Bulletin of the Mineral Research and Exploration

http://bulletin.mta.gov.tr

New age findings with microfossils of the Van Formation (Van, Eastern Anatolia)

Ayşegül GÜNEY[a*], Elvan DEMİRCİ[b], Kemal KORKMAZ[c] and Sefer ÖRÇEN[d]

[a]*Aksaray University, Faculty of Engineering, Department of Geological Engineering, Aksaray, Turkey*
[b]*Hacettepe University, Graduate School of Science and Engineering, Department of Geological Engineering, Beytepe, Ankara, Turkey*
[c]*Yenidoğan Street, Toki Sites, C2-3, 27, 12, 48, Talas, Kayseri, Turkey*
[d]*Sokullu Mehmet Paşa Avenue, 93/12, Çankaya, Ankara, Turkey*

Research Article

Keywords:
Calcareous Nanoplankton, Planktonic Foraminifera, Serravallian, Tortonian, Van Formation.

ABSTRACT

Van Formation, which is mainly represented by conglomerate, sandstone, marl and limestone, covers a large area around the Van province. The age of the unit was assigned in different localities of the region as late Oligocene - middle Miocene, early Miocene, Burdigalian - Langhian (early - middle Miocene) by previous studies. In order to determine the age of the upper levels of the formation in the east and southeast of Lake Van, a total of 98 samples collected from three measured stratigraphic sections. These samples have been examined in terms of calcareous nannoplankton and planktonic foraminiferal content. 33 species of 12 calcareous nannoplankton genera and 18 species of 9 planktonic foraminiferal genera representing the Serravalian - Tortonian interval have been identified. Calcareous nannoplankton and planktonic foraminiferal biozones of the unit could not be defined in the study area because of some samples do not contain calcareous nannoplankton and planktonic foraminifera, some samples are scarce in fossils and not all of the zonal markers have been identified. Considering the stratigraphic distribution of the calcareous nannoplankton and planktonic foraminiferal species that the formation contains, age of the Van Formation in the study area is re-evaluated as Serravallian - Tortonian (middle - late Miocene). This shows that marine features continued in the Tortonian (late Miocene) in the study area.

Received Date: 12.07.2020
Accepted Date: 15.03.2021

1. Introduction

The study area, located in the Eastern Anatolia Region, is located in the E - SE of Lake Van, within the Van L50 - b_2 sheet (Figure 1). In the study area, Maxon (1936) first investigated the petroleum possibilities of Lake Van and its surroundings and named the unit consisting of the alternation of conglomerate, sandstone, claystone and siltstone overlying the crystallized limestone as Van Formation. In the succeeding years, Arni (1939) made a geological map of the region at 1/100.000 scale and stated that the metamorphites in the region were Paleozoic, the ophiolites were Late Cretaceous-Paleocene and the limestones were Eocene aged. Ternek (1953), Şener (1992) and Yeşilova (2004) studied the geological features of the regions in the southeast of Van province, the south of Van province and the north of Lake Van, respectively. Ortynski and Tromp (1944) in Van province, Kıraner (1959) in the east of Lake Van, Demirtaşlı and Pisoni (1965) around Adilcevaz and Ahlat areas, Gelati (1975) around Lake Van - Erciş area made researches on the stratigraphic characteristics. Aksoy (1988) surveyed the stratigraphy and tectonics of the area around the Lake Van. Acarlar et al. (1991) stated that clastic deposits of the Oligocene - middle Miocene Van Formation were initially formed as

Citation Info: Yıldız, A., Demirci, E., Korkmaz, K., Örçen, S. 2021. New age findings with microfossils of the Van Formation (Van, Eastern Anatolia). Bulletin of the Mineral Research and Exploration 166, 33-52. https://doi.org/10.19111/bulletinofmre.897859

**Corresponding author: Ayşegül GÜNEY, ayildiz10@hotmail.com*

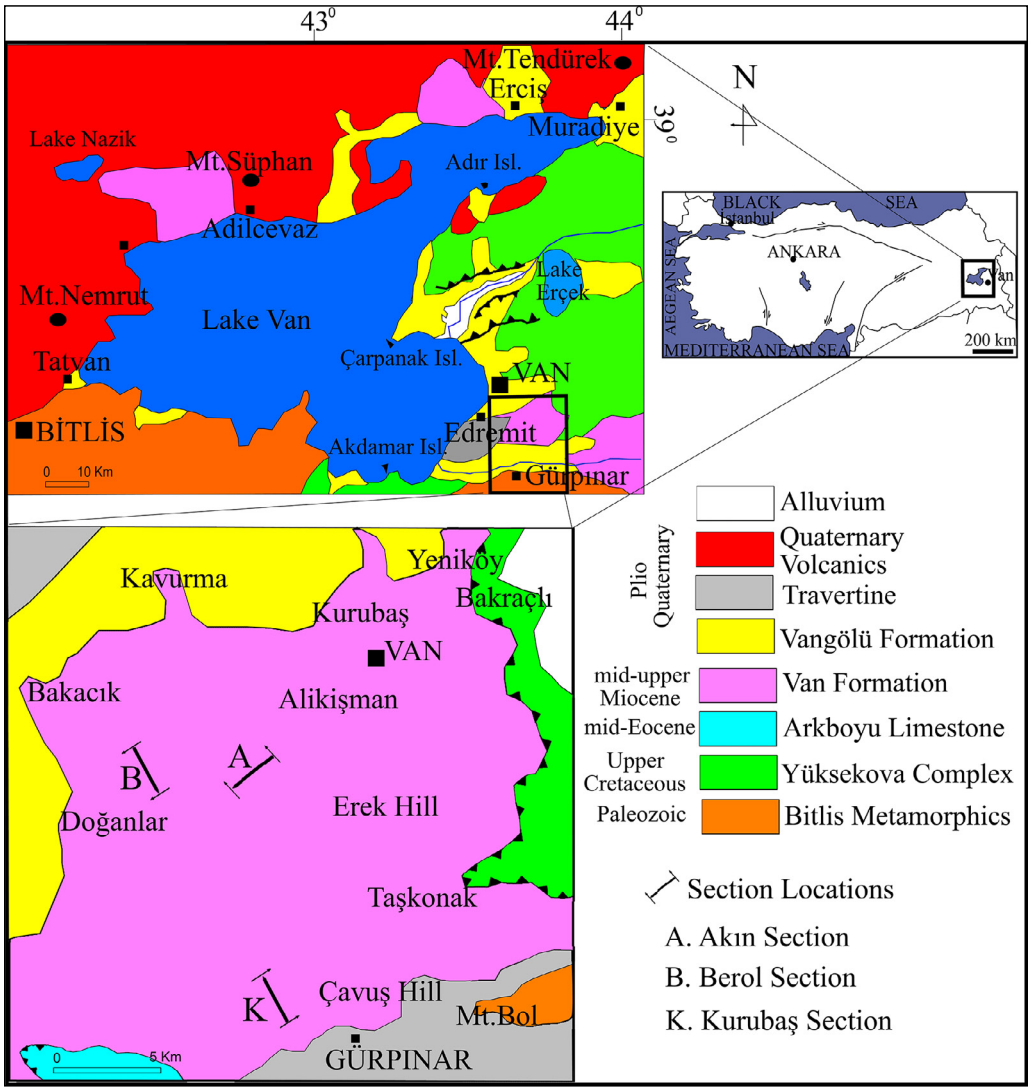


Figure 1- Location and geological maps of the study area, and the section locations (modified from Acarlar et al., 1991; Aksoy, 1988; Şener, 1992; Üner, 2003; Demirci, 2016).

autochthonous-para-autochthonous cover units, then the allochthonous units thrusted over each other and the Van Formation during various phases within the Late Cretaceous-middle Miocene interval. Moreover, structural geological studies were carried out in the area between Lake Van and Iranian border by Ketin (1977), around Van - Gürpınar - Başkale - Çatak areas by Balkaş (1980), around Van province by Şaroğlu and Yılmaz (1984) and Yılmaz (1990), in the Özalp-Iranian border by Şenel et al. (1984), throughout the Eastern Anatolia Region by Dewey et al. (1986), Yılmaz et al. (1987), Adıyaman et al. (1998), Trifonov et al. (1998), Koçyiğit and Beyhan (1998), Gürsoy et al. (2009), Okuldaş et al. (2013). Researches on volcanism in the region were conducted by Degens and Kurtman (1978), Savcı (1980), Elmas (1994), Sümengen (2008), Oyan (2018). Kempe et al. (1978) analyzed the hydrochemistry of water tributaries and mainstream rivers of Lake Van. Valeton (1978) made morphological and petrological investigations of terraces located in the vicinity of Lake Van. Wong and Degens (1978) and Degens and Kurtman (1978) prepared the bathymetric map of Lake Van. Wong and Finckh (1978) analyzed the water level changes of Lake Van for the 18,000 years and determined the resultant coastal terraces. Acarlar and Türkecan (1986) worked on the travertines formed along the eastern and the western border faults of Başkale Basin, and Barka and Şaroğlu (1995) on the Edremit Travertine. Sağlam (2003) made a detailed micropaleontological

study on the Van Formation cropping out in the east of Lake Van based on the five measured stratigraphic sections, and revealed the biostratigraphy of the formation according to the micropaleontological examination of the washing samples and the thin sections. As a result, Sağlam (2003) assigned a Burdigalian-Langhian (early-middle Miocene) age to the Van Formation; and based on the petrographic descriptions made on the limestone and calcarenite samples taken from the formation, it was revealed that the formation was a transgressive sequence and represented a deep marine environment considering the sedimentary structures obtained from the turbiditic sediments of the upper slope of the basin. Demirci (2016) examined the microfacies characteristics of the Van Formation outcropping around Van and revealed that the formation consists of rocks indicating environments from carbonate shelf to basin and that the sedimentary rocks of the Van Formation were formed in the submarine fan environment developed on the slope of a carbonate platform during the closure of the Neotethys.

The sediments of Van Formation, which covers a wide area around Van and are generally represented by conglomerate, sandstone, marl and limestone, play an important role in revealing the geological evolution and neotectonic characteristics of the region. It has been stated that the Van Formation was deposited in the late Oligocene-middle Miocene, early Miocene or Burdigalian-Langhian (early - middle Miocene) periods, considering the rock composition, macro and microfossil assemblages (Acarlar et al., 1991; Şener, 1992; Sağlam, 2003). In this study carried out on the Van Formation in the study area, the calcareous nannoplankton and planktonic foraminiferal content of the Van Formation were examined and the age of the formation in the study area was redefined.

2. Material and Method

A total of 98 samples of three measured stratigraphic sections taken from Van Formation constitute the materials of this study.

