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Early Eocene (middle-late Cuisian) Molluscs Assemblage from the Harpactocarcinid Beds, in the Yoncalı Formation of the Çankırı Basin, Central Anatolia, and Implications for Tethys Paleogeography

Çankırı Havzası Yoncalı Formasyonu (Orta Anadolu) Harpactocarcinid Yatağında Erken Eosen (orta-geç Küviziyen) Mollusk Birlikteliği ve Tetis Paleocoğrafyasındaki Yeri

Yavuz OKAN [1] and İzzet HOŞGÖR [2]

[1] Ankara University, Faculty of Engineering, Dept. of Geological Engineering, Tandoğan, 06100, Ankara, Turkey
[2] Transatlantic Petroleum (Turkey) corp., Ankara, Turkey

ABSTRACT

A diverse and abundant Early Eocene (middle-late Cuisian) molluscs assemblage from the Yoncalı Formation of the Çankırı Basin in central Anatolia is documented for the first time in this study. Six species of bivalves, four species of gastropods, and one species of scaphopod are described from the formation. The central part of the Yoncalı Formation consists mostly of sandstones, pelagic mudstone and limestones with harpactocarcinids and the molluscs found were derived from this part. Associated fauna found here included benthic foraminiferans, serpulids, undetermined echinoids and shark teeth, and dating was mainly based on the benthic foraminiferans. The distribution of bivalve, gastropod and scaphopod species suggest that this area has affinities with the East European Province of Turkey. The cosmopolitian distribution of the recorded species is useful for paleobiogeographic reconstruction. This reveals that there was a direct connection throughout the Tethyan realm and a connection between the Tethyan central Anatolia and Indo-Pasific realms, at least until the end of the Paleocene to Early Eocene (Early Tertiary), and this allowed the migration of benthic organisms.

Key words: Çankırı Basin, Early Eocene, Molluscs, Paleogeography, Turkey

ÖZ

Orta Anadolu'da Çankırı Havzası'nda ilk defa Erken Eosen (orta-geç Küviziyen) mollusk birlikteliği tanımlanmıştır. Yoncalı Formasyonu'nun orta kesimlerinden alınan mollusklardan, altı bivalv türü, dört gastropod türü ve bir skapod türü tanımlanmıştır. Çalışılan birim harpactocarcinidler ile birlikte kumtaşı, pelajik çamurtaşı ve kireçtaşından oluşmuştur. Birimin yaşı bentik foraminiferlere dayanarak verilmiştir. Molluskların birlikte bulunduğu diğer fosil toplulukları ise bentik foraminiferler, serpulidler, tanımlanamamış ekinitler ve köpekbalığı dişleridir. Bivalv, gastropod ve skapodların dağılımları incelendiğinde, çalışma alanının paleocoğrafik yapılanmada Doğu Avrupa bölgesinin bir parçası olduğunu gösterir. Tetis Bölgesi ele alındığında Paleosen sonundan Erken Eosen'e kadar Tetis'in orta Anadolu ve Hint-Pasifik bölgesiylede bağlantılı olduğu bentik organizmaların yayılımyla ortaya çıkmaktadır.

Anahtar kelimeler: *Çankırı Havzası, Erken Eosen, Mollusk, Paleocoğrafya, Türkiye*

INTRODUCTION

Turkey is comprised of many tectonic belts separated by sutures. The tectonic belts were formed by the total closure of the Tethyan ocean and related basins. The palaeogeographic reconstruction of the study area (Figure 1) in Early Eocene, and in particular its latitudinal position at about 35 N, places the southeastern margin of the Çankırı Basin, so during the Early Eocene, Çankırı Basin was part of the East European Province. (Tüysüz and Dellaloğlu, 1992; Smith et al., 1994). The Tethyan evolution of Turkey may be divided into Paleotethyan and Neotethyan phases. The present tectonic framework of Turkey was formed mainly as a result of the closure of the multibranched Neotethyan Ocean during the Late Mesozoic and Cenozoic (Şengör and Yılmaz, 1981). The closure of the Neotethyan ocean in Late Cretaceous times is recorded by the emplacement of deep-water margin units, melange and ophiolites onto the former passive margins of microcontinents. Integral to the suture zone are large Early Tertiary sedimentary basins situated around the central Anatolian block. Central Anatolia contains many intracontinental basins bordered by the Pontides to the north and the Taurides to the south (Figure 2). The central Anatolian basins developed in the Paleocene-Eocene, and include the Haymana, the Tuzgölü, the Kızılırmak, the Kırıkkale, the Sivas and the Çankırı Basins (Görür et al., 1998; Çemen et al., 1999). Rich fossiliferous strata in Early Eocene Basins are widespread in Central Anatolia. Serpulids and decapods from these strata have been previously recorded in detail (Hoşgör and Okan, 2006; Okan and Hoşgör, 2007; Schweitzer et al., 2007), but research on molluscs is very limited. Previously only four species, from one genus of Late Paleocene-Early Eocene ampullinid gastropods, have been described from the Haymana Basin, and the southern Çankırı Basin (Okan and Hoşgör, 2008). In recent years, an increasing diversity of Early Eocene molluscs have been discovered as a result of detailed field work. The occurence of bivalves, gastropods, scaphopods and other fossils in the Early Eocene part of the Yerköy region is documented here. All the fossils described are from the Yoncalı

formation (Figure 3), in the Çankırı Basin. The Yoncalı formation is a series of marine sedimentary sequences (Figure 4), with varied macrofossil assemblages dominated by decapods (*Harpactocarcinus yozgatensis* Schweitzer *et al.*, 2007) (Okan and Hoşgör, 2007; Schweitzer et al., 2007) and serpulids (*Rotularia spirulaea* Lamarck, 1818) (Hoşgör and Okan, 2006).

Figure 1. Location of Çankırı Basin (Ç) in the East European Province on a palaeogeographic map of the Early Eocene (after Smith et al., 1994; Okan and Hoşgör, 2008).

Şekil 1. Erken Eosen'de paleocoğrafik haritada Doğu Avrupa Bölgesindeki Çankırı Havzasının konumu (Smith vd., 1994; Okan ve Hoşgör, 2008).

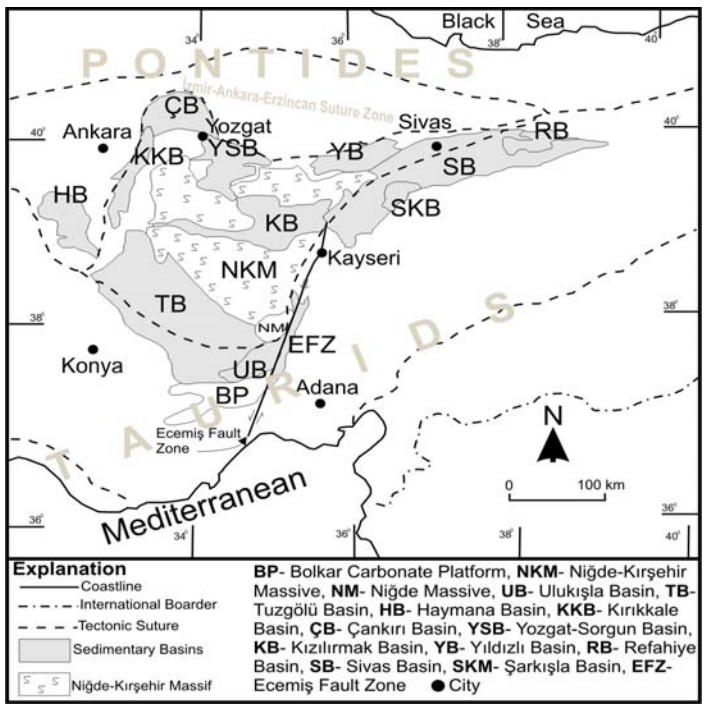


Figure 2. Major sedimentary basins and microcontinental units of Central Anatolia (adapted from Görür et al., 1998).

Şekil 2. Orta Anadolu mikrokıtaları ve önemli sedimanter havzalar (Görür vd., 1998'den değiştirilerek alınmıştır).

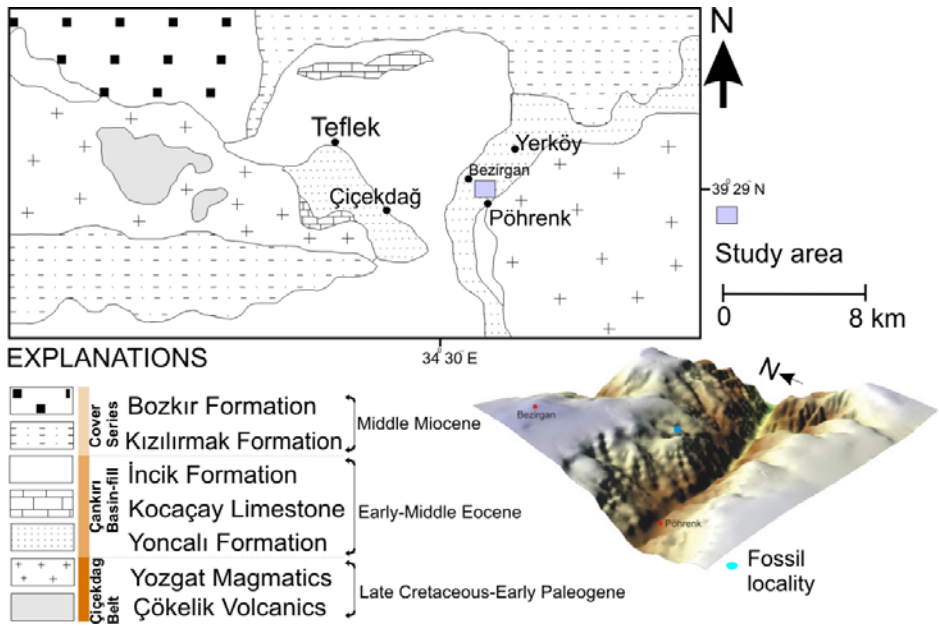


Figure 3. Schematic geological map and three dimensional construction of the study area showing the distribution of the main rock types (Akgün et al., 2002). Studied region is shown with square.

