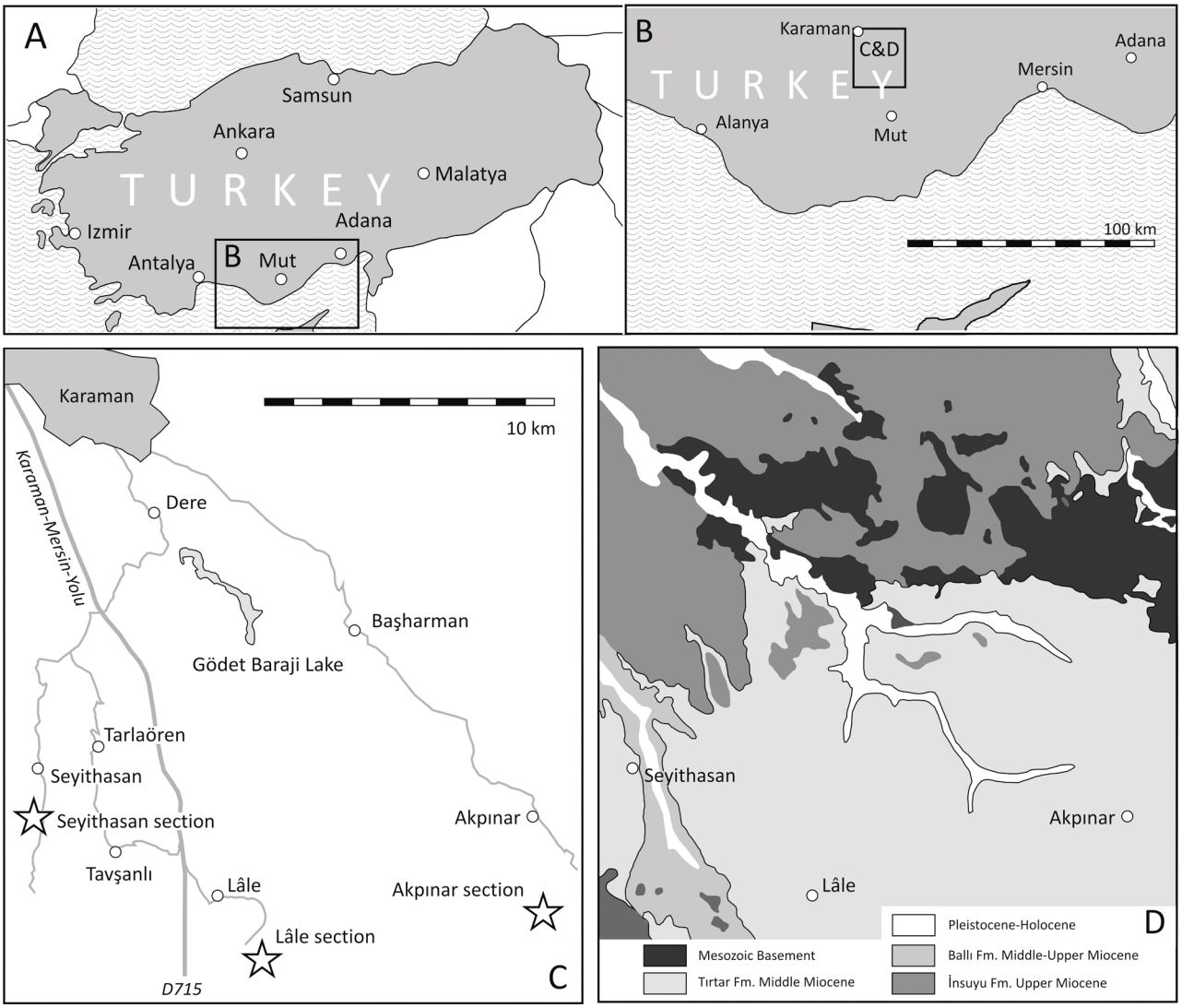

Figure 1. Geography of the investigation area on different scales (A-C indicate locality position). D: Geology of the Karaman high plain (same area as Fig. 1C) modified from Atabey *et al.* (2000) and Ulu & Balcı (2009).

