

The Ampullinid Gastropod *Globularia* (Swainson 1840) from the Late Thanetian–Early Ilerdian Kırkkavak Formation (Polatlı-Ankara) of the Tethyan Realm

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Abstract: Ampullinid gastropods are useful in correlating the Palaeogene marine strata of Central Anatolia. Ampullinid gastropods are found in the Late Paleocene–Early Eocene Kırkkavak Formation in the Macunköy area (Polatlı, west of Ankara). In the Haymana-Polatlı Basin, a variety of *Globularia* (Swainson 1840) species is described from the upper part of the Kırkkavak Formation, including *G. sireli* n.sp. The other taxa are *G. vapincana* (d'Orbigny 1850), *G. grossa* (Deshayes 1864) and *G. crassatina* (Lamarck 1804). The Kırkkavak fauna is known in western and central Europe, and central Asia. Some of the ampullinid gastropods and associated cerithid and neritid gastropods as well as bivalves are conspecific with forms from the Palaeogene of Europe and central Asia. The palaeobiogeographical affinity of the ampullinid *Globularia* fauna is typically Tethyan, with many taxa that are known particularly from western-central Tethys. The inferred palaeo-environment, as implied by the ampullinids, is a shallow shelf.

There is a marked stratigraphic lag between the first appearance of *Globularia* species in central Anatolia in the Late Paleocene–Early Eocene, and the later documented appearance of the genus in the Early Eocene–Early Oligocene in Europe. This suggests that central Anatolia was located on the westward migration route of the Early Eocene ampullinid faunas.

Key Words: *Globularia*, Late Paleocene–Early Eocene, Kırkkavak Formation, Turkey

Tetis Bölgesi Kırkkavak Formasyonu'nda (Polatlı-Ankara) Geç Tanesiyen–Erken İlerdiyen Ampullinid Gastropod *Globularia* (Swainson 1840)

Özet: Orta Anadolu'da denizel Paleojen katlarının karşılaştırılmasında ampullinid gastropodlar kullanılabilir. Macunköy bölgesinde (Orta Anadolu) Kırkkavak Formasyonu'nda Geç Tanesiyen–Erken İlerdiyen'de ampullinid gastropodlar bulunmuştur. Haymana-Polatlı Havzası içinde Kırkkavak Formasyonu'nun üst kesimlerinde değişik *Globularia* (Swainson 1840) türleri içinde *Globularia sireli* n.sp. de tanımlanmıştır. Diğerleri, *G. vapincana* (d'Orbigny 1850), *G. grossa* (Deshayes 1864) ve *G. crassatina* (Lamarck 1804)'dir. Batı Avrupa, Orta Avrupa ve Orta Asya'da iyi bilinen fauna Kırkkavak Formasyonu'nda da tanımlanmıştır. Ampullinid gastropodlar ile birlikte bulunan cerithid ve neritid gastropodlar ve bivalvler de, Avrupa ve Orta Asya'da Paleojen için belirteç fosillerdir. Sığ bir şelf ortamını işaret eden ampullinidler, paleobiocoğrafik olarak batı-orta Tetis için, Tetis'in iyi bilinen formlarını içermektedir.

Orta Anadolu'da *Globularia* türleri stratigrafik olarak Geç Paleosen–Erken Eosen için belirleyici olsalarda, Avrupa'da Erken Eosen'den Erken Oligosen'e kadar etkilidirler. Orta Anadolu'nun ampullinid gastropod faunasının batıya doğru göçünde önemli bir bölge olduğu düşünülebilir.

Anahtar Sözcükler: *Globularia*, Geç Paleosen–Erken Eosen, Kırkkavak Formasyonu, Türkiye

Introduction

The ampullinid gastropods were important benthic fossils in shallow marine and marine-brackish environments during Palaeogene time. They are well known in the Tethys region in Palaeogene formations from France, Italy, Germany, Bulgaria, Romania, Poland, Serbia and other Alpine regions further east (Cossmann 1889, 1925; Bontscheff 1896; Oppenheim 1896, 1903; Cossmann & Pissaro 1900, 1910, 1911; Malaroda 1954; Meszaros 1957; Vlaicu-Tătărim 1963; Karagiuleva 1964; Pavic

1970; Moiescu 1972; Anderson 1975; Krach 1981; Amitrov 1994). Along with foraminifers, corals, molluscs, echinoderms, annelids and decapods, they are common constituents of Palaeogene rocks in central Anatolia (Stchépinsky 1941, 1946; Erünel 1942; Sirel 1975, 1976a, b, 1998; Özcan 2002; Hoşgör & Okan 2006; Okan & Hoşgör 2007; Özcan *et al.* 2007; Schweitzer *et al.* 2007). Many ampullinids occur in carbonate rocks, recording deposition in warm, relatively shallow-water and brackish water in tropical to subtropical

environments. Despite their local abundance, only a few monographic studies, such as Stchépinsky (1941, 1946) and Erünal (1942) are devoted to the Palaeogene molluscs of central Anatolia. Paleocene–Eocene, marine macrofossil-bearing strata display a patchy distribution throughout Anatolia. Some of the best-known units are the Thanetian–Cuisian beds exposed at Polatlı, central Anatolia (Stchépinsky 1941; Erünal 1942; Sirel 1975, 1976a, B, 1998; Ünalın *et al.* 1976; Özcan 2002; Çolakođlu & Özcan 2003; Özcan *et al.* 2007). Polatlı is located in the southwestern part of Ankara. In this region, Palaeogene molluscs are found at a single locality near the village of Macunköy (Figure 1), close to the northwestern margin of the Haymana-Polatlı Basin. The locality has been extensively sampled during previous years by the authors, resulting in the recovery of rich bivalve, ampullinid, cerithid and nerithid gastropod as well as bivalve faunas.