Şekil 3. Çalışma bölgesinin önemli birimleri (Akgün vd., 2002) ve jeolojik yapıyı gösteren sayısal modeli.

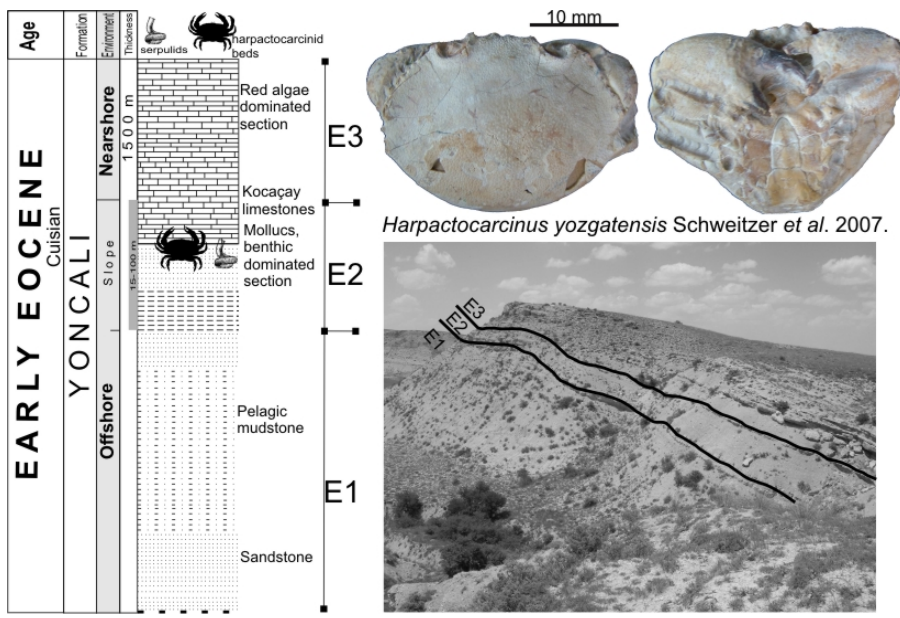


Figure 4. Generalized stratigraphic columnar section, showing the rock units in the study area of the Çankırı Basin (Schweitzer et al., 2007). Molluscs are collected from harpactocarcinid beds; crab specimen shown is in place from field image.

Şekil 4. Çankırı Havzasında çalışma alanının kaya birimlerini gösteren genel stratigrafik kolon (Schweitzer vd., 2007). Harpactocarcinid yatağında yengeç fosilleri ile birlikte bulunan Mollusk lokalitesinin arazi görüntüsü.

Dating the Paleocene-Eocene formations in central Turkey is commonly done using benthic foraminifera. However, in some cases molluscs are used as tool for dating Early Eocene shallow marine sequences. Biostratigraphic control for the neritic Lower Tertiary unity is provided by large foraminifera, such as *Laffitteina*, *Nummulites*, *Discocyclina* and *Assilina*, and also for pelagic units by *Globorotalia* and *Globigerina* species. For benthic Lower Tertiary biozones the stage names 'Ilerdian' and 'Cuisian' are commonly used in Turkey. The Ilerdian stage overlaps with the late Thanetian and early Ypresian (Early Eocene), and the Cuisian corresponds to the late Ypresian (Berggren et al., 1995; Serra-Kiel et al., 1998; Okay et al., 2001; Okan and Hoşgör, 2008).

A marine molluscan fauna has not previously been found in these sedimentary units. The objective of this paper is to describe the molluscs recovered from samples with decapods; and their taxonomic descriptions and paleobiogeographic affinities allow new insights into Tethys paleogeography at the begining of the Cenozoic.

GEOLOGICAL SETTING, ASSOCIATED BIOTA AND FAUNAL COMPOSITION

The Çankırı Basin lies adjacent to the İzmir-Ankara-Erzincan Suture Zone along which the Pontides and the Taurides are thought to have collided and amalgamated (Şengör and Yılmaz, 1981; Tüysüz and Dellaloğlu, 1992) (Figure 2). The fill of the Çankırı Basin is more than 4 km thick and comprises accumulated sedimentation from different cycles (Kaymakçı et al., 2003). In the investigated area, the sedimentary fill of the Çankırı Basin of Early to Late Eocene age unconformably overlies the Late Cretaceous Çiçekdağ Belt (Akgün et al., 2002). Generally, there are three composite stratigraphic units in this region: 1) the Çiçekdag Belt forming the basement, 2) the Çankırı basin-fill, and 3) the cover series (Erdoğan et al., 1996). The Çiçekdağ Belt is represented by the Yozgat magmatics and Çökelik volcanics of the Campanian to Paleogene ages. The mafic volcanic rocks, the Çökelik volcanics of the Çiçekdağ Belt, are cross-cut by the Yozgat granitoids. The basin fill of the Çankırı Basin is mainly composed of three lithostratigraphic units, being the Bayat volcanics of Early Eocene age, and the Yoncalı and İncik Formations of the Middle Eocene age. The cover series is dominated by Miocene to Pleistocene red sandstone, and a conglomerate of the Bozkır, Kızılırmak and Değim formations overlies the lithological units of the Çankırı Basin-fill (Ketin, 1955; Erdoğan et al., 1996; Akgün et al., 2002; Karadenizli et al., 2003).

The Çankırı Basin-fill deposits have the characteristics of a continental and shallow-marine environment. The general composition of the Yoncalı Formation is sandstone, pelagic mudstone and limestone with a thickness of about 1500 m (Figure 4). The molluscs fossils, which are the main subject of this study, were collected from the central part of the Yoncalı Formation (Hoşgör and Okan, 2006). Beds containing the bivalves, gastropods, scaphopods and associated biota in the Kocaçay limestone, crop out as discontinuous bodies in the region and attain 15 to 100 m in thickness. The samples analysed come from sandstones and limestone beds with decapods (*Harpactocarcinus yozgatensis* Schweitzer et al., 2007) from the central Yoncalı

formation (Okan and Hoşgör, 2007; Schweitzer et al., 2007) (Figure 4). Specimens were collected from a single exposure in the Yoncalı Formation, on the Kırşehir J32-b2, quadrangle, at latitude 34^0 68'' N, longitude 39^0 25'' E.

The molluscs fossils are associated with *Nummulites distans* Deshayes (A and B forms), *Assilina laxispira* Dela Harpe (Sirel, personal commun., 2007); the serpulids are *Rotularia spirulaea* Lamarck, 1818 (Hoşgör and Okan 2006); there are also undetermined echinoids and shark teeth. According to Serra-Kiel *et al*. (1998), these foraminiferal species indicate SB-11-12 zones (middle-late Cuisian). Based on this, the Yoncalı formation is middle-late Cuisian in age. The decapods reported in Okan and Hoşgör (2007) and Schweitzer et al., (2007) are typical taxon for middle-late Cuisian (late Ypresian). The uppermost part of the Kocaçay limestone includes only algae fossils. Foraminiferal assemblage reveals the warm and shallow marine conditions for the middle-late Cuisian period. The sandstone and shale alternation points to cyclic high energy periods of transportation of coarse material from the coastal area. Towards the top of the sequence, the increments in the algae content suggest that warm, shallow and low energy conditions dominated in the region during the middle-late Cuisian time interval. A significant decrease in sedimentation had occurred by that time, due to a rapid change from shallower (nearshore) to deepwater (offshore) conditions in the depositional environment during the late Ypresian time (Figure 4) (Hoşgör and Okan, 2006; Schweitzer et al., 2007).

Exhaustive analysis of the samples studied allowed us to identify 11 mollusc species. The mollusc assemblage is abundant and biostratigraphically useful. Six species of bivalves (*Atrina affinis* (Sowerby, 1821), *Chlamys solea* (Deshayes, 1824), *Cardita (Venericardia) aizyensis* Deshayes, 1860, *Chama fimbriata* Defrance 1817, *Panopea gastaldii* Michelotti, 1861, *Corbula (Bicorbula) gallica* Lamarck, 1805), four species of gastropods (*Velates perversus* (Gmelin, 1789), *Rimella fissurella* (Linne, 1758), *Calyptraea (Trochita) aperta* (Solender, 1766), *Globularia vapincana* (d'Orbigny 1850)), and one species of scaphopod (*Dentalium montense* Briart and Cornet, 1889) are described from the Yoncalı Formation.

The material used in this study is housed in the Department of Geological Engineering, Ankara University (AU).