Reefs and associated facies are present in spectacular outcrops revealing a complex internal architecture, with textbook examples for sequence stratigraphy (Gül & Eren, 2003; Mandic *et al.*, 2004; Bassant *et al.*, 2005). Towards the north, the Mut Basin is bordered by the Bolkar mountains marking the transition with the high plain of the Karaman area. There, the Mut Formation is separated from the younger Tırtar Formation by a discordance and/or by terrestrial deposits, which were defined as Dağpazarı Formation by Atabey *et al*. (2000).
The sedimentary facies of the Tırtar Formation are comparable to those from the Mut Fm. and comprise clayey marls, marly sand, reefoid limestones and patch reefs (Ulu & Balcı, 2009).

Samples

Three sections on the Karaman high plain are most important in terms of mollusc faunas and were named according to the nearest villages Seyithasan, Lâle and Akpınar (Fig. 1). Four samples were processed: Seyithasan 1 (N 37° 02.004', E 33° 13.298'), Seyithasan 2 (N 37° 01.989', E 33° 13.236'), Lâle (N 37° 00.827', E 33° 16.844') and Akpınar (N 37° 00.093', E 33° 25.257'). All samples contain well preserved calcareous nannoplankton assemblages dominated by the reticulofenestrids *Reticulofenestra pseudoumbilica*, *R. minuta* and *R. gelida*. Benthic foraminifers are frequent as well but only the Akpınar sample yielded planktonic foraminifers.

-- Seyithasan 1

Nannoplankton: few, well preserved, common ascidian spicules.
Braarudosphaera bigelowii (Gran & Braarud, 1935) Deflandre, 1947; rare
Coccolithus pelagicus (Wallich, 1877) Schiller, 1930; rare
Cyclicargolithus floridanus (Roth & Hay, 1967) Bukry, 1971; rare
Helicosphaera carteri (Wallich, 1877) Kamptner, 1954; rare
Helicosphaera intermedia Martini, 1965; rare
Helicosphaera walbersdorfensis Muller, 1974; rare
Reticulofenestra gelida (Geitzenauer, 1972) Backman, 1978; common
Reticulofenestra minuta Roth, 1970; few
Reticulofenestra pseudoumbilica (Gartner, 1967) Gartner, 1969 (5-7μm); rare
Reticulofenestra pseudoumbilica (Gartner, 1967) Gartner, 1969 (>7μm); rare
Reticulofenestra sp.; rare
Thoracosphaera saxea Stradner, 1961; rare
Triquetrorhabdulus sp.; rare
Umbilicosphaera jafari Muller, 1974; few.

Reworked from Paleogene/lower Miocene deposits:
Reticulofenestra bisecta (Hay, Mohler & Wade, 1966) Roth, 1970; rare

-- Seyithasan 2

Nannoplankton: common, well preserved, common ascidian spicules.
Calciosolenia murrayi Gran, 1912; rare
Calcidiscus macintyrei (Bukry & Bramlette, 1969) Loeblich & Tappan, 1978; rare
Calcidiscus leptoporus (Murray & Blackman, 1898) Loeblich & Tappan, 1978; rare
Calcidiscus tropicus Kamptner, 1956 sensu Gartner, 1992; rare
Coccolithus pelagicus (Wallich, 1877) Schiller, 1930; rare
Coronosphaera mediterranea (Lohmann, 1902) Gaarder, 1977; rare
Coronocyclus nitescens (Kamptner, 1963) Bramlette & Wilcoxon, 1967; rare
Cyclicargolithus floridanus (Roth & Hay, 1967) Bukry, 1971; rare
Discoaster deflandrei Bramlette & Riedel, 1954; rare
Discoaster variabilis Martini & Bramlette, 1963; rare
Helicosphaera walbersdorfensis Muller, 1974; rare
Holodiscolithus macroporus (Deflandre, 1954) Roth, 1970; rare
Pontosphaera discopora Schiller, 1925; rare
Pontosphaera japonica (Takayama, 1967) Nishida, 1971; rare
Pontosphaera multipora (Kamptner, 1948 ex Deflandre, 1954) Roth, 1970; rare
Reticulofenestra gelida (Geitzenauer, 1972) Backman, 1978; few
Reticulofenestra minuta Roth, 1970; few
Reticulofenestra pseudoumbilica (Gartner, 1967) Gartner, 1969 (5-7μm); rare
Reticulofenestra pseudoumbilica (Gartner, 1967) Gartner, 1969 (>7μm); few
Rhabdosphaera clavigera Murray & Blackman, 1898; rare