Globularia Swainson 1840, is synonymous with *Natica* Scopoli 1777 and *Ampullina* Deshayes 1830, and these synonyms have been used in lieu of *Globularia* by nearly every worker who has dealt with this gastropod. The genus has been studied in detail by Wrigley (1946), Karagiuleva (1964), Moisescu (1972). Kranz (1910), Popescu-Voitești (1910), Boussac (1911), Cossmann & Pissaro (1911), Gocev (1933), Furon & Soyer (1947), Meszaros (1957) and Vlaicu-Tatarim (1963) focused on '*Natica*' and '*Ampullina*' species from the Mediterranean area. In the present study, the authors describe *G. vapincana* (d'Orbigny 1850), *G. grossa* (Deshayes 1864), *G. crassatina* (Lamarck 1804) and *G. sireli* n.sp. as the representatives of the Ampullinidae Cossmann 1918 family, collected from the Late Thanetian–Early Ilerdian formations of the Polatlı region, and discuss their palaeobiogeographical distribution.

Stratigraphy and Geological Setting

The Haymana-Polatlı Basin in central Anatolia is an accretionary fore-arc basin formed by the destruction of the Neo-Tethys during the Late Cretaceous to Middle Eocene (Koçyiđit 1991). The basin is located approximately 70 km SW of Ankara in Central Anatolia and has a highly deformed, largely turbiditic sedimentary fill which is more than 5000 m thick in the centre of the basin. Different depositional conditions are shown toward the northwestern margin of the basin, where shallow and

marine clastics, reef carbonates, lacustrine and fluvial deposits were deposited (Ünalın *et al.* 1976; Ünalın & Yüksel 1978; Çiner *et al.* 1996). The sampled material is derived from fossiliferous shallow-water beds of this nearshore facies of the Haymana-Polatlı Basin. The section near the Macunköy area (Figure 1), records a transgressive interval where marine sediments were deposited over coarse terrestrial clastics, and contains abundant benthic foraminiferal associations and molluscan communities.

In the Polatlı region, the early Palaeogene portion of the succession includes mainly continental clastics of the Kartal Formation and shallow-marine clastic-carbonate units of the Kırkkavak Formation. The extensive Kartal Formation, assigned to the early Paleocene based on benthic foraminifera identified only in the lower part of the unit (Sirel 1975; Ünalın *et al.* 1976; Çolakođlu & Özcan 2003), is unconformably overlain by the Kırkkavak Formation with typical Thanetian benthic foraminifera. The 100-m-thick Kırkkavak Formation consists of friable siltstones, sandstones, limestones, conglomerates, and marls. The Paleocene and Eocene sequences in the Haymana-Polatlı Basin contain good reference sections, which can be compared to established benthic foraminiferal biozonations. The larger benthic foraminifera in the shallow-marine parts of these deposits primarily include nummulitids, orthophragmines and alveolinids that are usually found in many of the described stratigraphic sections (Sirel 1975, 1976, 1998; Çolakođlu & Özcan 2003; Özcan *et al.* 2007). For benthic Early Tertiary biozones the stage names 'Ilerdian' and 'Cuisian' are commonly used in Turkey (Figure 2). Ilerdian overlaps with the late Thanetian and early Ypresian (Early Eocene), and Cuisian correspond to the late Ypresian (Berggren *et al.* 1995; Serra-Kiel *et al.* 1998). A Late Paleocene–Early Eocene (Thanetian–Ilerdian) age determination of the lowest unit of the Kırkkavak Formation was based on larger benthic foraminifera (Sirel 1975, 1976, 1998) (Figure 2). The top part, rich in bivalves and gastropods found mainly in siltstones, marls, sandstones and argillaceous limestones, represents the final phase of shallow and marine sedimentation in the region.

Material, Preservation and Taxonomic Composition of the Studied Ampullinid Gastropod Fauna

Globularia gastropods occur abundantly in marl and sandstone facies. The material consists of poor to

