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Biostratigraphic interpretation and systematics of Alveolina assemblages from the Ilerdian–Cuisian limestones of Southern Eskişehir, Central Turkey

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Abstract

The Ilerdian–Middle Cuisian sedimentary succession of the Seyitgazi region, southern Eskişehir (Central Anatolia, Turkey) is composed of claystones, limestones and clayey limestones. It contains abundant benthic foraminifera, particularly species of *Alveolina*. From this succession, 28 species of *Alveolina* d'Orbigny are described and their comparative stratigraphic distribution with the *Alveolina* species in the Tethyan Eocene is documented. Generally, Ilerdian–Cuisian *Alveolina* assemblages of the Seyitgazi region have close affinities with coeval *Alveolina* assemblages described in different studies from the Tethyan Province. The Ilerdian unit of the study area is characterized by *Alveolina* species such as *Glomalveolina lepidula*, *Glomalveolina minutula*, *G. karsica*, *Alveolina vredenburgi*, *A. ellipsoidalis*, *A. avellana*, *A. aff. minervensis*, *A. dedolia*, *A. moussoulensis*, *A. subpyrenaica*, *A. laxa*, *A. aragonensis*, *A. varians*, *A. ilerdensis*, *A. trempina*, *A. citrea*, *A. pisella* and *A. decipiens*. Likewise, the Early Middle Cuisian unit is represented by *G. minutula*, *A. oblonga*, *A. schwageri*, *A. haymanensis*, *A. canavarii*, *A. aff. coudurensis*, *A. ruetimeyeri*, *A. muscatensis*, *A. cremae*, *A. bayburtensis* and *A. lehneri*.
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Keywords: *Alveolina*; Biostratigraphy; Cuisian; IIerdian; Eskişehir; Turkey

1. Introduction

The study area is located southwest and southeast of Seyitgazi town, 40 km south of Eskişehir, in western Central Anatolia, Turkey (Fig. 1). The Ilerdian–Cuisian shallow-water deposits in this region are represented by claystone, clayey limestones and limestones. They are noteworthy as they contain abundant porcellaneous foraminifera. The porcellaneous foraminiferal taxa in the shelf sediments, especially those in the shallower water limestones of Paleocene and Eocene, have been previously reported from Turkey (Dizer, 1964; Sirel, 1976a,b, 1992, 1998, 2000; Sirel and Gündüz, 1976; Sirel and Acar, 1982, 1993; Önoğlu-Gedik, 1996; Acar, 1995; Özgen et al., 1996; Özgen, 1998, 2000).

The main objective of this study is to describe the *Alveolina* species from the Ilerdian–Cuisian shallow-marine successions of the Seyitgazi (Eskişehir) region. The second objective is to compare the stratigraphic distribution of the *Alveolina* species described in this study to those described in previous studies in the Tethyan province including Turkey (Hottinger, 1960; Sirel, 1976a,b, 1998; Sirel and Gündüz, 1976; Drobne, 1977; Acar, 1995; Serra-Kiel et al., 1998).

2. Methods

The Ilerdian–Cuisian *Alveolina* species were sampled from three sections in the Seyitgazi region: Sarıbayır, Kışlatepe, and Kızılkayatepe (Figs. 2–4). Some 93 samples were collected. Abundant free *Alveolina* specimens were obtained