SYSTEMATIC PALEONTOLOGY

The classification of molluscs in this study follows that of Knight et al. (1960), Bieler and Mikkelsen (2006) and Waller (2006).

Class: Bivalvia Linne, 1758
Subclass: Pteriomorphia Beurlen, 1944
Order: Mytiloida Ferussac, 1822
Superfamily: Pinnoidea Leach, 1819
Family: Pinnidae Leach, 1819

Genus: *Atrina* Gray, 1842
Type Species: Pinna nigra Dillwyn, 1817.

Atrina affinis (Sowerby, 1821)
Pl.1, Fig. 1

1861 *Pinna affinis* Sowerby, Wood; p. 55, pl. 10, fig.1.
1965 *Pinna affinis* Sowerby, Glibert and Poel; p. 9.

1995 *Atrina affinis* (Sowerby), Marquet; p. 248, pl. 2, figs. 1-3; pl. 3, fig. 1.

Remarks. Atrina affinis from Belgium, orginally described as a *Pinna*, was redescribed by Marquet (1995) and placed in *Atrina*. Most of the European Early Cenozoic pinnids have been assigned to *Pinna margaritacea* Lamarck, 1806 (Marquet 1995, p. 242, pl. 2, fig. 4) or *Atrina affinis* (Sowerby, 1821) (= *Pinna affinis* Sowerby, 1821). Particularly, the main distinguishing character between these species is the more elongated shape of *Atrina affinis* and its less distinctly curved ridges on the ventral part of the shell. On the other hand, their morphological differences are minor and have never been clearly defined. Moreover, most European Paleogene pinnids are poorly preserved and commonly deformed. The width of the shell is therefore not a useful tool to determine their taxonomic character.

Order: Pectinoida H. and A. Adams, 1857
Superfamily: Pectinoidea Rafinesque, 1815
Family: Pectinidae Rafinesque, 1815

Genus: *Chlamys* Bolten, 1798
Type Species: Chlamys cinnabarina Bolten, 1798
.

Chlamys solea (Deshayes, 1824)
Pl. 1, Fig. 2

1824 *Pecten solea* Deshayes, p. 302, pl. 42, figs. 12-13.
1904-13 *Chlamys solea* (Deshayes), Cossmann and Pissarro; pl. 40, fig. 131-1; pl. 41, fig. 132-1952 *Chlamys solea* (Deshayes), Vasilenko; p. 70, pl. 4, fig.1.
1957 *Chlamys (Chlamys) solea* (Deshayes), Meszaros; p. 25-26, 89 pl. 3, fig. 6; pl. 15, fig. 1.

Remarks. *Chlamys solea* resembles examples found in the Early to Late Eocene Paris Basin and Bulgarian Paleoogene Basin *Chlamys (Chlamys) breviaurita* (Deshayes, 1824) (Karagiuleva 1964, p. 34-35, pl. 5, fig. 8) in having a concentric steps, but differs from the latter species in having a coarser sculpture and much broader umbonal angle. True *Chlamys* is well represented in Eocene to Holocene faunas, but its Paleocene history remains obscure. *C. solea* is similar in gross morphology to *Chlamys aquilonia* Waller & Marincovich, 1992 (Marincovich 1993, p. 14-15, fig. 10-1) in the Danian Arctic Region. *C. solea* clearly differs from these species by its significantly smaller size.

Subclass: Heterodonta Neumayr, 1883
Order: Carditoida Dall, 1889
Superfamily: Crassatelloidea Ferussac, 1822
Family: Carditidae Fleming, 1828

Genus: *Cardita* Bruguiere, 1792
Subgenus: *Venericardia* Lamarck, 1801
Type Species: Venericardia imbricata Lamarck, 1801

Cardita (Venericardia) aizyensis Deshayes, 1860
Pl. 1, Figs. 3,4

1860 *Cardita aizyensis* Deshayes, p. 762, pl. 61, figs. 32-34.
1904-13 *Cardita (Venericardia) aizyensis* Deshayes, Cossmann and Pissarro; pl. 31, figs. 97-11.
1957 *Cardita (Venericardia) aizyensis* Deshayes, Meszaros; p. 16-17, pl. 1, figs. 11-12.

Remarks. Our specimen is identical with specimens from the Early Eocene of France described by Cossmann & Pissarro (1904-13). The similar *Venericardia hortenensis* (Vinassa de Regny, 1897) (Karagiuleva, 1964, p. 129, pl. 38, figs. 4-5; pl. 39, fig. 2) has rounded ribs that are not as strongly radiating.

Order: Veneroida H. and A. Adams, 1856
Superfamily: Chamoidea Lamarck, 1809
Family: Chamidae Lamarck, 1809

Genus: *Chama* Linne, 1758
Type Species: Chama lazarus Linne, 1758

Chama fimbriata Defrance 1817
Pl. 1, Figs. 5, 6

1904-1913 *Chama fimbriata* Defrance, Cossmann and Pissaro; pl. 21, fig. 7.
1947 *Chama fimbriata* Defrance, Furon and Soyer; pl. 10, fig. 76-7.
1957 *Chama (Chama) fimbriata* Defrance, Meszaros; p. 12-13, 59, pl. 1, fig. 7; pl. 10, fig. 4.
1977 *Chama fimbriata* Defrance, Piccoli *et al*., pl. 2, fig. 21.

Remarks. The Chamidae originated in the Cenomanian. During the Tertiary, and especially since the Eocene, they became relatively abundant, peaking in the Pliocene tropical and subtropical faunas (Pastorino, 1991). This species is characterized by strong growth lamellae that develop spine-like projections where they are intersected by radiating costate. Paleocene species of Chama are known from Georgia (Palmer and Brann, 1966). In the Eocene this genus became relatively more frequent as suggested by the presence of *Chama calcarata* Lamarck in the Lutetian of France and *Chama granulosa* d'Archiac in the Middle-Late Eocene from Romania and Italy (Meszaros, 1957; Piccoli *et al*. 1977). *Chama fimbriata* Defrance, differs from *Chama calcarata* Lamarck (Meszaros, 1957; p. 59, pl. 10, figs: 3, 5) in having radiating costae of irregular size, shape, and distribution, that extend between about 1 cm to 5 cm from the beak of the left valve.

Superfamily: Hiatelloidea J. E. Gray, 1824
Family: Panopeidae Bronn, 1862

Genus: *Panopea* Menard, 1807
Type Species: Panope aldrovandi Menard, 1807.

Panopea gastaldii Michelotti, 1861
Pl. 1, Fig. 7

1861 *Panopea gastaldii* Michelotti, p. 54, pl. 5, fig. 10.
1911 *Panopea gastaldii* Michelotti, Boussac, p. 248, pl. 15, figs. 26, 35.
1925 *Panopea gastaldii* Michelotti, Schlosser, p. 26.
1964 *Panope gastaldii* Michelotti, Karagiuleva, p. 118, pl. 37, fig. 2.
1977 *Panopea gastaldii* Michelotti, Piccoli, Schiraldi, Sgarbossa and Tessarolo; pl. 3, fig. 36.

Remarks. Most of the Tethys provences, Paleocene-Eocene large deep burrowing bivalves have been assigned to *Panope heberti* Bosquet, 1849, *Panope allonsensis* (Boussac, 1911), *Panope remensis* Melleville, 1843, *Panope (P.) oppenheimi* Korobkov, 1941, *Panopea bachmanni* Mayer Eymar 1887, *Panopea canevae* (Fabiani, 1905) and *Panopea gastaldii*

Michelotti, 1861. The main distinguishing character between the *Panopea gastaldii* species is the more elongated shape of *Panope heberti* (Karagiuleva 1964, p. 117, pl. 36, fig. 2) and its short-thick anterior margin. *Panope allonsensis* (Karagiuleva 1964, p. 116, pl. 37, figs. 1, 4) is of a similar size, has a prominent beak like *Panopea gastaldii*, but the former has a anteriorly situated beak. *Panopea gastaldii* is bigger and has a more regular ornamentation than *Panope remensis* (Farchad 1936, p. 49, pl. 2, fig. 3), *Panope (P.) oppenheimi* (Meszaros 1957, p. 32, pl. 5, fig. 6), *Panopea bachmanni* (Piccoli *et al*. 1977, p. 24, text.fig. 15a.) and *Panopea canevae* (Piccoli *et al*. 1977, pl. 3, fig. 33).

Order: Myoida Stoliczka, 1870
Superfamily: Myoidea Lamarck, 1809
Family: Corbulidae Lamarck, 1818

Genus: *Corbula* Bruguiere, 1797
Subgenus: *Bicorbula* Fischer, 1887
Type Species: Corbula gallica Lamarck, 1805

Corbula (Bicorbula) gallica Lamarck, 1805
Pl. 1, Figs. 8, 9

1824 *Corbula gallica* Lamarck, Deshayes; p. 49, pl. 7, figs.1-3.
1911 *Corbula gallica* Lamarck, Boussac; p. 234, pl. 12, fig. 15; pl. 13, fig. 7; pl. 15, fig. 2-36.
1904-13 *Corbula (Bicorbula) gallica* Lamarck, Cossmann and Pissarro; pl, 3, fig. 20-2.
1933 *Corbula (Bicorbula) gallica* Lamarck, Glibert; p. 164, pl. 11, fig. 2.
1947 *Corbula gallica* Lamarck, Furon and Soyer; pl. 8, fig. 20-2.
1957 *Corbula (Bicorbula) gallica* Lamarck, Meszaros,; p. 34-35, pl. 5, figs. 7-8.
1963 *Corbula (Bicorbula) gallica* Lamarck, Vlaicu-Tatarim; p. 160-161, pl. 11, fig. 2-4; pl. 12, figs. 1-2.
1964 *Corbula (Bicorbula) gallica* Lamarck, Karagiuleva; p. 81, pl. 25, figs. 15, 17-19.
1977 *Corbula gallica* Lamarck, Piccoli, Schiraldi, Sgarbossa and Tessarolo; pl. 2, fig. 30.