Rhabdosphaera sicca (Stradner, 1963) Fuchs & Stradner, 1977; rare
Syracosphaera pulchra Lohmann 1902; rare
Syracosphaera histrica Kamptner, 1941; rare
Thoracosphaera saxea Stradner, 1961; rare
Triquetrorhabdulus rioi Olafsson, 1989; rare
Umbilicosphaera jafari Muller, 1974; rare
Umbilicosphaera rotula (Kamptner, 1956) Varol, 1982; rare.

Foraminifers: rare plankton with stratigraphically insignificant assemblage (*Globigerina* sp., *Globigerinoides* sp.). The benthos is dominated by Miliolidae with abundant *Borelis, Neoalveolina* and Peneroplidae. *Pararotalia, Cibicides, Elphidium, Ammonia* and Textulariidae are also frequent along with *Planostegina*, pointing to shallow water conditions.

-- Lâle river

Nannoplankton: common, well preserved, common ascidian spicules.
Coccolithus pelagicus (Wallich, 1877) Schiller, 1930; rare
Coronosphaera mediterranea (Lohmann, 1902) Gaarder, 1977; rare
Cyclicargolithus floridanus (Roth & Hay, 1967) Bukry, 1971; rare
Helicosphaera carteri (Wallich, 1877) Kamptner, 1954; rare
Pontosphaera sp.; rare
Reticulofenestra gelida (Geitzenauer, 1972) Backman, 1978; few
Reticulofenestra haqii Backman, 1978; rare
Reticulofenestra minuta Roth, 1970; common
Reticulofenestra pseudoumbilica (Gartner, 1967) Gartner, 1969 (>7μm); rare
Sphenolithus abies Deflandre *in* Deflandre & Fert, 1954; rare
Sphenolithus moriformis (Brönnimann & Stradner, 1960) Bramlette & Wilcoxon, 1967; few
Syracosphaera pulchra Lohmann, 1902; rare
Umbilicosphaera jafari Muller, 1974; rare
Umbilicosphaera rotula (Kamptner, 1956) Varol, 1982; rare.