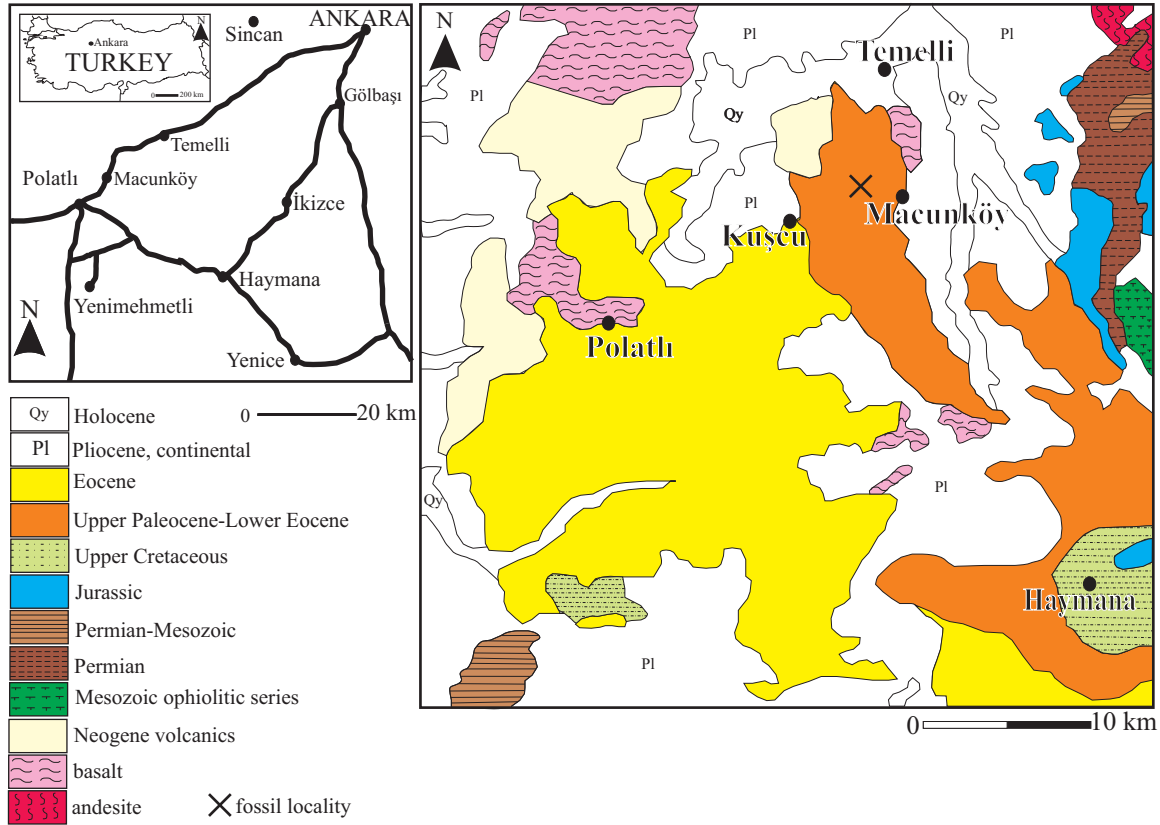


Figure 1. Location and geological map of the Macunköy area (after Erentöz 1975).

moderately well-preserved moulds. Fossils of *Globularia*, used in this study, were collected from the Kırkkavak Formation (Figure 3) from a section that lies in J28-c₁ quadrangle, northwest of the Macunköy area, and has been measured between X_1 : 88375, Y_1 : 40075, and X_2 : 88750, Y_2 : 40175 coordinates: its thickness is approximately 8.5 m).

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

In order to quantify morphologic variations, six shell parameters were used: height of shell (H) parallel to axis of coiling; maximum width (or maximum diameter) of shell (D), normal to axis of coiling; height of the last whorl (H_l); height of the aperture (H_a); and number of teleoconch whorls. The following abbreviations were used to describe the protoconch: dp is the maximum diameter and n is the diameter of the nucleus (Figure 4). To facilitate comparisons, certain measurements were combined into

ratios of shell height to width and total number of whorls, and height of last whorls (Figure 5).

In the ampullinid gastropods from the Macunköy area, which includes more than 100 complete specimens, several taxonomic groups are represented by numerous specimens, which show intraspecific morphologic variability. In addition to the complete specimens, there are numerous incomplete specimens damaged during extraction from the host rock. The macrofossils are represented mainly by gastropods and bivalves, among which the oysters are the most abundant group. Excluding oysters, which occur stratigraphically below the beds with *Globularia*, the fossils are predominantly gastropod shells. In addition to the four species of *Globularia*- *G. vapincana* (d'Orbigny 1850), *G. grossa* (Deshayes 1864), *G. crassatina* (Lamarck 1804) and *G. sireli* n.sp., the following gastropod taxa – are also recognized: *Campanile tchihatcheffi* d'Archiac 1850, *Cepatia cepacea* (Lamarck 1804), *Velates perversus* (Gmelin 1789), *Cerithium archiaci* Hebert & Renevier

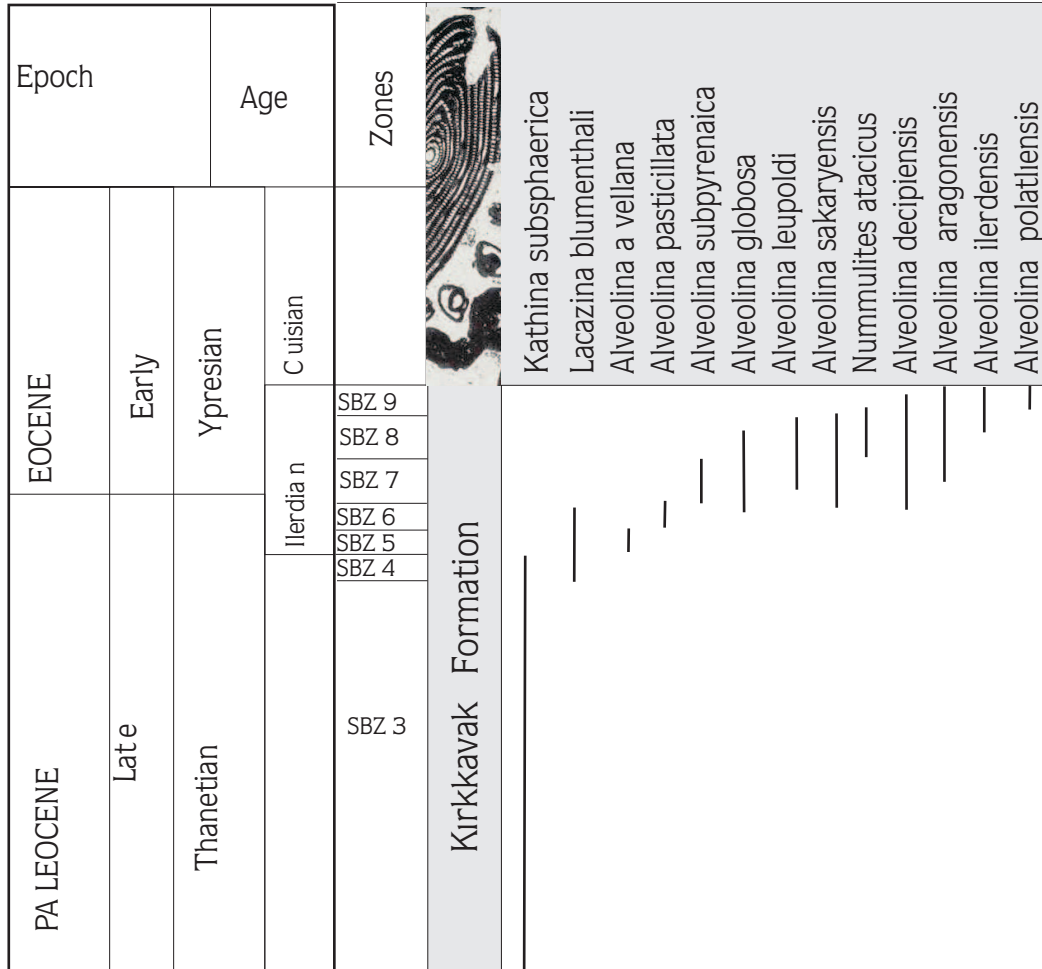


Figure 2. Late Paleocene–Early Eocene geochronology with local age names used in the stratigraphic columns and stratigraphic distribution of characteristic foraminifera of Kırkkavak Formation (Sirel 1976a, b; Berggren *et al.* 1995; Serra-Kiel *et al.* 1998).