In the examination of calcareous nannoplankton, the clean inner surfaces of the samples were scraped in powder form with a pin, and a drop of distilled water was added to the fine powder. The prepared suspension was dried in a thermostatted oven, and a small amount of liquid Canada Balsam was dropped on the coverslip and adhered on the dried slide. During this bonding process, air bubbles were eliminated with a metal rod. Later, the dried preparate was cleaned with a chemical cleaner (Xylol) and made ready for examination. 98 preparates prepared in this way were examined with and x1600 magnification and immersion oil under the Leica DM 2500P polarization microscope in the laboratory of the Department of Geological Engineering at Aksaray University, Faculty of Engineering, they were identified paleontologically and photographed by a Leica DFC 295 camera (Figures 6 - 8). Descriptions and stratigraphic distributions of the calcareous nannoplankton genera and species in slides were made by based on Martini (1971), Okada and Bukry (1980), Perch-Nielsen (1985), Young (1998), Bown (1999), Galovic and Young (2012), Grandstein et al. (2012) and Nannotax 1 - 26 sources (Table 4a). Wei (1988) method was

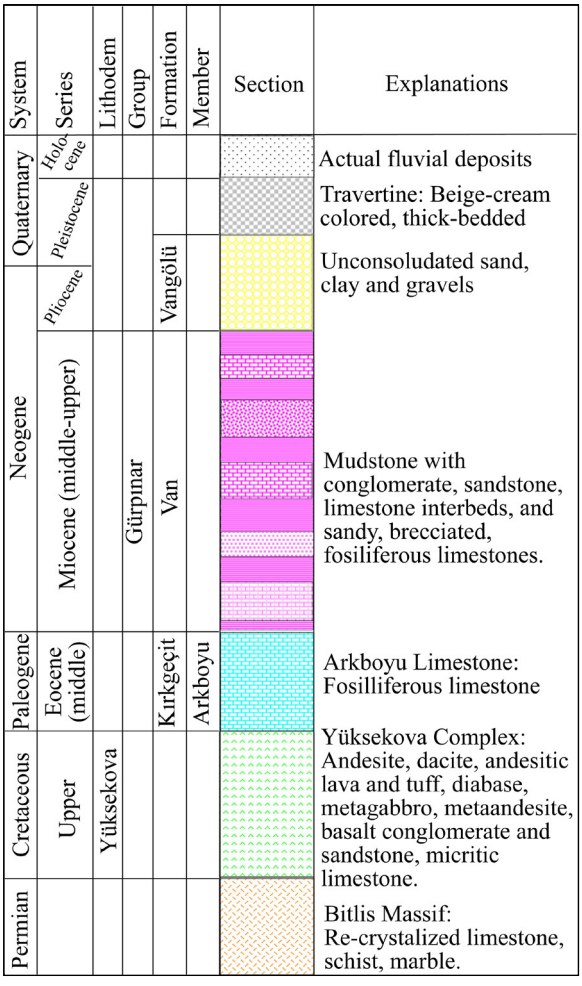


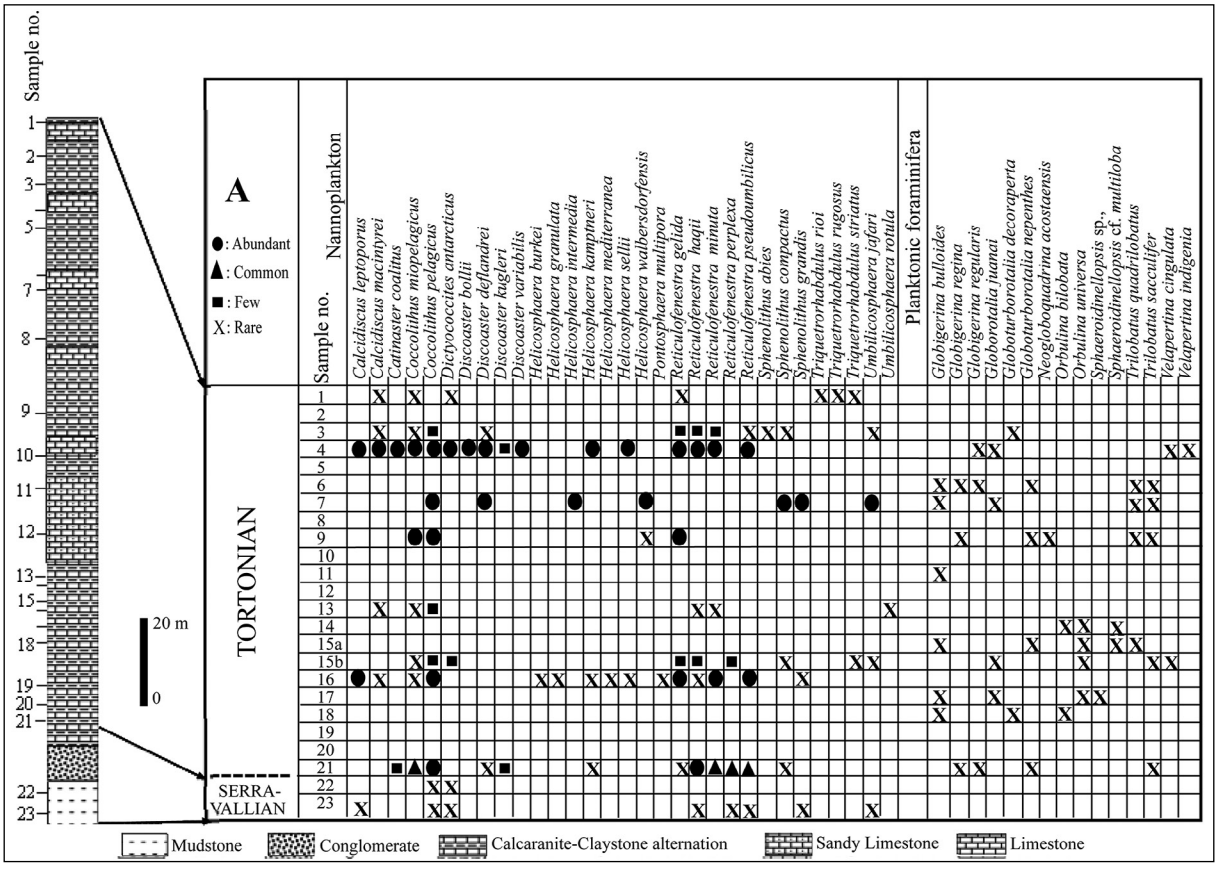
Figure 2- Generalized stratigraphic section of the study area (not to scale; modified from Şener, 1992 and Demirci, 2016).

taken as a basis while determining the abundance distribution of calcareous nannoplankton species. According to this method, the following descriptions were used: abundant for species with 1-10 individuals in a microscope field, common for species with 1 individual in 2 - 10 microscope field, few for species with 1 individual in 11 - 100 microscope field, rare for species with 1 individual in 101 - 1000 microscope area.

In order to determine the planktonic foraminifera, examinations were made on the thin sections for carbonate rock samples and by washing processes for the samples taken from marl, mudstone and claystone. In washing the samples, each 100-gram sample was decomposed with hot water containing 10% Perhydrol (H_2O_2) in a beaker. Decomposed samples were washed by passing through 60, 125 and 250 µm sieves with pressurized water. The residue on the sieves were separately dried in the oven, and the planktonic foraminifera were sorted under binocular microscope. Planktonic foraminiferal genera and species obtained in this way were examined and photographed under the Leica DCM 295 binocular microscope and Leica DFC 295 camera, respectively at the laboratory of Aksaray University, Faculty of Engineering, Department of Geological Engineering (Figures 9 - 10). Descriptions and stratigraphic distributions of planktonic foraminiferal genera and species in the slides were made by using the sources as Bolli (1957), Bolli and Bermudez (1965), Martini (1971), Bolli and Premoli Silva (1973), Okada and Bukry (1980), Bolli and Saunders (1985), Jenkins (1985), Young (1998), Grandstein et al. (2012), Rybar et al. (2015) (Table 4b). In calculation of the abundance of planktonic foraminifera by considering the same species in a 100-gram sample, following scale was used: abundant for 60 - 100, common for 30 - 60, few for 10 - 30, rare for 1 - 10 specimens.

Three stratigraphic sections taken from the Van Formation, geological map of the area involving the section locations, generalized stratigraphic section (not to scale) of the study area, and the tables showing the abundance and distribution of calcareous nannoplankton and planktonic foraminifera

Table 1- Abundance and distributions of the nannoplankton and planktonic foraminiferal species in the Akın measured stratigraphic section.

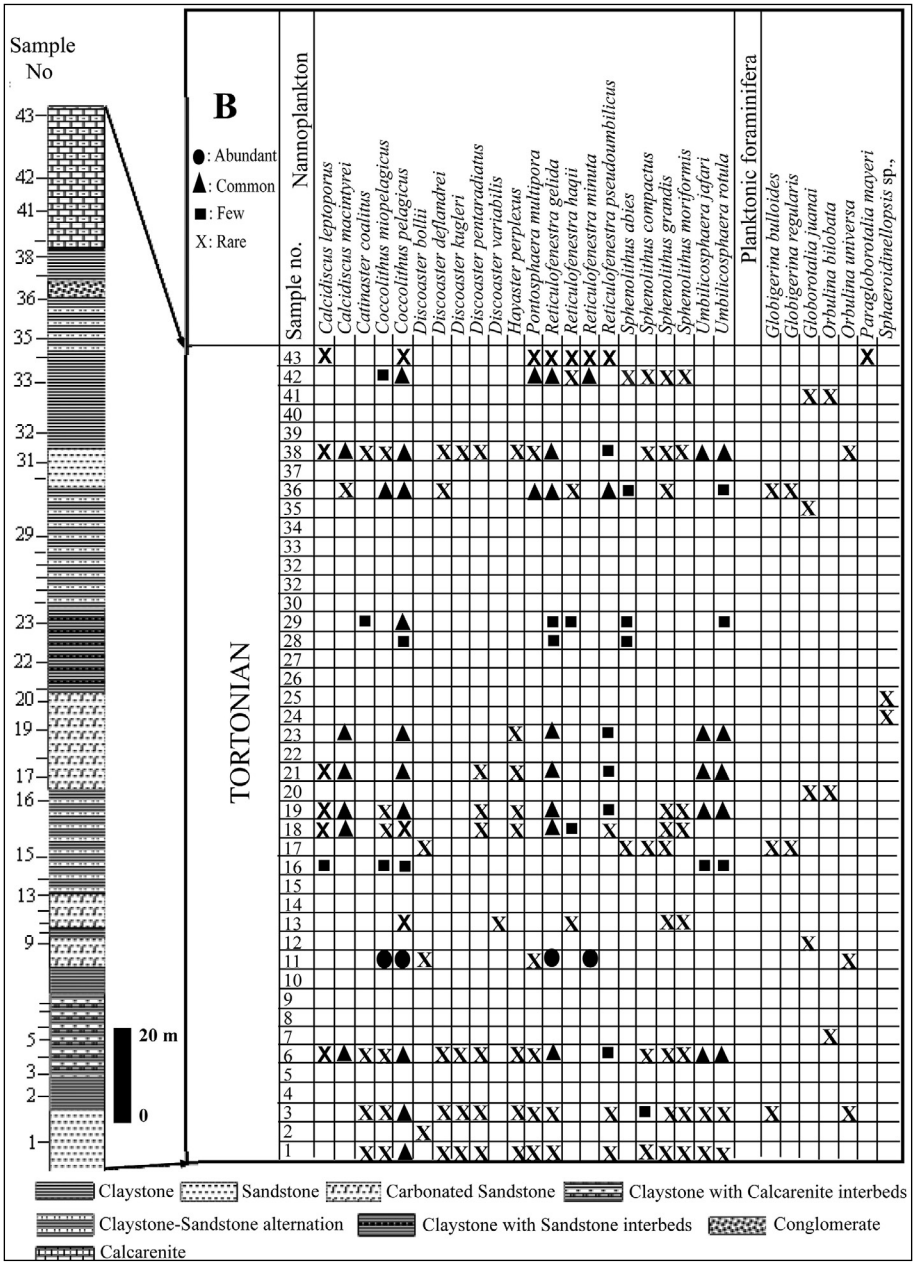


obtained from these sections were drawn in the computer. Calcareous nannoplankton and planktonic foraminiferal assemblages of the Van Formation illustrated as plates (Figures 1, 2; Tables 1 - 3). The age of the Van Formation in the study area was interpreted by using these tables.

3. Regional Geological Setting and Stratigraphy

Convergence between the Arabian - African plates and the Anatolian Plate and the resultant compressional regime played a prominent role in the geological evolution of Turkey. The most important effects of this N - S trending compressional regime are the strike-slip faults with NW and NE striking and the reverse faults with WNW - ESE striking in the Eastern Anatolia Region. Numerous active fault systems such as East Anatolia Fault Zone, Doğubeyazıt Fault Zone, Balıklıgöl Fault Zone, Ağrı Fault, Çaldıran Fault, Tutak Fault, Erciş Fault, Bulanık Fault have been formed due to the compressional regime within the scope of the young tectonics of the Eastern Anatolia Region

Table 2- Abundance and distributions of the nannoplankton and planktonic foraminiferal species in the Berol measured stratigraphic section.