-- Akpınar

Nannoplankton: common, well preserved, common ascidian spicules.
Braarudosphaera bigelowii (Gran & Braarud, 1935) Deflandre, 1947; rare
Calcidiscus leptoporus (Murray & Blackman, 1898) Loeblich & Tappan, 1978; rare
Calcidiscus tropicus Kamptner, 1956 *sensu* Gartner, 1992; rare
Coccolithus pelagicus (Wallich, 1877) Schiller, 1930; rare
Coronosphaera mediterranea (Lohmann, 1902) Gaarder, 1977; rare
Coronocyclus nitescens (Kamptner, 1963) Bramlette & Wilcoxon, 1967; rare
Cyclicargolithus floridanus (Roth & Hay *in* Hay *et al.*, 1967) Bukry, 1971; rare
Discoaster deflandrei Bramlette & Riedel, 1954; rare
Discoaster exilis Martini & Bramlette, 1963; rare
Discoaster sp.; rare
Helicosphaera carteri (Wallich, 1877) Kamptner, 1954; rare
Helicosphaera euphratis Haq, 1966; rare
Helicosphaera granulata (Bukry & Percival, 1971) Jafar & Martini, 1975; rare
Helicosphaera walbersdorfensis Muller, 1974; rare
Holodiscolithus macroporus (Deflandre, 1954) Roth, 1970; rare
Micrantholithus vesper Deflandre 1950; rare
Micrantholithus sp.; rare
Pontosphaera discopora Schiller, 1925; rare
Pontosphaera multipora (Kamptner, 1948 ex Deflandre, 1954) Roth, 1970; rare
Pontosphaera japonica (Takayama, 1967) Nishida, 1971; rare
Reticulofenestra minuta Roth, 1970; common
Reticulofenestra gelida (Geitzenauer, 1972) Backman, 1978 few/common
Reticulofenestra haqii Backman, 1978; few
Reticulofenestra pseudoumbilica (Gartner, 1967) Gartner, 1969 (5-7μm); rare
Reticulofenestra pseudoumbilica (Gartner, 1967) Gartner, 1969 (>7μm); rare
Rhabdosphaera clavigera Murray & Blackman 1898; rare

Rhabdosphaera sicca Stradner, 1963; rare
Sphenolithus moriformis (Brönnimann & Stradner, 1960) Bramlette & Wilcoxon, 1967; few
Syracosphaera pulchra Lohmann, 1902; rare
Thoracosphaera saxea Stradner, 1961; rare
Triquetrorhabdulus milowii Bukry, 1971; rare
Umbilicosphaera jafari Muller, 1974; rare
Umbilicosphaera rotula (Kamptner, 1956) Varol, 1982; rare.

Reworked from Eocene:
Reticulofenestra bisecta (Hay, Mohler & Wade, 1966) Roth, 1970; rare
Reticulofenestra hillae (Bukry & Percival,1971); rare.

Microfauna: very rich with foraminifers, ostracods and micromolluscs. The diverse benthic foraminifers are dominated by *Bolivina, Astrononion* and *Cibicides* and indicate a depositional depth on the inner shelf below 50 m water depth. Shallow water taxa, such as *Planostegina* and some miliolids might be transported.
Along with Miliolidae and Textulariidae typical benthic genera in the Akpınar sample are: *Alliatina, Asterigerinata, Astrononion, Baggina, Bolivina, Bulimina, Cancris, Cibicides, Cibicidoides, Dentalina, Elphidium, Fursenkoina, Glandulina, Globobulimina, Guttulina, Gyroidinoides, Hanzawaia, Heterolepa, Hoeglundina, Lamarckina, Lenticulina, Marginulina, Neugeborina, Nonion, Oridorsalis, Pappina, Planostegina, Planulina, Pseudoeponides, Pseudonodosaria, Pyramidulina, Reussella, Riminopsis, Robertinoides, Rosalina, Saracenaria, Siphonina, Siphonodosaria, Stomatorbina, Uvigerina* and *Valvulineria.*

The planktonic species are:
?*Neogloboquadrina* aff. *pseudopima* (Blow, 1969)
?*Neogloboquadrina partimlabiata* (Ruggieri & Sprovieri, 1970)
Cassigerinella chipolensis (Cushman & Ponton, 1932)
Catapsydrax sp.
Globigerina bulloides d'Orbigny, 1826
Globigerina cf. *ottnangiensis* Rögl, 1969
Globigerina cf. *ouachitaensis* Howe & Wallace, 1932
Globigerina falconensis Blow, 1959
Globigerina foliata Bolli, 1957
Globigerina occlusa Blow & Banner, 1962
Globigerina praebulloides Blow, 1959
Globigerina sp. cf. *bollii* Cita & Premoli Silva, 1960
Globigerina sp. ex gr. *officinalis* Subbotina, 1953
Globigerina tarchanensis Subbotina & Chutzieva, 1950
Globigerinella cf. *regularis* (d'Orbigny, 1846)
Globigerinoides bulloideus Crescenti, 1966
Globigerinoides cf. *quadrilobatus* (d'Orbigny, 1846)
Globigerinoides ruber (d'Orbigny, 1839)
Globigerinoides trilobus (Reuss, 1850)
Globoquadrina langhiana Cita & Gelati, 1960
Globoturborotalita druryi (Akers, 1955)
Orbulina universa d'Orbigny, 1839
Tenuitella clemenciae (Bermudez, 1961)
Tenuitella minutissima (Bolli, 1957)
Tenuitellinata selleyi Li, Radford & Banner, 1992
Turborotalita quinqueloba (Natland, 1938).

