New Planktonic Foraminifera Data from the Upper Cretaceous Pelagic Limestones of the Yüksekova Complex in the Maden Area (Southeast of Elazığ, Eastern Turkey)

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Abstract. The units situated in Southeast Anatolian Orogenic Belt within the Bitlis-Zagros suture zone, are still controversial. Therefore, it is important to obtain new data from the subduction/accretion complexes along the southeast Anatolian-Zagros suture belt in the Eastern Mediterranean. Hence, this study was carried out to find out whether the pelagic limestones overlying the volcanogenic rocks in the Maden area (southeast of Elazığ) belong to Yüksekova Complex or Maden Complex. The lavas intercalated with pelagic limestones are dark-colored, pillow shaped and massive basalts. They are commonly amygdaloidal structured showing surface cavities filled with secondary minerals. The thick-bedded limestones are mainly represented by rare planktonic foraminifera bearing wackestone and mudstone depositional texture. Rare planktonic foraminifera in the rocks are mainly represented by double keeled marginotruncanids, which are characteristic organisms of the Turonian-Santonian interval of the Late Cretaceous. Poor planktonic foraminifera assemblages obtained from the micritic limestones comprise Marginotruncana aff. marginata and M. cf. paraconcavata. According to these taxa, the age of the volcanogenic formation is Turonian-Santonian. The volcaniclastic sequence discussed in this study, were considered to be part of the Middle Eocene Maden Complex in previous studies. But, the results show that the studied volcaniclastic succession belong to the Yüksekova Complex as the age of the micritic limestones is Late Cretaceous but not Middle Eocene.

1. Introduction

The representatives of the Southern Neotethys oceanic lithosphere are observed as a distinct belt of ophiolites and ophiolitic mélanges that can be followed from the Troodos Mountains in Cyprus via SE Anatolia to Zagros Mountains and Oman in the East ([1], [2],[3]) (figure 1a). They were formed during the closure of the Southern Neotethys Ocean at the end of Mesozoic and Early Tertiary (e.g., [4], [5], [6], [7]). The Southern Neotethyan oceanic basin was active from the Triassic to at least the Eocene between the Tauride-central Iranian Block to the north and the Arabian Platform to the south ([8],[ 9], [10], [7], [11]). On the other hand, [12] revealed that the rupturing of the Gondwanan lithosphere responsible for the opening of the northern branch of Neotethys should have occurred during the Lower Triassic or earlier. Most of the Late Cretaceous Neotethyan ophiolites are obducted onto the Arabian passive margin (e.g. Kızıldağ, Oman, Kermanshah and Neyriz ophiolites) and/or are
accreted beneath the Tauride-central Iranian Block (e.g. Guleman, Göksun ophiolites of Turkey and Nain–Baft ophiolites of Iran) (figure 1A) ([9]; [13], [14], [15], [16], [10], [7], [11]).

Figure 1. a) Distribution of the ophiolites and mélange complexes in the Eastern Mediterranean and location of the study area (revised after [25]), b) Geological map showing the distribution of the main oceanic and continental units in SE of Elazığ city in E Turkey (after [26] and [27]) and location of the studied samples.
In this region, the studied rocks known as the Upper Cretaceous Yüsekova Complex are mainly composed of volcanosedimentary rocks, which are the main subject of this study. The Yüsekova Complex are found within imbricated slices of a mélangé complex exposed near the Maden area in southeast of Elazığ located on the Bitlis-Zagros suture zone (figure 1B). The Yüsekova Complex which is one of the oceanic crust representatives of the Amanos-Elazığ-Van ophiolite belt ([1],[2]) in SE Turkey. The other unit cropping out in the study area is the Guleman ophiolite. This unit is one of the ultramafic complexes of the Southeast Anatolian Ophiolite Belt and emplaced onto the lower Miocene Lice formation of the Arabian plate and in turn transgressively overlain by the flyschoidal sedimentary formations of the Upper Cretaceous-Lower Eocene Hazar Group and Middle Eocene Maden Complex, and tectonically overlain by Bitlis-Püüğürge Metamorphics (figure 1b) ([17], [18]) [19], [20], [21], [22]). [23] reported the existence of Middle Eocene planktonic foraminifera bearing pelagic limestones intercalated with transitional or tholeiitic basaltic lavas of the Maden Complex in the study area. [24] stated that the Middle Eocene Maden magmatism developed by lithospheric removal and asthenospheric upwelling associated with the extensional collapse of Southeastern Anatolian in this region.