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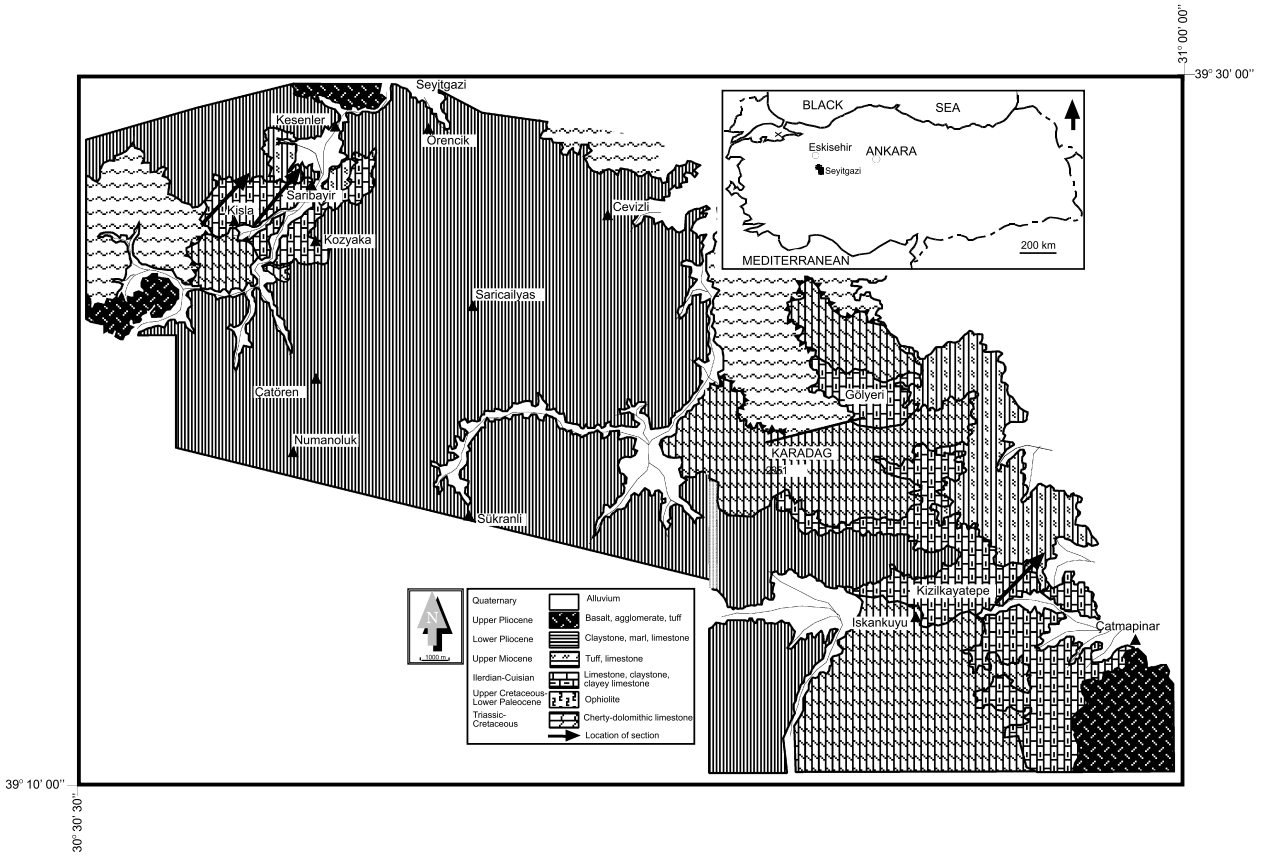


Fig. 1. The geological map of the Seyitgazi area and the location of the studied sections (Modified from Ozcan et al., 1989).

from the claystone, sandy limestone and clayey limestone beds of the Ilerdian–Cuisian unit. Systematic descriptions of the *Alveolina* species were based on oriented thin sections. All *Alveolina* species are described and stored in the collection at Cumhuriyet University, Faculty of Engineering, Department of Geological Engineering, Sivas (Turkey).

3. Description of sections

The Ilerdian–Cuisian unit, which is composed of claystones, limestones and clayey limestones, overlies the basement melange (Ozcan et al., 1989) unconformably. This unit is also unconformably overlain by tuffite and lacustural limestones of the Upper Miocene.

The description of three sections measured from the Ilerdian–Cuisian units is given below:

Sarıbayır section: The Sarıbayır section was measured approximately 2 km southwest of Sarıbayır village, which is southwest of Seyitgazi town (Fig. 1). The section is situated in the Eskişehir J25 quadrangle (start point: 39°23′29″ latitude, 30°36′08″ longitude; end point: 39°25′38″ latitude, 30°37′05″ longitude). It represents a continuous sequence from Early Ilerdian to Middle Cuisian. The lower unit is composed of an alternation of dark yellow to greenish sandy limestone, interbedded limestones and clayey limestones. The clayey limestone beds contain abundant, well-preserved Early-Late Ilerdian *Alveolina* species. The upper unit is composed of an alternation of multicoloured, sometimes reddish claystones and clayey limestones. The claystones and clayey limestones also include abundant, well-preserved, Early-Middle Cuisian *Alveolina* species (Fig. 2).

*K*ışlatepe section: The Kışlatepe section was measured about 2 km west of Kışla village, which is southwest of Seyitgazi town (Fig. 1). It is situated in the Eskişehir J25 quadrangle (start point: 39°23′27″ latitude, 30°35′58″ longitude; end point 39°4′33″ latitude, 30°36′54″ longitude).

The Kışlatepe section also represents a continuous sequence from Early Ilerdian to Middle Cuisian (Fig. 3). The lithological characteristics of the unit are similar to that of the Sarıbayır section.

*K*ızılkayatepe section: The Kızılkayatepe section was measured about 4 km east of İskankuyu village, which is southeast of Seyitgazi town (Fig. 1). It is situated in the Eskişehir J25 quadrangle (start point: 39° 14′ 10″ latitude, 30° 54′ 25″ longitude; end point: 39° 15′ 49″ latitude, 30° 55′ 27″ longitude). The Kızılkayatepe section is a continuous sequence ranging from Early Ilerdian to Early Cuisian (Fig. 4). The lithological characteristics of the unit are identical to the Sarıbayır section.

