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Characteristic mollusc, larger foraminifera findings and environmental interpretations of the Middle Eocene Kocaçay formation deposits around Ayvalıca (Bayat, Çorum)

Müjde GÜRSOY[a] and Muhittin GÖRMÜŞ[b]

[a]*MTA General Directorate of Mineral Research and Exploration Şehit Cuma DAĞ Natural History Museum Paleontology Department 06800 Çankaya ANKARA*
[b]*Ankara University Engineering Faculty Geology Engineering Department 06830 Gölbaşı ANKARA.*

Research Article

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ABSTRACT

Although the Çankırı-Çorum Basin was studied for various purposes such as geological, stratigraphical, tectonic, coal and oil exploration, studies on fossils are limited. Especially there have not been detailed studies on molluscs and larger foraminifera. The research area is located at the vicinity of Ayvalıca (north of Çankırı-Çorum basin). The Middle Eocene Kocaçay formation, which outcrops in the Çankırı-Çorum Basin, is widespread around Bayat Çorum in the north of the basin, Sulakyurt Kırıkkale in the west, Çiçekdağı Kırşehir in the south and Sungurlu Çorum in the middle of the basin. The formation is composed of conglomerate, carbonated sandstone, limestone and sandy marls and also includes rich larger foraminifera and molluscs. This study mainly focuses on taxonomy and environmental interpretations of *Ostrea roncaensis* (Partsch in coll. Bayan, 1870) de Gregorio, 1884, *Velates perversus* (Gmelin, 1791) species from *Mollusca and Nummulites beaumonti* d'Archiac and Haime, 1853, *N. aturicus* Joly and Leymerie,1848, *N. perforatus* (de Montfort, 1808) and *Assilina exponens* (Sowerby, 1840) species from larger Foraminifera. In addition, considering faunal features from bottom to top *Ostrea roncaensis*, *Velates perversus*, *Nummulites aturicus* and *Assilina exponens* Abundance Biozones were identified. The age range of the Kocaçay Formation is determined as Lutetian-Bartonian. Lithological and faunal contents indicate that sediments of the Kocaçay formation were deposited within lagoon to nummulitic sets in a shallow marine environment.

1. Introduction

Çankırı-Çorum basin where the field of study is carried out is one of the most important storage basins of Central Anatolia with a sedimentary thickness of 11,000 meters from Paleocene to Pliocene (Birgili et al., 1975). It is known that the Paleogene part of the sequence is composed of marine and Neogene part consists of terrestrial deposits. The basin is surrounded by the North Anatolian Fault (NAF) and Ophiolitic Melange in the north, Sakarya Massif in the east and Kırşehir Massif in the south. In this study, the mollusc and foraminiferal findings in the Middle Eocene Koçaçay formation were represented in the vicinity of Ayvalıca Village (Bayat, Çorum) located north of Çankırı-Çorum Basin (Figure 1).

There are studies about geology and stratigraphy (Lahn, 1939, 1943; Yücel, 1953; Erol, 1953, 1959; Ketin, 1955; Akarsu, 1959; Alpan, 1968; Norman,

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* *Corresponding author: Müjde GÜRSOY, mujde.gursoy@mta.gov.tr*

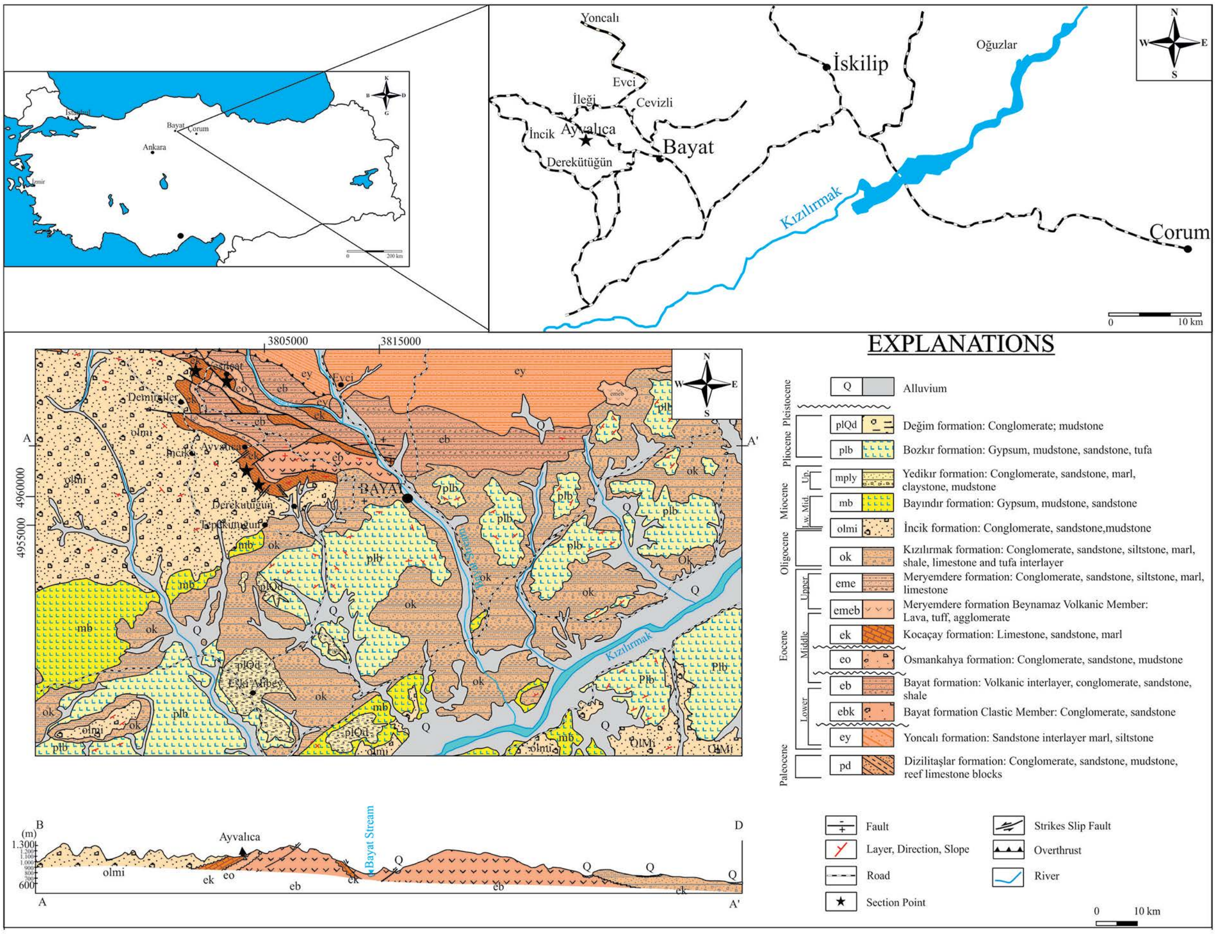

Figure 1- Location and geology map of Bayat (Çorum); it was revised from MTA Çorum G32 sheet at 1/100.000 scale (Sevin and Uğuz, 2011).

1972, 1975*a, b*; Çalgın et al., 1973; Birgili; et al., 1975; Çapan and Buket, 1975; Ergun, 1977; Yoldaş, 1982; Hakyemez et al., 1986; Bilgin et al., 1986; Erdoğan et al., 1996; Ateş et al., 2010; Bilgiç, 2012), sedimentology (Şenalp, 1974, 1980; 1981; Karadenizli, 1999; Karadenizli and Kazancı, 2000; Karadenizli et al., 2003 and 2004) and detailed the North Anatolian Fault (NAF) tectonism (Tüysüz and Dellaloğlu, 1992, 1994; Görür et al., 1998; Seyitoğlu et al., 1997; 2000; Kaymakçı, 2000; Kaymakçı et al., 2001; 2009). Due to the thick storage and salt content in the basin, oil exploration and coal geology investigations were carried out (Maucher, 1937; Blumental, 1938; 1948; Erol, 1953; 1959; Reckamp and Özbey, 1960; Savajo, 1961; Aziz, 1973; Tanrıverdi, 1973*a, b*,1974; Akyol, 1978 and Keskin, 1992). However, there are limited studies in the Çankırı-Çorum basin that contain environmental interpretations based on molluscs, large foraminifera systematics and these fossils (Okan and Hoşgör, 2009). Accordingly, the aim of this study is to investigate the association of mollusc and coarse foraminifera found in Kocaçay formation which is outcropping around Ayvalıca Village and to reveal the age and environmental characteristics of the formation.

2. Material and Method

This study was conducted by MTA General Directorate Şehit Cuma Dağ Natural History Museum (2018-08-16-01, 2017-08-16-01, 2016-08-16-01 project code number) within the frame of the Project "Çankırı-Çorum Basin Eocene -Oligocene Stratigraphy and Paleogeography". During this study one measured section and samples from 26 levels were collected. The mollusc samples were cleaned with hydrogen peroxide in the laboratories of the Museum and necessary measurements were made with vernier caliper measuring instrument.

Clean samples were selected and photographed. Thin sections of foraminifera samples were prepared at the Paleontology and thin section laboratories of Ankara University Geological Engineering Department, and photographed in Leica microscope in the laboratories of the Museum. Systematic determinations were made according to Bouchet et al. (2010) for bivalves, Bouchet et al. (2005) for gastropods and Loeblich and Tappan (1988) for Foraminifera systematics. All fossils identified were recorded in the Museum inventories and are conserved in the Museum archives.

3. Stratigraphy

3.1. Lithostratigraphy

Çankırı-Çorum Basin is a basin where Paleogene aged marine and Neogene terrestrial sediments are deposited on the basement developed as a result of the collision of Kırşehir and Sakarya continents in the Late Paleocene - Early Eocene age range (Tüysüz and Dellaloğlu, 1992;1994).

The basin begins with the Cretaceous aged Boğazkale Ophiolite consisting of radiolarite, serpentinite and limestone blocks at the bottom. Paleocene aged Dizilitaşlar formation, which contains conglomerate, sandstone, siltstone, marl and limestone, is deposited in the convergent and middle parts of the submarine spectrum. On the Dizilitaşlar formation, the Ypresian aged Hacıhalil formation is deposited in a fluvial environment with conglomerate and sandstone intercalations containing coal veins in the north. It is represented by Lutetian Karabalçık, Bayat, Osmankahya and Kocaçay formations in the region. Karabalçık is conglomerate and sandstone alternation and it's most prominent feature is that it contains good quality lignite veins. The volcano-sedimentary Bayat formation presents a sequence of tuff, agglomerate and lava flows at the base and coarse sandstone and conglomerates at the top; formation is important in terms of coal potential. Osmankahya, consisting of red coloured pebble, sandstone and siltstone, reflects the deposition in the fluvial environment. The shallow marine Kocaçay formation is overlain by a graded transition. Oligocene fluvial İncik formation consisting of red-burgundy and characteristic clastic terrestrial sediments, over Kocaçay with angular unconformity. Subsequently, the Kızılırmak formation, consisting of lacustrine Bayındır formation and meandering stream sediments, is composed of Oligo-Miocene aged gypsum. The age of Kızılırmak formation was found to be Late Oligocene by micromammals and vertebrate (Giant Rhino - *Paraceratherium* n.sp.) fossil studies (Karadenizli et al., 2004; Vural et al., 2010; Oyal, 2016; Oyal et al., 2017). The Kızılırmak formation is overlain by the Pliocene Değim formation. The youngest formation of the basin ends with Bozkır formation and Plio-Quaternary Değim formation consisting of sediments deposited by rivers in terrestrial environment (Figure 2).