The Yüsekova Complex suggests a “supra-subduction-type” oceanic crust generation (e.g., [14], [15], [28]). The tectonic setting of this unit was well constrained after ([29], [3]). [30] stated that the volcanic rocks were formed in a marginal basin to the south of the Anatolian Block, in response to roll-back of the South-Tethyan slab. Similar basins were also reported from SW Iran [31]. On the other hand, [27] assert that the ongoing compression between the Tauride-Anatolide and the Arabian plates gave way to the formation of the Yüsekova-type subduction–accretion complexes, where all kinds of oceanic lithologies were accommodated to form mélanges along the Amanos-Elazığ-Van Suture Belt in southern Turkey. Besides, [3] revealed that based on systematic sampling of radiolarian cherts of the oceanic sediments in association with basalt blocks within the Yüsekova Complex and the geochemical fingerprinting of these pillow basalts have resulted in identification of an intra arc – back arc pair.

Planktonic foraminifera have been abundant in most oceanic environments since their appearance in the Middle Jurassic and are the most commonly used microfossil group for biostratigraphic zonation and reconstruction of past sea surface-water conditions and palaeoclimate ([32], [33]). This study deals with geological, petrographical and micropaleontological aspects of the volcanic and coeval sedimentary rocks of the Yüsekova Complex in Maden area of southeastern Elazığ city. In this regard, we sampled the pelagic limestones intercalated with the basaltic volcanics, which were previously dated as Late Cretaceous based on the alternating radiolarian cherts by [34], [3] and [27] around Maden area within the Elazığ region before. The aim of this study is to date the pelagic limestones intercalated with the volcanic rocks and radiolarian cherts by their planktonic foraminiferal assemblages.

2. Results
2.1. Stratigraphy and petrography

In the studied area, the lower contact of the volcanogenic unit is not observed, and it is transitional with the underlying gray colored limestones of the Hazar group of Late Cretaceous to Early Eocene age. The lavas are often interlayered with radiolarite, cherts, micritic limestones and rarely with mudstones etc. within the Yüsekova Complex. The lavas, intercalated within the volcanic-sedimentary sequence are pillow shaped lavas and massive lava flows in which they constitute the bulk sequences (figure 2 A-E). They are hard, tough, compact and widely distributed in the area (figure 2 A-E). They are generally dark-colored such as grayish, claret red, brown or black. The outer shells of pillow shaped lavas are chloritised and with slightly to sometimes dense porous (2-3 mm). The rocks are mainly basaltic in composition. They are commonly amygdaloidal basalts showing surface cavities filled with secondary minerals such as chlorite, chalcedony, calcite, epidote or zeolites (figure 3 A-E). The fine-grained groundmass representing that part of the viscous semi-crystalline lavas show commonly chloritisation and spilitisation. The spilitic rocks are composed mainly of
plagioclase ± pyroxene ± olivine ± K-feldspar ± hornblende ± magnetite ± ilmenite, in order of decreasing abundance (figure 3 A-E). Subhedral plagioclase crystals (Ab$_{5.15}$An$_{0.30}$), mostly accompanying all minerals, coarse crystalline, radial, beam-like, elongate prismatic, poikilitic and spherulitic (figure 3 A-E). The plagioclases possess various textural types such as spongy, boxy and sieve texture. Intersertal textural plagioclases are quite common that the angular spaces between larger crystals is occupied by glass, or glass and small crystals.