Remarks. This species is the most abundant species in the West-central European Paleogene Basins, where it occurs in nearly shallow-water sedimentary facies. The species that appears most similar in morphology to the present one is *Corbula semicostata* (Bellardi, 1852) (Boussac 1911, p. 233, pl. 14, figs. 30, 39-42, 49-50) which is well known in Early-Middle Eocene faunas of the Alpine regions. *Corbula (Bicorbula) gallica* differ from *Corbula semicostata* by having a relatively more elongated shape, with a strongly produced posterior margin.

Class: Gastropoda Cuvier 1797
Subclass: Prosobranchia Milne Edwards 1848
Order: Archaeogastropoda Thiele 1925
Suborder: Neritopsina Cox and Knight 1960
Superfamily: Neritoidea Rafinesque 1815
Family: Neritidae Rafinesque, 1815

Subfamily: Neritinae Rafinesque 1815
Genus: *Velates* Montfort 1810
Type Species: Velates conoideus de Montfort 1810, by original designation= *Neritina schmideliana* (Chemnitz 1853)= *Nerita perversa* Gmelin 1791.

Velates perversus (Gmelin, 1789)
Pl. 2, Figs. 1-8

1904-13 *Velates schmiedeli* (Chemnitz.), Cossmann and Pissarro; pl. 6, fig. 40-1.
1936 *Velates* cf. *V. perversus* (Gmelin), Pinard; p. 101.
1952 *Velates perversus* (Gmelin), Eames; p. 12.
1947 *Velates schmiedeli* Chemnitz, Furon and Soyer; 230, pl. 6, fig. 40-1
1954 *Velates schmidelianus* Chemnitz, Malaroda; p. 37, pl. 2, fig. 1; pl. 10, fig. 14.
1957 *Velates (Velates) schmiedelianus* Chemnitz, Meszaros; p. 37, 112, pl. 6, fig. 1; pl. 21, fig. 10; pl. 22, fig.1.
1963 *Velates schmiedelianus* Chemnitz, Vlaicu-Tatarim; p. 163.
1964 *Velates perversus* (Gmelin), Karagiuleva; p. 132-133, pl. 40, figs. 3-10.
1969a *Velates perversus* (Gmelin), Iqbal; p. 43, pl. 5, fig. 69.
1969b *Velates perversus* (Gmelin), Iqbal; p. 42, pl. 16, fig. 4.
1972 *Velates schmidelianus* (Chemnitz), Kecskemétiné-Körmendy; p. 220, pl. 5, fig. 7; pl. 6, figs. 1-2.
1973 *Velates perversus* (Gmelin), Iqbal; p. 21, pl. 24, fig. 5; pl. 25, fig. 6.
2000 *Velates perversus* (Gmelin), Bonci, Cirone, Merlino and Zaliani; p. 214, pl. 3, fig. 4.
2006 *Velates perversus* (Gmelin), Mikuž; p. 54, pl. 1, fig. 1; pl. 2, fig. 1; pl. 3, fig. 1.
2008 *Velates perversus* (Gmelin), Okan and Hoşgör, text-fig., 6-e.

Remarks. The species of the neritid gastropods *Velates perversus* (Gmelin) are represented by better preserved and more abundant material than are the other gastropods; therefore, this section discusses the neritids (Figure 5). Vokes (1935) argued that the oldest *Velates* is *V. cuneatus* (Gabb) of Campanian age. Kenn and Cox (1960) give the range of *Velates* Cenomanian through Eocene, which is the same range as that given by Cossmann (1925), who listed the species upon which he based the range (Woods and Saul, 1986). Typical *Velates*, then, with an expanded, thick, inner lip callus covering the apertural face and inner lip teeth reduced to coarse serrations (Figure 5), is known only from the Eocene. The shell in *V. perversus* is large and thick. Its geometry is roughly conical, with 2-3 tightly coiled apical whorls. When referring to shell morphology in *Velates*, it is convenient to refer to an abepertural and an apertural side, corresponding to the cone-shape surface and the basis of the cone, respectively (Savazzi, 1992).

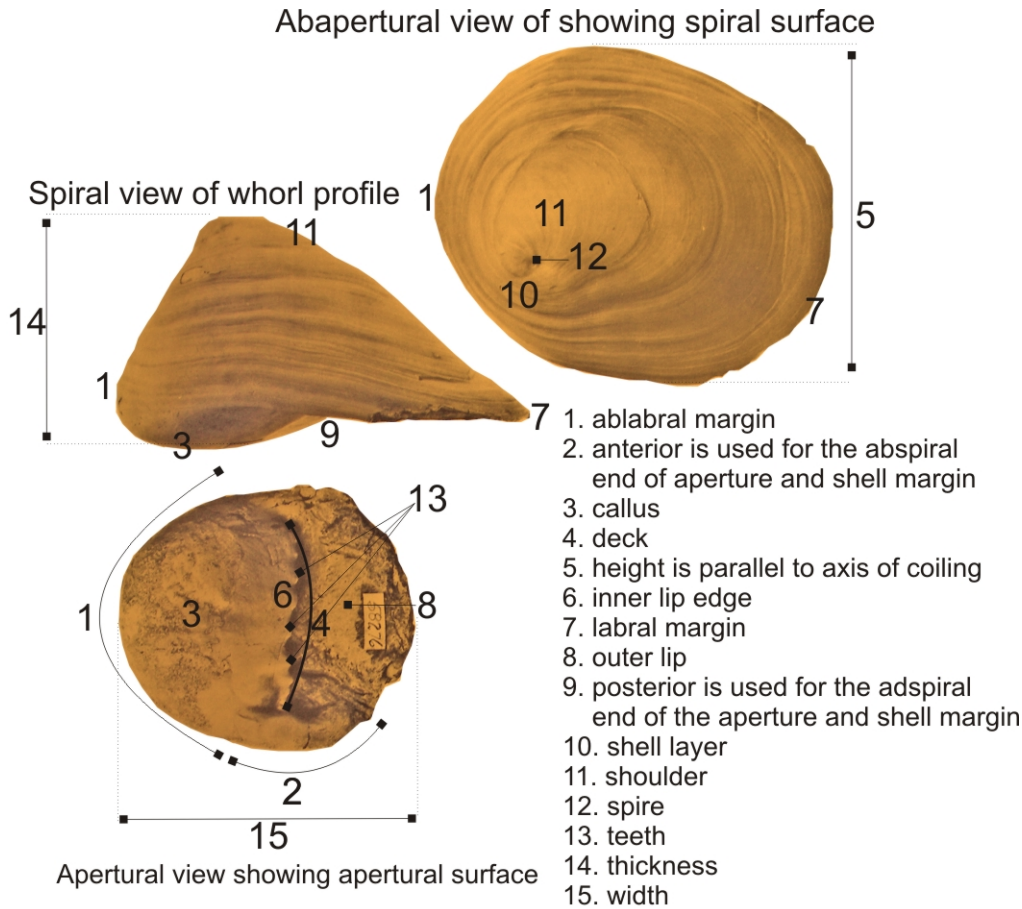
Several taxa (*V. noetlingi* Cossmann and Pissaro, 1909; *V. balkanicus* Bontscheff, 1896; V. *equinus* Bezonçon, 1870) are more similar to *V. perversus*. *V. noetlingi* is more oval, and has a very low spire (Cossmann and Pissaro, 1909, p. 76). *V. balkanicus* (Bontscheff, 1896 p. 380, pl. 6, Figs. 1-6) is similar to *V.perversus*. It differs from *V. perversus* in is thickened outer lip, thicker more rolled ablabral deck margins, and slightly less convexly swollen deck surface. V. *equinus* (Cossmann and Pissaro, 1910; pl. 6, fig. 40.2) differs from *V. perversus* in its stronger, broader teeth on the inner lip and in its roundly inflated whorl with no trace of the shoulder angulation.

Subclass: Opisthobranchia Milne Edwards 1848
Order: Mesogastropoda Thiele, 1925
Superfamily: Calyptraeoidea Lamarck, 1809
Famıly: Calyptraeidae Lamarck, 1809

Genus: *Calyptraea* Lamarck, 1799
Subgenus: *Trochita* Schumacher, 1817
Type Species: *Patella trochiformis* Gmelin, 1791.

Calyptraea (Trochita) aperta (Solender, 1766)
Pl. 3, Figs. 1-4

1766 *Trochus apertus* Solander, p. 9, figs. 1, 2.



Dimensions of *Velates perversus*.