Stratigraphic section of the study area and it's vicinity is found in the Ayvalıca village: The Bayat formation is represented by gray, brown andesite and conglomerate, sandstone and siltstone. It continues with the Kocaçay formation consisting of red coloured conglomerate, sandstone, siltstone and marls and yellowish gray shallow marine sandstone, siltstone, limestone and marls. İncik formation unconformably covers the underlying units. The boundary between Kocaçay and İncik formation sediments is very clear because of the colour difference (Figure 3a-b and Figure 4). The Kocaçay formation contains a large amount of macro and micro fossils (Figure 5).

Ayvalıca measurement stratigraphic section: Ayvalıca measured stratigraphic section, was revised from Çankırı-G32 sheet at 1/100.000 scale. The starting coordinates of the section are X: 97660 Y: 501102 Z: 1132 m and the ending coordinates are X: 97197 Y: 500804 Z: 1043 m. Thickness of 480 m was measured by systematic sampling at 26 points. The section starts at the bottom with sandstones and mudstones, mainly dominated by *Ostrea roncaensis*. At this level, the presence of cerithides and ampullunides is noticeable in addition to significant algal aggregates (Figure 5c). A thin layer with red silt is consequent to marl and *Ostrea roncaensis* horizon with a thickness of 20-25 cm. The conglomerate level of 30 cm thick with round radiolarite and serpentinite pebbles is consequent to sandy silty unit with abundant fossils. This unit is succeeded by a second ostreid accumulation. Above this, there is a thick layer of fossiliferous limestone containing 30-40 cm thick ostreid, cerithid, ampullinide. The sandstone, siltstone alternation is succeeded by the ostreid horizon for the third time. After the marly level, there is a 20 cm thick *Velates perversus* limestone layer. Beginning from the *Velates*

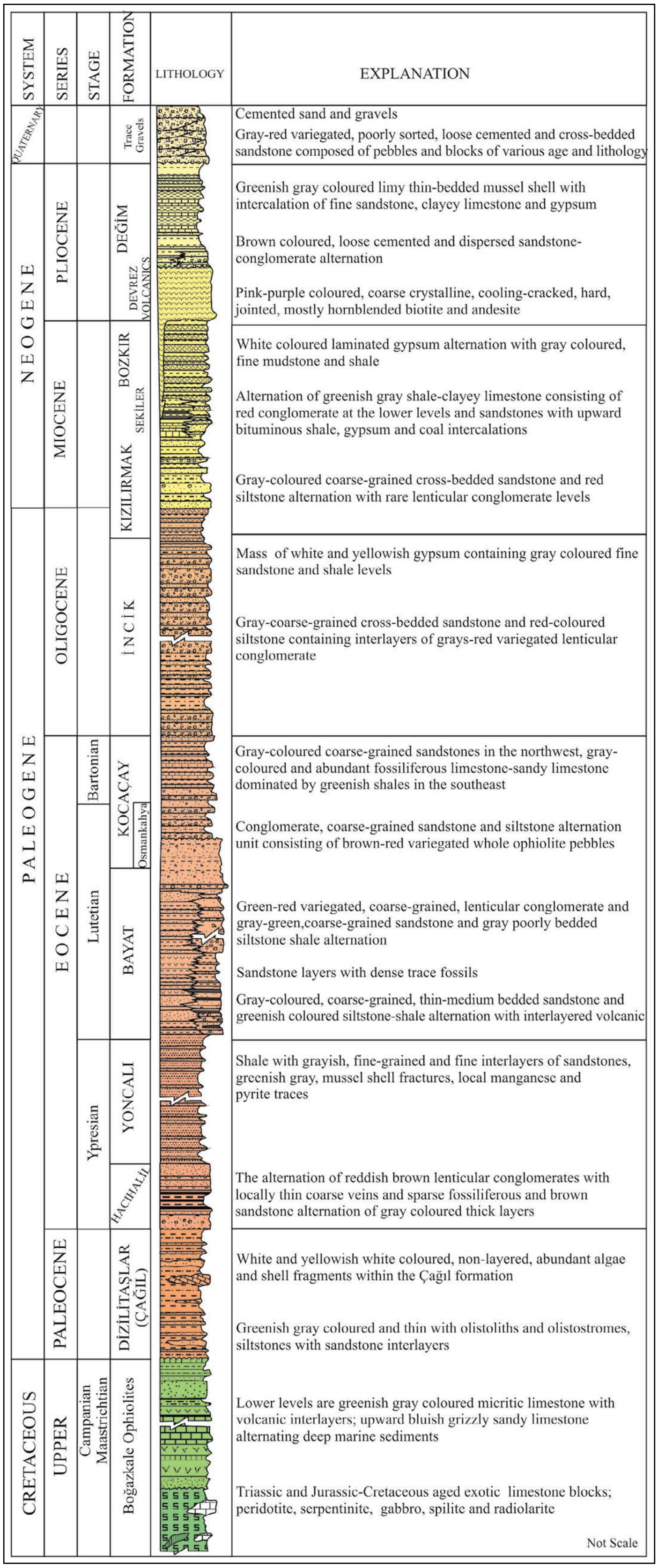

Figure 2- Generalized stratigraphic section of the Çankırı-Çorum Basin (Yoldaş, rearranged from 1982; the red frame shows the formations outcrop in the village of Ayvalıca).

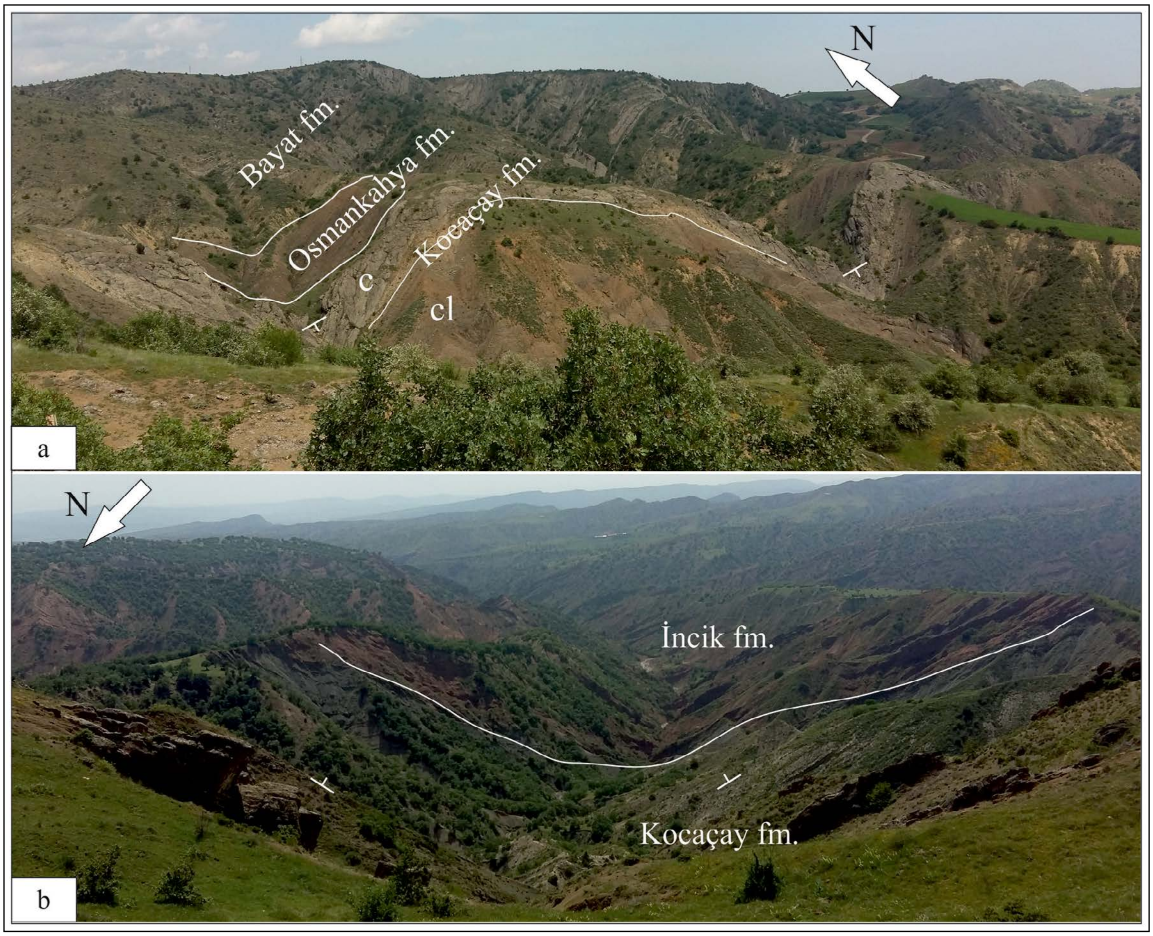

Figure 3- Land views of lower a) and upper, b) boundary relations of Kocaçay formation, east and south of Ayvalıca village, c) carbonate dominant levels, cl. clastic carbonate levels.

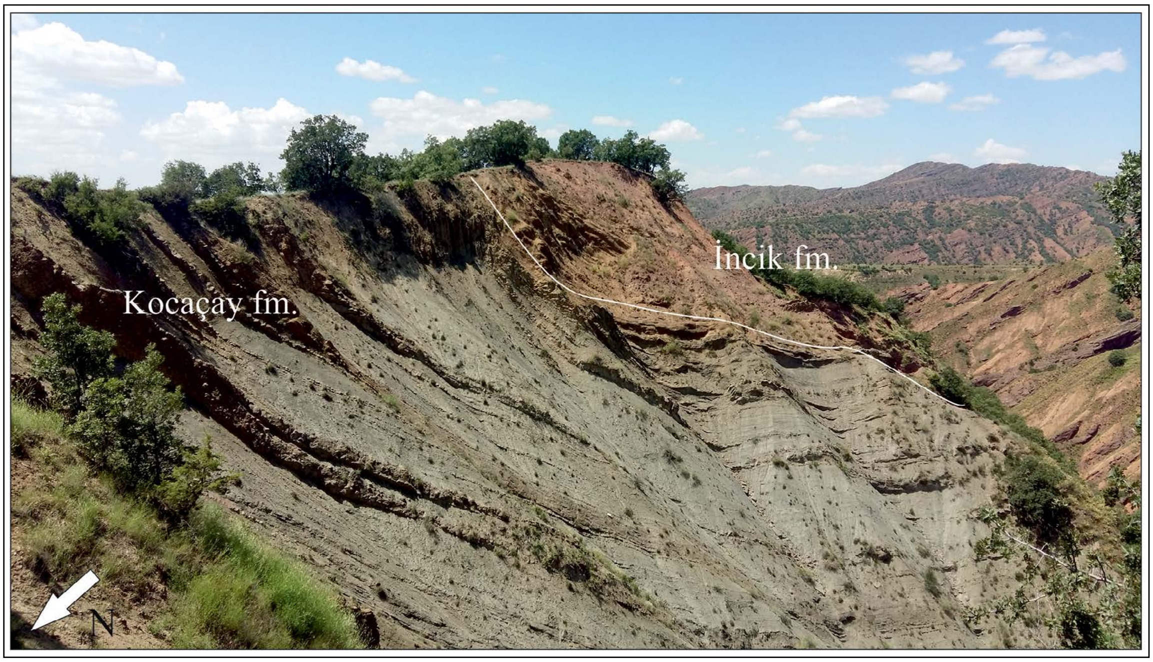

Figure 4- Top of the section, unconformity of Kocaçay and İncik formations.