The sedimentary rocks within the volcano-sedimentary sequence are composed of micritic and argillaceous limestones (figure 2 A-E). The micritic limestones are pink, red or brown colored and indurated. Average thickness ranges from 40-50 cm to 1.5-3 m. The limestone samples are mainly represented by rare planktonic foraminifera bearing wackestone and mudstone depositional texture according to [35] classification (figure 4 A-C). This type of facies is result of deposition in relatively deep marine environment ([36], [37], [38]). As a result of complete recrystallization of the original depositional texture, micrite was transformed into microspar. All the allochemes (including planktonic foraminifera) embedded within the micritic matrix were also recrystallized and mostly dolomitized (figure 4 A-C). Rare ostracods and radiolaria accompany the planktonic foraminifera. Besides, tiny unidentifiable bioclasts are observed in almost each samples (figure 4 B-C). Solution seams and stylolites show that the pelagic limestones are deformed (figure 4 A).

**Figure 2.** Field photographs of the pelagic foraminiferal limestones overlying basalts of Yüksekova Complex, located in the Maden area (SE Elazığ, Turkey),  
A) 1.5-2 m thick pink colored and twisted laminated micritic limestones (ML); Davudan road; Sample MDN-10 (x: 555907, y: 425613),  
B) Pillow-shaped lavas (PB) of the Yüksekova Complex, Davudan road, Sample MDN-10,  
C) The volcanics (V) intercalated with micritic limestones (ML) are gray colored, porous outer shells, sometimes with pillow structures, and contains mudstones at the top; Karatop-Arslantaş road, Sample MDN13 (x: 561862, y: 4252435),  
D) Pink colored and twisted laminated micritic limestones (ML) deposited on the volcanogenic roks (V), Alacakaya road-Kayalı; Sample MDN-15 (x:563908, y:4251191),  
E) The greenish-reddish basaltic lavas (B) intercalated with brownish-reddish lenses of micritic limestones (ML), Maden-Hazar road; Sample MDN-20 (x: 554392, 4252132).
2.2. Paleontology
Rare planktonic foraminifera observed in the pelagic limestones are mainly represented by double keeled marginotruncanids, which are characteristic organisms of the Turonian-Santonian interval of the Late Cretaceous [39]. Recrystallization and deformation hamper identification of the planktonic foraminifera in species level. Poor planktonic foraminifera assemblages comprise Marginotruncana aff. *marginata* (figure 4 E), and *M.* cf. *paraconcavata* (figure 4 D). MDN 10 and 15 are the two samples including identifiable planktonic foraminifera. These two marginotruncanid species are known from the several Turonian-Santonian pelagic deposits of the Tethyan Ocean ([40], [41], [42], [37], [43], [44], [45], [46], [47], [48], [39], [49], [50], [51], [52]).

3. Discussion and Conclusions
In this study, the pelagic sediments deposited in a deep marine environment coevally with volcanogenic rocks in the Maden area approximately 80 km southeast of Elazığ city (eastern Turkey) situated in southeastern Orogenic Belt within the Bitlis-Zagros suture zone were investigated (figure 1A, 1B). The pelagic limestones in the study area are intercalated and sometimes overlie the volcanogenic rocks (figure 2 A-E). Poor planktonic foraminifera assemblages obtained from the micritic limestones comprise *Marginotruncana* aff. *marginata* and *M.* cf. *paraconcavata*. (figure 4 A-E). These two marginotruncanid species are known from the several Turonian-Santonian pelagic deposits of the Tethyan Ocean. The studied volcanic rocks are basalts that are dark grayish, claret red, dark brown or black massive mostly pillow basalt showing surface cavities filled up by secondary minerals (figure 3 A-D). The volcanic rocks related to pelagic deposits usually indicate variolitic, microlitic, porphyric and amygdaloidal textures and mainly consist of plagioclase ± pyroxene ± olivines (figure 3 A-D).