4. Systematic paleontology

Superfamily ALVEOLINACEAE Ehrenberg, 1839
Family ALVEOLINIDAE Ehrenberg, 1839

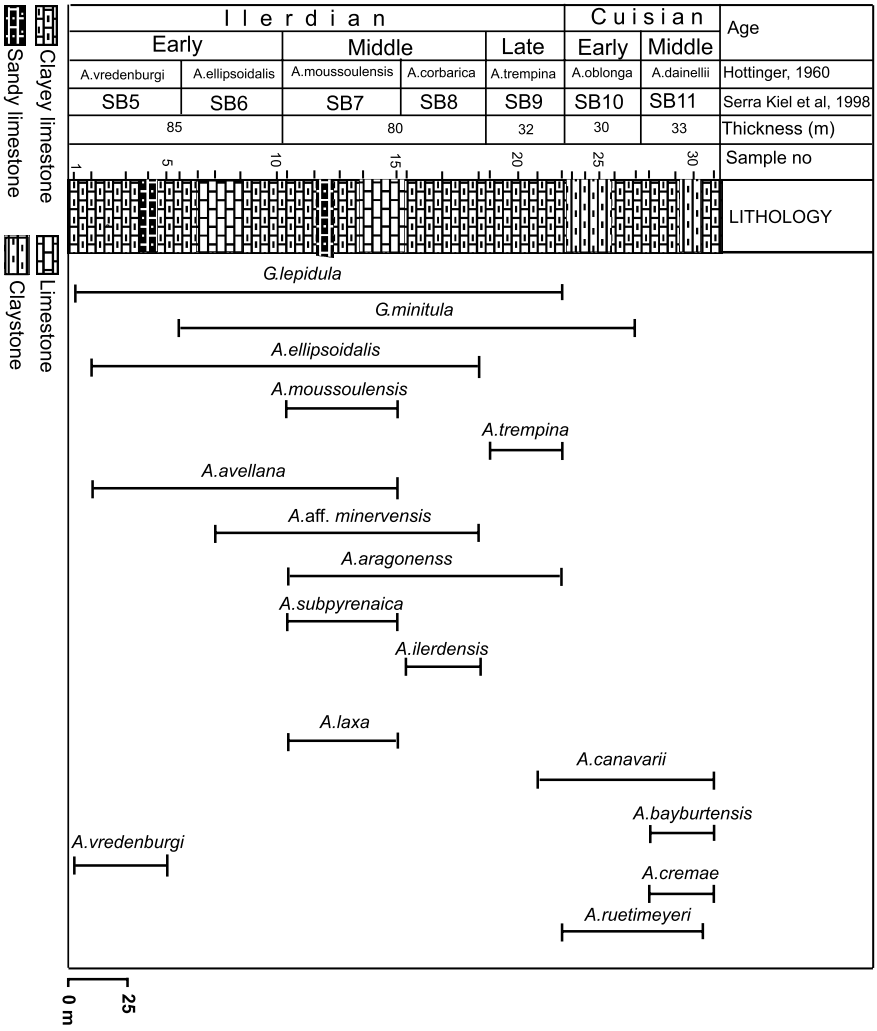


Fig. 2. Stratigraphic distributions of the *Alveolina* species in the Sarıbayır section.

Genus *Alveolina* d'Orbigny, 1826
Subgenus *Glomalveolina* Hottinger, 1960
Type species *Alveolina dachelensis* Schwager, 1883

Glomalveolina lepidula (Schwager), 1883
(Fig. 5a)

Alveolina ellipsoidalis Schwager var. *lepidula* Schwager, 1883, p. 98, pl. 25, Figs. 3a–g.

Alveolina (*Glomalveolina*) *lepidula* (Schwager) – Hottinger, 1960, p. 57, text-figs. 20–22, pl. 1, Figs. 25–29; pl. 2, Figs. 9, 25. – Drobne, 1977, p.13, Figs. 2/e, 3f–i. – Sirel, 1998, pl. 30, Figs. 5, 6, 9–13.

Description: Test is small, oval and has an axial diameter ranging from 1.28 to 1.38 mm and equatorial diameter from 1 to 1.25 mm. The index of elongation varies between 1.15 and 1.27. The proloculus is spherical with a diameter of 40–80 μm. It is followed by one or two whorls of milioline chambers and by six or nine whorls of adult chambers with chamberlets. The small microsphere is followed by early streptospiral coiled chambers of two cycles. The following chambers are planispirally coiled. The basal layer is thin. In some axial sections, the axial thickening of the basal layer is observed. Chamberlets are spherical in shape in the inner whorls and ovoid or rectangular in the outer whorls.

Range: This species is observed in the Early-Late Ilerdian of the Sarıbayır and Kışlatepe sections (Figs. 2, 3). The stratigraphic distribution of this species is similar to the *Alveolina* zones of Hottinger (1960) and Serra-Kiel et al. (1998).

Glomalveolina minutula (Reichel), 1936
(Fig. 5d)

Alveolina minutula Reichel in O. Renz, 1936, p. 138, pl. 12, fig. 2a.

Alveolina (Glomalveolina) minutula (Reichel) – Hottinger, 1960, p. 62, text-figs. 29/23; pl. 1, Figs. 31–33. – Sirel, 1998, pl. 30, Fig. 2.