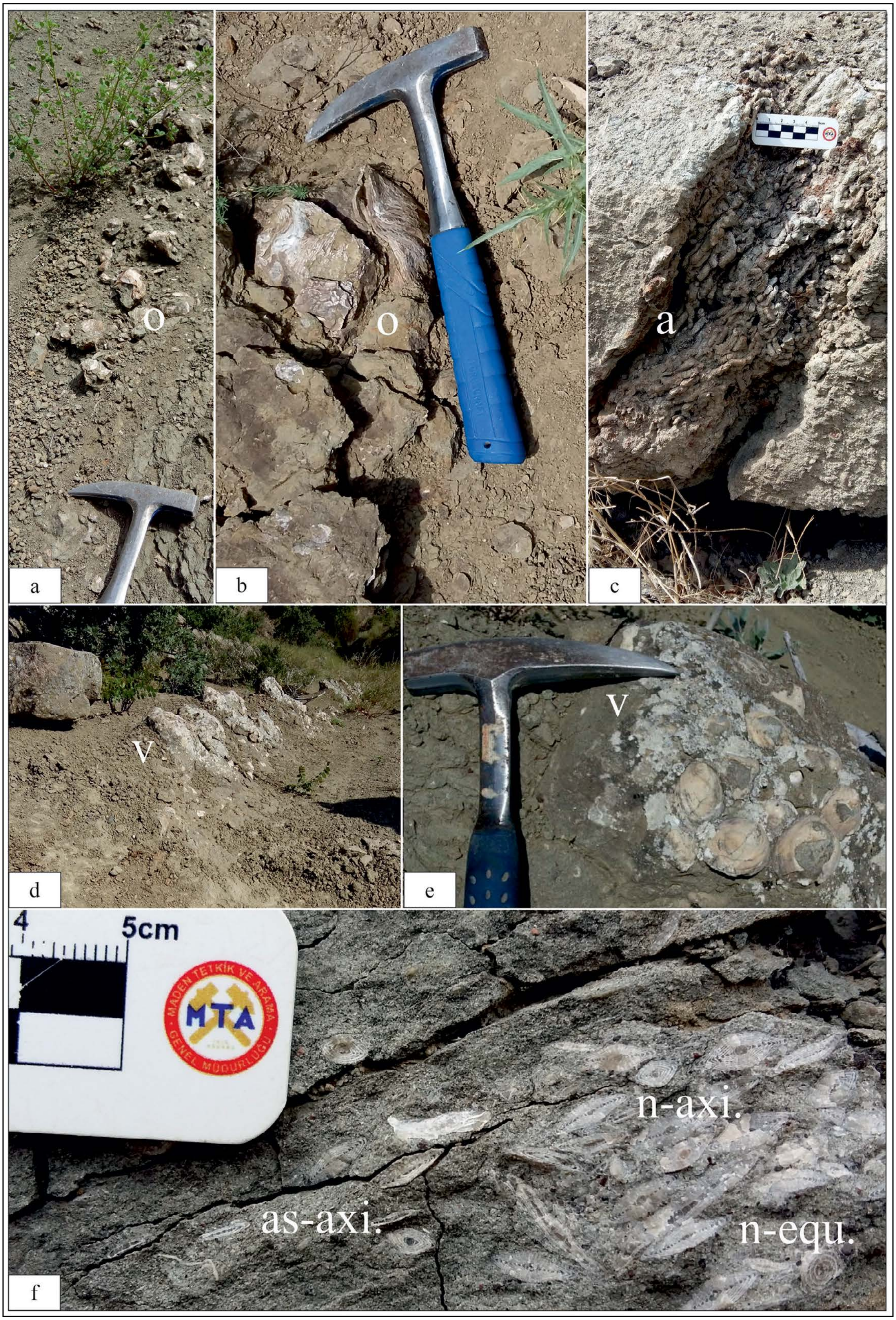

Figure 5- Ayvalıca section fossil views; a-b) *Ostrea roncaensis* (o) accumulations, a) General view, b) detail view; c) view from algae (a) containing levels; d-e) *Velates perversus* (v) level, d) general view, e) detail view; f) view from Nummulitic sandstone, *Nummulites* sp. (n-axi.) axial and (n-equ.) equatorial and *Assilina* sp. (as-axi.) axial.

level, the nummulite set, which is approximately 250 m long, contains plenty of coarse sandy marly nummulite. The Nummulite set ends with a 20 cm thick yellow limestone layer at the top. At this level, the abundance of *Nummulites perforatus* is replaced by the *Assilina exponens* species. Fossil content decreases in the upper part of the sequence. The transition to İncik formation is angular unconformable (Figure 6).

3.2. Biostratigraphy

Abundance zones have been identified in the deposits of Koçaçay formation around Ayvalıca and these are the abundance zones of *Ostrea roncaensis, Velates perversus, Nummulites aturicus* and *Assilina exponens*.

Ostrea Abundance Zone: It forms a distinct horizon especially at the basement level of the Koçaçay formation. Overlapping aggregates are evident. There are abundant *Ostrea* at marly levels. The dimensions of the individuals were width: 4-10 cm, height: 7-11 cm; thickness: 1-4 cm in width and average dimensions are width: 6 cm, height: 11 cm, thickness: 2.5 cm. The sludge matrix ratio is about 20-30% at the horizon level. *Ostrea*'s double-valved preserved ones are the majority. The *Ostrea* agglomerated horizon begins

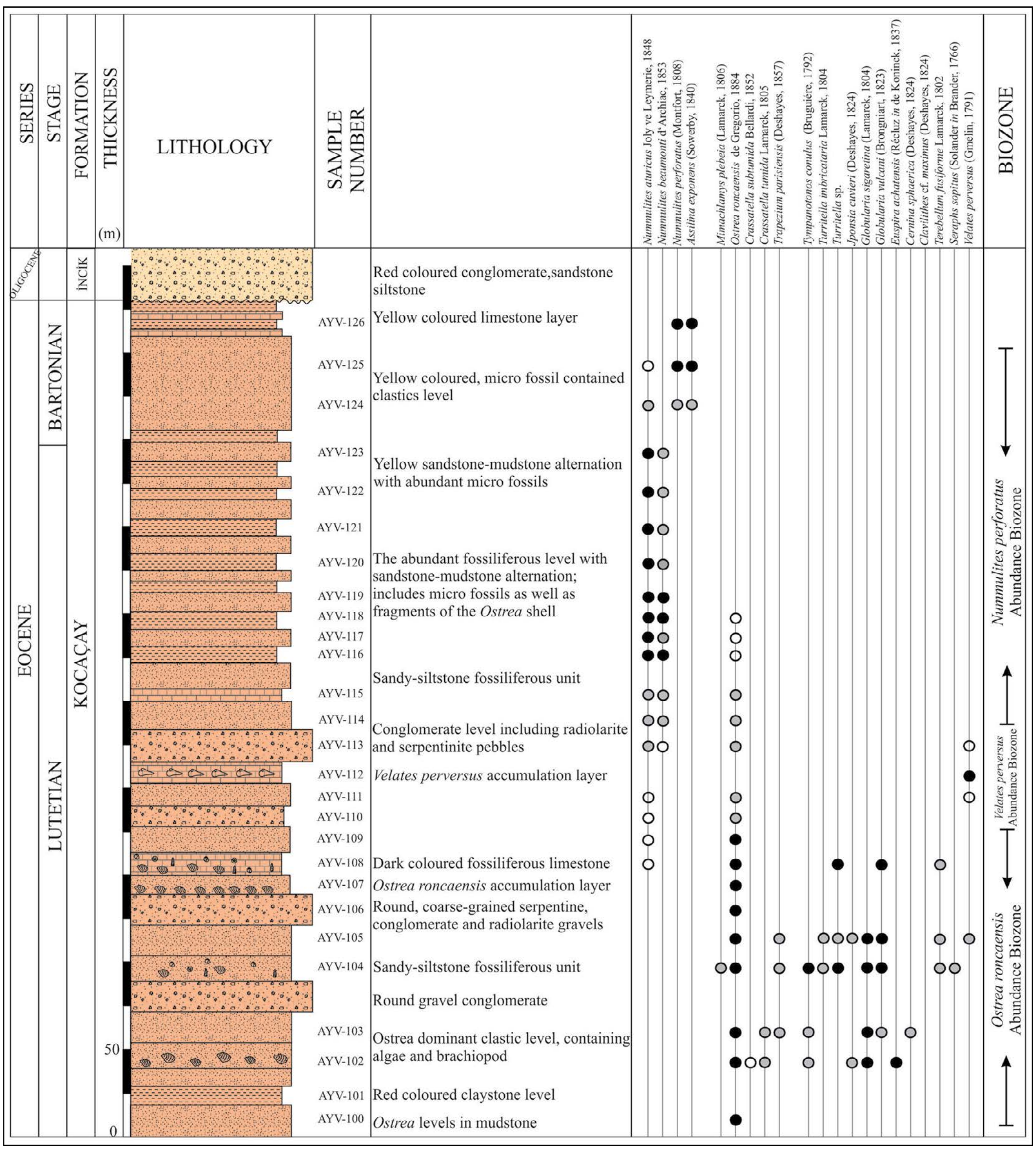

Figure 6- Measured Stratigraphic Section taken from the east of Ayvalıca village (fossil proportions ○%5, ●%20, ●%40).

with a thickness of about 1 meter at the bottom, and the next two horizons are 20-25 cm thick. Nummulitic marls are very low in number and are mostly observed as broken pieces. Ostreids generally live in estuaries or lagoons where eutrophic conditions prevail, abundant nutrients supply from land and algal growth occur (Volety, 2013). *Ostrea roncaensis* determines the Lutetian level in Ayvalıca (Figure 5a-b).

Velates Abundance Zone: The *Velates* abundance zone which succeeded the following three *Ostrea* zones is observed just in front of the nummulite set. Between the two marly levels, only the *Velates perversus* accumulation is evident in the limestone layer of approximately 20 cm in thickness. *Velates perversus*, first described by Gmelin (1791), is a characteristic neritid gastropod with a flat cone-shaped shell, short spiry of one or two rounds and a smooth and shiny outer surface that is not visible in other epifaunal gastropods. Measurements of samples collected from the study area; width: 5-5.5 cm, height: 2-3.5 cm and mouth opening varies between 2.6-2.8 cm. *Velates* generally live epifaunal in coarse grained shallow ponds, medium and high energy environments (Savazzi, 1992). In Ayvalıca, *Velates perversus* shows the Lutetian level (Figure 5d-e).

Nummulites Abundance Zone: The *Nummulites perforatus* species, which started to be seen in the range of 150-200 m, form a large set after the *Velates* level. Marns contain abundant and large samples. Towards the top of the embankment, the yellow limestone layer, 20-30 cm in thickness, becomes again fossiliferous (Figure 7). Continuation of this level increases the remarkableness rate of *Assilina exponens*. The diameter of the *Nummulites* shells is 6-20 mm and their thickness is 3-8 mm, with an average diameter of 12 mm and a thickness of 5 mm. *Nummulites* are generally known to live in reef margins and shallows (Tuzcu and Karabıyıkoğlu, 1991). However, especially in Lutetian massiveness and plenty of carbonate deposits in different parts of Turkey, *Nummulites* set formations are striking. It is observed that the *Nummulites* in the Ayvalıca area are up to 60-70% in the carbonates developed as a set feature. It is stated in the literature that *Nummulites* generally continue their whole lives slowly on seaweeds on leaking carbonate soils, immobilized or by using pseudopots and spend their lives in oligotrophic regions (Kopaevich et al., 2008). Their abundance is explained by the existence of suitable conditions throughout the Eocene series and the formation of autochthonous, allochthonous, semi-autochthonous communities with some hydrodynamic conditions (Aigner, 1986).