![Figure 3](image.png)

**Figure 3.** Microphotographs showing mineralogy and variolitic, microlitic and doleritic textures of the lava flows/basalts overlain by the pelagic foraminiferal limestones in the Maden area (SE Elazığ, Turkey). **A)** Coarse grained, radial-beam-bunchy shaped and spherulitic plagioclases make up 95% of medium and coarse-grained basic rocks, almost no containing mafic components; Sample MDN-10, **B)** Radial-beam shaped, medium-sized and twinned plagioclases in a intensely opaque groundmass; Sample MDN-13, **C)** Intersertal textured basalt, Sample MDN-15, **D)** The microlytic porphyritic textured basaltic rocks filled with secondary silica and carbonate fillings and cracks, Sample MDN-20.

Abbreviations: pl: plagioclase, op: opaque mineral, ch: chlorite, cc: calcite.
Figure 4. Microfacies characteristics and planktonic foraminifera of the pelagic limestones, A) Wackestone with planktonic foraminifera (pf), stylolites (s) are common (sample MDN 10), B) Wackestone/Mudstone with planktonic foraminifera (pf) and unidentifiable bioclasts (b) (sample MDN 15), C) Wackestone with unidentifiable tiny bioclasts (b) (sample MDN 13), D) Marginotruncana cf. paraconcavata (sample MDN 15), E) Marginotruncana aff. marginata (sample MDN 15).

The most of the pelagic deposits and associated volcanic rocks in the Maden area in the southeast Anatolian orogenic belt have been previously assigned to the Middle Eocene Maden Complex in previous studies ([53], [54], [17], [55], [56], [57], [58], [18], [19], [9], [59], [13], [23], [7], [60], [61], [62], [24] etc.). But, the Late Cretaceous age data obtained from the pelagic deposits in the Maden area by this study shows that the pelagic rocks and intercalated volcanogenic rocks belong to Yüksekova Complex not to the Maden Complex. Conclusively, the ages obtained by this study are consistent with the radiolarian ages obtained from pelagic cherts in the Yüksekova Complex by [27] in the same area. Therefore, we trace deep sequences of the Late Cretaceous Tethyan Ocean in the Maden area of Elazığ city.

References
[1] M. C. Göncüoğlu, “Introduction to the Geology of Turkey: Geodynamic evolution of the pre-Alpine and Alpine terranes,” 66, 2010.
[2] M. C. Göncüoğlu, “A Review of the Geology and Geodynamic Evolution of Tectonic Terranes in Turkey,” In Mineral Resources of Turkey (pp. 19-72). Springer, Cham., 2019.
[3] M. Ural, M. Arslan, M. C. Göncüoğlu, U. K. Tekin. and S. Kürüm, “Late Cretaceous arc and back-arc formation within the Southern Neotethys: whole-rock, trace element and Sr-Nd-Pb isotopic data from basaltic rocks of the Yüksekova Complex (Malatya-Elazığ, SE Turkey),” Ofioliti, 40 (1), 2015.
[4] M. C. Göncüoğlu, K. Dirik and H. Kozlu, “General characteristics of pre-Alpine and Alpine Terranes in Turkey: Explanatory notes to the terrane map of Turkey,” Ann. Géol. Pays Hellén., vol.37, pp. 515-536, 1997.

[5] A. H. F. Robertson, “Overview of the genesis and emplacement of Mesozoic ophiolites in the Eastern Mediterranean Tethyan region,” Lithos, vol. 65, pp. 1-67, 2002.

[6] A. H. F. Robertson, “Development of concepts concerning the genesis and emplacement of Tethyan ophiolites in the Eastern Mediterranean and Oman regions,” Earth Sci. Rev., 66: 331-387, 2004.

[7] A. H. F. Robertson, O. Parläk, T. Rızaoğlu, U. C. Ünlüenç, N. İnan, K. Taşlı and T. Ustaömer, “Tectonic evolution of the South Tethyan ocean: evidence from the Eastern Taurus mountains (Elazığ region, SE Turkey).” In: A.C. Ries, R.W.H. Butler, and R.H. Graham (Eds.), Deformation of the continental crust, ” The legacy of Mike Coward, Geol. Soc. London Spec. Publ., 272: 231-270, 2007.