Description: Test is spherical. The axial and equatorial diameters vary between 0.8–2.2 and 0.9–2.0 mm, respectively. The index of elongation ranges from 0.9 to 1.1. The proloculus is very small (about 40–50 μm in diameter) and followed by milioline early chambers. Later chambers are planispirally coiled. The chamberlets are small, numerous and circular in section.

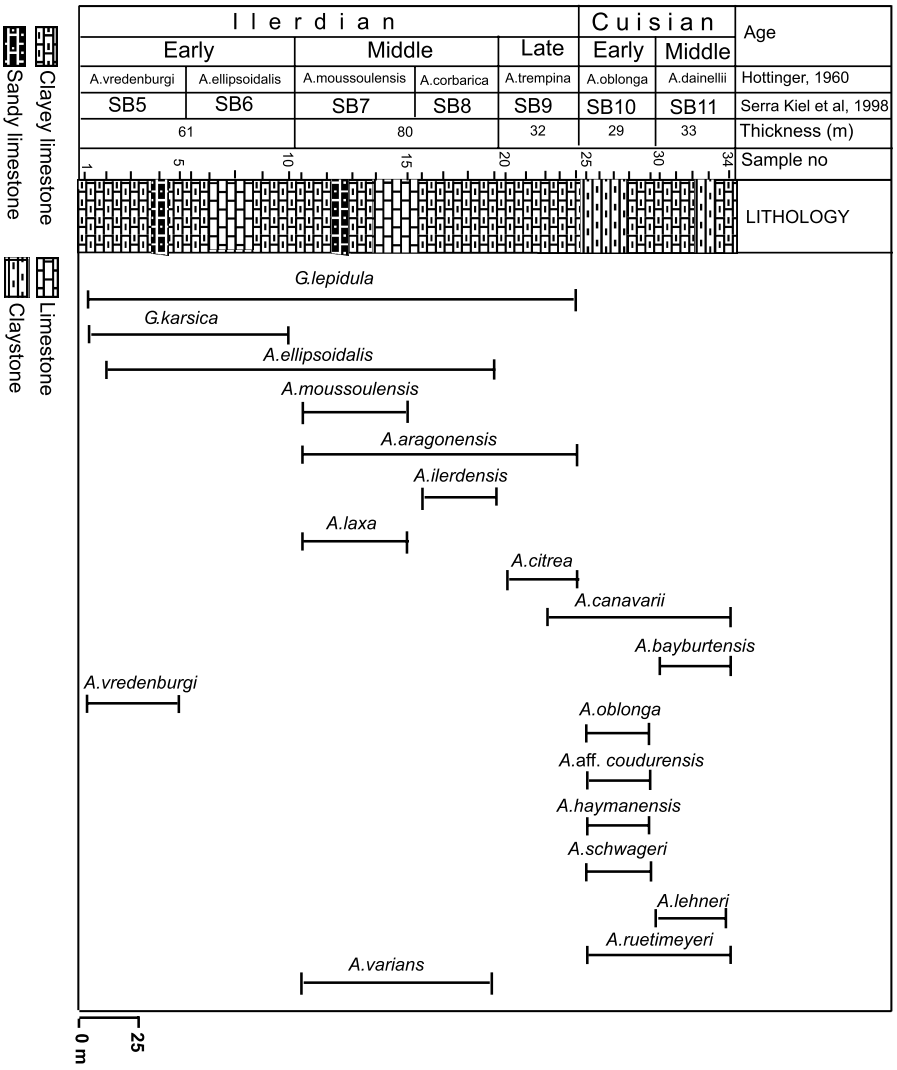


Fig. 3. Stratigraphic distributions of the *Alveolina* species in the Kışlatepe section.

Remarks: This species differs from *G. lepidula* in possessing many chamberlets and smaller elongation index.

Range: Glomalveolina minutula is observed from upper part of the Early Ilerdian to Early Cuisian of the Sarıbayır section (Fig. 2). However, it is shown in the Middle Ilerdian–Early Cuisian by Hottinger (1960) and in the Early–Middle Cuisian by Serra-Kiel et al. (1998, Fig. 2). Furthermore, this species was found in the Early Ilerdian of the Kars region (Eastern Turkey) by Sirel (1998).

Glomalveolina karsica Sirel, 1998

(Figs. 5b and c)

Alveolina (Glomalveolina) karsica Sirel, 1998, pl. 30, Figs. 7 and 8; pl. 31, Figs. 6, 7, and 11.

Description: Test is small, subspheric with axial and equatorial diameters ranging from 0.42–0.67 mm and 0.39–0.69 mm, respectively. The index of elongation is from 1 to 1.1. The proloculus is very small and followed by two cycles of streptospiral early chambers. However, later chambers are tightly coiled. Chamberlets are small and spherical in the inner whorls, but relatively large and oval in the outer whorls.

Range: G. karsica is shown in the Early Ilerdian of the Kışlatepe section. This species is found in the same level of the Kars region (Eastern Turkey) (Sirel, 1998).