1854, *Batillaria diacanthina* Cossmann 1899, and *Cerithium fodiatum* Bellardi 1852 (Figure 6).

The ampullinids from the Macunköy area are better preserved and more abundant than the other gastropods; hence this paper discusses the *Globularia* species.

Systematic Palaeontology

The systematic arrangement of higher taxa largely follows the scheme proposed by Lozouet *et al.* (2001), and Bouchet & Rocrai (2005).

- Class Gastropoda Cuvier 1797
- Subclass Orthogastropoda Ponder & Lindberg 1995
- Superordo Caenogastropoda Cox 1960
- Ordo Architaenioglossa Haller 1892
- Superfamily Ampullinoidea Cossmann 1918
- Family Ampullinidae Cossmann 1918
- Genus *Globularia* Swainson 1840

Type Species. *Ampullaria sigaretina* Lamarck 1804, from the Eocene of Europe.

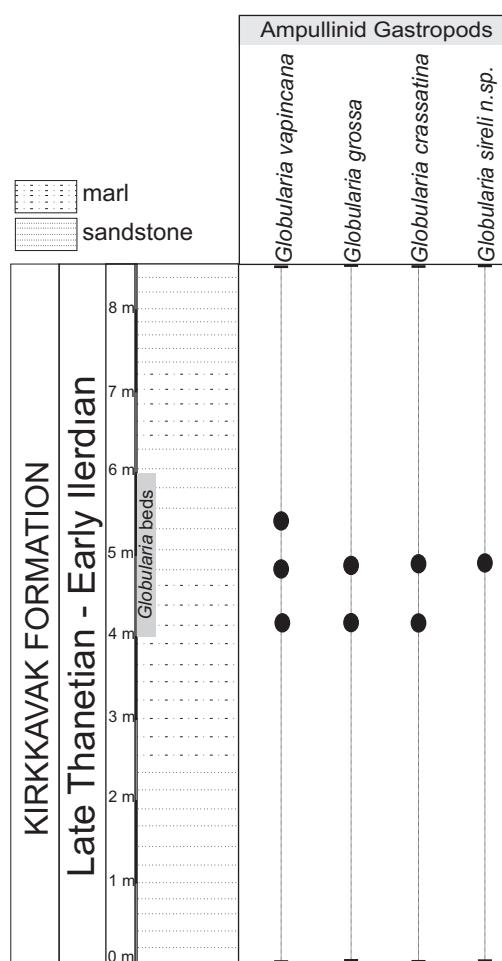


Figure 3. Measured section of Macunköy area, with stratigraphic ranges of all identified *Globularia* species.

Globularia vapincana (d'Orbigny 1850)

Plate I (a)–(i)

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, figs. 1–9.

Figured Specimens. AUPM. 0601, AUPM. 0603, AUPM. 0604.

Horizons and Localities. Macunköy area, Polatlı, Turkey, sandstone and marl units, level 4–5.5 m.

Dimensions. (Measurements in millimetres)

Specimen	H	HI	Ha	D	n	dp
AUPM. 0601	45	36	29	32	1	1.4
AUPM. 0602	36	30	25	29	0.9	1.2
AUPM. 0603	60	50	41	43	1	1.5
AUPM. 0604	43	31	29	29	0.9	1
AUPM. 0605	46	39	33	38	1	1.3
AUPM. 0606	52	42	34	37	1	1.2
AUPM. 0607	42	33	28	34	1	1.1
AUPM. 0608	44	34	30	36	1	1.2
AUPM. 0609	57	49	39	38	–	–
AUPM. 0610	54	45	39	42	–	–
AUPM. 0611	38	33	26	27	0.8	1
AUPM. 0612	45	36	27	30	0.7	0.8
AUPM. 0613	33	29	21	24	0.6	0.7
AUPM. 0614	42	36	31	34	0.9	1
AUPM. 0615	41	34	30	35	1	1.2
AUPM. 0616	70	63	53	54	2	2.3
AUPM. 0617	42	33	30	34	–	–
AUPM. 0618	45	36	31	34	0.9	1

Description and Discussion. Shell globose, large, spire low, body whorl greatly inflated, slightly rounded; shell thick, number of whorls about 5–6, whorl profile gently rounded with a tendency for the last volution to be slightly flattened on the posterior half of the whorl, suture moderately impressed.

Many species of *Globularia* have been described from the Palaeogene strata of the Tethys realm. *Globularia* was considered to be synonymous with *Natica* Scopoli 1777 and *Ampullina* Deshayes 1830 by d'Orbigny (1850), Bayan (1873), Boussac (1911), Cossmann & Pissaro (1911),