Conclusion

The planktonic foraminifers of Akpınar point towards a Serravallian age of the deposits based on the rare occurrence of ?*Neogloboquadrina partimlabiata*, which is restricted to the Serravallian. Moreover, the absence of Tortonian marker species such as *Globigerina nepenthes* Todd, 1957 and *Neogloboquadrina acostaensis* Blow, 1959 supports this dating.
The nannoplankton assemblage is also indicative for the Serravallian Nannoplankton Zone NN6 sensu Martini (1971) based on the absence of *Discoaster kugleri* Martini & Bramlette, 1963 and the presence of *Cyclicargolithus floridanus* [In an unpublished MTA report, however, colleague Mário Cachão (Universidade de Lisboa) mentioned the occurrence of *Discoaster kugleri* in some of the samples. We were not able to detect this species in our samples again but the presence of this species would suggest a correlation of parts of the Tırtar Formation also with the nannoplankton zone NN7 (Hilgen *et al*., 2012)]. The last oc-

currence of *C. floridanus* (dated at 13.33 Ma. by Lourens *et al*., 2004) was used as an additional event to define the CN5a/CN5b boundary of Okada & Bukry (1980), which corresponds to the NN6/NN7 boundary of Martini (1971). The samples contain also *Coronocyclus nitescens*, which has its last occurrence slightly below the NN6/NN7 boundary (Young, 1998) at 12.12 Ma. (Lourens *et al*., 2004). As the NN6/NN7 boundary predates the Serravallian/Tortonian boundary, the samples can clearly be dated as Serravallian.

Our data confirm the holoplanktonic-mollusc-based biostratigraphy of A.W. Janssen (1999, 2012), who proposed a middle to late Serravallian age. Therefore, the rich Karaman mollusc fauna may partly correspond to late Badenian assemblages of the Paratethys Sea but represents largely a time equivalent of the Sarmatian of the Paratethys. Coeval faunas along the eastern Atlantic coast are preserved in the Aquitaine Basin (*e.g*. Salles, Mios, Orthez-Le Paren; Cahuzac *et al*., 1995; Lozouet, 1998; Cahuzac & Janssen, 2010) and the Loire Basin (Glibert, 1949; Bosellini & Perrin, 2008).