Alveolina ellipsoidalis Schwager, 1883

(Figs. 5e and f)

Alveolina ellipsoidalis Schwager, 1883, p. 96, pl. 25, Figs. 1–2. – Hottinger, 1960, p. 64, pl. 2, Figs. 1–8, text-figs. 20c, 33a,b. – Sirel, 1976b, p. 92, pl. 2, Figs. 5, 6, 8–11; pl. 6, Fig. 6. – Drobne, 1977, p.16, pl.1, Figs. 1–3.

Description: Megalospheric test of small size, oval to slightly inflated oval, axial diameter 3.2–5.4 mm, equatorial diameter 2.5–4.3 mm. The index of elongation is about 1.2. Proloculus spherical to subspherical in shape and its diameter ranges from 320 to 400 μm. Coiling is tight and basal layer is thin in the all growth stages. Chamberlets are dense and spherical to oval in shape. Microspheric test of medium size, ellipsoidal to elongated oval. The axial and equatorial diameters reach 7.9 and 5.4 mm, respectively. The index of elongation is 1.4. First few whorls are irregularly coiled, followed by 16 relatively tightly coiled

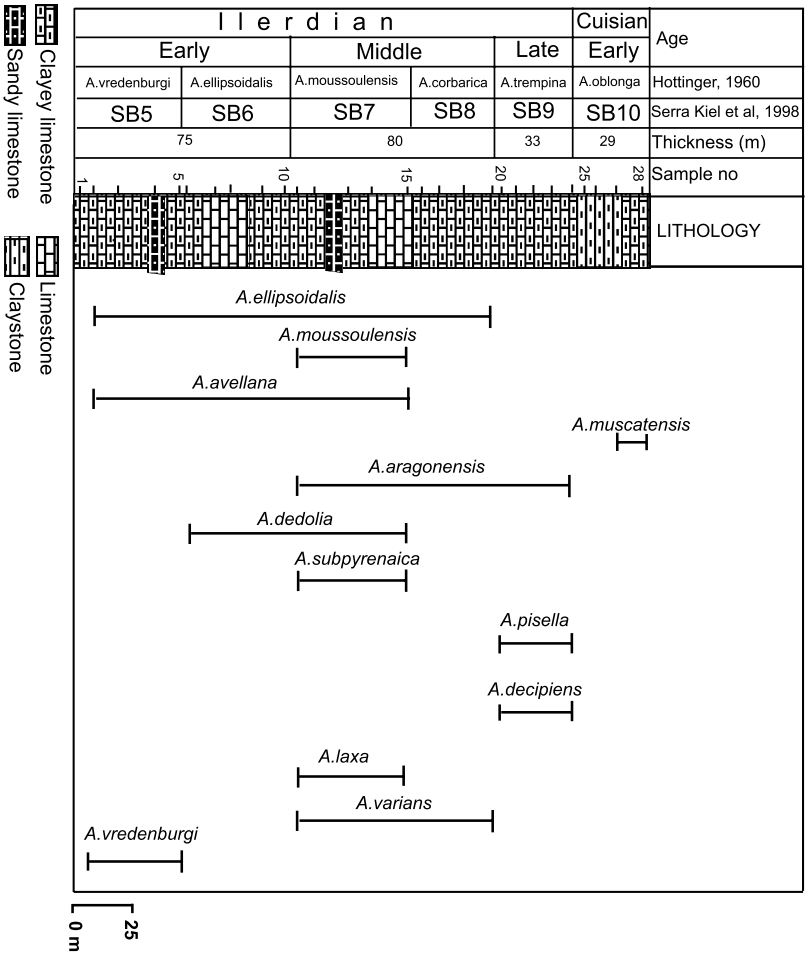


Fig. 4. Stratigraphic distributions of the *Alveolina* species in the Kızılkayatepe section.

whorls. The basal layer is very thin throughout. The chamberlets small, dense and spherical in the inner whorls, oval in the outer whorls.

Remarks: A. ellipsoidalis is distinguished from *A. moussoulensis* by its relatively tight coiling and test shape.

Range: A. ellipsoidalis is seen in the Early–Middle Ilerdian in all sections of the study area. Acar (1995) located the species in the Early-Late Ilerdian levels of the Polatlı region (Central Turkey), but Hottinger (1960) defined this species in upper parts of Early Ilerdian (*Alveolina ellipsoidalis* zone). Similarly, Serra-Kiel et al. (1998, Fig. 2) showed it in the same levels as Hottinger (1960).

Alveolina moussoulensis Hottinger, 1960

(Fig. 5g)

Alveolina moussoulensis Hottinger, 1960, p. 65, pl. 2, Figs. 10–16, text-figs. 20d, 24, 34. – Sirel, 1976b, pl. IV, Fig. 9.

Description: Test is medium sized, inflated oval to slightly elongated oval with truncated poles. The equatorial diameter ranges from 3 to 3.82 mm. The axial diameter reaches 4.8 mm; the index of elongation ranges from 1.1 to 1.2. Proloculus is spheric to oval (250–455 μm in diameter). First four to five whorls are tightly coiled. The following whorls are coiled relatively loose. However, the basal layer in the all whorls is always thin. Chamberlets are oval, dense and subrectangular toward the last whorls.