[8] A. M. C. Şengör and Y. Yılmaz, “Tethyan evolution of Turkey: A plate tectonic approach,” Tectonophysics, vol. 75, pp.181-241, 1981.

[9] Y. Yılmaz, “New evidence and model evolution of the southeast anatolian orogen,” Geological Society of America Bulletin, 105, 251-271, 1993.

[10] A.H. Robertson, T. Ustaömer, O. Parläk, U. C. Ünlüenç, K. Taşlı and N. İnan, “The Berit transect of the Tauride thrust belt, S Turkey: Late Cretaceous – Early Cenozoic accretionary/collisional processes related to closure of the Southern Neotethys,” Journal of Asian Earth Sciences, 27(1), 108-145, 2006.

[11] H. S. Moghadam, H. Whitechurch, M. Rahgoshay and I. Monsef, “Significance of Nain-Baft ophiolitic belt (Iran): Short-lived, transtensional Cretaceous back-arc oceanic basins over the Tethyan subduction zone,” Comptes Rendus Geoscience, 341 (12), 1016-1028, 2009.

[12] K. Saynt, Y. Bedi, U. K. Tekin, M. C. Göncüoğlu and C. Okuyucu, “Middle Triassic back-arc basaltic rocks from the blocks in the Mersin Melange, southern Turkey: Implications for the geodynamic evolution of the Northern Neotethys,” Lithos, 268, 102-113, 2017.

[13] Y. Yılmaz, E. Yiğitbaş and S. Genç, “Ophiolitic and metamorphic assemblages of southeast Anatolia and their significance in the geological evolution of the orogenic belt,” Tectonics, 12(5), 1280-1297, 1993.

[14] O. Parläk, V. Höck, H. Kozlu and M. Delaloye, “Oceanic crust generation in an island arc tectonic setting, SE Anatolian orogenic belt,” Geol. Mag., vol. 141, pp. 583-603, 2004.

[15] O. Parläk, T. Rızaoğlu, U. Bağcı, F. Karaoğlu and V. Höck, “Tectonic significance of the geochemistry and petrology of ophiolites in southeast Anatolia, Turkey,” Tectonophysics, vol. 473, pp.173-187, 2009.

[16] U. Bağcı, O. Parläk and V. Höck, “Whole-rock and mineral chemistry of cumulates from the Kızıldağ (Hatay) ophiolite (Turkey): clues for multiple magma generation during crustal accretion in the southern Neotethyan ocean,” Mineralogical Magazine, 69 (1), 53-76, 2005.

[17] D. Perincek, “The geology of Hazro-Korudağ-Cüngüş- Maden-Ergani-Hazar- Elazığ-Malatya Area,” Guide Book, Geol. Soc. Turk., 33 pp, 1979.

[18] G. Aktaş and A. H. F. Robertson, “The Maden Complex, SE Turkey: evolution of a Neotethyan active margin. In: J.E. Dixon and A.H.F. Robertson (Eds.), The geological evolution of the Eastern Mediterranean,” Blackwell Sci. Publ., Oxford, p. 375-402, 1984.

[19] G. Aktaş and A. H. F. Robertson, “Tectonic evolution of the Tethys suture zone in SE, Turkey: Evidence from the petrology and geochemistry of Late Cretaceous and Middle Eocene extrusives. In: J. Malpas et al. (Eds.), Ophiolites - Oceanic crustal analogues,” Proceed. Troodos Ophiolite Symp., Geol. Survey. Cyprus, p. 311-328, 1990.

[20] A.F. Bingöl, “Petrographic and petrologique characteristic of the Guleman ophiolite (Eastern Taurus-Turkey),” Geosound 13/14, 41-57, 1986.
[21] M. E. Rizeli, M. Beyarslan, K. L. Wang and A. F. Bingöl, “Mineral chemistry and petrology of mantle peridotites from the Guleman ophiolite (SE Anatolia, Turkey): Evidence of a forearc setting," *Journal of African Earth Sciences*, 123, 392-402, 2016.