(Şaroğlu and Yılmaz, 1984). It was determined that the Erciş Fault, located in the north of Van, consists of several parallel blocks, and traces of the Erciş Fault were determined generally within Plio-Quaternary deposits (Şaroğlu and Yılmaz, 1984). However, considering the predominant rocks, the basin could be generalized as comprising metamorphic rocks of the Bitlis Massif to the south, young volcanoclastic rocks in the west and north; and volcanic rocks and ophiolite of the Yüksekova Complex and young-actual fluvial and lacustrine clastics and carbonates to the east (Özkaymak, 2003).

The stratigraphic sequence in the study area begins with the Permian metamorphics of the Bitlis Massif at the base. The sequence continues upwards with the Upper Cretaceous Yüksekova Complex, the Akkuyu Member of the middle Eocene Kırkgeçit Formation consisting of fossiliferous limestone, the middle - late Miocene Van Formation, Plio-Quaternary Vangölü Formation. The Van Formation, the subject of this study, is described in detail below (Figure 2).

3.1. Van Formation

Description: The formation was first described by Acarlar et al. (1991). The name of the formation was derived from the Van province where it outcrops.

Type locality and type section: There is no type locality presenting a complete type section of the formation. Different levels of the formation are observed in different places. The late Oligocene aged base of the unit is well observed in Koçköy, while the early Miocene part is in the north of Tekmal and east of Alabayır village. The base of the formation consisting of ophiolite-derived conglomerates outcrop in the northern slope of the Çilehane Mountain. The lower-middle levels formed of the alternation of sandstone-shale-breccia limestone are best observed between the are Alabayır, Beyüzümü, Aşıt villages and Tekmal. The olistostromal conglomerate level is best seen in the Kırma Hill. Its middle parts bearing olistoliths are best observed around Şahgeldi and Esenpınar villages. Its upper part, which is composed of calcarenite - sandy limestone - carbonated sandstone alternation, is well exposed in the south of Ovapınar village. Kurubaş strait is the best place where the uppermost parts of the formation consisting of claystone - siltstone - sandstone alternation is observed (Acarlar et al., 1991; Demirci, 2016).

Lithological features: The Van Formation consists of clastics (conglomerate, sandstone etc.), carbonate and clayey (claystone, mudstone etc.) rocks. At the basal levels of the formation, white colored tuffites and yellowish - light grey colored, thin- to mid-bedded clayey limestones containing tuff clasts are seen between the basaltic lava flows, sandstones and calcarenites as interbeds. The Van Formation begins with different rock types in the localities where its base is best observed such as: northern slope of Çilehane Mountain, north of Koçköy (around Erciş), northwest of Tekmal and east of Alabayır village. The formation unconformably overlies the Dirbi Mélange with its ophiolite-derived conglomerates at the northern of Çilehane Mountain. In Kocaköy, there are Miogypsina- and coral-bearing pebbly limestones at the base of the unit. Van Formation unconformably overlies the Karataş Formation in this area. In the northwest of Tekmal, the formation begins with coral-bearing conglomerate and brecciated limestones at the bottom. To the east of Alabayır village, brecciated limestone, calcarenite and clayey limestone are observed at the base of the formation. These various lithologies at the base of the formation are generally overlain by sandstone, shale alternation which consists of various. This alternation includes variable thickness of brecciated limestone, calcarenite and fine conglomerate levels. In the upper parts of the sequence, olistostromal conglomerate and blocky levels are also added to the alternation of sandstone, shale. An alternation of calcarenite, sandy limestone, carbonated sandstone is dominant in the upper levels of the unit. The dominant lithology of the unit is sandstone, shale alternation. Sandstones, thin to mid-bedded, occasionally thick-bedded, contains ophiolitic components and plant traces, and are usually carbonate-cemented. Some sandstone levels contain abundant mica minerals, and in places they are coarse grained and pebbly. These parts are in the form of intercalations within the sandstone-shale alternation. Sandstones sometimes contain macrofossil shells and there are greyish brown, thin-bedded, sandy carbonate levels between them. Sandstones and shales are greenish brown and brown colored. Conglomerates, mostly polygenic, contain ophiolite gravels (derived from Yüksekova Complex and Erekdağı Ophiolite) and fragments of recrystallized limestone, schist, volcanite and limestones. They are in the form of intercalations within the sandstone, shale alternation

and have thicknesses generally varying between 1 - 2 m to 20 m. The conglomerates contain a sandy matrix and are carbonate cemented. Brecciated limestones, observed as interbeds within the shales, are carbonate cemented, grey colored, thick-bedded or massive, and bears pelecypod shells. Their thicknesses range between 1 - 2 m to 30 - 40 m. Calcarenites are more common in the upper parts of the Van Formation. All the lithologies that the Van Formation comprises show lateral and vertical transition. In addition, Adilcevaz Limestone seen in the north and west of Lake Van represents the lateral change of the calcarenite - sandy limestone alternation in the upper parts of the formation (Acarlar et al., 1991).

Contact relations: the Van Formation unconformably overlies all the older units, and covered by terrestrial units with an unconformity (Acarlar et al., 1991).

Distribution and thickness: The formation, widely distributed in the northwest, east and southeast of Lake Van, is observed at the Ovapınar village in the Van K51 - a_2 sheet; at Sürüyolu and Otlakbaşı villages in the K51 - a_3 sheet; Bağdaşan, Aşağı Kalecik and Değirmenözü villages K51 - a_4 sheet; at Kevenli and Bakraçlı villages and in the Kurubaş Strait in the L50 - b_2 sheet; at Pirgarip village and on the northern slope of the Çilehane Mountain in the K50 - b_3 sheet; at Esenpınar and Şahgeldi villages in the K50 - b_4 sheet; at Yeniköy in the K50 - c_1 sheet; at Aşıt and Kolsatan villages and around Koçköy in the K50 - c_2 sheet; around Alabayır village and Kırma Hill in the K50 - c_3 sheet; at İrenini Mountain in the K50-d_2 (Acarlar et al., 1991).

According to Acarlar et al. (1991), thickness of the formation is about 1200 m Sağlam (2003) determined its thickness as 256 m. The thickness of the formation was determined as 66 - 277 m in the study area located in the east and southeast of Lake Van.

Correlation: According to Acarlar et al. (1991) and Demirci (2016), the Van Formation can be correlated with the early Miocene aged Adicevaz Limestone sequence, with transgressive shelf characteristics, located around Adilcevaz and Ahlat areas in Demirtaşlı and Pisoni (1965) and Yeşilova (2004)'s studies. It has been stated that the formation could also be correlated with the Mendikdere Formation of Şenel et al. (1984) which contains the Oligocene - Miocene coarse detritals located in the area between Özalp - Başkale (Iranian border), and with the early Miocene Alibonca Formation described by Şener (1992).

Depositional environment: According to Acarlar et al. (1991), the Van Formation started to develop due to the transgression in the Oligocene. The conglomerates deposited in the shallow marine environment in this phase formed the base of the unit. Transgressive development continued with coral- and miogypsinid-bearing limestones, and in the last phase of transgression, the development of the submarine fan began with the tilting in the basin. The rock units forming the basement were added to the submarine fan environment probably developed in the east as olistoliths. The fan deposits contain thick sandstones and conglomerates representing channel facies and debris flows and calciturbidites carried from canyons incised in Adilcevaz Limestone. The depositional environment of the formation was interpreted by Sağlam (2003) and Demirci (2016) as the transgressional products that show transition between shallow-deep carbonate shelf and submarine fans due to sea level changes and tectonism during the closure of the southern branch of Neotethys.

Fossil content and age: The age of the formation was stated as late Oligocene-middle Miocene by Acarlar et al. (1991), as early Miocene by Şener (1992), as late Oligocene? - Langhian by Sağlam (2003).

Acarlar et al. (1991) assigned a late Oligocene age for the lower boundary of the formation in the locality of Koçköy (around Erciş) to the north of Lake Van. This age was determined based on the corals species as *Astrocoenia bodellei, A.nana, Cereiphyllia* cf. *tenuis, Diploria* cf. *dumblei, Heliastraea canalis, Hydnophora affinis, Hydronophyllia oligocenica, Pavona* cf. *hypocrateriformis, Phyllocoena lucasiana* from the pebbly limestones at lower levels of the formation. The researchers identified benthic foraminifera such as *Miogypsina irregularis, M.*cf. *intermedia, Miogypsinoides* cf. *dehaarti, Lepidocyclina (Nephrolepidina)* cf. *taurnoueri* in calcarenite, sandy limestones, clayey limestones, carbonated sandstone from the base of the formation in the northwest of Tekmal and the east of Alabayır village, and middle and upper levels of some localities; and planktonic foraminifera such as *Catapsydrax dissimilis, Globigerinoides sicanus,*

Globorotalia obesa, Globoquadrina cf. *dehiscens, G.*cf. *altispira, Trilobatus* cf. *trilobus* in the shales of the Van Formation. According to these determinations, they assigned an early Miocene (Burdigalian) age to the lower and middle levels of the formation. The same researchers, determined the coral species such as *Aphrastraea autignacensis, Aquitanastraea* cf. *pruvosti, Chydnophora solidior, Cladocora* cf. *manipulata, Favites neglecta, F.neglecta* var. *minor, F.mimbastensis, F.neugeboreni* var. *burdigalensis, Heiastrea nerthensis, H.taurinensis, H.saucatsensis, Hydnopora solidor, Lithophyllia michelotti, Meandrina africana, Paleoplesiastreaea desmoulinsi, Platycoenia tarbellensis, Porites collegniana, P.conoidea, Tarbellastrae abditaxis, T.conoidea, T.eggenburgiensis, T.*cf. *ellisiana, T.mimbastenis, T.reussiana, Thegioastrea crassicostata, T.diversiformis, T.*cf. *rosacea*, and aged the middle - upper levels of the formation as early-middle Miocene (Burdigalian - Langhian - Helvetian). Considering all these data, Acarlar et al. (1991) accepted the age of the Van Formation as late Oligocene - middle Miocene.

Sağlam (2003), in the study conducted in the east of Lake Van, could not be obtained any paleontological findings since the lower part of the Van Formation is represented by alluvial fan sediments. The author considered that due to the early Burdigalian age obtained from the carbonates overlying this unit, he thought that the lower boundary of the formation might be of late Oligocene? - Aquitanian age.

Sağlam (2003) identified the benthic foraminifera such as *Amphistegina lessonii, Lepidocyclina* sp., *Miyogypsina irregularis, Operculina complanata*, and a macrofossil assemblage containing *Ostrea* sp., *Pecten* sp., (pelecypod), *Clypeaster* sp. (echinoid), tabulate corals in the benthic foraminiferal-algal-echinoid packstone-grainstone facies which overlie the alluvial fan located at the bottom of the Van Formation. Benthic foraminiferal species as *Amphistegina lessonii, Bulumina* sp., *Cibicides* sp., *Gavelinella* sp., *Guttulina* sp., *Lenticulina* sp., *Lepidocyclina* sp., *Miogypsina irregularis, M.intermedia, Nodosaria* sp., *Operqulina complanata, Peneroplis* sp., *Textularia* sp.; planktonic foraminiferal species as *Catapsydrax dissimilis, Globigerinoides bisphericus, G.ruber, G.subquadratus, Globoquadrina altispira altispira, G.dehiscens, Globorotalia continuosa, G. scitula, Globigerina praebulloides, Orbulina sturalis, Paragloborotalia mayeri, Praeorbulina sicana, Trilobatus immaturus, T.sacculifer, T.trilobus*; gastropod, coral and pelecypod fossils were from the algal-benthic-planktonic foraminiferal packstone (calcarenite) levels in upper levels of the Van Formation which overlie the aforementioned levels. Based on the fossil assemblages, *Miogypsina irregularis* (lower Burdigalian) and *Miogypsina intermedia* (upper Burdigalian) benthic foraminiferal biozones, and *Trilobatus trilobus* (? lower - upper Burdigalian) and *Orbulina sturalis* (Langhian) planktonic foraminiferal biozones were determined from the bottom towards the top of the formation respectively. According to the Sağlam (2003), age of the upper boundary of the Van Formation to the east of Lake Van was assigned as Langhian (middle Miocene).