Remarks: Alveolina moussoulensis differs from *A. aragonensis* in having tight and regular coils and truncated poles.

Range: This species is found in the lower part of the Middle Ilerdian of the Sarıbayır, Kışlatepe and Kızılkayatepe sections (Figs. 2–4). Similarly, Hottinger (1960) and Serra-Kiel et al. (1998) defined it in the same interval.

Alveolina trempina Hottinger, 1960

(Fig. 5h)

Alveolina trempina Hottinger, 1960, pl. 2, Figs. 17–19, text-figs. 35a and b.

Description: Test is long, oval to slightly fusiform. The axial and equatorial diameters are about 6.3 and 2.1 mm, respectively. The index of elongation is 2.8. Spherical megalosphere (about 235 μm in diameter) is followed by tightly coiled whorls, but axial thickening of the basal layer increases from the inner whorls (0.07 mm) to the outer whorls (0.31 mm) of the test. There are many chamberlets, which are spherical to oval in shape.

Remarks: A. trempina is distinguished from *A. ruetimeyeri* in having less axial thickening of the basal layer.

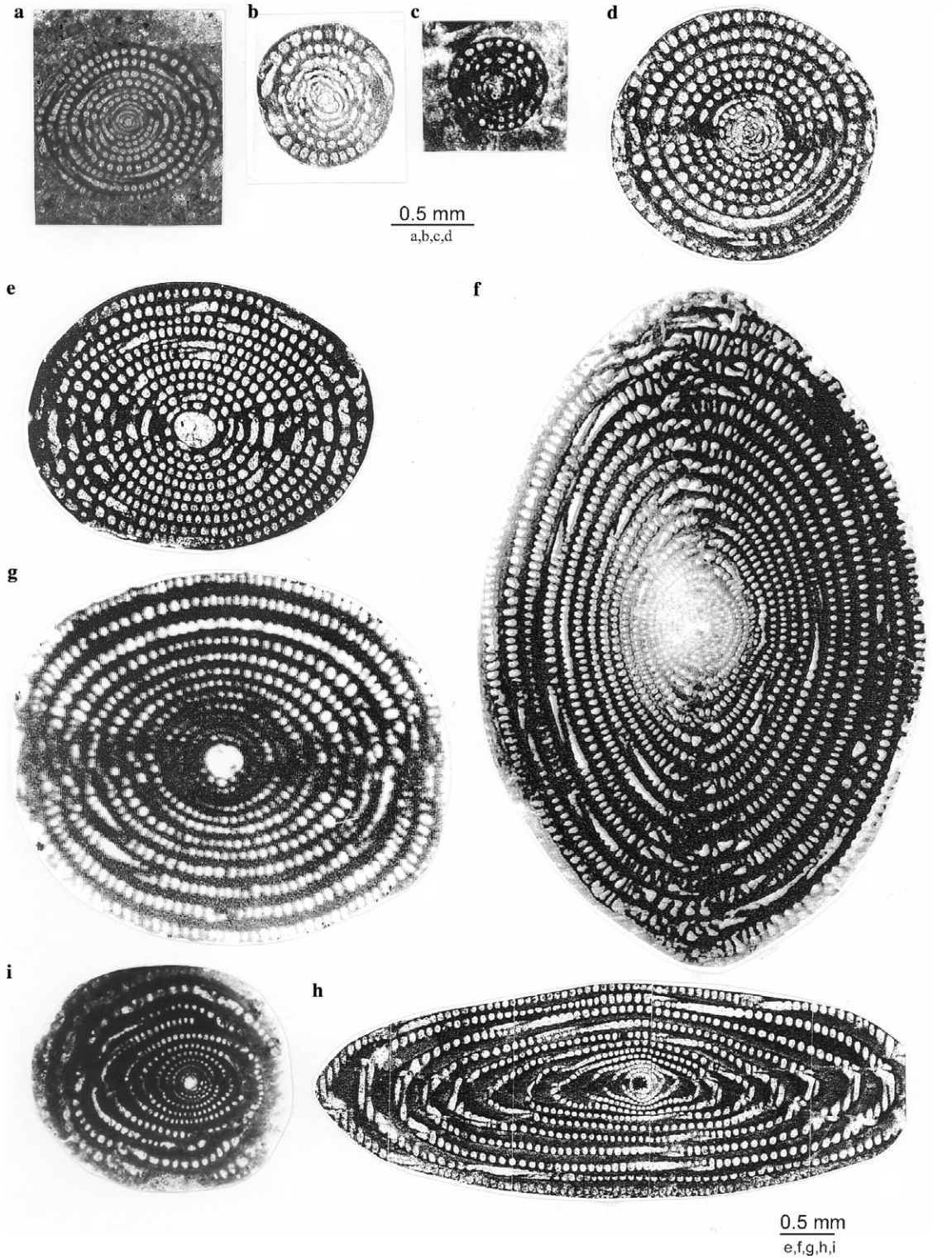


Fig. 5. (a) *Glomalveolina lepidula* (Schwager), axial section of megalospheric specimen, Sarıbayır section (S.12), ×30. (b–c) *Glomalveolina karsica* Sirel, axial sections of megalospheric specimen, Kıslatepe section (b-Ks.2, c-Ks.4), ×30. (d) *Glomalveolina minutula* (Reichel), axial section of microspheric specimen, Sarıbayır section (S.20), ×30. (e–f) *Alveolina ellipsoidalis* Schwager, axial sections, e – megalospheric specimen, Sarıbayır section (S.3), f – microspheric specimen, Kıslatepe section (Ks.7), × 20. (g) *A. moussoulensis* Hottinger, axial section of megalospheric specimen, Kızılkayatepe section (Kz.12), ×20. (h) *A. trempina* Hottinger, axial section of megalospheric specimen, Sarıbayır section (S.20), × 20. (i) *A. muscatensis* White, axial section of megalospheric specimen, Kızılkayatepe section (Kz.27), ×20.

Range: A. trempina is observed in the Late Ilerdian of the Sarıbayır section (Fig. 2). Hottinger (1960) defined this species at similar levels (*Alveolina trempina* zone). Serra-Kiel et al. (1998) also found this species in the Late Ilerdian.