[22] I. Uysal, A. Kapsiotis, R. M. Akmaz, S. Saka and H. M. Seitz, “The Guleman ophiolitic chromitites (SE Turkey) and their link to a compositionally evolving mantle source during subduction initiation,” *Ore Geology Reviews*, 93, 98-113, 2018.

[23] E. Yiğitbaş and Y. Yılmaz, “New evidence and solution to the Maden Complex controversy of the Southeast Anatolian orogenic belt (Turkey),” *Geologische Rundschau*, 85, 250-263, 1996.

[24] M. A. Ertrük, M. Beyarslan, S. L. Chung and T. H. Lin, “Eocene magmatism (Maden Complex) in the Southeast Anatolian orogenic belt: Magma genesis and tectonic implications,” *Geoscience Frontiers*, 9 (6), 1829-1847, 2018.

[25] M. C. Göncüoğlu, “Comments on a single versus multiarmed Southern Neotethys in SE Turkey and Iran,” *3rd Intern. Symp. of IGCP 589 Development of the Asian Tethyan realm. Abstr. and Proceed.*, p. 89-95, 2014.

[26] MTA, “Geological Map of Turkey, 1:500.000 scale the Erzurum Quad-rangale,” *Gen. Direc. of Min. Res. and Expl.*, Ankara, Turkey, 2002.

[27] U. K. Tekin, M. Ural, M. C. Göncüoğlu, M. Arslan and S. Kürüm, “Upper Cretaceous Radiolarian ages from an arc-back arc within the Yûksekoova Complex in the Southern Neotethyan mélange, SE Turkey,” *C. R. Palevol.*, 14 (2): 73-84, 2015.

[28] Y. Özdemir, “Geochemistry of tholeiitic to alkaline lavas from the east of Lake Van (Turkey): Implications for a late Cretaceous mature supra-subduction zone environment,” *Journal of African Earth Sciences*, 120, 77-88, 2016.

[29] Y. Rolland, D. Perinçek, N. Kaymakçı, M. Sosson, E. Barrier and A. Avagyan, “Evidence for~ 80–75 Ma subduction jump during Anatolide–Tauride–Armenian block accretion and~ 48 Ma Arabia–Eurasia collision in Lesser Caucasus–East Anatolia,” *Journal of Geodynamics*, 56, 76-85, 2012.

[30] Y. Rolland, M. Hässig, D. Bosch, O. Bruguier, R. Melis, G. Galoyan, G. Topuz, L. Sahakyan, A. Avagyan, M. Sosson, “The East Anatolia–Lesser Caucasus ophiolite: An exceptional case of large-scale obduction, synthesis of data and numerical modelling,” *Geoscience Frontiers*, 2019.

[31] H. Whitechurch, J. Omrani, P. Agard, F. Humbert, R., Montigny and L. Jolivet, “Evidence for Paleocene–Eocene evolution of the foot of the Eurasian margin (Kermanshah ophiolite, SW Iran) from back-arc to arc: implications for regional geodynamics and obduction,” *Lithos*, 182, 11-32, 2013.

[32] C. Hemleben, M. Spindler and O. R. Anderson, “Modern Planktonic Foraminifera,” *Springer-Verlag*, New York, 363 p, 1989.

[33] J. W. Murray, Ecology and distribution of planktonic foraminifera,” In: Lee, J.J. & Anderson, O.R. (eds.):*Biology of Foraminifera*, Academic Press, London, 255–285, 1991.

[34] M. Ural, M. C. Göncüoğlu, M. Arslan, U. K. Tekin and S. Kürüm, “Petrological and paleontological evidence for generation of a back-arc arc system within the closing southern branch of Neotethys during the Late Cretaceous,” In: A. Begiraj et al. (Eds.), Proceed. 20th CBGA Congr., *Bull. Shk. Gjeol. Spec. Issue, 2/2014: 51-54, 2014.