The age of upper levels of the formation within the study area have been determined as Serravallian-Tortonian (middle-late Miocene) based on the calcareous nannoplankton and planktonic foraminiferal assemblages determined in the study area located in the east and southeast of Lake Van (Figures 3 - 10, Tables 1 - 4).

4. Measured Stratigraphic Sections and Microfossils Findings in the Study Area

4.1. Akın (A) Measured Stratigraphic Section

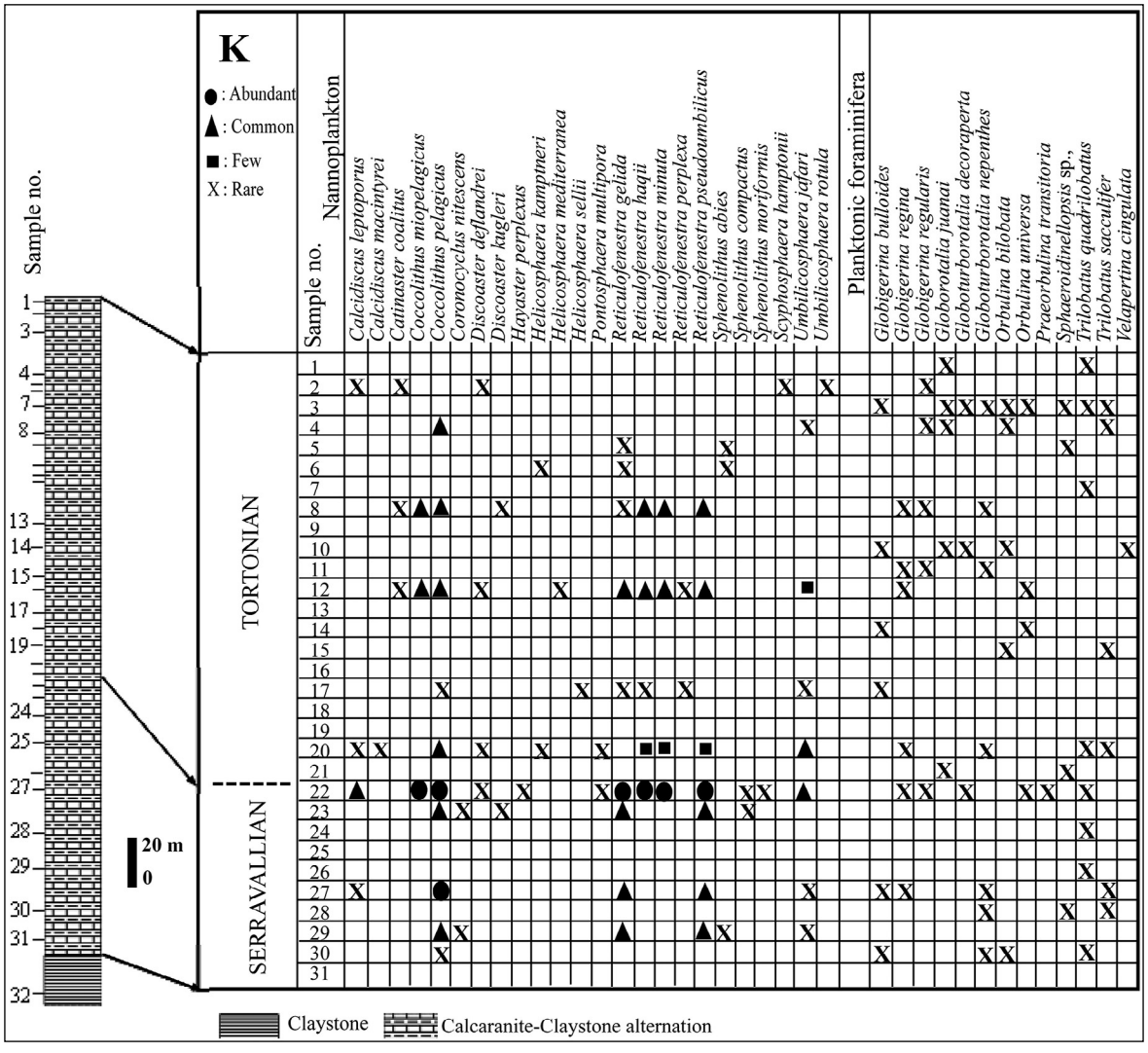
The section, approximately 160 m-thick, was taken from the Akın village on the Van - Gürpınar highway (start coordinate: (A^1) 38S 0357773 / UTM 4252495, end coordinate: (A^2) 38S 0358479 / UTM 4253010, bedding: N35W/15ºNE, elevations for start and end coordinates are 1916 m and 2064 m, respectively). In the measured section, the base of the Van Formation cannot be clearly observed since it is covered by

Figure 3- Akın measured stratigraphic section (view from Bekir Hill; modified from Demirci, 2016).

Figure 4- Berol measured stratigraphic section (view from Doğanlar village, modified from Demirci, 2016).

Figure 5- Kurubaş measured stratigraphic section (modified from Demirci, 2016).

Table 3- Abundance and distributions of the nannoplankton and planktonic foraminiferal species in the Kurubaş measured stratigraphic section.



young sediments. The section starts with 10 m-thick, red colored, unconsolidated mudstone. It is overlain by 8 m-thick conglomerate which comprising ophiolite-derived clasts ranging between the size of 0.5 mm - 26 cm. An alternation of pinkish calcarenites and greenish claystone with 41 m thickness rests on these conglomerates. Towards the upper levels of the section, 20 m-thick, grey colored (brown in altered surfaces), pelecypod-bearing, occasionally granully, sandy limestones sequence with ophiolite-derived conglomerate interbeds is observed. Towards the top of the section, a 46 m-thick alternation of limestone,

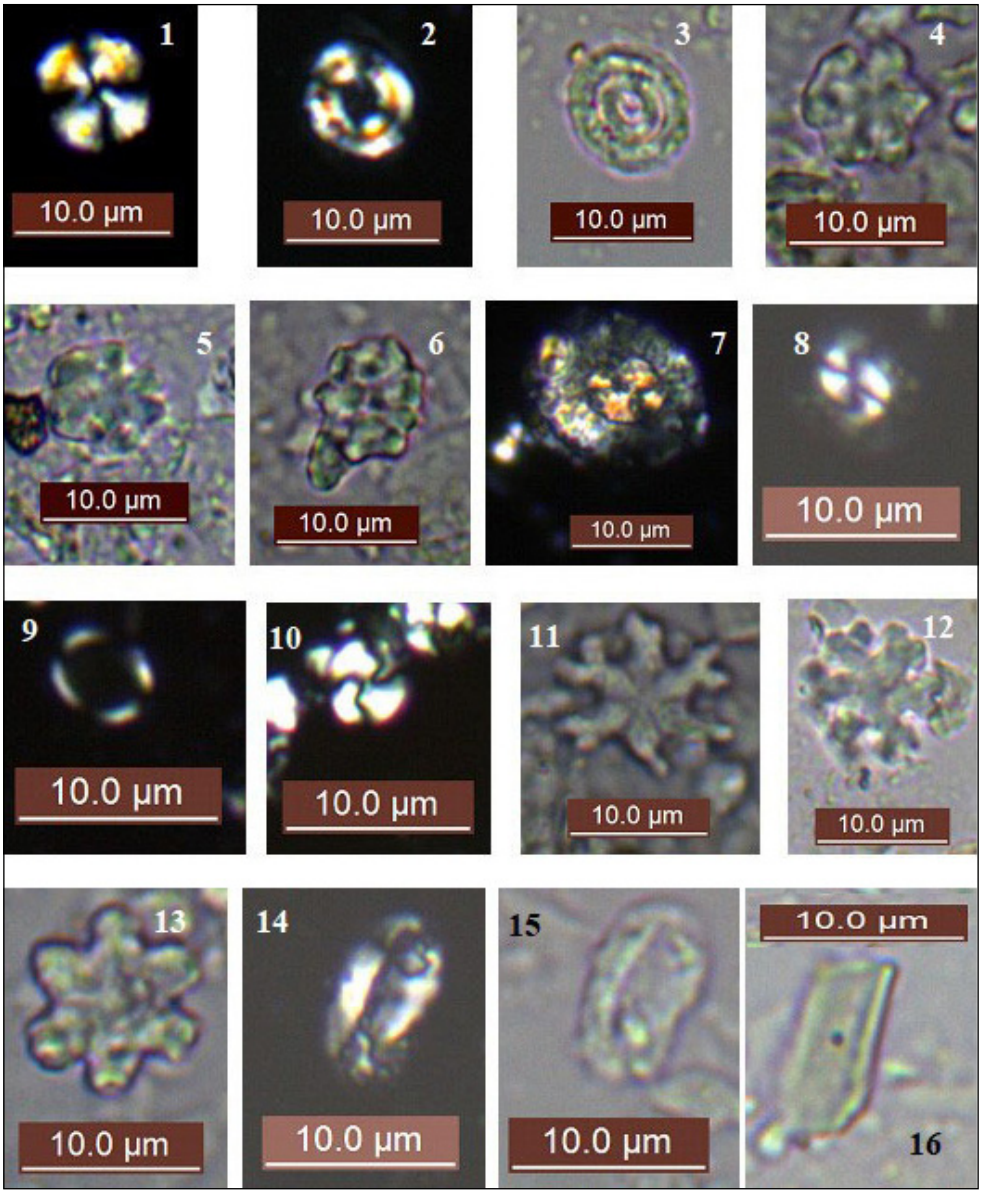


Figure 6- Photomicrographs of calcareous nannoplankton identified in the samples collected from the study area (P: under polarized light, N: under normal light; 1 (P) - *Calcidiscus leptoporus* (Murray and Blackman), sample no: A - 16; 2 (P), 3 (N) - *Calcidiscus macintyrei* (Bukry and Bramlette), sample no: K - 20; 4 - 6 (N) - *Catinaster coalitus* Martini and Bramlette, sample no: K - 2, A - 4, A - 21; 7 (P) - *Coccolithus miopelagicus* Bukry, sample no: B - 19; 8 (P) - *Coccolithus pelagicus* (Wallich), sample no: A - 16; 9 (P) - *Coronocyclus nitescens* (Kamptner), sample no: K - 23; 10 (P) - *Dictyococcites antarcticus* Haq, sample no: A - 1; 11 (N) - *Discoaster bollii* Martini and Bramlette, sample no: A - 4; 12 (N) - *Discoaster deflandrei* Bramlette and Riedel, sample no: A - 4; 13 (N) - *Discoaster kugleri* Martini and Bramlette, sample no: A - 4; 14(P), 15 (N) - *Helicosphaera burkei* Black, sample no: A - 16; 16 (N) - *Scyphosphaera hamptonii* da Gama and Varol, sample no: K - 2).

calcarenite and claystone is seen. This part of the sequence consists of the beige colored limestones with micro-, macrofossils, *Ostrea* sp., bioturbation structures, and grey colored calcarenites and claystones. This alternation is covered by a 35 m-thick limestones-calcarenite-claystone alternation at the uppermost part of the sequence (Figure 3, Table 1).

Calcareous nannoplankton species *Calcidiscus leptoporus, Coccolithus pelagicus, Dictyococcites antarcticus, Reticulofenestra haqii, R. perplexa, R. pseudoumbilicus, Sphenolithus grandis* and *Umbilicosphaera jafari* were identified approximately in the first 10 m of the section from the base where samples numbered 23 - 22 were taken. Considering the stratigraphic distribution of the determined calcareous nannoplankton genera and species, this part of the section has been aged as Serravallian.