Alveolina avellana Hottinger, 1960

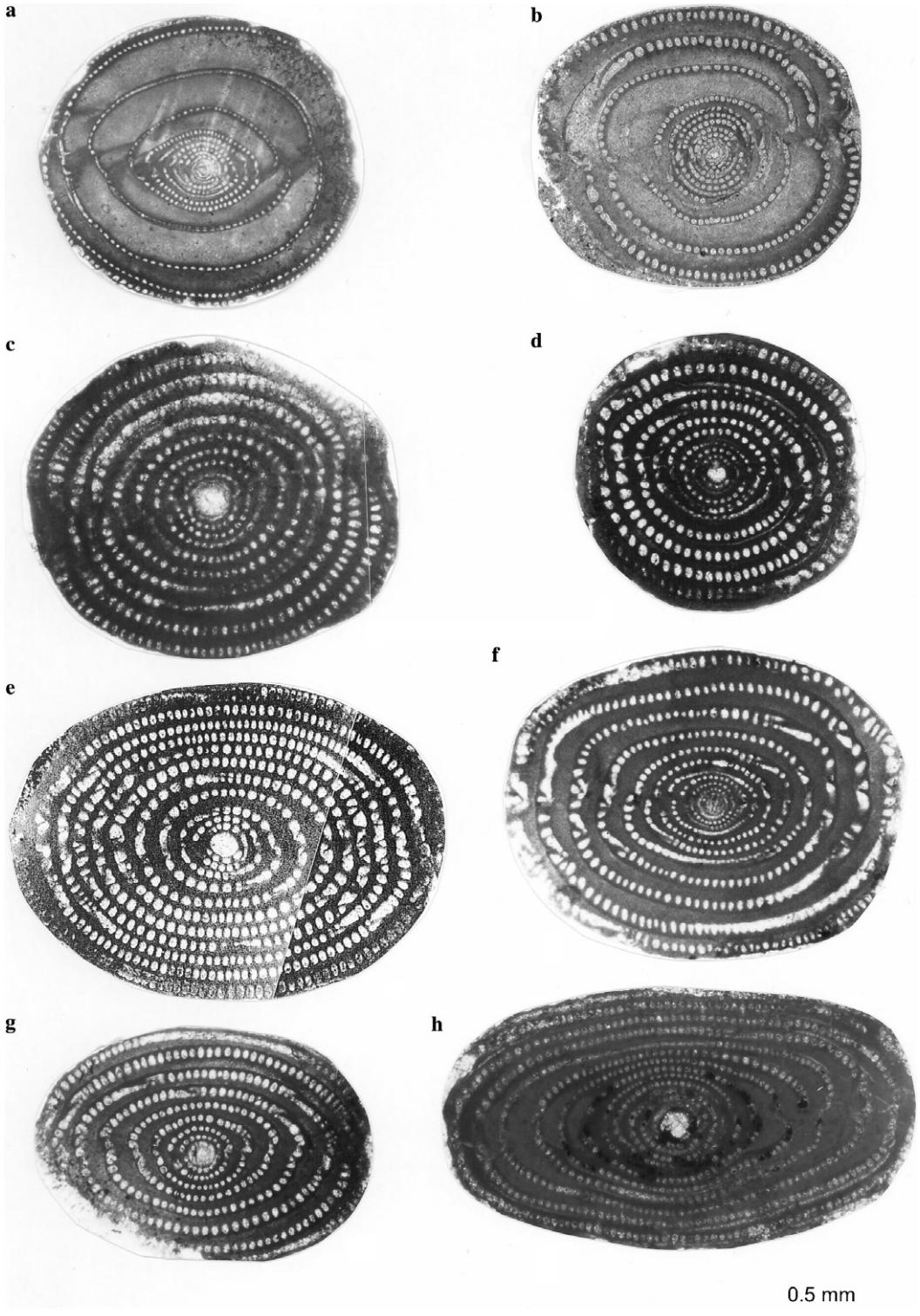


Fig. 6. (a) *A. avellana* Hottinger, axial section of megalospheric specimen, Kızılkayatepe section (Kz.6). (b) *A.* aff. *minervensis* Hottinger, subaxial section, Sarıbayır section (S.12). (c–d) *A. dedolia* Drobne, axial sections of megalospheric specimens, Kızılkayatepe section (4-Kz.11; 5-Kz.10). (e) *A. aragonensis* Hottinger, axial section of megalospheric specimen, Sarıbayır section (S.17). (f–g) *A. subpyrenaica* Leymerie, axial sections of megalospheric specimens, Kızılkayatepe section (6-Kz.12; 7-Kz.13). (h) *A. ilerdensis* Hottinger, axial section of megalospheric specimen, Kıslatepe section (Ks.17). All enlarged ×20.

(Fig. 6a)

Alveolina avellana Hottinger, 1960, pl. 6, Figs. 14–17, text-figs. 59. – Dizer, 1964, p. 267, pl. 1, Figs. 1 and 2.

Description: Test small and slightly elongated spherical. The axial diameter measures 3.23–4.6 mm, the equatorial diameter 2.94–3.91 mm and the index of elongation is 1.09–1.17. The proloculus is very small, subspherical in shape with a diameter of 60–115 μm. The proloculus is followed by irregularly coiled whorls. The following four to five whorls are coiled tightly, when the test is fusiform. The later

three whorls are flosculinized and the basal layer is very thick along axial and equatorial zones. The maximum thickness of the basal layer as measured in the equatorial zone ranges from 0.11 to 0.35 mm. Flosculinization decreases toward the outer whorls. Chamberlets are small, dense in the juvenile stage, slightly depressed in the flosculinized stage.

Range: This species is described in the Early-Middle Ilerdian of the Sarıbayır and Kızılkayatepe sections (Figs. 2, 4) as was done by Serra-Kiel et al. (1998). However, Hottinger (1960) defined it in the lower part of the Early Ilerdian (*Alveolina cucumiformis* zone).

Alveolina muscatensis White, 1992

(Fig. 5i)

Alveolina muscatensis White, 1992, pl. 2, Figs. 1–6, 9.

