Introduction

Late Palaeocene gastropods of Turkey, particularly from NW and Central Anatolia, are not well-studied and there are very few articles dealing with the taxonomy and stratigraphy of this group. Stchépinsky (1941) summarized and reported ten species from the Kocaeli region of NW Anatolia. Recently Okan & Hoşgör (2008) listed four ampullinid gastropod species from the Polatlı region (Late Thanetian–Early Ilerdian). In contrast, Early Eocene (Cuisian) gastropod faunas from NW Anatolia (Stchépinsky 1946) and from Central Anatolia (Çankırı Basin) have recently been intensively studied (Okan & Hoşgör 2009). The gastropod record is particularly incomplete, with most discoveries represented by isolated spine and shell fragments. The earliest known Cenozoic Angaria [Angaria polyphylla (d’Orbigny 1850)] is from the Early Palaeocene (Danian) of the Paris Basin in France (Pacaud et al. 2000). Here we describe the first discoveries from Kırkkavak hill, representing the first definitive record of angariids in Turkey. The age of the formation is supported by the foraminiferal-red alga assemblages at this locality.

Geological Background

A number of Late Cretaceous–Tertiary sedimentary basins formed in many localities on the Tauride-Anatolide Platform. The basins in the central eastern part of the platform were formed during Late Cretaceous–Early Tertiary time (Şengör & Yilmaz 1981; Yıldız et al. 2001; Okan & Sirel 2008; Okan & Hoşgör 2009). The Haymana-Polatlı Basin is located about 70 km SW of Ankara in Central Anatolia. The material was sampled from the Kırkkavak hill (Figure 1) section of the Upper Cretaceous–Middle
Eocene forearc sequence of the Haymana-Polatlı Basin succession (Koçyiğit 1991), which includes extremely fossiliferous shallow marine beds. The Lower Cenozoic sediments are rich in marine fossil microbiota and consist of various rock types. The Palaeocene to middle Eocene parts of the basin sequence are characterized by abundant and diverse nummulitids and alveolinids (Özcan et al. 2007). Molluscs are locally abundant in some horizons, scarce in others (Stchépinsky 1941; Erünal 1942; Okan & Hoşgör 2008). Many researchers have focused on the stratigraphy, tectonics and general geology of the area due to the importance of the Haymana Basin sequence in terms of oil potential. Such studies were carried out in different parts of the basin (Figure 2).

The investigated outcrop is situated near Karahamzalı Village, 13 km south of Polatlı (SW Ankara) (1: 25000 scale topographic sheet-J28-a2). The section starts from Karahamzalı Village and extends to the north of Kırkkavak hill (Figure 1). The Palaeocene sequence, up to 900 m thick, unconformably overlies Upper Jurassic rocks and can be divided into two conformable units, both attributed to the Danian–Thanetian (Sirel 1975, 1998, 2009; Sirel & Acar 2008). The lower part of the sequence comprises a conglomerate, sandstone, marl and limestones (Kartal Formation, Danian–Selandian), while the upper part consists of yellowish, thick-bedded limestones with sandy marl interbeds (Kırkkavak Formation, Thanetian). The present gastropod inventory is based mainly on sandy and clayey limestones outcropping in the Kırkkavak section (Figure 3). The Kırkkavak section, measured northeast of Kırkkavak hill southwest of Karahamzalı Village (Figure 1), is the type locality of *Angaria calvii* n. sp. This section, containing only Thanetian rocks, is composed of limestones, sandy and clayey limestones (Figure 3).

**Micropalaeontology and Palaeoenvironment**

The age of Lower Palaeogene shallow-marine carbonate successions of the Haymana-Polatlı Basin has usually been determined using the very rich fauna of larger foraminifera (Dizer 1968; Sirel 1975, 1998, 2009; Sirel et al. 1986; Özcan et al. 2001; Özcan 2002). The sediments of the Kırkkavak Formation yielded numerous foraminifera that could be studied in thin section (Figure 4). The sediments containing them were collected in association with the gastropods described herein (Figures 3 & 4). The benthic foraminifera include *Smoutina subsferea, Nummulites heberti, Spherogypsina globula, Quenqueloculina* sp.,

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*Figure 1.* Location, geological map and field photographs of Kırkkavak hill (Okan & Sirel 2008).
Other fossils that are recognizable in thin section include calcareous red algae and bryozoa. A particular Palaeocene element is Distichoplax biseralis, a taxonomically uncertain calcareous red alga (Lithophylloideae) that is generally restricted to this time interval (Rasser et al. 2005).

Serra-Kiel et al. (1998) defined twenty shallow-water benthic foraminiferal biozones (SBZ 1–20) in the Tethyan Palaeocene and Eocene. The age of the studied section in the Kırkkavak Formation, determined by the rich assemblage of foraminifera, is well constrained. The foraminifera indicate a Late Palaeocene (early Thanetian) age. This age corresponds to the SBZ 3 benthic foraminiferal zone based upon the Serra-Kiel et al. (1998) scheme.

Benthic foraminifera were the most common constituents of Upper Palaeocene–Lower Eocene shallow-marine carbonates. The foraminiferal and calcareous red algae assemblage are supposed to bear photosymbiotic microalgae, which explains their maximum abundances in oligotrophic, tropical shallow-marine environments. Additionally, the problematic alga Distichoplax biseralis and the well-sorted components suggest deposition in a high-energy shallow marine environment (Rasser et al. 2005; Scheibner et al. 2007). Most of the trochoids can be interpreted as inhabitants of hard substrates of coral reefs or other shallow-water oligotrophic habitats, where they scraped algae (see Harzhauser 2004).