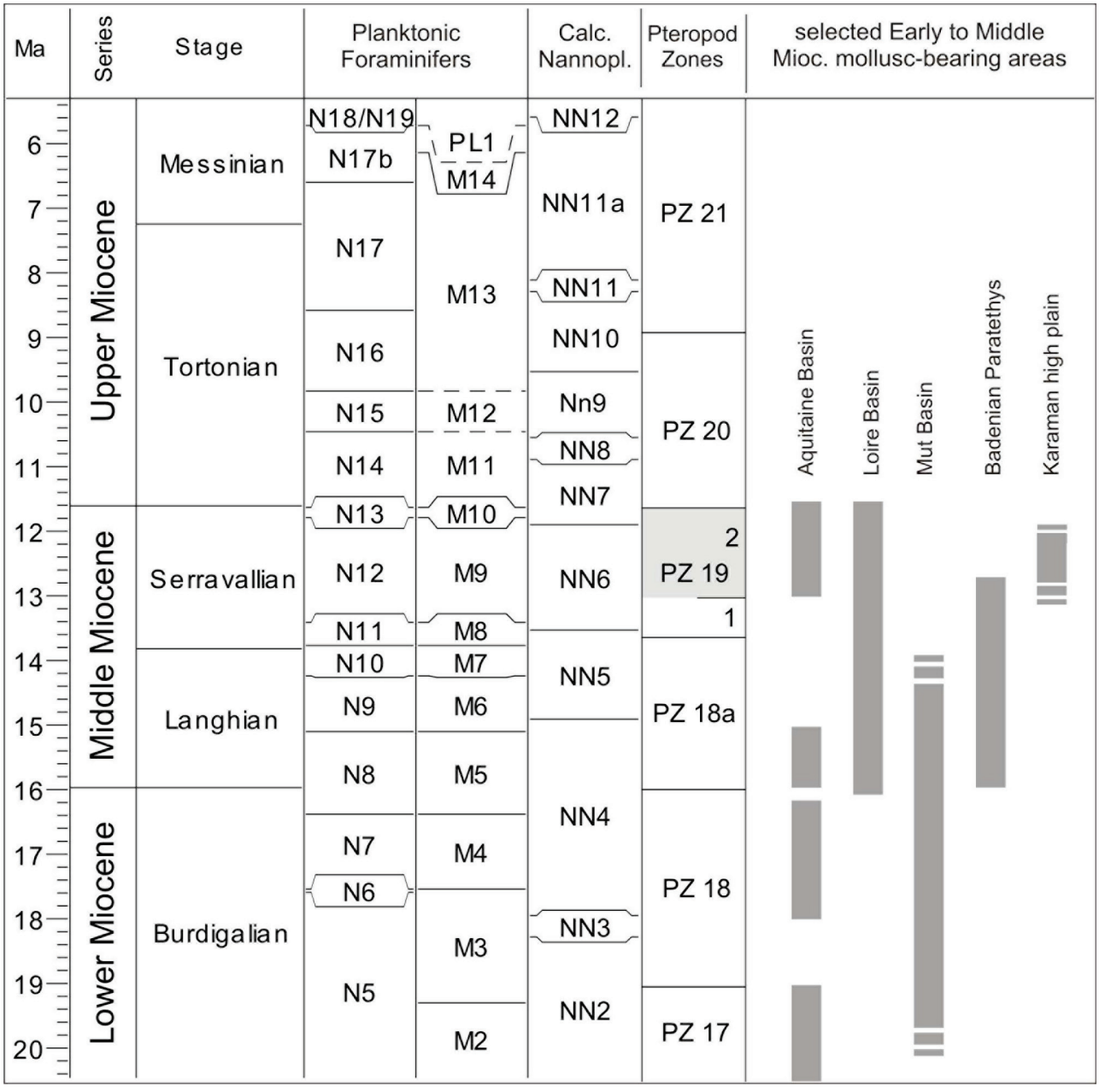

Figure 2. Miocene stratigraphy and biostratigraphy; modified from a chart produced with the Time Scale Creator program, provided by the International Commission on Stratigraphy (available at: http://stratigraphy.org/column). Pteropod zonations after Janssen (2012); shaded area in PZ 19 indicates the pteropod biozone proposed by Janssen (2012) for the Karaman high plain samples. Important mollusc bearing basins and regions are indicated for comparison [Aquitaine and Loire basins; Müller & Pujol (1979), Folliot *et al.* (1993), Cahuzac *et al.* (1995), Lozouet (1998), Bossellini & Perrin (2008); Mut Basin: Mandic *et al*. (2004), Bassant *et al.* (2005); Badenian of the Paratethys Basins: Harzhauser & Piller (2007)].

Therefore, the mollusc fauna of the Karaman area provides an exceptional opportunity to cover the poorly resolved interval between the Langhian-early Serravallian faunas and the Tortonian ones in the circum-Mediterranean area.

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