In the part between 10 m - 160 m of the section from where samples numbered 21 - 1 were taken, calcareous nannoplankton species occurring in Tortonian such as

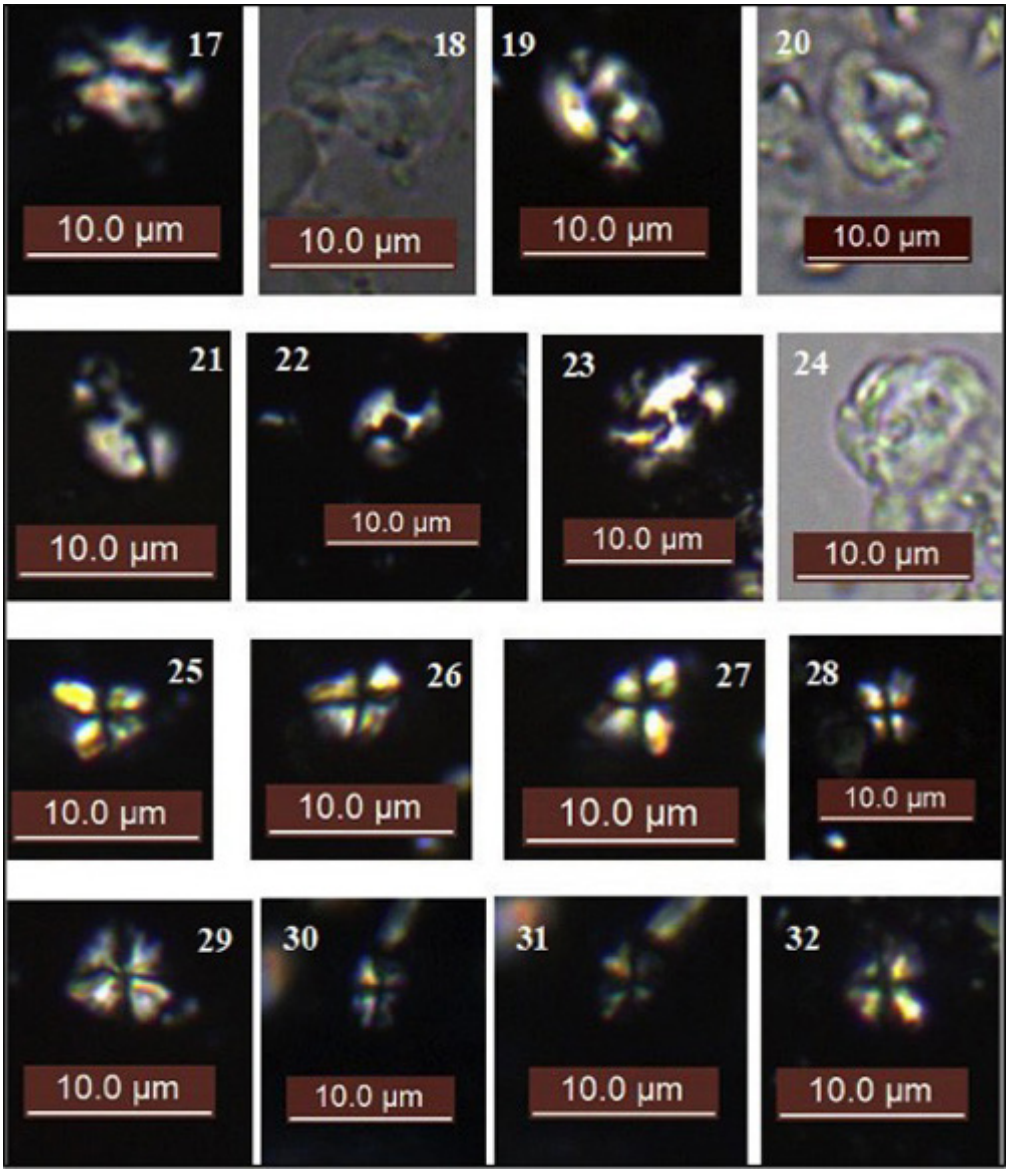


Figure 7- Photomicrographs of calcareous nannoplankton identified in the samples collected from the study area (P: under polarized light, N: under normal light; 17 (P), 18 (N) - Helicosphaera *kamptneri* Hay and Mohler, sample no: A - 4; 19 (P), 20 (N) - *Helicosphaera mediterranea* Muller, sample no: A - 16; 21 - 23 (P), 24 (N) - *Helicosphaera sellii* Bukry and Bramlette, sample no: A - 4, K - 7; 25 - 32 (P) - *Sphenolithus abies* Deflandre, sample no: B - 23, K – 29).

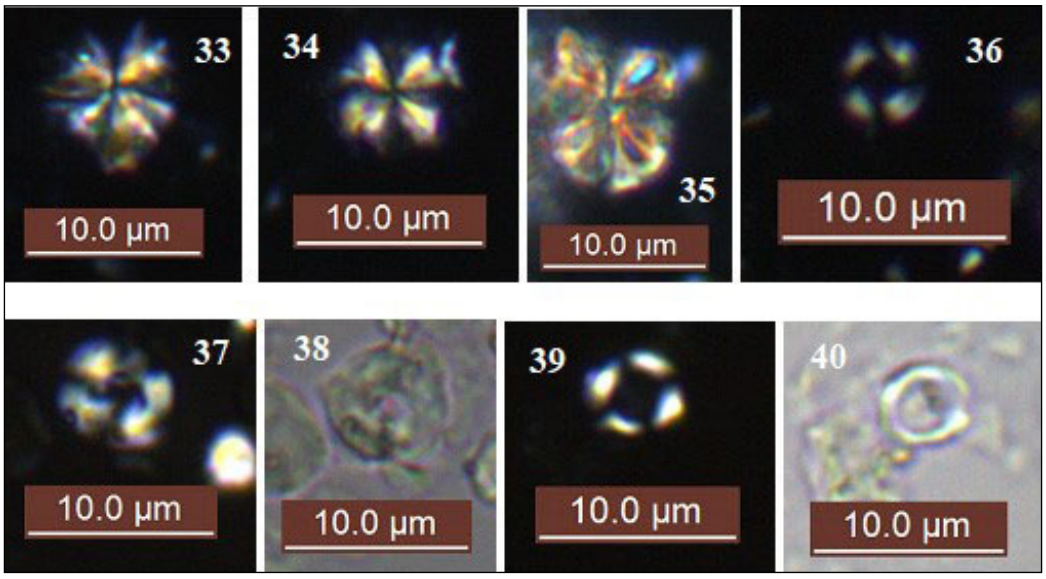


Figure 8- Photomicrographs of calcareous nannoplankton identified in the samples collected from the study area (P: under polarized light, N: under normal light; 33 - 35 (P) - *Sphenolithus grandis* Haq and Berggren, sample no: B - 1, A - 7; 36 - 37 (P), 38 (N) - *Umbilicosphaera jafari* Muller, sample no: B - 38, A - 3; 39 (P), 40 (N) - *Umbilicosphaera rotula* (Kamptner), sample no: B - 23).

Catinaster coalitus, *Discoaster bollii, Helicosphaera sellii* and *Triquetrorhabdulus striatus* were identified, accordingly, this part has been aged as Tortonian. In this part of the section, calcareous nannoplankton species ranging in the Tortonian such as *Calcidiscus leptoporus, C.macintyrei, Coccolithus miopelagicus, C.pelagicus, Dictyococcites antarcticus, Discoaster deflandrei, D.kugleri, D.variabilis, Helicosphaera burkei, H.granulata, H.intermedia, H.kamptneri, H.mediterranea, H.walbersdorfensis, Pontosphaera multipora, Reticulofenestra gelida, R.haqii, R.minuta, R.perplexa, R.pseudoumbilicus, Sphenolithus abies, S.compactus, S.grandis, Triquetrorhabdulus rioi, T.rugosus, Umbilicosphaera jafari* and *U. rotula* were determined.

The planktonic foraminifera first appearing in the Tortonian such as *Neogloboquadrina acostaensis* and *Globorotalia juanai,* and the species, common in the Tortonian, such as *Globigerina bulloides, G. regina, G. regularis, Globoturborotalia decoraperta, G. nepenthes, Trilobatus quadrilobatus, T. sacculifer, Orbulina bilobata, O.universa, Sphaeroidinellopsis* sp., *Sphaeroidinellopsis* cf. *multiloba, Velapertina cingulata, V.indigenia* were also identified from the same levels of the section and this part of the section is also dated as Tortonian according to planktonic foraminifers. (Figures 6 - 10, Tables 1, 4a,b).

4.2. Berol (B) Measured Stratigraphic Section

The section, 160 m-thick, was taken from the north of Doğanlar village (start coordinate: (B^1) 38S 0355499 / UTM 4252566, end coordinate: (B^2) 38S 0356158 / UTM 4252951, bedding: N70E/10ºNW, elevations for start and end coordinates are 1822 m and 1991 m, respectively). The section starts with 15 m-thick, beige colored sandstone with ophiolitic origin. The section towards the top is as follows, respectively: 4 m-thick, greenish grey claystone; 18 m-thick greenish dark grey claystone with calcarenite interbeds; 5 m-thick green claystone; 6 m-thick yellowish carbonated sandstone; 2 m-thick greenish-black claystone; 8 m-thick beige colored carbonated sandstone with 1 - 1.5 m bedding thickness; 22 m-thick alternation of greenish claystone and grey sandstone; 21 m-thick yellowish grey colored carbonated sandstone bearing ophiolitic and siliciclastic fragments; 19 m-thick, green colored claystone intercalated with ophiolitic-siliciclastic sandstone; 22 m-thick alternation of green claystone and brown siliciclastic sandstone; 14 m-thick, yellowish colored, siliciclastic sandstone with ophiolitic materials; 16 m-thick greenish claystone; 11 m-thick alternation of green claystone and greenish grey siliciclastic sandstone; 3 m-thick, reddish colored, ophiolitic conglomerate with a bedding thickness of 1 - 5 cm; 9 m-thick greenish