Assilina Abundance Zone: An increase of *Assilina exponens* is observed in front of the nummulit set. In front of the embankment, which is dominated by lenticular *Nummulites*, clay carbonate comes after around 25 cm yellow hard limestone layer, contains

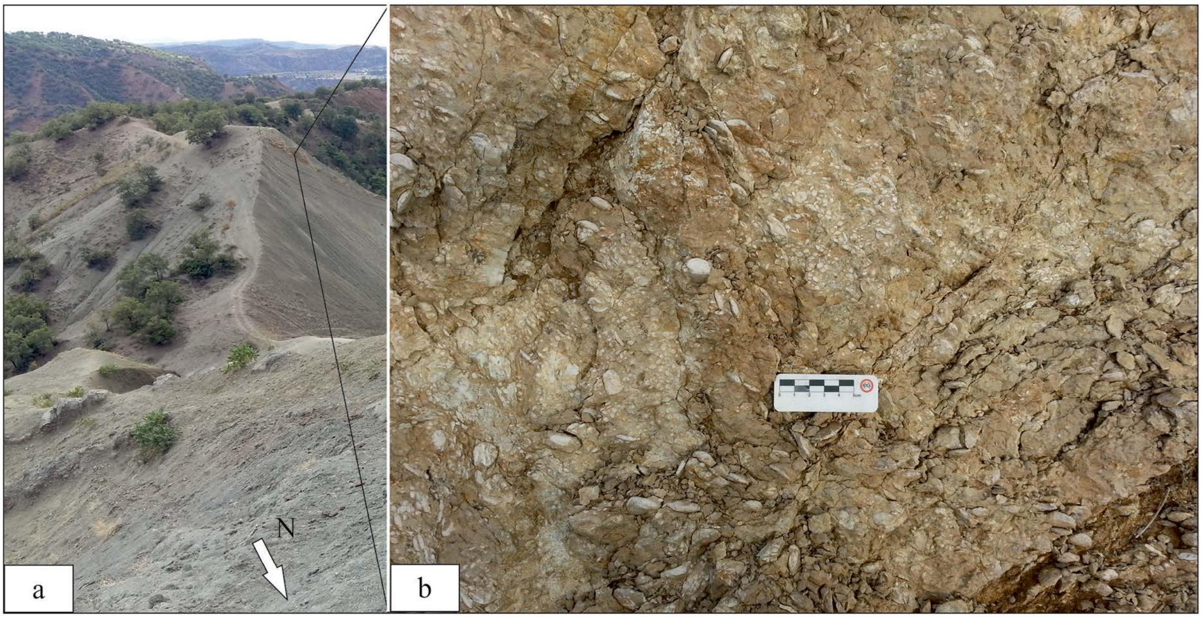

Figure 7- a) General and b) detailed land views belonging to the Nummulit bank.

abundant *Assilina* fossils. The diameters of the samples are between 18-25 mm in average and 2-3 mm in thickness. In addition, very large *Assilina* microspheric individuals with a diameter of 3-4 cm and very small macrospheric individuals of 1-2 mm in diameter are also present in the community.

4. Systematic

In this section, systematic descriptions of mollusc and benthic species forming biozones are given. Systematic determinations are made according to Bouchet et al. (2010) for bivalves, Bouchet et al. (2005) for gastropods and Loeblich and Tappan (1988) for Foraminifera systematics.

Class : Bivalvia Linnaeus, 1758

Subclass Pteriomorphia Beurlen, 1944

Ordo : Ostreida Férussac, 1822

Family : Ostreidae Rafinesque, 1815

Subfamily : Ostreinae Rafinesque, 1815

Genus : *Ostrea* Linnaeus, 1758

***Ostrea roncaensis* (Partsch *in coll.* Bayan, 1870) De Gregorio, 1884**

Figures 5a-b; Plate 1, Figures 1-5

1870 *Ostrea roncana* Partsch *in coll.*(?) Bayan, p. 484, no. 42.

1884 *Ostrea roncaensis* De Gregorio, p. 197.

1896 *Ostrea roncaensis* De Gregorio, p. 109, pl. 21, fig. 19; pl. 22, figs. 1-3; pl. 23, fig. 1.

1912*a Ostrea roncaensis* De Gregorio, Vogl, p. 90.

1912*b Ostrea* cfr. *roncaensis* De Gregorio, Vogl, p. 77.

1944 *Ostrea roncana* Partsch, Stchépinsky, p. 90.

1953 *Ostrea roncana* Partsch, Szöts, p. 211, 232, pl. 9, figs. 1-4.

1956 *Ostrea roncana* Partsch, Szöts, p. 22, 207, pl. 9, figs. 1-4.

1964 *Ostrea roncana* Partsch, Kopek and Kescskemétiné, p. 341-342.

1967 *Ostrea roncaensis* De Gregorio, Malaroda, p. 21.

1972 *Ostrea roncana* Partsch, Kescskemétiné-Körmendy, p. 204.

1980 *Ostrea roncana* Partsch, Kopek, p. 115.

1988 *Ostrea roncana* Partsch, Abate et al., p. 147, pl. 3, fig. 15.

1999 *Ostrea roncana* Partsch *in coll.*(?), Ozsvárt, p. 103, pl. 11, figs. 3-7; pl. 12, figs. 1-3; pl. 13, figs. 1-2.

2011 *Striostrea (Parastriostrea) roncana* (Partsch *in coll.,* Bayan, 1870), Abad-Garcia, p. 632-635, pl. 25, figs. 1-4; pl. 26, figs. 1-3.

2012 *Ostrea roncana*? Partsch, Abouessa et al., p. 76, fig. 5E.

Description: The sample has a medium-sized thickened shell. Shell plate or mug type; traces of residual komata on the edges of the shell and growth coverslips or traces on the upper surface of the lid are evident. Muscle scar is in the middle, crescent or kidney shape. The ligament site is of Ostreoid type. The left cover is slightly convex and the large, right cover is straight or slightly concave. The gripping area is nearly circular. With these characteristics, the sample belongs to the Ostreinae subfamily.

Similarities and Differences: For the sample identified for the first time by Bayan (1870), even though other sources used it as Partsch in coll., no information was found on behalf of Bayan (1870) dePartsch. Therefore it is considered as Ostrea roncana Partsch in coll. (?) Bayan. There is no picture related to the species described in the literature. De Gregorio (1896) argued that there is no picture in the description made by the Bayan and that the species should be "O.roncaensis" with reference to the name of the place. De Gregorio emphasized that the shell shape and thickness of the sample, which reached larger dimensions, differed individually and did not have limited features. The similarities of our specimens with the figures mentioned in the 3 plates in the study of De Gregorio (1896) are quite compatible. Studies of Szöts (1953, 1956), Abate et al. (1988), Ozsvárt (1999) and Abad-Garcia (2011) show similarities with the figures mentioned in the synonymous list.

Location and Stratigraphic Level: The measured stratigraphic sections taken from Bayat Ayvalıca village, it is the most abundant sample from the lowest levels (AYV 100-109), decreasing considerably after the nummulite bank. Archive numbers are 2018/1 and 2018/6.

Paleogeographic Distribution and Stratigraphic Level: Bayan (1870) found *O.roncana* species in Roncá northern Italy; De Gregorio (1884 and 1896) stated that the *O.roncaensis* in the Veneto region of Roncá was spread in the Middle Eocene. Vogl (1912*a, b*) emphasized that it was the same species as *O.roncana* Bayan and *O.roncaensis* De Gregorio within the Eocene identified fauna in Drvenik, Croatia. Oppenheim (1918) evaluated fossil findings from studies in Samsun, Yozgat, Sivas, Malatya, Maraş and Antep in his article with the title "Fossils from Asia Minor"; *O.roncana* with thick shells, which is known to be unique to Roncá, was identified in Merzifon at the Auversian level. Stchépinsky (1944) stated that *O.roncana* species, which he defined in his studies in Malatya region, spread in Lutetian. Szöts (1953) stated that they were identified in the Transdanub basin, Tatabánya, Pusztavám, Mór, Kisgyón in the Early Eocene, in Vicenzo (Roncá) and Egyptian Middle Eocene rocks outside Hungary. Szöts (1956) found that one of the most common fossils in the Middle Eocene limestones and marls in the southern Bakony basin was *Ostrea roncana* and reported from the Early Eocene to the early Bartonian. Kopek and Kescskemétiné (1964) described it at the base of the late Lutetian in Bakony, Hungary; transition to *Nummulites perforatus* was observed at the upper levels of the section. Kescskemétiné-Körmendy (1972) identified numerous mollusc fossils in the coal-fired units in the Hungarian Dorog basin. The author identified the spread of *O.roncana* as Early-Middle Eocene in the Bakony region. It was recorded as *Nummulites perforatus* biozone, mentioning that the fauna consisted of corals and molluscs living at a distance up to 10 m from the seaside. Kopek (1980) stated that *O. roncana* species, which he defined as "coral-mollusc level in the Middle Eocene, is very abundant in the plates below the *Nummulites perforatus* level in the Bakony mountain range in western Hungary. Abate et al. (1988) stated that the species they identified in their studies in northeastern Italy spread in the Middle Eocene in Roncá, Soave and Castelcerino, and added that the best preserved specimens of the species are in Hungary. Ozsvárt (1999) stated that the species spread in the Middle Eocene in his studies in Csordakút basin in Hungary. Abad-Garcia (2011) in his doctoral study on the Catalan Eocene mollusks *Striostrea (Paraostrea) roncana* species in the north of Barcelona Castellterçol, stated that they spread in the Middle Eocene. The author, Szöts (1953) emphasized that the Hungarian samples and the Catalan samples were compatible with each other, but should be included in the *Paraostrea* (Harry, 1985) sub-genus because of the overlapping growth lines. Abouessa et al. (2012) described the recurrent *Ostrea roncana* deposits at the Priabonian base levels in their study in the Libya Sirt basin. They stated that *O. roncana* shells, which had grown to form reefs on each other, were filled with cavities formed by sponges and bivalves of the Pholadidae family (Figure 8).

Class: Gastropoda Cuvier, 1795

Subclass: Neritimorpha Golikov and Starobogatov 1975

Ordo: Neritoina Rafinesque, 1815

Superfamily: Neritadea Rafinesque, 1815

Family: Neritidae Rafinesque, 1815

Subfamily: Neritinae Rafinesque, 1815

Genus: *Velates* Montfort, 1810

***Velates perversus* (Gmelin, 1791)**

Figures 5d-e; Plate 2, Figures 1-5

1786 *Nerita schmideliana sinistrosa* Chemnitz, p. 130, pl. 114, figs. 975-976.

1791 *Nerita perversa* Gmelin, t. 1, p.6, p. 3686, no. 329/72.

1824 *Nerita conoidea* Deshayes, t. 2, p. 149, pl. 18, figs. 1-8.

1834 *Velates perversa* Cuvier, v. 3, p. 62, pl. 22, fig. 7.

1883 *Nerita (Velates) schmideliana*, Chemnitz, Koch, p. 128.

1894 *Velates schmideliana* Chemnitz, De Gregorio, p. 31, pl. 6, fig. 181.

1896 *Velates schmideliana* Chemnitz, De Gregorio, p. 54, pl. 6, fig. 1-3; pl. 7, figs. 1-8.

1901 *Velates schmidelianus* Chemnitz, Oppenheim, p. 182-183.

1904 *Velates schmidelianus* Chemnitz, Dainelli *in* Canavari, p. 155.

1905 *Velates schmidelianus* Chemnitz, Dainelli *in* Canavari, p. 14-16.

1910-13 *Velates schmiedeli* Chemnitz, Cossmann and Pissarro, pl. 6, fig. 40-1.