Specimens (mm)	Height	Width	Thickness	Inner lip length	Deck width
AUY07106	70	65	32	25	12
AUY07107	80	68	36	-	-
AUY07108	76	62	34	-	-
AUY07109	71	66	33	30	14

Figure 5. Diagrams for *Velates perversus* (Gmelin) (modified from Woods and Saul, 1986).

Şekil 5. Velates perversus (Gmelin) türünün tanımlanmasında esas alınan diyagramlar (Woods ve Saul, 1986 dan değiştirilerek alınmıştır).

1904-1913 *Calyptraea aperta* (Solender), Cossmann and Pissaro, pl. 12, fig. 1.

1911 *Calyptraea aperta* (Solender), Boussac; p. 276-277.

1925 *Calyptraea aperta* (Solender), Schlosser; p. 89, pl. 3, fig. 22.

1933 *Calyptraea* cf. *aperta* (Solender), Isaeva; p. 12, pl. 1, fig. 16.

1938 *Calyptraea (Calyptraea) aperta* (Solender), Glibert; p. 54, pl. 1, fig. 21.

1957 *Calyptraea (Trochita) aperta* (Solender), Meszaros; p. 40, 133-134, pl. 7, figs. 4-7; pl. 26, fig. 4.

1964 *Calyptraea (Trochita) aperta* (Solender), Karagiuleva; p. 159-160, pl. 43, fig. 14.

Remarks. Specimens of *Calyptraea (Trochita) aperta* (Solender) are common at the Yoncalı formation. This limpet-like gastropod has a conical shell that is almost circular in outline. The Calyptraeoidea are very modified caenogastropods. They tend to modify their shells to a dorso-ventrally flattened, limpet or limpet-like morphology. They also tend to an almost sessile habit. The species is known in North America from the Eocene to the Miocene (Harris and Palmer, 1946) and in Europe from the Late Paleocene to the Late Eocene. Karagiuleva (1964) (p, 159; pl. 43, figs. 12-13) suggested that *C. (T.) suessoniens* (d'Orbigny, 1847) from Bulgaria was closely related. However, this species never developed the rows of foliated spines.

Superfamily: Stromboidea Rafinesque, 1815
Family: Strombidae Swainson, 1840

Genus: *Rimella* Agassiz, 1840
Type Species: *Rostellaria fissurella* Linne 1758.

Rimella fissurella (Linne, 1758)
Pl. 3, Figs. 5, 6

1866 *Rostellaria fissurella* Lamarck, Deshayes; p. 458
1911 *Rimella fissurella* (Coquebert and Brongniart), Boussac; p. 317, pl. 18, fig. 89.
1911 *Rimella fissurella* (Linne), Cossmann and Pissarro; pl. 30, fig. 1.
1925 *Rimella fissurella* (Linne), Schlosser; p. 36, 99, pl. 3, fig. 25; pl. 8, fig. 8.
1933 *Rimella fissurella* (Linne), Glibert; p. 56-57, pl. 3, fig. 12.
1933 *Rimella fissurella* (Linne), Gocev; p. 187, pl. 5, şek. 10.
1947 *Rimella fissurella* (Linne), Furon and Soyer; p. 68, 117, 162, pl. 14, fig. 1.
1957 *Rimella fissurella* (Linne), Meszaros; p. 43-44, 139, pl. 8, fig. 2-3; pl. 27, fig. 7.
1963 *Rimella fissurella* (Linne), Vlaicu-Tatarim; p. 171-172, pl. 16, fig. 8.
1964 *Rimella fissurella* (Linne), Karagiuleva; p. 163, pl. 44, fig. 6.
1988 *Rimella fissurella* (Lamarck), Abate, Baglioni, Bimbatti and Piccoli; p. 138, pl. 1, fig. 13.

Remarks. Rimella labrosa (Sowerby, 1823) (Karagiuleva, 1964, p. 162-163, pl. 44, figs. 7-8) from the Late Eocene of Bulgaria is clearly distingushed from this species by its slender outline, and less angulated and wider aperture.

Superfamily Ampullinoidea Cossmann 1918
Family Ampullinidae Cossmann 1918
Genus *Globularia* Swainson 1840
Type Species. Ampullaria sigaretina Lamarck 1804.

Globularia vapincana (d'Orbigny 1850)
Pl. 3, Figs. 7, 8

1850 *Natica vapincana* d'Orbigny, p. 345.
1873 *Natica vapincana* d'Orbigny, Bayan, p. 104-105, pl. 15, figs. 1-2.
1911 *Natica (Ampullina) vapincana* d'Orbigny, Boussac, p. 327-328, pl. 20, figs. 11, 13.
1957 *Ampullina vulcani* (Brongniart) var. *vapincana* d'Orbigny, Meszaros, p. 128, pl. 25, fig. 7.
1964 *Globularia (Globularia) vapincana* (d'Orbigny), Karagiuleva, p. 176, pl. 51, fig. 1-9.
2008 *Globularia vapincana* (d'Orbigny 1850), Okan and Hoşgör, p. 789, pl. 1, figs. 1-9.

Remarks. *Globularia (Globularia) vulcani* (Brongniart 1864) (Karagiuleva 1964, p. 175, pl. 49, fig. 4) from the Middle Eocene of Bulgaria is very similar in size and shape to this species but the former differs from the latter by having a less distinctive carination and higher whorls of the spire. The large taxonomic description and geologic occurrences of *Globularia* are listed and summarized in Okan and Hoşgör (2008).

Class: Scaphopoda Bronn, 1862
Ordo: Dentaliida Starobogatov, 1974
Family: Dentaliidae Gray, 1824

Genus: *Dentalium* Linne, 1758
Dentalium montense Briart and Cornet, 1889
Pl. 3, Fig. 9

1889 *Dentalium montense* Briart and Cornet, p. 80, pl. 24, fig. 12.
1915 *Dentalium (Fustiaria) montense* Briart and Cornet, Cossmann; p. 6, pl. 1, figs. 18-19.
1975 *Dentalium (Pseudantilis) montense* Briart and Cornet, Anderson; p. 142, pl. 12, figs. 1-2.

Remarks. The sculpture of this specimen is highly reminiscent of that of *Dentalium montense* Briart and Cornet 1889, which was descibed as *Dentalium (Fustiaria) montense* Briart and Cornet,1889, by Cossmann (1915) from the synchronous Belgic formation.

STRATIGRAPHIC AND PALEOGEOGRAPHIC IMPORTANCE

The Early Cenozoic timescale provides a framework within which to examine the evolution and geographic distribution of various animal groups such as terrestrial vertebrates, marine invertebrates and the larger Foraminifera and, thereby, the history of this period of the Tethys sea. The *Nummulites* limestones are extended from the West Pacific, to the Central Mediterranean, and to the Atlantic (Figure 6) (Racey, 2001). Apart from the many correlations of Tethyan Early Cenozoic based on benthic foraminifera and calcareous nannoplankton, we remember several studies based at least partially on molluscs (Figure 7), for instance by Meszaros (1960), Renzi (1975), Maxamed and Carush (1982), Piccoli et al. (1977), Piccoli (1984), Piccoli et al., (1986), Abate et al., (1988), Amitrov (1994) and Okan and Hoşgör (2008.).

In the Eocene time, the mollusc faunas of France (Loire-Paris Basin), Italy (Venetian and Piedmont Basin) and other large European Basins are very similar or almost the same. The environmental conditions must have been essentially the same. In particular, bivalves and gastropods of shallow seas represent a good means for paleobiogeographic correlations and, to some extent, also stratigraphic markers, if the comparision is made within homogeneous or between similar environments (Piccoli, 1984; Piccoli et al., 1986; Amitrov, 1994). The fossil mollusc assemblages of the Eocene have been examined for this purpose from the following areas (Figure 7); Southern England (Edwards, 1854; Wood, 1861, Wrigley, 1946, 1949); the Venetian Basin (NE Italy) (Malaroda, 1954; Piccoli and Mocellin, 1962; Piccoli et al., 1977; Abate et al., 1988; Mavros, 1990), the Piedmont Basin (NW Italy) (Bonci et al., 2000), the Loire-Paris Basin and Vigny (France) (Deshayes, 1824; Cossmann, 1895; Cossmann and Pissaro, 1904-13; Farchad, 1936; Pinard, 1936; Furon and Soyer, 1947), Belgium (Glibert, 1933; Glibert

and Poel 1965; Marquet, 1995), Germany (Schlosser, 1925; Anderson, 1975), the Transylvanian Basins (Romania) (Popescu-Voiteşti, 1910; Meszaros, 1957; Vlaicu-Tatarim, 1963; Meszaros et al., 1969), the Dinaric carbonate platform (Pavic, 1970; Mikuz, 2006), the Bulgarian Paleogene basins (Bontscheff, 1896; Douville, 1908; Gocev, 1933; Karagiuleva, 1964), the Hungarian Paleogene basins (Douville, 1908; Szöts, 1953; Kecskeméti-Körmendy, 1972; Laszlo, 1974; Kecskeméti-Körmendy and Meszaros 1980; Bodó, 1992), the Crimea (Douville, 1908; Isaeva, 1933; Vasilenko, 1952), the Turkısh Paleogene basins (Haymana-Polatlı, Çankırı Basins and KB Malatya) (Stchepinsky, 1941; Erünal, 1942; Örçen, 1985; Okan and Hoşgör, 2008; herein) chosen as sample zone of the Tethys, North Africa (Tunusia and Egypt) (Cuvillier, 1930, Abbass, 1972; Elbassyony, 2004), Iran (Chahida, 1978), Qatar (Boukhary, 1985; Abu-Zeid and Boukhary, 1984), Pakistan (Iqbal, 1969a, 1969b, 1973) and India (Vokes, 1937; Eames, 1952).