Systematic Palaeontology

Figured material is housed in the Paleontological Collections of the Geological Department of Ankara University, with specimen numbers prefix AU08. OI. The systematic study follows the classification of Hickman & McLean (1990) and Bouchet & Rocroi (2005).

Class Gastropoda Cuvier 1797
Subclass Orthogastropoda Ponder & Lindberg 1997
Order Vetigastropoda Salvini-Plawin 1989
A NEW SPECIES OF ANGARIID GASTROPOD, TURKEY

Superfamily Trochoidea Rafinesque 1815
Family Turbinidae Rafinesque 1815
Subfamily Angariinae Thiele 1924
Genus Angaria Röding 1798


*Angaria calvii* n.sp.
Plate 1 (Figures a–f)

Derivation of Name. In honor of Prof. Dr. Wilhelm Salomon-Calvi, the founder of the Geological Department of Ankara University.

Type Material. Holotype and paratype from the type locality.

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**Figure 3.** Measured stratigraphic section and distributions of benthic foraminifera, calcareous red algae (Lithophyloideae) and *Angaria calvii* n. sp., in the early Thanetian of the study area.

Holotype. The specimen illustrated on Plate 1, Figures a–c. 08.K.2.1.

Paratype. The specimen illustrated on Plate 1, Figures d–f. 08.K.11.1.

Age. Kırkkavak Formation, early Thanetian.

Geographic Distribution. Known only from the type locality.
Dimensions. Holotype 08.K.2.1: Height: 4.4 mm, Width: 5.8 mm, Height of the last whorl: 2.6 mm, Height of the aperture: 2.1 mm. Paratype 08.K.11.1: Height: 6 mm, Width: 8.6 mm, Height of the last whorl: 4 mm, Height of the aperture: 3.1 mm.

Description. Shell small, rather thick, evenly convex, with three to four rapidly increasing penultimate whorls. Spire low, slightly elevated. Body whorl large and ornamented with wavy keel at the periphery of the whorl. Suture deep with a flat sutural ramp ornamented with angular rows of undulate striae on the teleoconch whorls. Last whorl descends to aperture. Aperture circular, inner lip and outer lip smooth. A wide and deep umbilicus; the umbilical margin is broadly dented.

Diagnosis. Shouldered whorls with pronounced spines at the periphery, sutures deep, wide umbilicus with dentitions.
Discussion. The superfamily Trochoidea has been described as the diverse clade within the Vetigastropoda, and as one of the most diverse among all marine gastropods. Trochoideans have an extensive fossil record, thought to extend back at least as far as the Middle Triassic (Hickman & McLean 1990). Angaria polyphylla (d'Orbigny 1850) (Pacaud et al. 2000; figure 2.6) which is strongly reminiscent of the Paris Basin (Vigny) shells in its spire whorl shape, differs obviously in its spiral ornamentation at the adapical suture, and the less rapidly increasing whorls. Angaria pakistaniaca Eames 1952 from the Eocene of Pakistan is larger and differs in having a broad-conical shape. Angaria calvii n. sp. is similar to Angaria apenninica (Sacco 1896) from the Early Oligocene strata in Western Tethys from France, Italy, Greece and as far east as Iran, but differs in having a smaller shell, ornamentation on the upper surface of the shouldered whorls and strong spines on the peripheral angulation of the body whorl. The new species somewhat resembles Angaria (Angaria) scobina (Brongniart 1823) from the early Oligocene of Romania (Moisescu 1972; p. 69, plate 36, figure 8) but differs in having a deep sutures, strong spines, and a wide umbilicus.

Conclusions and Palaeobiogeographic significance of the new species
The present paper presents Angaria calvii n. sp. from the Kırkkavak Formation of the Haymana-Polatlı Basin near Ankara, Central Anatolia in the Mediterranean Alpine fold belt. The genus Angaria has been reported sporadically in Eurasia, E. Africa and Australia within shallow warm-water faunas from Middle Jurassic to Recent, with a significant radiation since the Eocene to early Miocene (Piccoli 1984). Known Palaeogene occurrences of Angaria within the Tethys-Mediterranean region (Palaeocene–Early Oligocene) are summarized graphically in Figure 5, based on Cossmann (1915), Martin (1931), Eames (1952), Moisescu (1972), Llompart (1977), Piccoli & Savazzi (1983), Baldi (1986), Bonci et al. (2000), Pacaud et al. (2000), Harzhauser & Mandic (2001) and Harzhauser (2004). These works focus mainly on Old World Cenozoic Angaria species. Angaria has been variously reported as ranging from Early Palaeocene–Danian [Angaria polyphylla (d’Orbigny 1850)] to Early Oligocene (Figure 5). Angaria calvii n. sp. provides the first evidence that representatives of the family Turbinidae belonging to the genus Angaria lived in Turkey in the Late Palaeocene. This suggests that central Anatolia was located on the east-west migration route (Figure 5) of the Late Palaeocene–Eocene Angaria species.

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References
A NEW SPECIES OF ANGARIID GASTROPOD, TURKEY


PLATE 1

(a) – (f) Angaria calvii n. sp., Holotype: (a) apical view, (b) lateral view, (c) basal view 08.K.2.1, Paratype: (d) apical view, (e) lateral view, (f) basal view 08.K.11.1. (scale bars 10 mm).