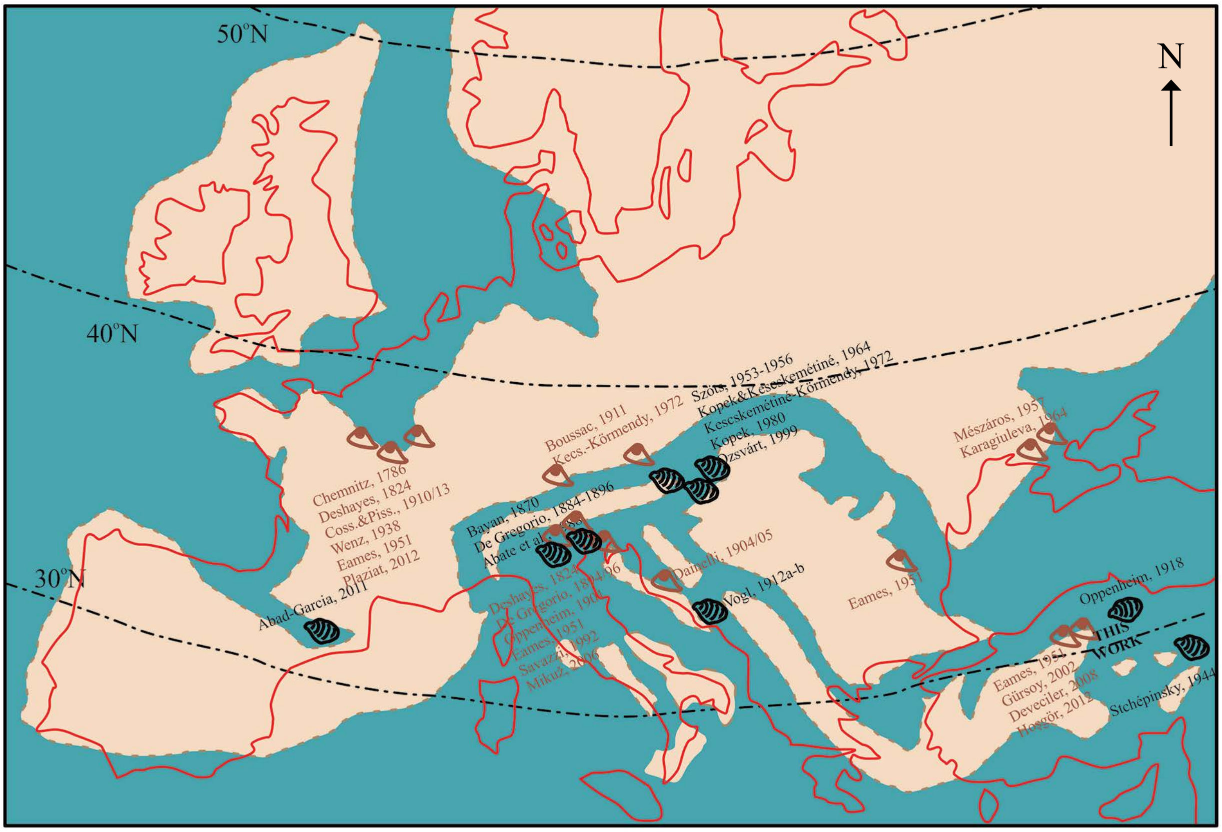

Figure 8- The paleogeographic distribution of *Ostrea roncaensis* ( ) and *Velates perversus* ( ) species throughout the Lutetian in Europe (it was revised from Plaziat, 1981 and Payros et al., 2015).

1912 *Velates schmiedeli* Chemnitz, Boussac, p. 321.

1918 *Neritina perversa* Gmelin, Favre, pl. 4, figs. 58a-c; pl. 5, figs. 59a-c, 60a-c, 61a-c.

1938 *Velates perversus* (Gmelin), Wenz, p. 417, fig. 1016.

1952 *Velates perversus* (Gmelin), Eames, p. 12-16.

1953 *Velates schmideli* (Chemnitz), Szöts, p. 143, pl. 1, figs. 41-56.

1957 *Velates (V.) schmidelianus* Chemnitz, Mészáros, p. 37, pl. 6, figs. 1, 1a.

1963 *Velates schmiedelianus* (Chemitz), Vlaicu-Tătărîm, p. 163-164.

1964 *Velates perversus* (Gmelin), Karagiuleva, p. 132, pl. 40, figs. 3a, b; 10.

1972 *Velates schmidelianus* Chemnitz, Kecskemétiné-Körmendy, p. 220, pl. 5, fig. 7; pl. 6, figs. 1-2.

1992 *Velates perversus* (Gmelin), Savazzi, p. 350, figs. 1A-G.

1992 *Velates perversus* (Gmelin), Squires and Demetrion, p. 26, figs. 55-56.

1994 *Velates perversus* (Gmelin), Squires and Demetrion, p. 126.

2002 *Velates perversus* (Gmelin), Gürsoy, pl. 1, figs. 2a, 2b.

2006 *Velates perversus* (Gmelin), Mikuž, p. 54, pl. 1, figs. 1a-1b; pl. 2, fig. 1; pl. 3, figs. 1a-1c.

2008 *Velates perversus* (Gmelin), Deveciler, p. 20, pl. 1, figs. 1-3.

2012 *Velates perversus* (Gmelin), Gürsoy and Taner, p. 64, figs. 2a, 2b.

2012 *Velates perversus* (Gmelin), Hoşgör, p. 40, pl. 3, figs. 7-9.

2012 *Velates perversus* (Gmelin), Plaziat, pp. 3-50, figs. 1-15.

Description: The shell is flat and wide. Spir is very short and consists of 1-2 rounds. The protocol is downward and slightly curled to the right. The last lap has grown quite fast and swollen. The mouth opening is wide and half-moon shaped. There are notches along the inner lip. The shell is decorated with very thin growth lines.

Similarities and Differences: It is fully compatible with Chemnitz (1786) figures 975 and 976 and Cuvier (1834) drawing 7. Deshayes (1824) included *N. perversa* and *N. schmideliana* species in the synonymous list of the species he defined as *Nerita conoidea*, which is similar to our example. It fully conforms to the figures in De Gregorio (1896)'s plates 6 and 7. Cossmann and Pissorro (1910-13)'s pictures are very similar to the one in figure 40-1. The mouth shape, notches on the inner lip, growth lines on the shell are completely similar with Wenz (1938)'s figure 1016. Our samples are fully compatible with Szöts (1953) 41-56 and Kecskemétiné-Körmendy (1972)'s figures. Squires and Demetrion (1992) and Savazzi (1992) show similarities with the shapes mentioned in the synonymous list in terms of shell form, growth lines and notches in aperture opening. Gürsoy (2002) and Gürsoy and Taner (2012), is similar to the form given in the synonymous list, although in the Çorum basin *Velates* forms, the coils in the first rounds are more prominent. Mikuž (2006) shows a similarity within the plates 1 and 2 in terms of shell form, growth lines and notches in aperture. Deveciler (2008) and Hoşgör (2012) show similarities with the forms indicated on the plates, which are mostly core forms and their apical tours are not significant. It is similar to the figures given in the Plaziat (2012)'s study in which he examined the morphological structure of *Velates* species.

Location and Stratigraphic Level: Bayat formed a horizon (AYV-112) during the transition from *Ostrea roncaensis* horizons to nummulite set in Ayvalıca. Archive numbers are 2018/35 and 2018/36.

Paleogeographic Distribution and Stratigraphic Level: Chemnitz (1786) stated it's spread in Ypresian in Paris basin; Deshayes (1824) stated that it was very abundant in Rethissuil, Guise, Soissonnais in the north east of Paris and also it was observed in Vicentin in Ronca. Koch (1883) stated that well-preserved echinoids and mollusks were found in the limestones where the Middle Eocene fossilization was very rich, from Hungary to Romania (Magyarokereke and Marótlaka). Other fossils found with *Nerita (Velates) schmideliana* are *Natica caepacea, N. cigaretina, Cerithium giganteum, Xenophora agglutinans, Echinolampas giganteus, Euspatangus crassus*. The author stressed that all the fossils studied show the Middle Eocene and are also present in the Paris basin. De Gregorio (1894) noted that it is rarely seen in Mt. Postale, but it is more common in S.G.Ilarione in the Vicentin region, where he studied the Parisien level, which corresponds to the Lutetian level in northern Italy. He emphasized that the *Velates schmideliana* species, which he described in his study in Ronca in Lower and Middle Eocene sediments in northern Italy in 1896, showed a wide spread in the region and the climatic conditions were effective in this spreading. Oppenheim (1901), stated it in Italy, Vicenza in Grancona, Mossano, St. Nicola and St. Priabonian in Giovanni; Koch (1883), asserted the coexisting species such as *Terebellum* sp., *Natica caepacea*, *Nerita (Velates) schmideliana* and especially the giant cerithides characterizing Middle Eocene (Parisien=Lutetian) sharply in his article evaluating the studies conducted in 1882 in the north-east of Budapest. Dainelli (1904, 1905) described it in the Middle Eocene strata of Bribir, Ostroviza and Zazvic. For the sample described by Cossmann and Pissorro (1910-13) in Laon in northern France, the stratigraphic extension is given as Cusian (Thanetian-Lutetian). Boussac (1912) described in the Nummulitic limestones in Diablerets, Switzerland. Wenz (1938) stated that it spread in Ypres in Belgium and Saint Gobain in France during the Upper Eocene. Eames (1952), in his study on Western Pakistan and Western India Eocene, mentioned that the *Velates perversus* species had a wide spread throughout the Eocene, Ypresian in Tibet, Egypt, Iran, Somalia, Pyrenees, Sudan; early Lutetian in France, Italy, Anatolia and Egypt Mokattam; Lutetian in Italy, the Alps, France, Hungary and the Balkans, Iran, Iraq, Armenia; it was also discovered in the French Alps, Northern Italy, Croatia in the Priabonian stage and throughout the Eocene in Niger, Chat, Sicily, Russia. Szöts (1953) stated it spread in the Early Eocene around Mór, Kisgyón, Dudar, Zirc, Úrkút in the Transdanube basin; in the Middle Eocene in Esztergom, Bajót, Tatabánya, Dudar, Bakony; in Paris Basin in the Early-Middle Eocene. Mészáros (1957) stated that the spread of *Velates (V.) schmidelianus* existed during the first marine cycle in the Lower and Middle Eocene in Transylvania and in the Upper Eocene in the secondary marine cycle. In addition, it has spread in the Lower-Middle

Eocene in the Paris and Loire basins in France; during the Eocene in Hungary; Eocene in Bulgaria; Eocene in Egypt; Middle Eocene in Morocco and Tunisia; Lower Eocene in Crimea; Eocene in Switzerland and Bavaria; Eocene-Oligocene in Northern Italy; Eocene in southern France; Upper Eocene in Transcaucasia. Mészáros stated the spread of the species is at the Eocene-Oligocene interval in general. Vlaicu-Tătârîm (1963) described the species, which was observed in all mesogenic areas from the Paris basin to Burma, late Lutetian in Cluj, Romania. Karagiuleva (1964) has summarized in a table that it spreads in the Eocene-Oligocene in Bulgaria; Paleocene and Lower-Middle Eocene in England-France Basin; Paleocene-Eocene in North Africa; Eocene in Pyrenees and Southern France; Eocene-Oligocene in the Alps and Northern Italy; Upper Eocene in Yugoslavia; Eocene in Northwest Transylvania; Lower and Upper Eocene in Ukraine and Crimea. Kecskemétiné-Körmendy (1972) described the mollusc-bearing Middle Eocene sandstone benches in the Doroger basin of Hungary. Squires and Demetrion (1992, 1994) reported the stratigraphic distribution of the *Velates perversus* species Thanetian (Late Paleocene) -Bartonian (late Middle Eocene) in Europe and India. Savazzi (1992) described the species in Verona, Roncá' in the Middle Eocene is equivalent to the Mollusk layers called "Capay" and "Domengine", which correspond to the Early Eocene-early Middle Eocene interval on the Pacific coast of North America. The geographical distribution of the species was determined in Pakistan, India, Myanmar, Tibet, Middle East, North Africa, Western Europe, Florida, Panama and Southern California Baja, Mexico. In the studies around Ankara, Gürsoy (2002) reported that it spread in the Paleocene-Eocene in Temelli Polatlı; Deveciler (2008) stated it's extension in Lutetian-Bartonian in Haymana; Hoşgör (2012) determined it's extension in Early-Middle Eocene in Haymana-Polatlı. Mikuž (2006) made a comparison of two *Velates perversus* from Early and Middle Eocene areas. He noted that the *Velates* from the Goriška brda region were the largest and well-preserved *Velates* in Slovenia, while those in Gračišće near Istria Pazin had only the core parts left. Plaziat (2012) studied the morphology, stratigraphic and paleogeographic distribution of the *Velates* species, which is known as *V.perversus* or *V.schmidelianus,* he emphasized that is the most characteristic species found in subtropical seas in the whole northern hemisphere from Thanatian to Early Oligocene. He indicated that the Tetis or Mesogen type species is not only observed in France, Italy and northern Spain, but also spread from the Himalayas to the island of California and Java (Figure 8).