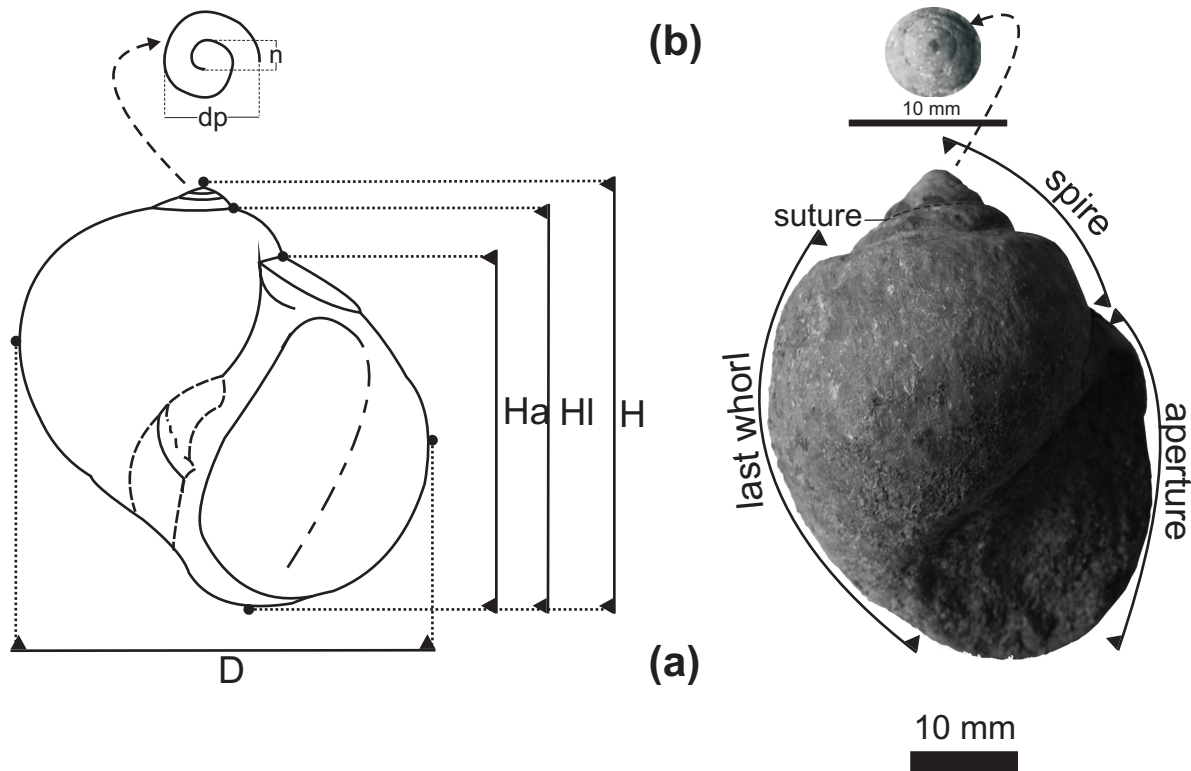


Figure 4. Measurements taken from the shell of the *Globularia* species. (a) Teleoconch. Abbreviations: H– maximum height (mm); HI– height of the last whorl (mm); Ha– height of the aperture (mm); D– maximum diameter (mm). (b) Protoconch. Abbreviations: dp– maximum diameter (mm); n– diameter of the nucleus (mm).

Furon & Soyer (1947), Meszaros (1957) and Vlaicu-Tatarim (1963) but Wrigley (1946) and Karagiuleva (1964) treated it as a distinct genus because: *Ampullina sigaretina* Lamarck 1804 (Deshayes 1824, p. 170, pl. 21, figs. 5–6; Cossmann & Pissarro 1902, p. 219, pl. 23, fig. 25), the type species of *Globularia*, from the Eocene of Europe, has a straight inner lip whereas that of *Globularia* has a distinctly larger last whorl and conspicuous carination.

Despite the Eocene age of the type of *Globularia vapincana*, we believe that our Turkish specimens are conspecific or very closely related because they are very similar to the specimens figured by Karagiuleva (1964).

The most similar species is *Globularia (Globularia) vulcani* (Brongniart 1864) (Karagiuleva 1964, p. 175, pl. 49, fig. 4), which differs from the *Globularia vapincana* (d'Orbigny 1850) in having a less distinctive carination and higher whorls of the spire.

Globularia grossa (Deshayes 1864)

Plate I (j)–(l), Plate II (a)–(c)

1864 *Natica grossa* Deshayes, p. 65, pl. 70, figs. 24–26.

1911 *Ampullina grossa* (Deshayes), Cossmann & Pissarro, pl. 10, fig. 12.

1946 *Globularia grossa* (Deshayes), Wrigley, p. 93, figs. 15–16.

1947 *Ampullina grossa* (Deshayes), Furon & Soyer, p. 108, 155.

1963 *Ampullina grossa* (Deshayes), Vlaicu-Tatarim, p. 168, pl. 15, figs. 1, 3.

1964 *Globularia (Globularia) grossa* (Deshayes), Karagiuleva, p. 178, pl. 48, figs. 3, 6.

1972 *Globularia grossa* (Deshayes), Moisescu, p. 102–103, pl. 32, figs. 3–4, 6–8.