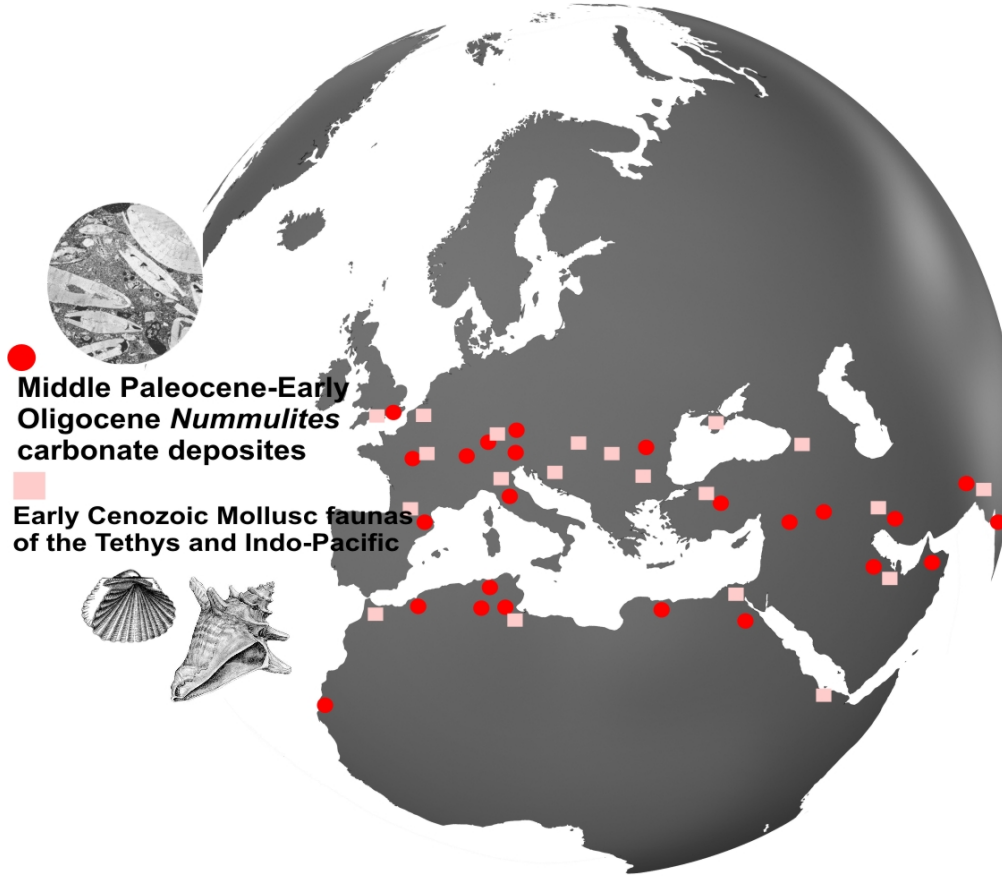


Figure 6. Geographical distribution of the Middle Paleocene-Early Oligocene *Nummulites* carbonate deposites (modified from Racey, 2001) and Early Cenozoic Mollusc Faunas (Maxamed and Curush, 1982; Piccoli et al., 1986).

Şekil 6. Orta Paleosen-Erken Oligosen aralığında Nummulites karbonat depolanmalarının (Racey, 2001'den) ve Erken Eosen Mollusklarının coğrafik dağılımı (Maxamed ve Curush, 1982; Piccoli vd., 1986).

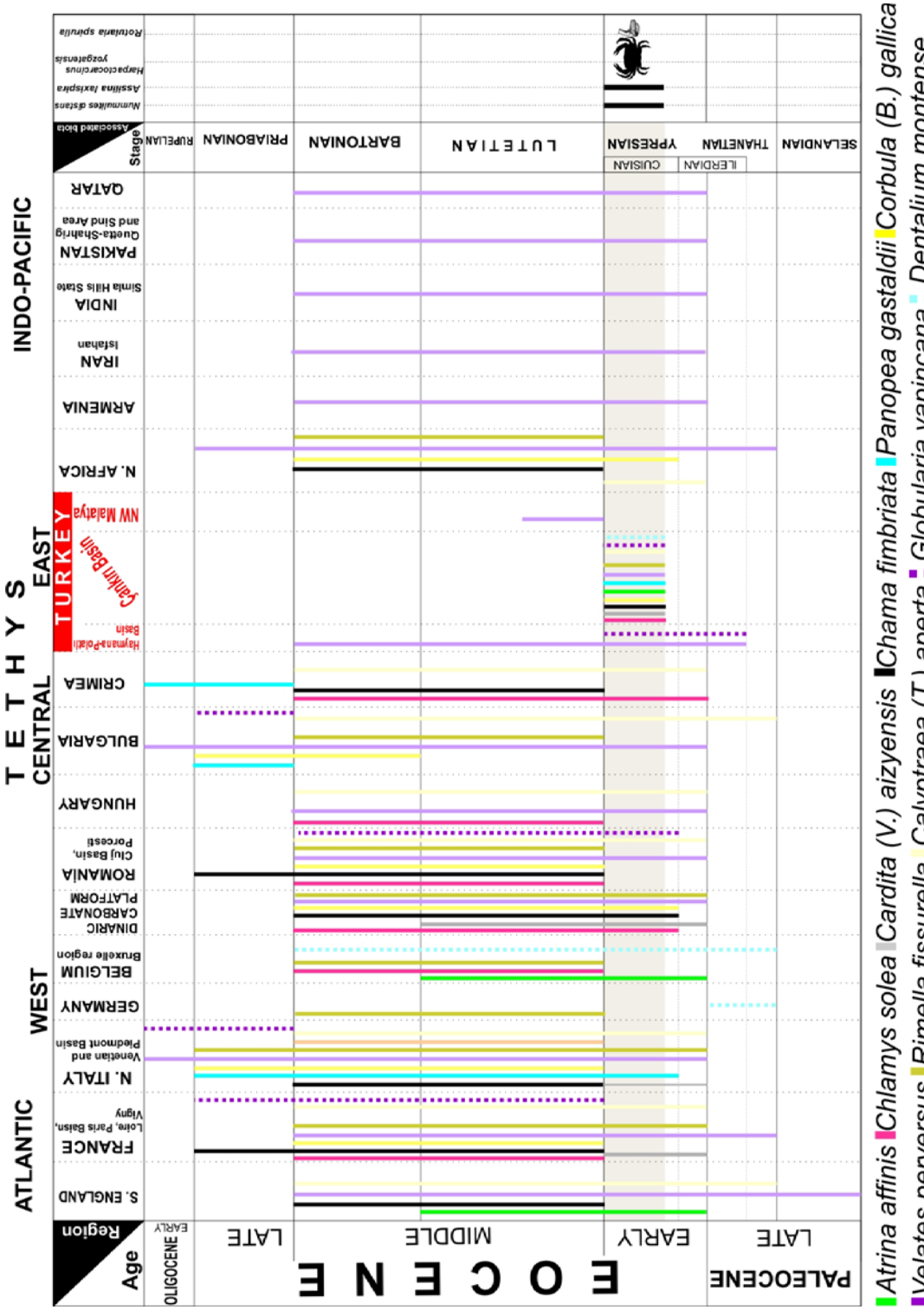


Figure 7. Stratigraphic and geographic distribution of the mollusc assemblage from Early Eocene of the Çankırı Basin.

Şekil 7. Çankırı Havzası Erken Eosen mollusk topluluğunun stratigrafik ve coğrafik dağılımı.

In this study, the stratigraphic ranges and paleogeographic distributions of some of the species have been modified. The following species are found here for the first time within Turkey; *Atrina affinis* (Sowerby), *Chlamys solea* (Deshayes), *Cardita (Venericardia) aizyensis* Deshayes, *Chama fimbriata* Defrance, *Panopea gastaldii* Michelotti, *Corbula (Bicorbula) gallica* Lamarck. The stratigraphic ranges of some of the species in this study have been changed after calibration with the benthic foraminifera and their studied invertebrate groups (decapods and serpulids) with which they are associated.

The identified mollusc faunas are stratigraphically and geographically widely distributed species. In Turkey these occur in the Early Eocene (middle-late Cuisian) of the Çankırı Basin. They are also described from the Paleocene to Early Oligocene of Europe (Figure 7).

DISCUSSIONS AND CONCLUSIONS

Molluscs were identified from the middle part of the Yoncalı formation which also contains decapods. Within the Yoncalı Formation, Akgün et al. (2002) described the first palynomorph assemblages of the Early-Middle Eocene age. Hoşgör and Okan (2006) studied the nummulitic limestones of shallow marine environment origin and showed by aid of serpulids that these are Early Eocene in age. A more detailed biostratigraphical study of the Yoncalı Formation with new decapods was performed by Schwietzer et al. (2007). These authors dated various macrofauna by comparing them to nummulites assemblages of the Early Eocene age. From the Central Anatolian area the only age date for the sedimentary rocks with nummulitic limestones is given in Sirel (1998) and Özcan et al. (2007).