Phyllum : Foraminifera d'Orbigny, 1826

Class : Globothalamea Pawlowski, Holzmann and Tyszka, 2013

Ordo : Rotaliida Delage and Hérouard, 1896

Super Family : Nummulitoidea Blainville, 1827

Family : Nummulitidae Blainville, 1827

Genus : *Nummulites* Lamarck, 1801

***Nummulites aturicus* Joly and Leymerie, 1848**

Plate 3, Figures 1a, 2-4

1848 *Nummulites aturica* Joly and Leymerie, p. 187, pl. 2, figs. 9, 10.

1911*b* *Nummulites atacicus* Leymerie, Boussac, p. 28, pl. 2, fig. 26; pl. 3, fig. 15; pl. 5, fig. 14.

1981 *Nummulites aturicus* Joly and Leymerie, Schaub, p. 95, pl. 15, figs. 20-26; pl. 16, fig. 1-30.

2007 *Nummulites aturicus* Joly and Leymerie, Görmüş et al., p. 6, pl. 2, figs. 1-4.

2011 *Nummulites aturicus* Joly and Leymerie, Less et al., p. 821, figs. 38 q, r, t, u.

Description: Species have been identified from microspheric individuals in the study area. The valve is bulging and lenticular. The edges are less sharp looking. The average diameter is between 15-20 mm and the thickness is 2-3 mm. On the surface of the shell, the partition network is radial, slightly wavy, and in some others granular. In the granular species, the granules are larger in the central part. Equatorial cross-sections are slow-winding and the number of turns is high. 20 turns were counted in the sample with the diameter of 20 mm and 26 turns were counted in the sample with the diameter of 25 mm. The wall is thicker than in the other types. The compartments are slightly curved. The compartment width is greater than the height. It has a rectangular appearance. The first chamber is very small. Round heights reach to 1 mm in the middle sections. The most prominent feature of the species is that the shape of the shell is lenticularly bulged, the edges are sharp, the chambers are rectangular and the winding is regular and frequent. Macrospheric individuals of the species have smaller diameters of 5-6 mm. Thickness is 2-3 mm.

Similarities and Differences: Avşar (1991, 1994) made a description of macrospheric individuals belonging to the species from Yozgat and Malatya areas. Örçen (1986) defined both macrospheric and microspheric individuals in the Malatya area. The dimensions of the microspheric individuals described by Örçen (1986) were found to be slightly smaller. It is separated from the *N.perfaratus* by the sharpness of the shell edges and the arrangement of the chambers from the center to the edge.

Location: It is one of the most abundant samples found in the section. The most abundant sample points are between AYV 116-123.

Stratigraphic Level: The paleogeographic distribution of the species is extensive. The age range is also known as Lutetian and according to Serra-Kiel et al. (1998) it is a species observed in the the SBZ16 biozone. Kenawy et al. (1993) described it in the Middle Eocene (late Lutetian) in the Nile valley in Egypt, Less et al. (2011) described it in the Early-Middle Bartonian in the Thrace basin, Örçen (1986) described it from Lutetian around Malatya, Avşar (1991, 1994) described it from late Lutetian around Yozgat and Malatya, Görmüş et al. (2007) described it in Lutetian again around Dinar and Avşar (2012) described it in the Upper Lutetian-Bartonian sediments around Darende, Less et al. (2011) described it in the late Bartonian (SBZ18) in the Thrace basin.

***Nummulites* cf. *beaumonti* d'Archiac and Haime, 1853**

Plate 3, Figures 10-12

1853 *Nummulites beaumonti* d'Archiac and Haime, p. 133.

1981 *Nummulites beaumonti* d'Archiac and Haime, Schaub, pl. 53, figs. 17-19, 22-25.

2006 *Nummulites beaumonti* d'Archiac and Haime, Eraslan, p. 36, pl. 2, figs. 8-15.

2019 *Nummulites beaumonti* d'Archiac and Haime, Al Menoufy, p. 154, figs. 3G-Q.

Description: The shell is lenticular with sharp edges. Species have been identified from the macrospheric individuals. In these individuals, the diameter was measured as 5-6 mm and the thickness as 1-2 mm. The number of laps is between 6-8. Microspheric individuals are slightly larger and their diameter varies between 7-9 mm. In equatorial sections, the chambers are rectangular and their height is more than their width. Compartments are thin, slightly curved and flat.

Similarity and Difference: *N. beaumonti*'s smallness in size, and the greater height of the chambers than the width, shows its difference from other nummulite species.

Location: With *Nummulites aturicus,* they were detected only to a lesser extent, near the upper levels of the section (AYV 116-119).

Stratigraphic Level: Örçen (1986) made definition in the late Lutetian around NW Malatya Medik-Ebreme , Eraslan (2006) described it in middle-late Lutetian in Ankara Bağlum-Kazan. Al Menoufy (2019) described it in the SBZ19 biozone from the United Arab Emirates, Avşar (1991, 1994) described it in the late Lutetian around Yozgat and Malatya; it was described in the middle Lutetian in the SBZ15 biozone in Aydıncık (Yozgat) by Avşar et al. (2010); Örçen (1986, 1992) described it in the Late Lutetian in Malatya and Bursa.

***Nummulites perforatus* (De Montfort, 1808)**

Plate 4, Figures 1-4

1808 *Egeon perforatus* de Montfort, t. I, pp. 166-167.

1911*a Nummulites perforatus* (Montfort), Boussac, pp. 15-16, pl. 6, figs. 5, 8.

1911*b Nummulites perforatus* (Montfort), Boussac, p. 21, pl. 3, figs. 1-7, 13, 14, 16.

2010 *Nummulites perforatus* (Montfort), Deveciler, p. 193, pl. 1, figs. 1-6, pl. 2, figs. 1-8.

2019 *Nummulites perforatus* (de Montfort, 1808), Al Menoufy, p. 149, figs. 3A-F.

Description: Illustrated samples were identified from microspheric individuals. The shell is lenticular. Very swollen and rounded edges are the characteristics of the species. The diameter and thickness of the shell are 18-30 mm and 6-8 mm respectively. The partition network is light meandered. The arrangement of the chambers in the equatorial sections is also among the most descriptive features of the species. In advanced microspheric individuals, the initial 6-7 rounds are tight, It is rare in the next 8-15 rounds and very tight in three-phase coiling in the laps towards the last edges.. The number of tours is between 30-45. The chambers are rectangular in shape and the width of the chambers is higher than their height. Macrospheric individuals are smaller. The partition network is radial, slightly wavy. Between the chamber lines there are small granules.

Similarity and Difference: It is similar to *Nummulites aturicus* species. In contrast, the *Nummulites perfaratus* type is easily differentiated from other nummulite species by its bulging shell, rounded margins and the difference of coiling in three-phase equatorial chambers.

Location: It is found intensely at the top levels of the Ayvalıca section (AYV 125-126).

Stratigraphic Level: Avşar (1989, 1991, 1994) determined it in his research in the vicinity of Elazığ, Yozgat and Malatya in the Late Lutetian, Deveciler (2010) made a description in Bartonian in the Haymana field and Al Menoufy (2019) determined it in SBZ19 biozone from United Arab Emirates. According to Serra-Kiel et al. (1998), it is a species belonging to the SBZ17 biozone.

Family : Nummulitidae Blainville, 1827

Genus : *Assilina* d'Orbigny, 1839

***Assilina exponens* (Sowerby, 1840)**

Plate 4, Figures 5-11

1837-1840 *Nummulites exponens* Sowerby *in* Sykes, 2(5), p. 719, pl. 12, fig. 14.

1879 *Assilina exponens* Sowerby, De La Harpe, t. 16, p. 212.

1911*b Assilina exponens* Sowerby, Boussac, p. 100.

1976 *Assilina exponens* (Sowerby), Sirel and Gündüz, p. 39, pl. 10, fig. 9; pl. 11, fig. 1-9.

2006 *Assilina exponens* (Sowerby), Eraslan, p. 35.

2012 *Assilina exponens* Sowerby, Dinçer and Avşar, p. 46, pl. 2, figs. 1-12.

Description: The shape of the shell is thin lenticular in microspheric individuals; and it is flat and very flat. Partition traces are common and evident. The shell diameter reaches 30-40 mm. The shell thickness is between 1-2 mm. The coils in the equatorial section are regular and more loosely coiled towards the edges than the first coils. The chambers are rectangular, the width of the chambers is more than it's height. In axial sections, the tours cover each other, especially in the final sections. Macrospheric individuals are lenticular and traces of chambers are also evident. Several granules are observed in the center of the shell. The diameter of the shell varies between 5-6 mm and the thickness varies between 1-2 mm. The first chamber is round, oval shaped. In equatorial sections, the sections are vertical, slightly radial.

Similarity and Difference: It is easily distinguished from other genera and species due to the flattened shell of *Assilina exponens* species, U shaped tours, the presence of splitting traces on the shell.

Location: It is found intensely at the top levels of the section (AYV 125-126).

Stratigraphic Level: Sirel and Gündüz (1976) determined it aroun Polatlı in the Cuisian-Lutetian; Örçen (1986, 1992) determined it around KB Malatya Medik-Ebreme and Bursa in the late Lutetian, Avşar (1992) determined it around Mersin Namrun in the Lutetian; Özgen (1998) determined it around Çölmekçiler, Hacıgüzel, Çukurca (Bolu) and Safranbolu, Alparslan, İnözü, Ahmetoğlu (Kastamonu) in the Lutetian aged sediments. Örçen (1986, 1992) determined it around Malatya and Bursa in the late Lutetian; Avşar vd. (2010) determined it in the Aydıncık (Yozgat) SBZ16 biozone in the late Lutetian; Dinçer and Avşar (2012) determined *A.exponens* species around Malatya Darende in the SBZ16 biozone in the Late Lutetian.

5. Discussion

Living environments, life styles and life cycles of mollusks observed in the form of agglomeration are important for the interpretation of past environments. Therefore, it is necessary to analyze today's mollusc lives. According to Volety's (2013) study on the properties and habitats of ostreids, ostreids generally live in brackish shallow waters such as estuaries with lower salinity than ocean water, forming beds or reef-like colonies. The larvae begin their lives by clinging to a hard surface, preferably other ostreid shells. They are hermaphrodites, that is, they start their lives as male individuals, sometimes turning to female and sometimes male. If the temperature of the water rises, they pass to the breeding period. They mostly live in eutrophic environments where food is abundant; they use their gills to take up oxygen in the water, feed themselves with algae and plankton. An adult ostreid can filter water up to 1500 times its volume daily. Ostreids survive in intertidal reefs by tightly closing their lids until the water returns when exposed to outdoor conditions during low tide. Thanks to this adaptation, the organism is kept away from other organisms, air and temperature changes. Volety (2013) suggested that the healthy formation of ostreid reefs should be supported in order to clean the estuaries naturally due to these characteristics.