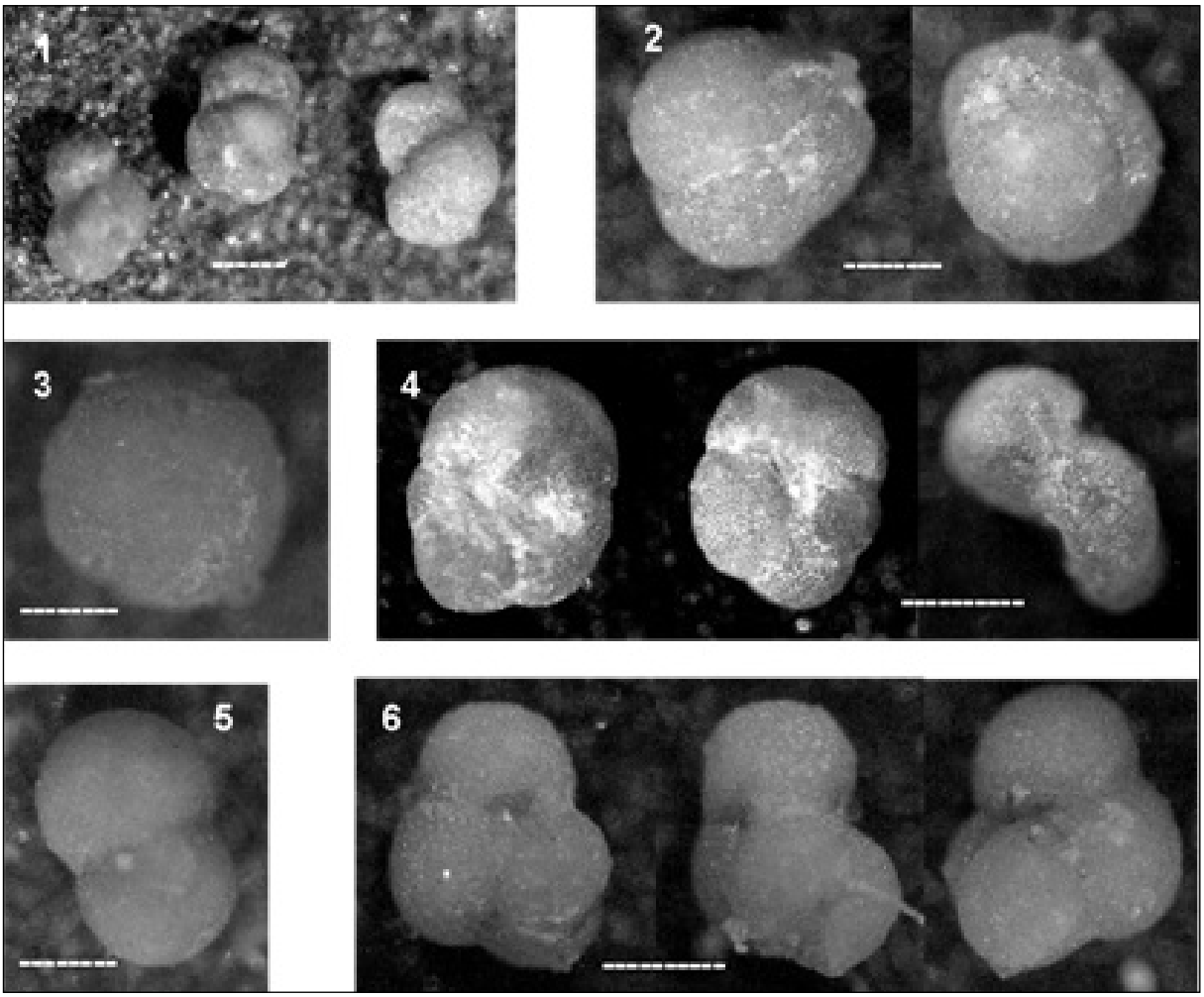


Figure 9- Photomicrographs of plantonic foraminifera identified in the samples collected from the study area (scale 200 µm; 1 - *Globoturborotalia nepenthes* Todd, sample no: A 21; 2 - *Globigerina regina* Crescenti, sample no: K 27; 3- *Orbulina universa* d'Orbigny, sample no: K 12; 4 -*Globigerina regularis* d'Orbigny, sample no: A 21; 5 - *Orbulina bilobata* (d'Orbigny), sample no: K 4; 6 - *Trilobatus quadrilobatus* (d'Orbigny), sample no: K 22).

grey claystone; 18 m-thick, grey colored (brown in altered surfaces) calcarenites containing abundant benthic foraminifera and macrofossils (gastropod, lamellibranch, echinoid, coral etc.) and with 0.5 mm to 4 cm sized gravels in places; and in the uppermost levels of the section, 15 m-thick, grey colored (yellowish in altered surfaces), foraminifera- and macrofossil-bearing biocalcarenites (Figure 4, Table 2).

The calcareous nannoplankton species such as *Catinaster coalitus, Discoaster bollii* and *D. Pentaradiatus* which first appeared in the Tortonian were identified from the levels where samples numbered 1 - 43 were taken along the whole section. In addition, the calcareous nannoplankton species such as *Calcidiscus leptoporus, C.macintyrei, Coccolithus miopelagicus, C.pelagicus, Discoaster deflandrei, D.kugleri, D.variabilis, Hayaster perplexus, Pontosphaera multipora, Reticulofenestra gelida, R.haqii, R.minuta, R.pseudoumbilicus, Sphenolithus abies, S.compactus, S.grandis, S.moriformis, Umbilicosphaera jafari* and *U.rotula*, ranging in the Tortonian, were identified from the samples collected throughout the whole section.

Towards the upper levels of the section where the samples numbered 1-43 were taken, planktonic foraminiferal species *Globorotalia juanai* occurring only in the Tortonian, and the species *Globigerina bulloides, G.regularis, Orbulina bilobata, O.universa, Paragloborotalia mayeri, Sphaeroidinellopsis* sp.

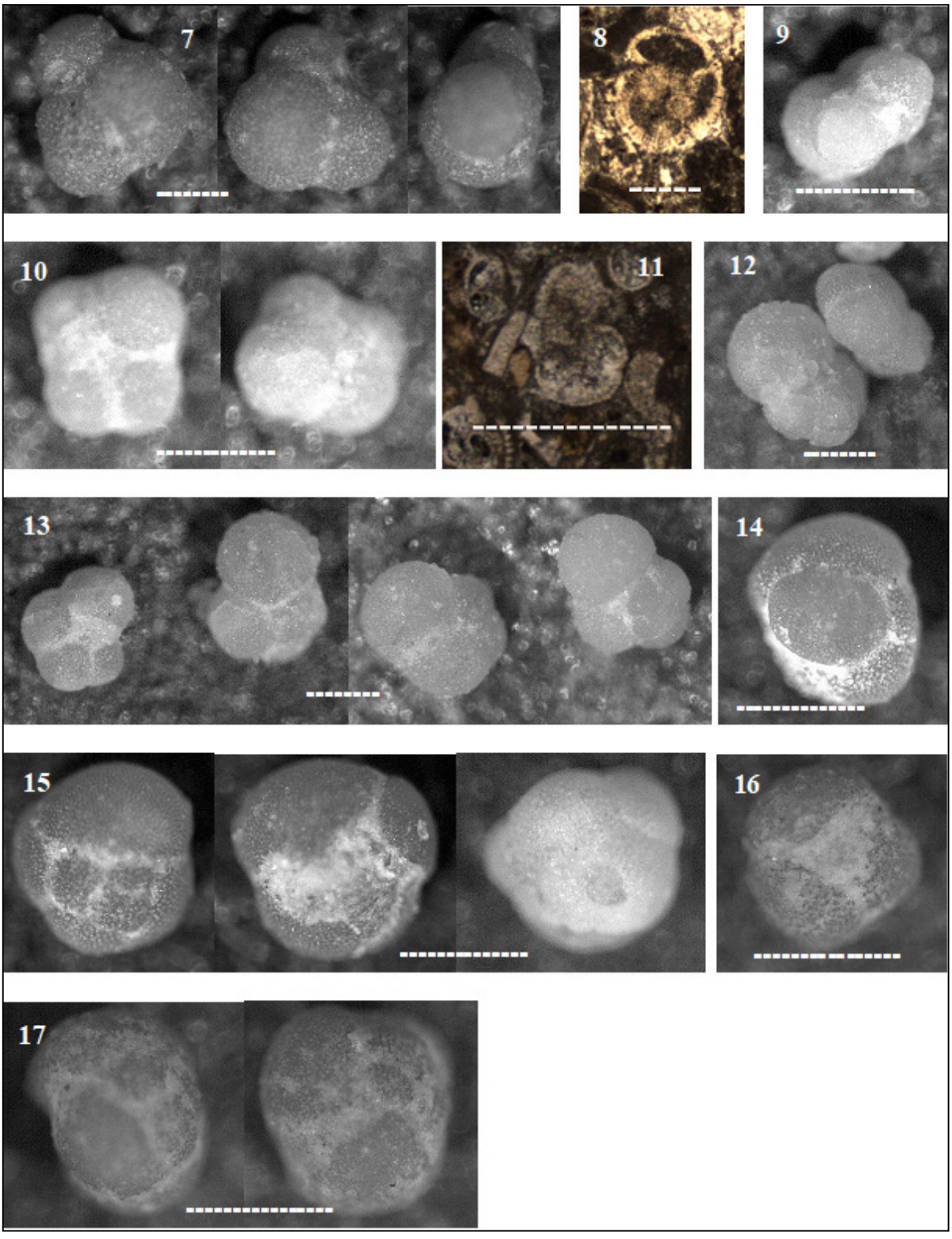
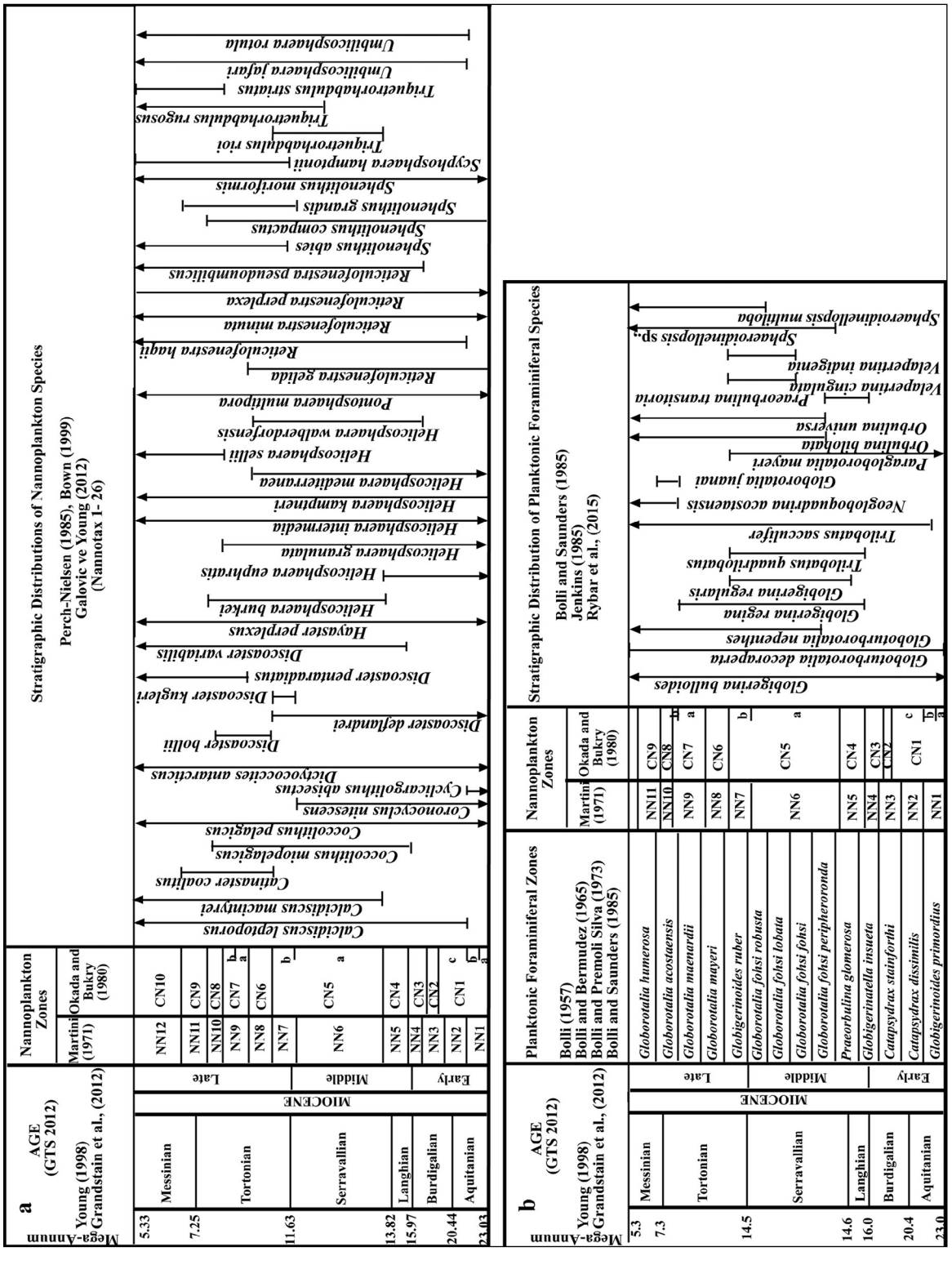


Figure 10- Photomicrographs of plantonic foraminifera identified in the samples collected from the study area (scale 200 µm; 7 - *Trilobatus sacculifer* (Brady), sample no: K 2; 8 - *Sphaeroidinellopsis* sp., sample no: B 25; 9 - 10 - *Neogloboquadrina acostaensis* Blow, sample no: A 9; 11 - *Sphaeroidinellopsis* cf. *multiloba* (Le Roy), sample no: A 15; 12 - 13- *Globorotalia juanai* Bermudez and Bolli, sample no: A 7; 14 - 15 - *Velapertina cingulata* Popescu, sample no: A 21; 16 - 17- *Velapertina indigenia* (Luczkowska), sample no: A 4).