[35] R. J. Dunham, “Classification of carbonate rocks according to depositional texture,” In: W. E. Ham, (Ed). Classification of Carbonate Rocks, *Am. Ass. Petrol. Geol. Mem. 1*, 108-121, 1962.

[36] J. L. Wilson, “Carbonate facies in geologic history,” *Springer-Verlag*, 428 pp, 1975.

[37] F. Robaszynski and M. Caron, “Cretaceous planktonic foraminifera: comments on the Europe-Mediterranean zonation,” *Bulletin de la Société Géologique de France*, 166, 681–692, 1995.

[38] E. Flügel, “Microfacies of Carbonate Rocks: Analysis, Interpretation and Application,” *Springer-Verlag*, 976 pp, 2004.
[39] I. Premoli Silva, D. Verga, “Practical manual of Cretaceous planktonic foraminifera. In: Verga, D., Rettori, R. (Eds.). International School on planktonic foraminifera, 3rd Course: Cretaceous. Universities of Perugia and Milan, Tiporafia Pontelecino, Perugia (Italy), 283 pp, 2004.

[40] F. Robaszyński and M. Caron, “Atlas de Foraminiferes planctoniques du Cretace moyen,” Parts 1–2. Cahiers de Micropaleontologie 1 and 2, 1–185. 1-181, 1979.

[41] F. Robaszyński, M. Caron, J. M. Gonzales Donoso and A. A. H. Wonders, “Atlas of Late Cretaceous Globotruncanids,” Revue de Micropaléontologie, 26, 145-305, 1984.

[42] W. V. Sliter, “Biostratigraphic zonation for Cretaceous planktonic foraminifers examined in thin section,” Journal of Foraminiferal Research, 19, 1-19, 1989.

[43] F. Robaszyński, M. Caron, C. Dupuis, F. Amedro, J. M. Gonzales Donoso, D. Linares “A tentative integrated stratigraphy in the Turonian of Central Tunisia: Formations, zones, and sequential stratigraphy in the Kalaat Senan Area,” Bull. Centres Rech. Explor. Prot. Elf-Aquitaine, 14, 213-384, 1990.

[44] I. Premoli Silva and W. V. Sliter, “Cretaceous planktonic foraminiferal biostratigraphy and evolutionary trends from the Bottaceione section, Gubbio, Italy,” Palaeontographia Italica, 82, 1–89, 1995.

[45] F. Robaszyński, “Planktonic foraminifera–Upper Cretaceous, Chart of Cretaceous Biochronostratigraphy. In: de Graciansky, P.C., Hardenbol, J. and Vail, P.R. (eds.): Mesozoic and Cenozoic sequence stratigraphy of European basins,” Society for Sedimentary Geology (SEPM), Special Publication, 60, 782 p, 1998.

[46] I. Premoli Silva, and W. V. Sliter, “Cretaceous paleoceanography: Evidence from planktonic foraminiferal evolution. In: Barrera, E., Johnson, C.C. (Eds.), The Evolution of Cretaceous Ocean–Climatic System,” Geological Society of America, Special Paper, 332, 301-328, 1999.

[47] M. R. Petrizzo, “Upper Turonian-lower Campanian planktonic foraminifera from southern mid-high latitudes (Exmouth Plateau, NW Australia: biostratigraphy and taxonomic notes,” Cretaceous Research, 21(4), 479-505, 2000.

[48] M. R. Petrizzo, “Late Cretaceous planktonic foraminiferal bioevents in the Tethys and in the Southern ocean record: an overview. Journal of Foraminiferal Research, 23, 330–337, 2003.

[49] M. Caron, S. Dall’Agnolo, H. Accarie, E. Barrera, E.G. Kauffman, F. Amédro and F. Robaszynski, “High-resolution stratigraphy of the Cenomanian-Turonian boundary interval at Pueblo (USA) and Wadi Bahliou (Tunisia): stable isotopes and bioevents correlation,” Géobios 39, 171-200, 2006.