In the study area, the dimensions, abundance and repetition of the ostreid individuals in the horizons suggest that too much nutrients come to the environment from the land and that it is a eutrophic paleoenvironment rich in algae. Although determined at marly levels, it was observed that larvae preferred other ostreid individuals as hard ground, thus stacking one another and forming several horizons. In the area under tidal influence, *Ostrea roncaensis* individuals in the estuary when the water is drawn may be affected by changing environmental conditions by closing their lids tightly. Because of their physical structure, they have a higher chance of survival compared to other organisms in the environment and therefore showed a higher population than other organisms. The maximum level of viability may have led to a reduction of oxygen in the environment after a while, leading to the death of organisms.

Nummulites, which are prominent in the study area with their dominant character, have been described by Purton and Brasier (1999) as the dinosaurs of the unicellular world. *Nummullites millecaput* as being the largest species in Lutetian, with a diameter of 160mm, due to their extinction only in the Late Eocene-Oligocene range, they were reduced in size and diversity. In their study on the giant Eocene *Nummulites* in the Hampshire basin, they put forward that the abundant and large-sized Middle Eocene *Nummulites* grow rapidly under eutrophic conditions with high nutrient intake, and as individuals grow and their shells become more calcified, the risk of prey decreases.

The nature and distribution of foraminifera are important in determining the different generations of the nummulite sets. Since the Cretaceous, the milliolids have characterized the reef lagoon, the *Nummulites* have been characterized by their reef margin, front and shallows (Tuzcu and Karabıyıkoğlu, 1991). Racey (2001) emphasized that *Nummulites* have more than 300 species but only 5% of them can form nummulite sets. He pointed out that the species forming this embankment are stratigraphically limited to the Late Early-Middle Eocene interval. *Nummulites* sets are often less associated with other micro- or macro-fossils, suggesting that the deposition develops in the nutrient-poor oligotrophic environment. Kopaevich et al. (2008) found that *Nummulites* generally live symbiotically with photosynthetic algae and therefore prefer warm (~ 25 ° C), clear and shallow waters (<120 m) in the euphotic zone. In the symbiotic relationship, the *Nummulites* provided shelter for algae, while algae produced nutrients and oxygen for the *Nummulites*. Light intensity and energy of water are the two most important factors controlling foraminifera distribution. Our field observations about the *Nummulites* show that the peak of the nummulit set, which forms a hill, is closer to the theory, that the paleodepth is between 10-30 m and that they live in shallow and warm euphoric zones and eutrophic environments. It is thought that by the abundance of nutrients from the estuary they increase in large number and size of development and form the nummulite set.

When all of the above mentioned informations and field observations are taken into consideration, the storage environment modeling developed by Catuneanu is thought to be constructed in Ayvalica Village as the land model. Catuneanu (2006) classified storage in sea-to-land transition systems in three broad categories: These are: 1. nonmarine (areas out of reach of sea floods); 2. coastal (intermittently under the influence of seawater); 3. marine (areas permanently covered with seawater) (Figure 9).

Ostreids are known to live in the estuary or lagoon and *Nummulites* in the reef edge or in front of the reef. When these informations are evaluated together with our land findings, transgressive river mouth

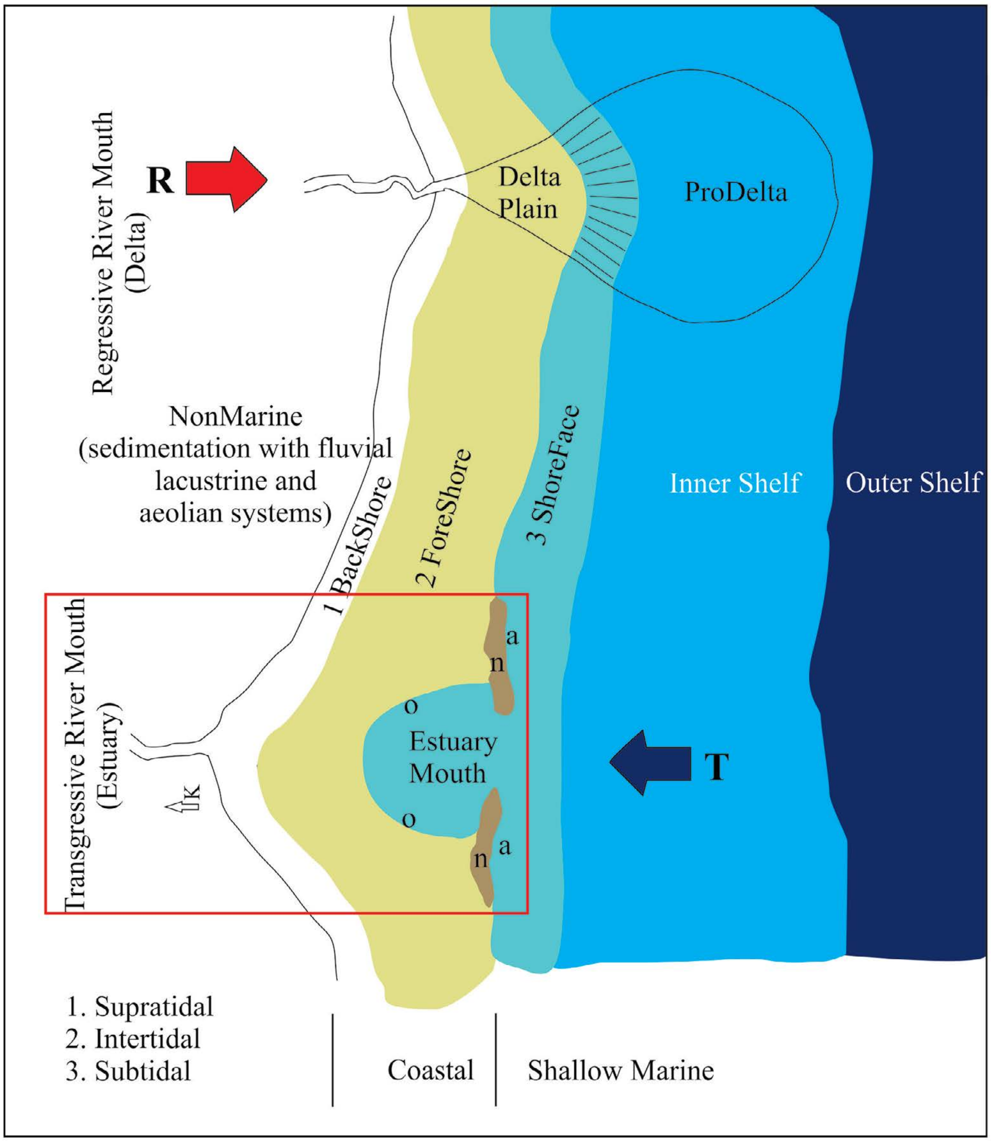

Figure 9- Transition from marine to non-marine environments; Regressive (R) and Transgressive (T) area and the coastline is an open shoreline (rearranged from Catuneanu, 2006). The estimated study area is indicated by a red frame (o-*Ostrea*, n-*Nummulites*, a-*Assilina*).

modeling is striking in the classification of the storage environment given by Catuneanu (2006).

6. Conclusions

In this study, two molluscs *Ostrea roncaensis, Velates perversus* and four foraminifers *Nummulites aturicus, N. beamunti, N. perfaratus* and *Assilina exponens* which are most abundant in Ayvalıca area, were identified and also *Ostrea*, *Velates*, *Nummulites* and *Assilina* abundance biozones were determined. According to the macro and microfauna content observed in the Koçaçay formation sediments, the age range is determined as Lutetian-Bartonian.

Environmental interpretations were performed with the obtained data. Ostreids are generally bivalves living in brackish water in the estuary environment (Volety, 2013). *Nummulites* are known as euphotic shallow, warm water foraminifera (Purton and Brasier, 1999). Field studies and living environments of the mentioned organisms show a transgressive river mouth environment where water is drawn from time to time (Figure 8 and 9). *Ostrea roncaensis* accumulations, which are repeated several times, constitute the clue to the established theory. The abundance and size of ostreids, which develop with intense nutrient flow from the land, as well as the presence of cerithid, ampullinide and especially algae indicate transgressive river mouth environment. The absence of ostreids outside the estuary is evident in the development of a thick nummulite set. All data lead us to the conclusion that the Kocaçay formation in Ayvalıca was deposited in a sedimentary environment starting from the estuary conditions and continuing with shallow warm sea (Figure 10).

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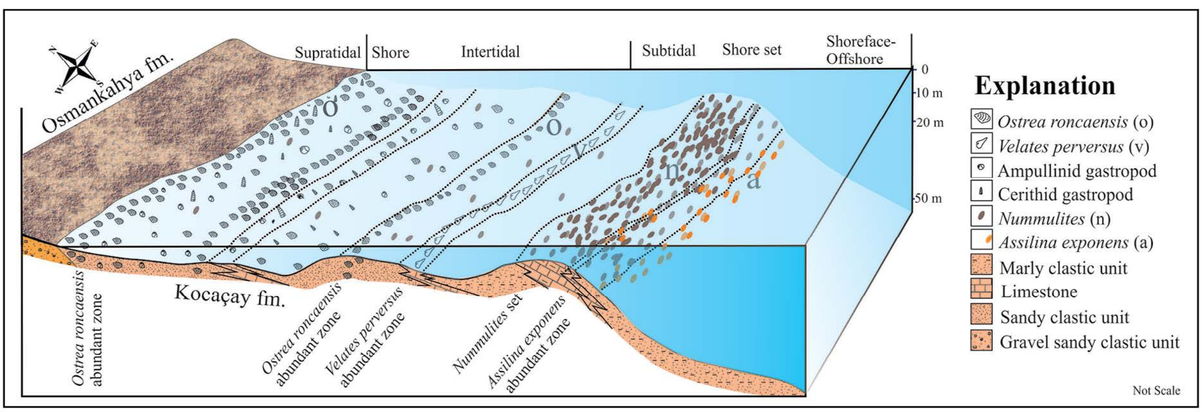

Figure 10- Study area, depositon model of Kocaçay formation.

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PLATES

Plate 1

(1-6) *Ostrea roncaensis* (Partsch *in coll*. Bayan, 1870) De Gregorio, 1884

Left (lower) valv (1)inside; (2) outside and (3) side profile view

Right (upper) valv (4) inside view; left and right valves (5) profile view; (6) left (lower) valv inside view.