Table 4- Stratigraphic distributions of; a) calcareous nannoplankton and b) planktonic foraminifera species identified from the measured stratigraphic sections taken from the study area.



ranging in the Tortonian were identified. Accordingly, these parts of the section have been aged as Tortonian (Figures 6 - 10, Tables 2, 4a, b).

3.3. Kurubaş (K) Measured Stratigraphic Section

The section, with a total thickness of 277 m, was taken from the 4 km northwest of Gürpınar on the Van -Gürpınar highway (start coordinate: (K^1) 38S 0360208 / UTM 427283, end coordinate: (K^2) 38S 0360072 / UTM 4247580, bedding: N60E/40ºSE, elevations for start and end coordinates are 1985 m and 2012 m, respectively). The section starts at the bottom with 20 m-thick grey claystone; and continues with 257 m-thick, yellowish, beige, brown colored calcarenite and grey claystone (Figure 5, Table 3).

The planktonic foraminiferal species *Globigerina bulloides, Globoturborotalia nepenthes* representing a Serravallian age and the species ranging in the Serravallian such as *Globigerina regina, G.regularis, Globoturborotalia decoraperta, Orbulina bilobata, O.universa, Praeorbulina transitoria, Sphaeroidinellopsis* sp., *Trilobus quadrilobatus,* and *T.sacculifer* were identified in the part of 130 m-thickness from the base of the section where samples numbered 31 - 22 were taken; hence, a Serravallian age has been assigned to the this part of the section. The calcareous nannoplankton species, ranging in the Serravallian, such as *Calcidiscus leptoporus, Coccolithus miopelagicus, C.pelagicus, Coronocyclus nitescens, Discoaster deflandrei, D.kugleri, Hayaster perplexus, Pontosphaera multipora, Reticulofenestra gelida, R.haqii, R.minuta, R.pseudoumbilicus, Sphenolithus compactus, S.moriformis* and *Umbilicosphaera jafari* were determined from the same levels of the section. Based on these findings, this part of the section as well has been aged as Serravallian.

Planktonic foraminifera *Globorotalia juanai* indicating a Tortonian age, and the species, common in the Tortonian, such as *Globigerina bulloides, G.regina, G.regularis, Globoturborotalia decoraperta, G.nepenthes, Orbulina bilobata, O.universa, Sphaeroidinellopsis* sp., *Trilobatus quadrilobatus, T.sacculifer, Velapertina cingulata* were identified in the upper levels of the section where the samples numbered 21 - 1 were taken. Thus, this part of the section has been aged as Tortonian.

The calcareous nannoplankton species appearing in the Tortonian such as *Catinaster coalitus, Helicosphaera sellii* and the species, common in the Tortonian, such as *Calcidiscus leptoporus, C.macintyrei, Coccolithus miopelagicus, C.pelagicus, Discoaster deflandrei, D.kugleri, Helicosphaera kamptneri, H.mediterranea, Pontosphaera multipora, Reticulofenestra gelida, R.haqii, R.minuta, R.perplexa, R.pseudoumbilicus, Scyphosphaera hamptonii, Sphenolithus abies, Umbilicosphaera jafari, U.rotula* were determined in the same levels. Therefore, the age of these levels of the section has been appointed as Tortonian (Figures 6 - 10, Tables 3, 4a,b).

5. Results

The Van Formation which has a wide distribution around Van province and is represented mainly by conglomerate, sandstone, marl, limestone, has been stated in the previous studies from different localities considering the rock composition, macro and microfossil assemblages as being deposited in the late Oligocene-middle Miocene, early Miocene or Burdigalian-Langhian (early-middle Miocene) periods (Acarlar et al., 1991; Şener, 1992; Sağlam, 2003).

In this study carried out on the Van Formation in the east and southeast of Van (L50 - b_2 sheet), three measured stratigraphic sections have been taken. A total of 98 samples including 24 samples from Akın (A) section, 43 samples from Berol (B) section and 31 samples from Kurubaş (K) section have been examined in terms of calcareous nannoplankton and planktonic foraminiferal content. Consequently, 33 species of the 12 calcareous nannoplankton genera and 18 species of 9 planktonic foraminiferal genera representing the Serravallian - Tortonian (middle - late Miocene) interval have been identified. In this study, the calcareous nannoplankton content was studied for the first time in the deposits of the Van Formation in the study area. Calcareous nannoplankton and planktonic foraminiferal biozones of the formation could not be determined in the study area since some samples from the Van Formation neither contains calcareous nannoplankton nor planktonic foraminifera, some samples are scarce in fossils and not all of the index fossils have been identified. The age of the Van Formation within the study area has been considered as Serravallian-Tortonian (middle - late Miocene) based on the calcerous nannoplanton and planktonic foraminiferal content the formation has.

The base of the Van Formation in the study area cannot be observed since it is covered by young sediments in the Akın measured section, and in Kurubaş-Doğanlar region, lying with a thrust contact over the Upper Cretaceous and Eocene units (Figures 1 - 10, Tables 1 - 4a,b).

In the light of the findings obtained from this study, this can be inferred that the Van Formation which covers a large area around Van deposited transgressively during the closure of the Neotethys in an environment showing a transition between shallow to deep carbonate shelf and even submarine fan.

The study area is located within the Van Gölü Basin. The evolution of the Van Gölü Basin is related to geological events from the continental collision that initiated as a result of the subduction of the Arabian Plate beneath the Eurasian Plate and causing the closure of the southern branch of Neotethys. The continental collision started about 10 - 14 million years ago is still continuing today (Şengör and Kidd, 1979; Şaroğlu and Güner, 1981; Dewey et al., 1986; Şaroğlu and Yılmaz, 1986). The Eastern Taurides extending in an area from Hatay to Iran and bordering the Southeastern Anatolia Region to the north, have been shaped as a folded mountain belt that has been uplifting from the beginning of this continental collision. Van Gölü Basin is located just north of the basin named as Bitlis - Zagros Suture Zone in the literature. According to Koçyiğit et al. (2001), the Bitlis Ocean (southern branch of Neotethys) did not close until the middle-late Miocene (Serravallian), later on with its closure, amalgamation of the Arabian Plate to the Eurasian Plate occurred, and the continental collision took place (Özkaymak, 2003). According to the age findings based on the marine organisms (calcareous nannoplanktons and planktonic foraminifera) in this study, it can be concluded that the marine conditions in the study area maintained in Tortonian (late Miocene) as well. Within the scope of these findings, it can be interpreted that the closure phase of the southern branch of Neotethys in the east and southeast of Van province lasted until the Tortonian.

Acknowledgements

This study was supported by the Scientific Research Projects Department of Yüzüncü Yıl University within the scope of the Master Thesis Project no 2015 - FBE - YL033.

References

Acarlar, M., Türkecan, A. 1986. Başkale (Van) batı ve kuzeybatısının jeolojisi, Maden Tetkik ve Arama Genel Müdürlüğü, Rapor No: 7913, 87, Ankara (unpublished).

Acarlar, M., Bilgin, A. Z., Elibol, E., Erkan, T., Gedik, İ., Güner, E., Hakyemez, Y., Şen, A. M., Uğuz, M. F., Umut, M. 1991. Van Gölü doğusu ve kuzeyinin jeolojisi. Maden Tetkik ve Arama Genel Müdürlüğü, Rapor No: 9469, 94, Ankara (unpublished).

Adıyaman, Ö., Chorowicz, J., Köse, O. 1998. Relationships between volcanic patterns and neotectonics in Eastern Anatolia from analysis of satellite images and digital elevation models. Journal of Volcanolgy and Geothermal Research 85, 17- 32.

Aksoy, E. 1988. Van ili doğu - kuzeydoğu yöresinin stratigrafisi ve tektoniği. Doktora Tezi, Fırat Üniversitesi, Fen Bilimleri Enstitüsü, Jeoloji Mühendisliği Anabilim Dalı, 171.

Arni, P. 1939. Van vilayetinin jeolojisi hakkında rapor. Maden Tetkik ve Arama Genel Müdürlüğü, Rapor No: 883, Ankara (unpublished).

Balkaş, Ö. 1980. Başkale - Gürpınar - Çatak - Van alanının jeolojisi ve petrol olanakları. Türkiye Petrolleri Anonim Ortaklığı, Arşiv No: 1455, Ankara.

Barka, A., Şaroğlu, F. 1995. Van Gölü su yükselmesinin tektonik ile ilişkisi. Van Gölü'nün Su Seviyesinin Yükselmesi Nedenleri, Etkileri ve Çözüm Yolları Sempozyumu, 20 - 22 Haziran 1995, Van, 74-90.

Bolli, H. M. 1957. Planktonik foraminifera from the Oligocene - Miocene Cipero and Lengua formations of Trinidad. B.W.I. Bulletin of U. S. National Museum 215, 97-123.

Bolli, H. M., Bermudez, P. J. 1965. Zonation based on planktonik foraminifera of middle Miocene to Pliocene warm water sediments. Baletin Informativo, Asociation Venezolana de Geologia. Mineria Petroleo 8, 119-49.

Bolli, H. M., Premoli Silva, I. 1973. Oligocene to recent planktonik foraminifera and stratigraphy of the Leg 15 sites in the Caribbean Sea. Initial Report of Deep Sea Drilling Project No: 15, 475-97.

Bolli, H. M., Saunders, J. B. 1985. Oligocene to Holocene low latitude planktonic foraminifera. Bolli, H. M., Saunders, J. B., Perch-Nielsen, K. (Ed.). Plankton Stratigraphy 155-262.

Bown, R. 1999. Calcereous Nannofosil Biyostratigraphy. Department of Geologial Science University, Collage London, 312.

Degens, E. T., Kurtman, F. 1978. The geology of lake Van. The Mineral Research and Exploration Publications 169, 64-80, 6-11, Ankara.

Demirci, E. 2016. Akın ve Taşkonak Köyleri dolayında yüzeyleyen Serravaliyen - Tortoniyen (alt - orta Miyosen) yaşlı Van Formasyonu çökellerinin mikrofasiyes ve mikropaleontoloji özellikleri. Yüksek Lisans Tezi, Yüzüncü Yıl Üniversitesi, Fen Bilimleri Enstitüsü, Jeoloji Mühendisliği Anabilim Dalı, 138.

Demirtaşlı, E., Pisoni, C. 1965. Ahlat - Adilcevaz Bölgesi'nin jeolojisi (Van Gölü kuzeyi). Maden Tetkik ve Arama Dergisi 64, 22-23.

Dewey, J. F., Hempton, M. R., Kidd, W. S. F., Şaroğlu, F., Şengör, A. M. C. 1986. Shortening of continental lithosphere: the neotectonics of Eastern Anatolia – a young collision zone. Geological Society of London. Special Publication, 19, 3-36.

Elmas, A. 1994. Güneydoğu Anadolu'da geç Lütesiyen - geç Oligosen aktif kıta kenarı volkanizmasına bir örnek: Gövelek volkanitleri (Van - Erçek). Yerbilimleri Dergisi 3, 43-54.

Galovic, I., Young, J. R. 2012. Revised taxonomy and stratigraphy of Middle Miocene calcareous nannofossils of the Paratethys. Micropaleontology 58 (4), 305-334.