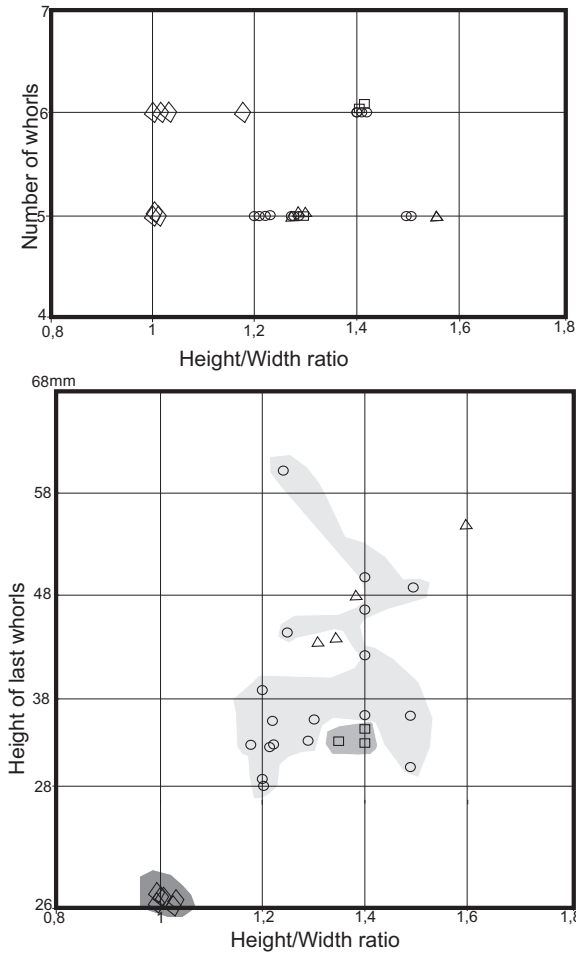


Figure 5. Plotted ratios derived from measurements of shell height (H), shell diameter (D), height of last whorl (Hi) and number of whorls of the *Globularia* species, Circles– *G. vapinana*, Squares– *G. grossa*, Triangles– *G. crassatina*, Diamonds– *G. sireli* n. sp.

Figured Specimens. AUPM.G13, AUPM.G15.

Horizons and Localities. Macunköy area, Polatlı, Turkey, sandstone and marl units, level 4–5 m.

Dimensions. (Measurements in millimetres)

Specimen	H	Hi	Ha	D	n	dp
AUPM. 06.G13	44	35	29	31	1	1.2
AUPM. 06.G14	43	34	26	32	0.8	1
AUPM. 06.G15	48	37	31	34	0.8	1

Description and Discussion. Shell globose, large, with relatively low spire, teleoconch has five to six whorls, body whorl slightly to moderately inflated, suture impressed, substantial spiral sculpture. This species is reminiscent of *Globularia (Globularia) vapinana* (d'Orbigny 1850), which was recorded by Karagiuleva (1964) (p. 178, pl. 48, figs. 3, 6) from the Eocene of Bulgaria. The higher and convex body whorl, and the resulting wider aperture of *G. grossa* prevent confusion between the two taxa.

Globularia crassatina (Lamarck 1804)

Plate II (d)–(g)

1882 *Natica crassatina* Lamarck, Abich, p. 251–253, pl. 6, figs. 1–2; pl. 7, fig. 11.

1910 *Natica crassatina* Lamarck, Kranz, p. 242–244, pl. 5, fig. 6.

1910 *Natica crassatina* Lamarck, Popescu-Voitești, p. 84, pl. 3, fig. 5.

1911 *Natica (Megatylotus) crassatina* Lamarck, Boussac, p. 329.

1933 *Natica crassatina* Lamarck, Gocev, p. 180, pl. 3, figs. 3–4.

1946 *Ampullinopsis crassatina* (Lamarck), Wrigley, p. 97–98, fig. 30.

1947 *Natica crassatina* Deshayes, Furon & Soyer, p. 196, pl. 30, fig. 40.

1957 *Megatylotus (Megatylotus) crassatinus* (Lamarck), Meszaros, p. 129, pl. 25, fig.6; pl. 26, fig. 1.

1964 *Globularia (Ampullinopsis) crassatina* (Lamarck), Karagiuleva, p. 180, pl. 50, figs. 1, 3, 5; pl. 51, figs. 2–4; pl. 52, fig. 1.

1972 *Ampullinopsis crassatina* (Lamarck), Moiescu, p. 109–115, pl. 33, figs. 1–3; pl. 34, fig. 1.

2004 *Ampullinopsis crassatina* (Lamarck), Harzhauser, p. 110–111, pl. 13, figs. 4–7.

Figured Specimens. AUPM. 06.C01, AUPM. 06.C02.

Horizons and Localities. Macunköy area, Polatlı, Turkey, sandstone and marl units, level 4–5 m.