[50] D. E. Anthonissen and J. G. Ogg, “Cenozoic and Cretaceous biochronology of planktonic foraminifera and calcareous nanofossils. In: Gradstein, F. M., Ogg, J. G., Schmitz, M. D. and Ogg, G.M. (eds.). The Geologic Time Scale 2012, vol. 2. Amsterdam, the Netherlands: Elsevier, pp. 1083–1127, 2012.

[51] A. T. Huber and M. R. Petrizzo, “Evolution and taxonomic study of the Cretaceous planktic foraminiferal genus Helvetoglobotruncana Reiss, 1957,” The Journal of Foraminiferal Research 44(1):40-57, 2014.

[52] R. Cocció and I. Premoli Silva, “Revised Upper Albian–Maastrichtian planktonic foraminiferal biostratigraphy and magnetostratigraphy of the classical Tethyan Gubbio section (Italy),” –Newsletter on Stratigraphy,” 48/1, 47–90, 2015.

[53] B. Erdoğan, “Geology and volcanic rocks of the Southeast Anatolian Ophiolite Belt of the Ergani - Maden Region,” Bulletin of the Geological Society of Turkey, v. 25, 49-59, 1982.

[54] I. Özkaya, “Origin and tectonic setting of some melange units in Turkey,” The Journal of Geology, 90 (3), 269-274, 1982.

[55] D. Perinçek, and I. Özkaya, I., “Tectonic evolution of the northern margin of the Arabian Plate,” Yerbilimleri, vol. 8, pp. 91–101 (in Turkish with English abstract), 1981.
[56] E. Yazgan, “Geodynamic evolution of the eastern Taurus Region (Malatya-Elazığ area, Turkey),” In: Tekeli, O., Gönçüoğlu, M.C. (Eds.), Geology of the Taurus Belt, Proc. of Int. Sym., Publ. of Min. Res. and Expl. Inst. of Turkey, Ankara, pp. 199–208, 1984.

[57] A. Michard, H. Whitechurch, L. E. Ricou, R. Montigny and E. Yazgan, “Tauric subduction (Malatya–Elazığ province) and its bearing on the tectonics of the Tethyan realm in Turkey, In: Dixon, J.E., Robertson, A.H.F. (Eds.), The Geological Evolution of the eastern Mediterranean, ” Geol. Soc. Spec. Publ. London, pp. 361–373, 1985.

[58] M. Hempton, “Results of detailed mapping near Lake Hazar, eastern Taurus mountains. In: Tekeli, O., Gönçüoğlu, M.C. (Eds.), Geology of the Taurus Belt, Proceedings of International Symposium,” Publ. of Min. Res. and Expl. Inst. of Turkey, Ankara, pp. 223–228, 1984.

[59] M. Turan, E. Aksoy and A. F. Bingöl, “Geodynamic evolution of Eastern Taurus around Elazığ,” Hacettepe University, 25th Anniversary of Earth Sciences Symposium, 15- 18 November, Ankara, 1993.

[60] M. Altunbey and S. Çelik, “Geological, Mineralogical and Geochemical Properties of the Maden (Elazığ) Copper Mineralization,” Geosound, 47 (1), 2005.

[61] I. Kuşçu, G. G. Kuşçu, R. M. Tosdal, T. D. Ulrich and R. Friedman, “Magmatism in the southeastern Anatolian orogenic belt: transition from arc to post-collisional setting in an evolving orogen,” Geological Society, London, Special Publications, 340(1), 437-460, 2010.

[62] A. Şaşmaz, B. Türkyılmaz, N. Öztürk, F. Yavuz and M. Kumral, “Geology and geochemistry of Middle Eocene Maden complex ferromanganese deposits from the Elazığ–Malatya region, eastern Turkey,” Ore Geology Reviews, 56, 352-372, 2014.