Gelati, R. 1975. Miocene marine sequence from the Lake Van Area, Eastern Turkey. Rivista Italiana di Paleontologia Stratigrafia 81 (4), 477-490.

Grandstein, F. M., Ogg, J. G., Schmitz, M. D., Ogg, G. M. 2012. The Geologic Time Scale 2012, Elsevier, 1, 144.

Gürsoy, H., Tatar, O., Piper, J. D. A., Heimann, A., Koçbulut, F., Mesci, B. L. 2009. Palaeomagnetic study of Tertiary volcanic domains in Southern Turkey and Neogene anticlockwise rotation of the Arabian Plate. Tectonophysics 465, 114-127.

Jenkins, D. G. 1985. Southern mid-latitude Paleocene to Holocene planktonik foraminifera. Bolli, H. M., Saunders, J. B., Perch-Nielsen, K. (Ed.). Plankton Stratigraphy 263-282.

Kempe, St., Khoo, F., Gürleyik., Y. 1978. Hydrography of lake Van and its drainage area. The geology of lake Van. Mineral Research and Exploration Publications 30-44.

Ketin, İ. 1977. Van Gölü ile İran sınırı arasındaki bölgede yapılan jeoloji gözlemlerinin sonuçları hakkında kısa bir açıklama. Türkiye Jeoloji Kurumu Bülteni 20, 79-85.

Kıraner, F. 1959. Van Gölü doğu bölgesinin jeolojik etüdü, Nafta Vek. Demiryolları İnşaat Dairesi.

Koçyiğit A., Beyhan A. 1998. A new intracontinental transcurrent structure: the central Anatolian Fault Zone, Turkey. Tectonophysics 284, 317-336.

Koçyiğit, A., Yılmaz, A., Adamia, S., Kuloshvili, S. 2001. Neotectonics of east Anotolian Plateau (Turkey) and lesser caucasus: implication for transition from thrusting to strike-slip faulting. Geodinamica Acta 14, 177-195.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. Proceedings of the 2nd Planktonic Conference 1071, Roma, 739-785.

Maxon, J. H. 1936. Geology and petroleum possibilities of the Hermis dome. Derleme No: 225, 25.

Nannotax 1. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Coccolitales/Calcidiscaceae/Calcidiscus/C.%20leptoporus%20group/Calcidiscus%20leptoporus.11 September 2019.

Nannotax 2. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Coccolithales/Calcidiscaceae/Calcidiscua/C.%20leptoporus%20group/Calcidiscus%20macintyrei. 11 September 2019.

Nannotax 3. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Catinaster%20coalitus&module=Coccolithophores. 11 September 2019.

Nannotax 4. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Coccolithales/Coccolithaceae/Coccolithus/C.%20pelagicus%20group/Coccolithus%20miopelagicus. 11 September 2019.

Nannotax 5. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Coccolithales/Coccolithaceae/Coronocyc lus/Coronocyclus%20nitescens. 11 September 2019.

Nannotax 6. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Discoasterales/Discoasteraceae/Discoas ter/D.%20variabilis%20group/Discoaster%20bollii. 12 September 2019.

Nannotax 7. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Discoaster%20deflandrei&module= Coccolithophores. 12 September 2019.

Nannotax 8. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Discoaster%20kugleri&module=Coccolithophores. 12 September 2019.

Nannotax 9. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Discoaster%20pentaradiatus&module= Coccolithophor es. 12 September 2019.

Nannotax 10. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Discoasterales/Discoasteraceae/ Discoas ter/D.%20variabilis%20group/Discoaster%20variabilis. 12 September 2019.

Nannotax 11. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Zygodiscales/Helicosphaeraceae/ Helicos phaera/H.%20carteri%20group/Helicosphaera%20granulata. 12 September 2019.

Nannotax 12. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Helicosphaera%20intermedia&module= Coccolithopho res. 14 September 2019.

Nannotax 13. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Helicosphaera%20mediterranea&module= Coccolithoph ohores. 14 September 2019.

Nannotax 14. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Helicosphaera%20sellii&module= Coccolithophores. 14 September 2019.

Nannotax 15. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Helicosphaera%20walbersdorfensis&module= Coccolit hophores. 14 September 2019.

Nannotax 16. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Reticulofenestra%20perplexa&module= Coccolithop hores. 14 September 2019.

Nannotax 17. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Isochrysidales/Noelaerhabdaceae/Reticulofenestra/R.%20pseudoumbilicus%20group/Reticulofenestra%20pseudoumbilicus. 14 September 2019.

Nannotax 18. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Sphenolithus%20abies&module= Coccolithophores. 14 September 2019.

Nannotax 19. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Sphenolithus%20grandis&module=Coccolithophores. 14 September 2019.

Nannotax 20. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Discoasterales/Sphenolithaceae /Spheno lithus/S.%20moriformis%20group/Sphenolithus%20moriformis. 17 September 2019.

Nannotax 21. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Nannolith%20families%20 inc%20sed/ Ceratolithaceae/Orthorhabdus/Orthorhabdus%20rioi. 17 September 2019.

Nannotax 22. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Nannolith%20families%20inc %20 sed/Ceratolithaceae/Orthorhabdus/Orthorhabdus%20rugosus. 17 September 2019.

Nannotax 23. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Orthorhabdus%20striatus&module= Coccolithophores. 17 September 2019.

Nannotax 24. 2019. http://www.mikrotax.org/Nannotax3/index.php?taxon=Umbilicosphaera%20jafari&module= Coccolithopho res. 17 September 2019.

Nannotax 25. 2019. http://www.mikrotax.org/Nannotax3/index.php?dir=Coccolithophores/Coccolithales/Calcidiscaceae/ Umbili cosphaera/Umbilicosphaera%20rotula. 17 September 2019.

Nannotax 26. 2020. http://www.mikrotax.orgNannotax3 index.phpdir=Coccolithophores Zygodiscales PontosphaeraceaeScyphosphaera Scyphosphaera%20hamptoni. 24 Aralık 2020.

Okada, H., Bukry, D. 1980. Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation. Marine Micropaleontology 5, 321-325.

Okuldaş, C. 2013. Alaköy Fayı'nın jeomorfolojik özellikleri ve tektonik etkinliği (Van Gölü Havzası - Doğu Anadolu). Yerbilimleri 34 (3), 161-176.

Ortynski, I., Tromp, S. W. 1944. Geological report on atrip to the Van area, Maden Tetkik ve Arama Genel Müdürlüğü, Rapor No: 1519, Ankara (unpublished).

Oyan, V. 2018. Van Gölü'nün doğusundaki Otlakbaşı bazaltik volkanizmasının petrolojik ve jeokimyasal evrimi. Bulletin of the Mineral Research and Exploration 157, 1-23.

Özkaymak, Ç. 2003. Van şehri yakın çevresinin aktif tektonik özellikleri. Yüksek Lisans Tezi, Yüzüncü Yıl Üniversitesi, Fen Bilimleri Enstitüsü, Jeoloji Mühendisliği Anabilim Dalı, 95, Van.

Perch-Nielsen, K. 1985. Cenozoic Calcareous Nannofossils. Bolli, H. M., Saunders, J. B., Perch-Nielsen, K. (Ed.). Plankton Stratigraphy, Cambridge University Press, 427-554.

Rybar, S., Halasova, E., Hudackova, N., Kovaç, M., Kovacova, M., Sarinova, K., Sujan, M. 2015. Biostratigraphy, sedimentology and paleoenvironments of the northern Danube Basin: Ratkovce 1 well case study. Geologica Carpathica 66 (1), 51-67.

Sağlam, A. 2003. Van Gölü doğusu ve güneydoğusunda yüzeyleyen Van Formasyonu'nun stratigrafisi, paleontolojisi ve çökelme ortamları. Yüksek Lisans Tezi, Yüzüncü Yıl Üniversitesi, Fen Bilimleri Enstitüsü, Jeoloji Mühendisliği Anabilim Dalı, Van (unpublished).

Savcı, G. 1980. Doğu Anadolu Volkanizma'sının neotektonik önemi. Yeryuvarı ve İnsan 5, 3-4.

Sümengen, M. 2008. Başkale - L52 paftası: Türkiye 1/100.000 ölçekli jeoloji haritaları serisi. Maden Tetkik ve Arama Genel Müdürlüğü Yayınları, Ankara.

Şaroğlu, F., Güner, Y. 1981. Doğu Anadolu'nun jeomorfolojik gelişimine etki eden öğeler: tektonik volkanizma ilişkileri. Türkiye Jeoloji Kurumu Bülteni 24, 39-50.

Şaroğlu, F., Yılmaz, Y. 1984. Doğu Anadolu'nun neotektoniği ve ilgili magmatizması. Ketin Sempozyumu, İstanbul, 149-162.

Şaroğlu, F., Yılmaz, Y. 1986. Doğu Anadolu'da neotektonik dönemdeki jeolojik evrim ve havza modelleri. Maden Tetkik ve Arama Genel Müdürlüğü, Jeoloji Etütleri Dairesi, Ankara.

Şenel, M., Acarlar, M., Çakmakoğlu, A., Dağer, Z., Erkanol, D., Örçen, S., Taşkıran, M. A., Ulu, Ü., Ünal, M. F., Yıldırım, H. 1984. Özalp (Van) - İran sınırı arasındaki alanın jeolojisi. Maden Tetkik ve Arama Genel Müdürlüğü Rapor No: 7623, Ankara (unpublished).

Şener, S. 1992. Van ili yakın güneyinin jeolojisi ve denizel miyosen istifinin fasiyes özellikleri. Yüksek Lisans Tezi, Ankara Üniversitesi, Fen Bilimleri Enstitüsü, Ankara (unpublished).

Şengör, A. M. C., Kidd, W. S. F. 1979. Post-collisional tectonics of the Turkish Iranian Plateau and a comparison with Tibet. Tectonophysics 55, 361-376.

Ternek, Z. 1953. Van Gölü güneydoğu bölgesinin jeolojisi. Türkiye Jeoloji Kurultayı Bülteni 4 (2), 1-27.

Trifonov, V. G., Vostrikov, G. A., Trifonov, R. V., Karakhanian, A. S., Soboleva., O. V. 1998. Recent geodynamic characteristic in the Arabian - Eurasian and Indian Eurasian collision region by active fault data. Tectonophysics 308, 119-131.

Valeton, I. 1978. A morphological and petrological study the terraces around lake Van. Bulletin of the Mineral Reseach and Exploration 169, 64-80.

Yeşilova, Ç. 2004. Van Gölü kuzeyinde yüzeyleyen Adilcevaz Kireçtaşı'nın (Van Gölü kuzeyi) mikrofasiyes özellikleri. Yüksek Lisans Tezi, Yüzüncü Yıl Üniversitesi, Fen Bilimleri Enstitüsü, Jeoloji Mühendisliği Anabilim Dalı, 77.

Yılmaz, Y. 1990. Comparison of young volcanic associations of Western and Eastern Anatolia formed under a compressional regime: a review. Journal of Volcanology and Geothermal Research 44, 69-87.

Yılmaz, Y., F. Şaroğlu, Güner, Y. 1987. Initiation of the neomagmatism in East Anatolia. Tectonophysics 134, 177-199.

Young, J. R. 1998. Neogene. Bown, P. R. (Ed.). Calcareous Nannofossil Biostratigraphy, Cambridge 225-265.

Wei., W. 1988. A new technique for preparing quantitative nannofossil slides. Journal of Paleontology 62, 472-473.

Wong, H. K., Degens, E. T. 1978. The bathymetry of lake Van, Eastern Turkey: Degens, E. T., Kurtman, F. (Ed.). The Geology Lake Van, General Directorate of Mineral Reseach and Exploration Press 6-10.

Wong, H. K., Finckh, P. 1978. Shallow structures in lake Van, in the geology of lake Van. Degens, E. T., Kurtman, F. (Ed.). The Mineral Research and Exploration Institute of Turkey, Report No: 169.