Another implication for new data concerns the Atlantic, Mediterranean and Indo-Pacific Region distribution of the Early Tertiary molluscan fauna that we found in the Çankırı Basin. The Early Eocene molluscs assemblage described in this study exhibits a capability of being transported over long distances. In particular benthic molluscs, with a long larval life of a planktotrophic type, represent one of the best ways for reconstruction of the pathways of migration along marine currents through geologic time (Piccoli, 1984; Hoşgör, 2008.). This conclusion is in accordance with the suggestion of Piccoli (1984) and Piccoli et al. (1986) and may help in the correlation of these main provinces.

The data may contribute to a discussion on the Early Eocene paleogeography of the Eocene in the Tethyan realm. The similarity of the Early Eocene Molluscan fauna in the middle-eastern Tethys to that of further western Tethys basins and of the major oceans may indicate that these were already connected and that the former was shallow water, as was the Indo-Pacific.

In conclusion, the results of our new data can be summarised as follows:

1. Age determination using molluscan fauna data from a Yoncalı Formation within the Early Tertiary sedimentary sequences of the Çankırı Basin seems to indicate the presence of Early Eocene (middle-late Cuisian) mollusc assemblages from the decapod beds around the Yerköy area. This age is further confirmed by data from nummulites and serpulids.
2. The molluscan assemblage and associated biota suggest warm shallow-marine conditions

during middle-late Cuisian time. Essentially, these beds are interpreted to represent more shallow water facies.

3. The new data suggest that during the Early Eocene the Tethyan oceans in the east and west were not isolated; they were shallow water and connected to the Indo-Pacific ocean areas.

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GENİŞLETİLMİŞ ÖZET

Orta Anadolu'nun önemli havzalarından biri olan Çankırı Havzası Tersiyer süresince, Torid/Anatolid ve Sakarya kıtaları arasında yer alan bir çarpışma havzası olarak şekillenmiştir (Tüysüz ve Dellaloğlu, 1992). Havzanın güney sınırı boyunca, Yozgat-Yerköy arasında, Tersiyer yaşlı havza dolgusu egemen olarak karasal ve sığ denizel fasiyestedir ve Geç Kretase yaşlı Yozgat magmatiklerini veya volkanik seriyi uyumsuzlukla örter. Yoncalı formasyonu (sığ denizel kumtaşları, şeyller ve kireçtaşı mercekleri), İncik formasyonu (karasal konglomeralar ve kumtaşları) ve Bayat formasyonu (karasal lavlar ve proklastik kayalar) Erken-Geç Eosen yaşlıdır ve birbirleriyle yanal ve düşey geçişlidir (Erdoğan vd. 1996; Akgün vd. 2002). Yozgat-Yerköy İlçesinin güneyinde Pöhrenk Köyünün 1km KD da bulunan çalışma alanında, daha önceki yıllarda yapılmış olan çalışmalarla decapoda-yengeç fosilleri (Harpactocarcinus yozgatensis Schweitzer et al., 2007) ile birlikte annelid polychaetelerden bir tür (Rotularia spirulaea Lamarck, 1818) tanımlanmıştır (Hoşgör ve Okan, 2006). Bölgeye yapılan son arazi çalışmasında ise yengeç fosillerinin egemen olduğu seviyede mollusklar bulunmuştur. Yoncalı Formasyonu'nun orta kesimlerinden alınan mollusklardan, altı bivalv türü: Atrina affinis (Sowerby, 1821), Chlamys solea (Deshayes, 1824), Cardita (Venericardia) aizyensis Deshayes, 1860, Chama fimbriata Defrance, 1817, Panopea gastaldii Michelotti, 1861 ve Corbula (Bicorbula) gallica Lamarck, 1805, dört gastropod türü: Velates perversus (Gmelin, 1789), Rimella fissurella (Linne, 1758), Calyptraea (Trochita) aperta (Solender, 1766) ve Globularia vapincana (d'Orbigny, 1850) ve bir skapod türü: Dentalium montense Briart ve Cornet, 1887 tanımlanmıştır. Çalışılan birim harpactocarcinidler ile birlikte kumtaşı, pelajik çamurtaşı ve kireçtaşından oluşmuştur. Birimin yaşı bentik foraminiferlerden Nummulites distans Deshayes (A ve B formları), Assilina laxispira Dela Harpe'ye dayanarak SB 11-12 zonuna karşılık gelen Erken Eosen (orta-geç Küviziyen)'dir. Molluskların birlikte bulunduğu diğer fosil toplulukları ise bentik foraminiferler, serpulidler, tanımlanamamış ekinitler ve köpekbalığı dişleridir. Bivalv, gastropod ve skapodların dağılımları incelendiğinde, çalışma alanının paleocoğrafik yapılanmada Doğu Avrupa bölgesinin bir parçası olduğunu gösterir. Tetis Bölgesi ele alındığında Paleosen sonundan Erken Eosen'e kadar Tetis'in orta Anadolu ve Hint-Pasifik bölgesiyle de bağlantılı olduğu bentik organizmaların yayılımıyla ortaya çıkmaktadır.

PLATE 1

Figure 1. ***Atrina affinis*** (Sowerby, 1821), right valve, AUY07101.

Figure 2. ***Chlamys solea*** (Deshayes, 1824), left valve, AUY07102.

Figures 3-4. ***Cardita (Venericardia) aizyensis*** Deshayes, 1860

3. right valve, internal view,

4. right valve, external view, AUY07103.

Figures 5-6. ***Chama fimbriata*** Defrance, 1817

5. left valve, external view,

6. left valve, internal view, AUY07104.

Figure 7. ***Panopea gastaldii*** Michelotti, 1861, left valve, AUY07106.

Figures 8-9. ***Corbula (Bicorbula) gallica*** Lamarck, 1805

8. dorsal view,

9. left valve, external view, AUY07105.

(Scale bars 10 mm).

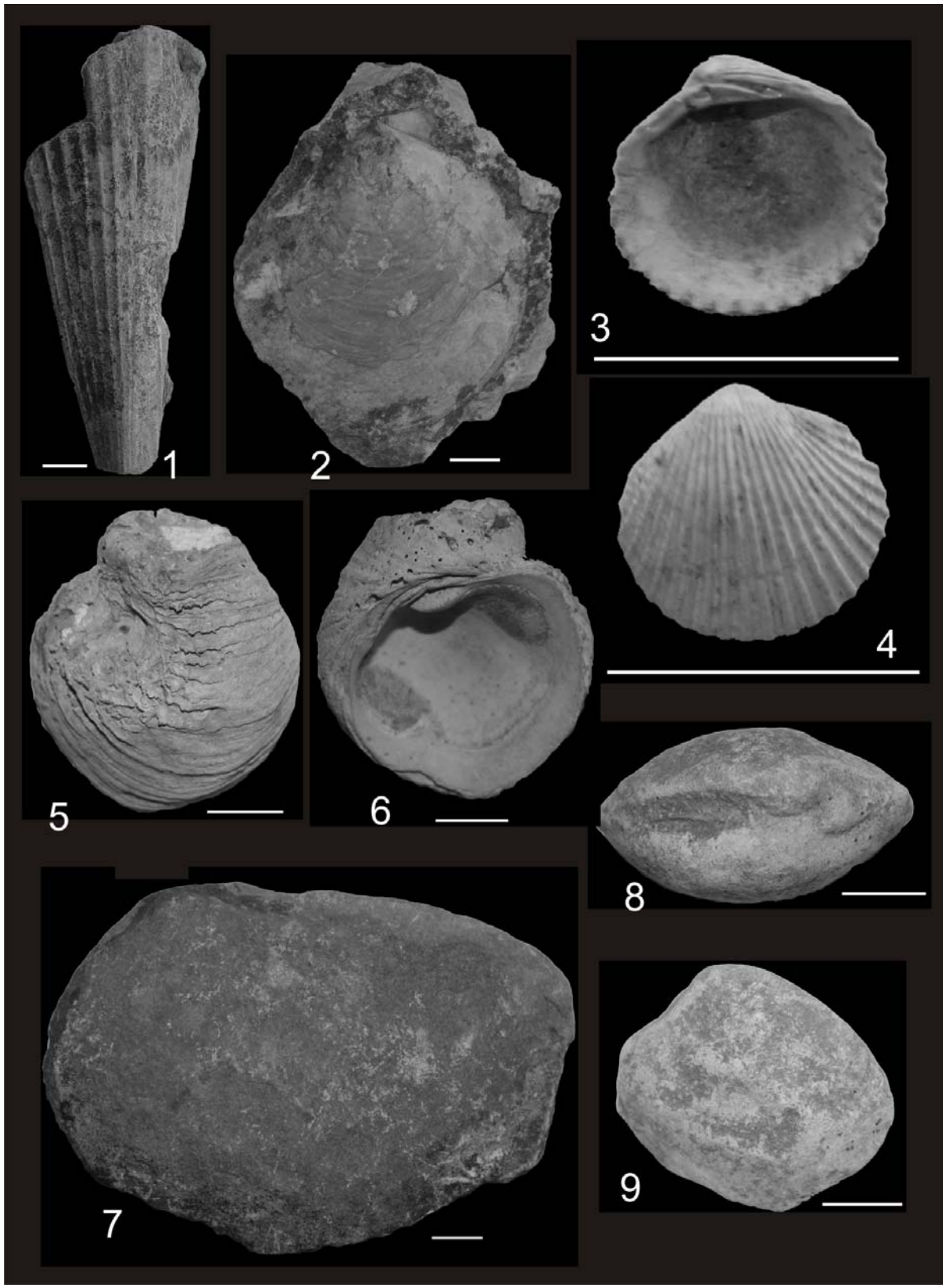
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PLATE 2

Figure 1-8. ***Velates perversus*** (Gmelin, 1789)

1. abapertural view showing spiral surface,

2. apertural view, AUY07106

3. abapertural view, AUY07107

4. abapertural view, AUY07108

5. abapertural view,

6. apertural view,

7-8. polished section showing thin shell in apertural area of last whorl, layers deposited, internally in spiral area, thick callus on apertural face and very thick callus around ablabral margin, AUY07109.