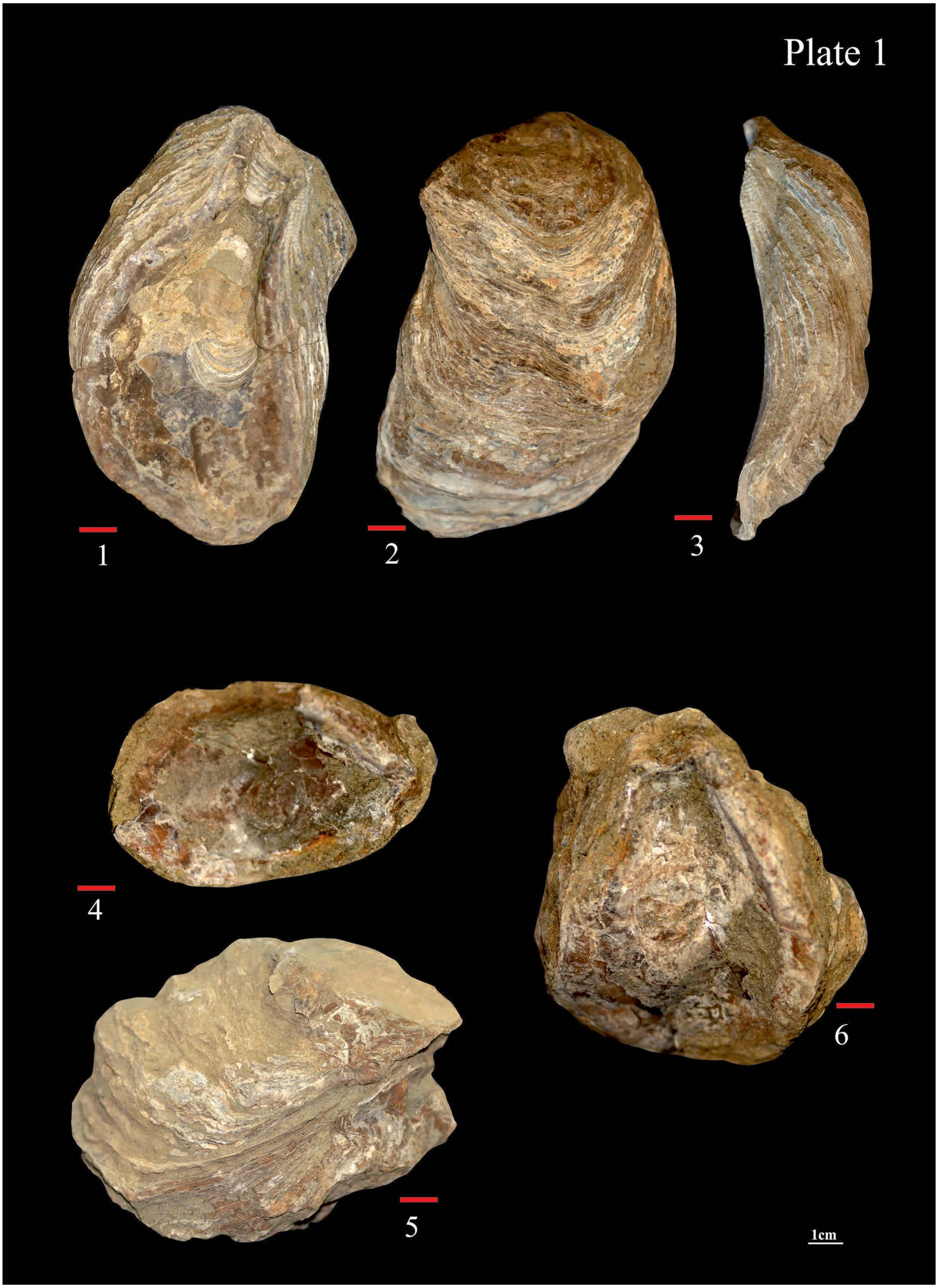
Plate 1
1
2
3
4
5
6
1cm

Plate 2

(1-5) *Velates perversus* (Gmelin, 1791)

(1) Top-abapertural view, (2) bottom-apertural and (3) side-whorl profile view

(4) Protoconk detailed view; (5) side-whorl profile view.


Plate 2
1
2
3
4
5

Plate 3

(1) *Nummulites* and *Assilina* external view

a *Nummulites aturicus* Joly and Leymerie, 1848

b *Nummulites beaumonti* d'Archiac and Haime, 1853

c *Assilina exponens* (Sowerby, 1840) form A

d *Assilina exponens* (Sowerby, 1840) form B

(2-4) *Nummulites aturicus* Joly and Leymerie, 1848

2-3 equatorial sections

4 axial section

(5) *Nummulites* sp., axial section

(6) *Nummulites* sp., equatorial section, form A

(7-8) *Nummulites* sp., equatorial sections, form B

(9-12) *Nummulites* cf. *beaumonti* d'Archiac and Haime, 1853

(9) equatorial section, form B

(10) equatorial section, form A (11-12) axial sections

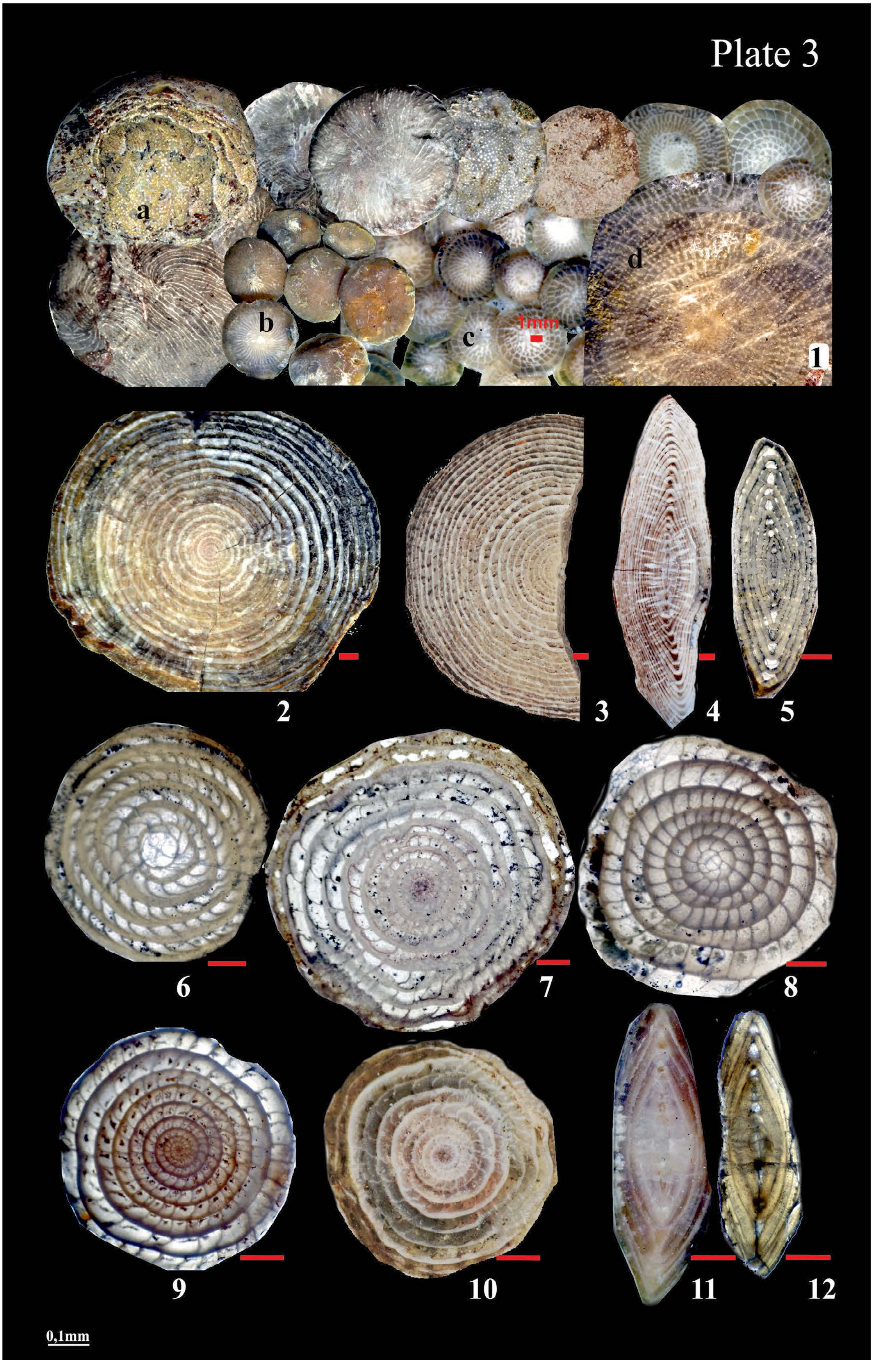
Plate 3
a
b
c
d
1mm
1
2
3
4
5
6
7
8
9
10
11
12
0,1mm

Plate 4

(1-4) *Nummulites perforatus* (De Montfort, 1808)

(1-2) equatorial sections, form B

(3-4) axial sections, form B

(5-6, 8-11) *Assilina exponens* (Sowerby, 1840)

(5) equatorial section, form B

(6) axial section, form B

(8) equatorial section, form A (contains micro trace)

(9) equatorial section, form A

(10-11) axial sections

(7) *Nummulites* sp.

(12) *Nummulites millecaput* Boubée, 1832 equatorial section, form A

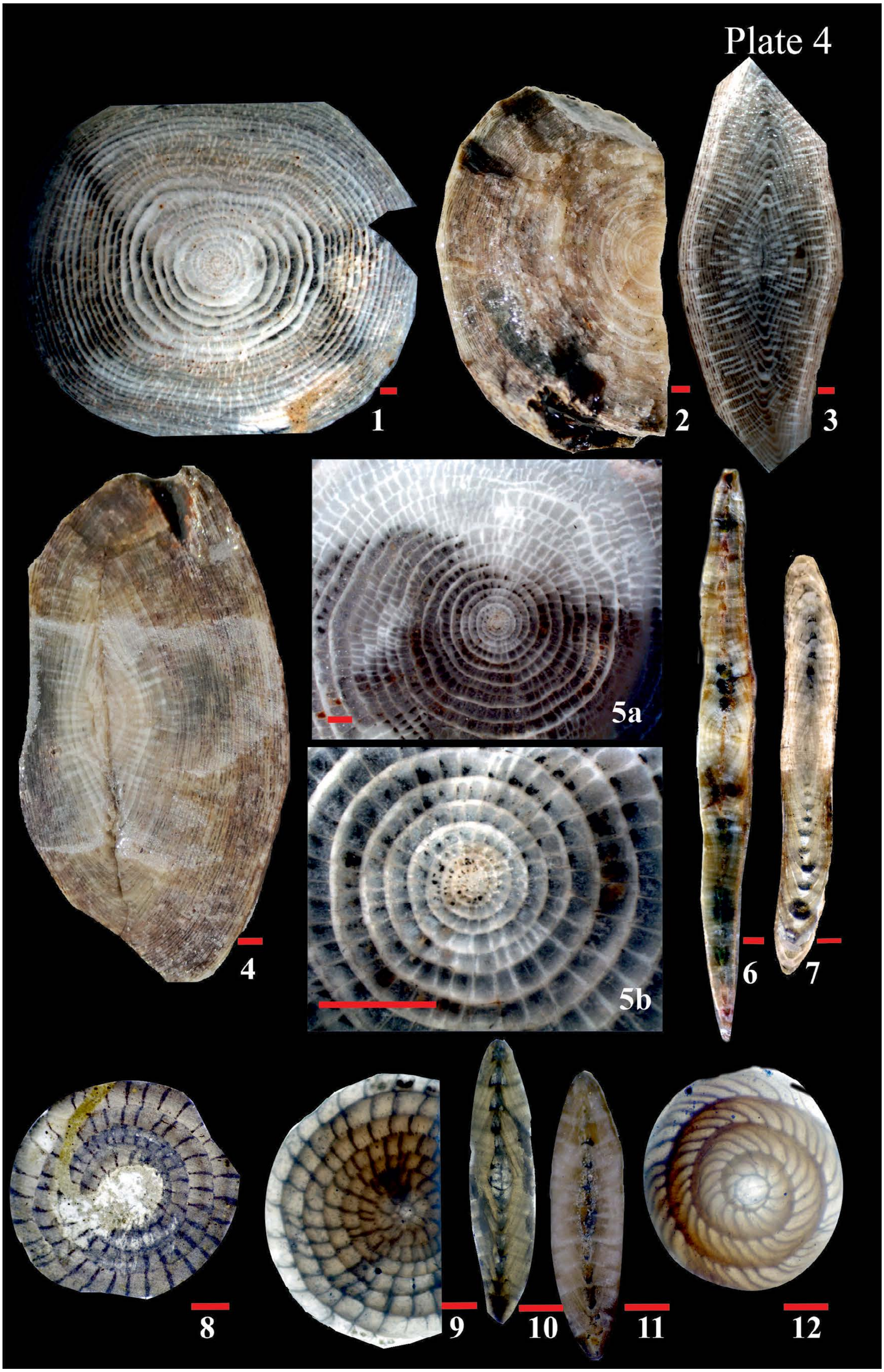
Plate 4
1
2
3
4
5a
5b
6
7
8
9
10
11
12