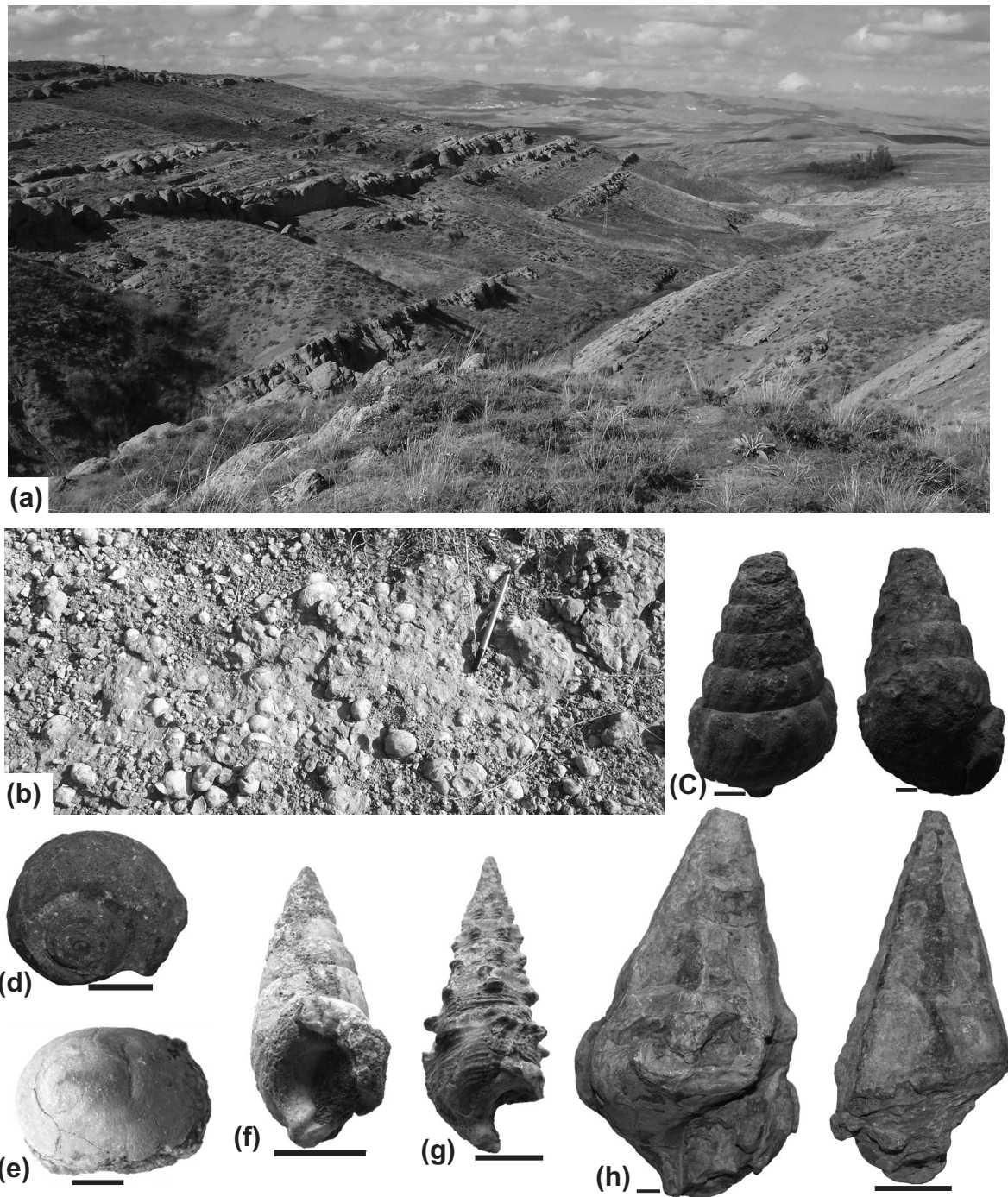


Figure 6. Field aspects and fossils of the Macunköy section: (a) overview of the section, seen from the west; (b) detail of the *Globularia* event; (c) non-ampullinid gastropod, *Campanile tchihatcheffi* d'Archiac 1850; (d) non-*Globularia* species, *Cepatia cepacea* (Lamarck 1804); (e) *Velates perversus* (Gmelin 1789); (f) Cerithid gastropods, *Cerithium archiaci* Hebert & Renevier 1854; (g) *Batillaria diacanthina* Cossmann 1899; and (h) *Cerithium fodacatum* Bellardi 1852 (scale bars: 10 mm).

Dimensions. (Measurements in millimetres)

Specimen	H	HI	Ha	D	n	dp
AUPM. 06.C01	54	48	36	39	1	1.2
AUPM. 06.C02	49	42	35	37	0.9	1
AUPM. 06.C03	66	55	44	42	–	–
AUPM.06.C04	52	45	37	38	–	–

Description and Discussion. Shell globose, large, spire high or low, moderately convex, whorls smooth, teleoconch approximately six whorls, suture moderately impressed to somewhat adpressed. The species *Ampullina picteti* Hebert & Renevier (Korobkov 1955, p. 229, pl. 39, fig. 2; pl. 15, fig. 3), from the Lutetian of Russia is similar, but is much stronger and larger, with a broader apical view.

Globularia sireli n.sp.

Plate II (h)–(m)

Derivation of Name. After Dr. Ercüment Sirel, for his extensive research on the Paleocene–Eocene rocks of the Haymana-Polatlı Basin.

Type Material. Holotype and paratype from the type locality.

Type Locality. Central Anatolia, Haymana-Polatlı Basin, Macunköy area, Polatlı, Turkey, sandstone unit, level 5 m.

Holotype. The specimen illustrated on Plate II, figure h–j. AUPM. 06.S.26.

Dimensions. (Measurements in millimetres)

Specimen	H	HI	Ha	D	n	dp
Holotype						
AUPM. 06.S.26	31	26	23	26	0.5	0.7
Paratypes						
AUPM. 06.S.21	28	26	19	25	0.4	0.6
AUPM. 06.S.22	29	26	20	27	0.6	0.7
AUPM. 06.S.23	30	27	23	28	0.7	0.8
AUPM. 06.S.24	29	26	21	28	0.6	0.7
AUPM. 06.S.25	30	26	24	27	0.8	0.9

Paratype. The specimens illustrated on Plate II figures k–m. AUPM. 06.S.21.

Age. Kirkkavak Formation, Late Thanetian–Early Ilerdian.

Geographic Distribution. Known only from the type locality.

Repository. Ankara University, Department of Geological Engineering, Palaeontology Laboratory, Ankara.

Description. Shell globose, spire about 1/3 height of shell, ornamentation is of prominent growth lines on last whorl, occasional specimens with very faint spiral striation, protoconch comprises 1–2 moderately convex whorls, teleoconch has 4 whorls, slightly convex just below the suture, suture impressed, slight single angulation along the umbilical edge, umbilicus wide and open.

Discussion. *Globularia sireli* n.sp. has not previously been recognized and was probably considered part of the superficially similar taxon *Ampullina forbesi* (Deshayes) (Stchépinsky 1946, p. 131, pl. 22, figs. 35–36). The generally smaller *Ampullina forbesi* is distinct, based on its wider umbilicus, its wider and evenly rounded whorls, and its protoconch develops a more convex whorl. Although *Globularia sireli* n.sp. species morphologically approaches *Globularia (Globularia) cochlearis* (Hantken 1875) and *G. (G.) aturiculata* (Grateloup 1845), it differs in having a very high spire and a pronounced elevation of the last whorl. This new species differs from *Globularia vapincana* (d'Orbigny 1850) in having a lower spire and smaller umbilicus. *Globularia (G.) grossa* (Deshayes 1864) from the Eocene of Bulgaria is also very similar. However, it is not conspecific with the Turkish species, on account of its lower spire and the convex last whorl. Finally, *Ampullina picteti* Hebert & Renevier (Vlaicu-Tatarim 1963, p. 167, pl. 18, fig. 3), from the middle Eocene of the Cluj Basin in Romania is also similar, but can be differentiated by its very convex last whorl and high spire.