(Scale bars 10 mm).

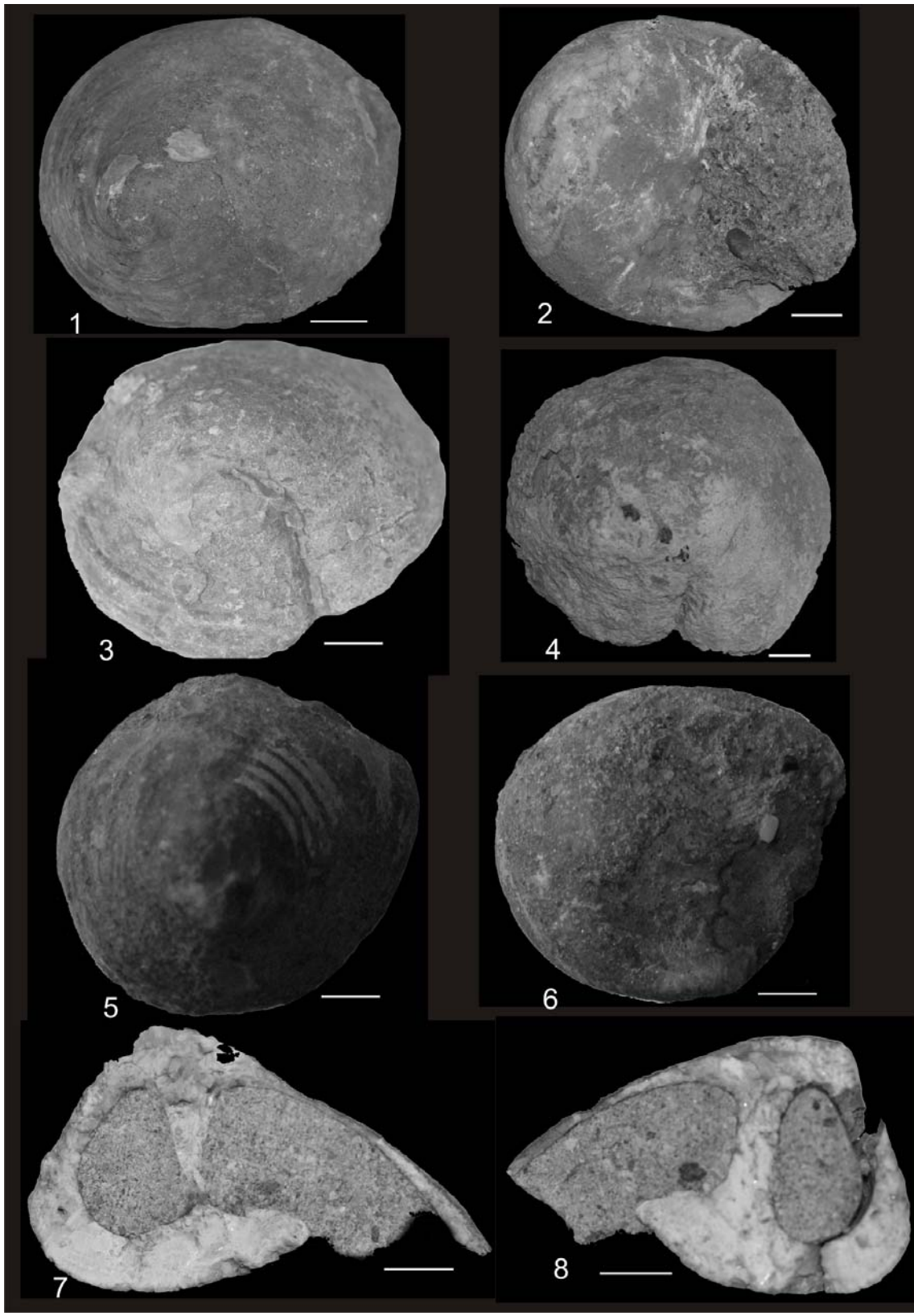
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PLATE 3

Figure 1-4. ***Calyptraea (Trochita) aperta*** (Solender 1766)

1. apical view, AUY07110.

2. apical view, AUY07111.

3. apical view,

4. apertural view, AUY07112.

Figure 5-6. ***Rimella fissurella*** (Linne, 1758).

5. abapertural view,

6. apertural view, AUY07113.

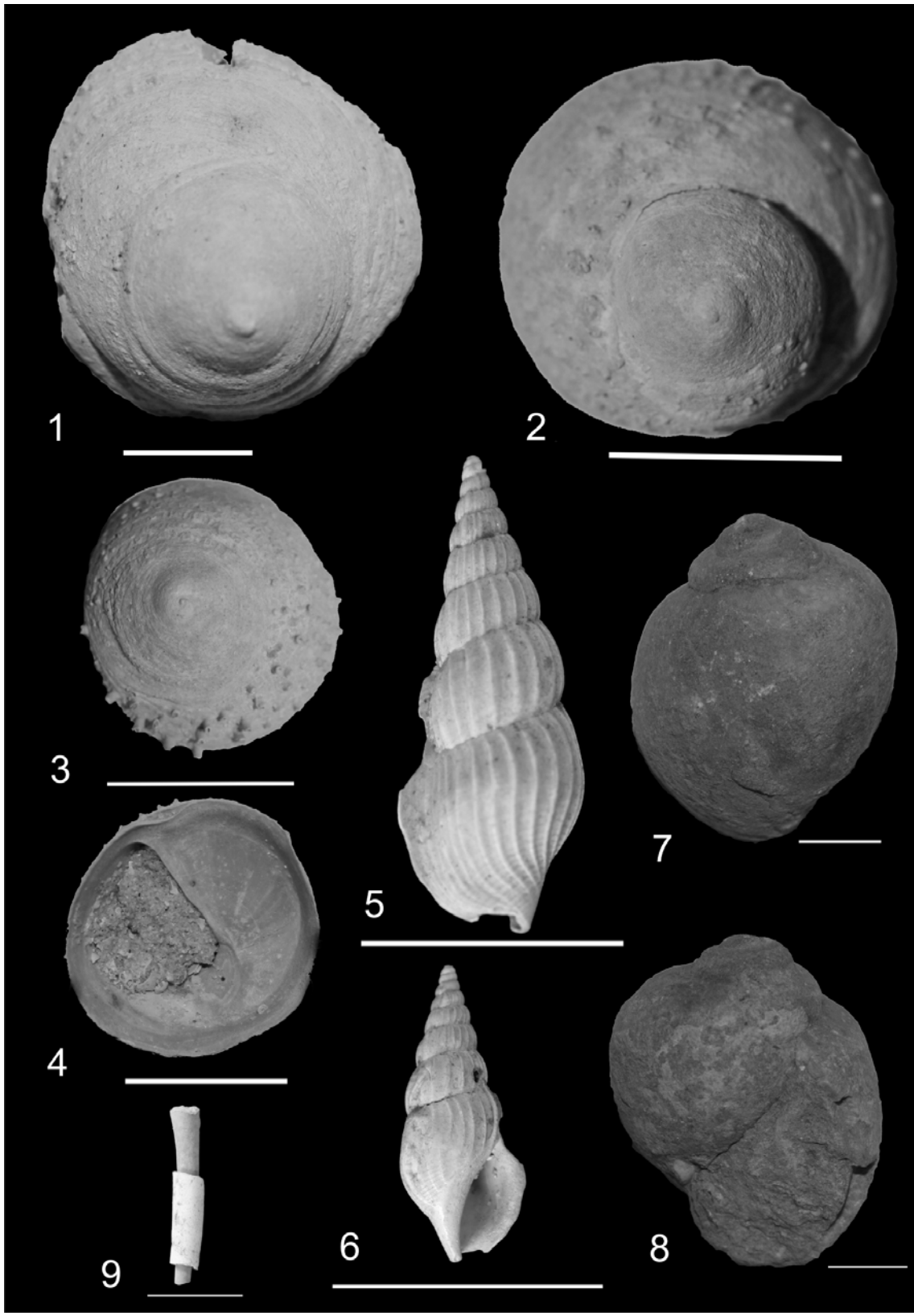
Figure 7-8. ***Globularia vapincana*** (d'Orbigny 1850).

7. abapertural view,

8. apertural view, AUY07114.

Figure 9. ***Dentalium montense*** Briart and Cornet, 1889, AUY07115.

(Scale bars 10 mm).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