Palaeobiogeography of *Globularia*

The geological occurrences of *Globularia* are listed and summarized in Figure 7. We relied on previous work by

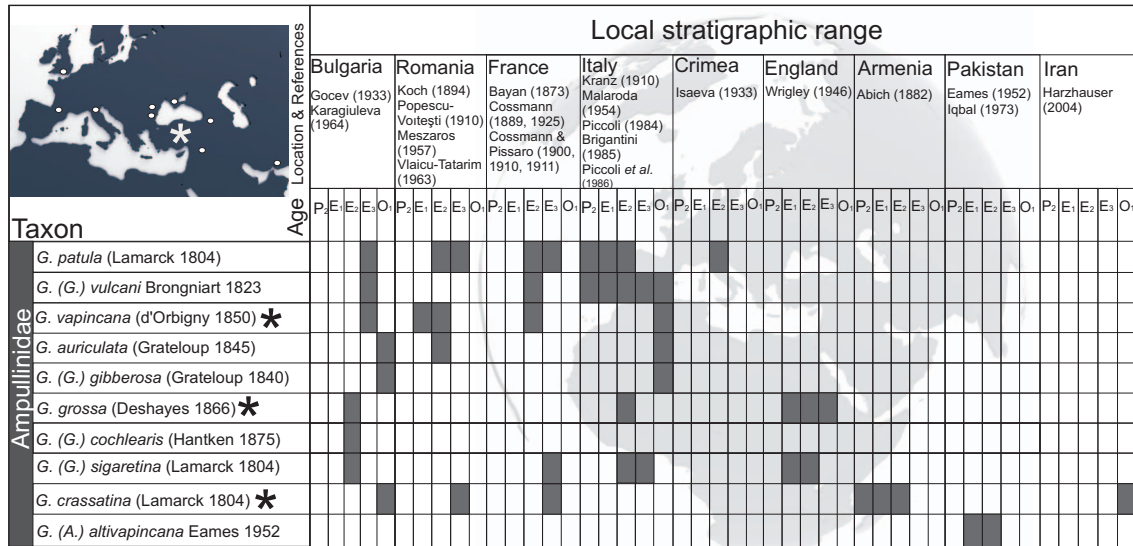


Figure 7. Stratigraphic range and geographic distribution of the most representative *Globularia* species. P₂– Late Paleocene, E₁– Early Eocene, E₂– Middle Eocene, E₃– Late Eocene, O₁– Early Oligocene.



Figure 8. Palaeogeographic map of the Late Paleocene–Early Eocene (redrawn from Smith et al. 1994).

Wrigley (1946), Meszaros (1957), Vlaicu-Tatarim (1963), Karagiuleva (1964), Moisescu (1972) and Harzhauser (2004) for this study. These works focus primarily on Old World *Globularia* species. *Globularia* has been variously reported as ranging from Late Paleocene, Early to Late Eocene and Early Oligocene. Ampullinids apparently originated within the Old World Tethyan palaeobiogeographic province. The clade's highest species diversity and longest recorded geologic range is documented from the Tethys realm (Amitrov 1994). *Globularia* taxa have been recorded from Palaeogene strata at various localities within and peripheral to the Tethyan province (Figure 7), including Africa (Adegoke 1977), western Europe (Bayan 1873; Cossmann 1889, 1925; Cossmann & Pissaro 1900, 1910, 1911; Kranz 1910; Boussac 1911; Wrigley 1946; Malaroda 1954; Brigantini 1985), central and eastern Europe (Popescu-Voitești 1910; Gocev 1933; Meszaros 1957; Vlaicu-Tatrim 1963; Karagiuleva 1964; Moisescu 1972), central Asia (Abich 1882; Isaeva 1933; Harzhauser 2004), and the Himalayan region (Eames 1952; Iqbal 1973).

The *Globularia* species demonstrate that central Anatolia was located on the main migration route of the

Late Paleocene–Early Eocene faunas, from the Himalayan region and central Asia to western Europe. It closely corresponds to the palaeobiogeographic maps (Figure 8) and discussion of Smith *et al.* (1994), Piccoli (1984) and Piccoli *et al.* (1986). The very long migration route and rapid dispersal of the gastropod larvae could explain the much earlier stratigraphic occurrence of the *Globularia* identified in central Anatolia (Late Paleocene to Early Eocene), as compared with their occurrences in western and eastern Europe (Early Eocene to Early Oligocene). The Late Thanetian–Early Ilerdian sea that extended from Asia across eastern and central Europe towards western Europe created diversified environments (Figure 8), which favoured *Globularia* migration and speciation and thus controlled the stratigraphic and geographic distribution of the Early Eocene ampullinids.

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PLATE I

All specimens are from the sandstone and marl members at the Macunköy area. (a–i) *Globularia vapincana* (d'Orbigny 1850): (a) lateral view, (b) apertural view, (c) apical view AUPM. 0601, (d) lateral view, (e) apertural view, (f) Apical view AUPM. 0603, (g) lateral view, (h) apertural view, (i) apical view AUPM. 0604, level 4–5.5 m; (j–l) *Globularia grossa* (Deshayes 1864): (j) lateral view, (k) apertural view, (l) apical view AUPM.G13, level 4–5 m. (scale bars 10 mm).



PLATE II

All specimens are from the sandstone and marl members at the Macunköy area. (a–c) *Globularia grossa* (Deshayes 1864): (a) lateral view, (b) apertural view, (c) apical view AUPM.G15, level 4–5 m; (d–g) *Globularia crassatina* (Lamarck 1804): (d) lateral view AUPM. 06.C01, (e) lateral view, (f) apertural view, (g) apical view AUPM. 06.C02 level 4–5; (h–m) *Globularia sireli* n sp.: (h–j) holotype AUPM. 06.S.26, lateral view, apertural and apical view, (k–m) paratype AUPM. 06.S.21, lateral view, apertural and apical view, level 5 m (scale bars 10 mm).