Description: Test is subspherical with an axial diameter of 3.29 mm and equatorial diameter of 2.35 mm. The index of elongation is 1.4. Proloculus is small, spherical and has a diameter of 147 μm. The first five whorls are tightly coiled. In the sixth–ninth whorls, coiling is relatively loose. The thickness of the basal layer ranges from 0.05 to 0.11 mm in the equatorial zone and 0.08–0.20 mm in the axial zone. The outer three whorls are coiled relatively tight. Chamberlets are spherical in the inner whorls, oval in the outer whorls.

Range: Alveolina muscatensis is shown in the upper part of Early Cuisian of the Kızılkayatepe section (Fig. 4). This species was defined as occurring in the Early Eocene of northern Oman (White, 1992).

Alveolina aff. minervensis Hottinger, 1960

(Fig. 6b)

Alveolina minervensis Hottinger, 1960, pl. 6, Figs. 14 and 17. – Sirel, 1976b, pl. IV, Figs. 1–6; pl.V, Fig. 14.

Description: Test is spherical. Axial and equatorial diameters are 3.22 and 3.31 mm, respectively. Index of elongation is 1. The proloculus is very small and followed by four to five tightly coiled whorls. Outer three whorls are flosculinized. The basal layer is very thick along axial and equatorial zones. The maximum thickness of the basal layer as measured in the equatorial zone ranges from 0.25 to 0.5 mm. Last three to four whorls are tightly coiled. Chamberlets are small, dense in the juvenile stage, slightly depressed in the flosculinized stage.

Range: This species is found in the Early Ilerdian-Middle Ilerdian of the Sarıbayır section (Fig. 2). However, it was defined in the Early Ilerdian (Hottinger, 1960).

Alveolina aragonensis Hottinger, 1960

(Fig. 6e)

Alveolina aragonensis Hottinger, 1960, pl. 6, Figs. 5–10, text-figs. 20e, 22h, 60b–f. – Sirel, 1976b, pl. III, Figs. 1–13; pl. IV, Fig. 10.

Description: Test oval to subspherical and medium sized. Axial diameter ranges from 3.52 to 4.76 mm and equatorial diameter 2.76–3.7 mm. The index of elongation ranges from 1.1 to 1.4. The diameter of the spherical proloculus varies between 235 and 307 μm. The first three to four whorls are tightly coiled, followed by two to three more loose and up to four to six relatively tight coils. Maximum thickness of the basal layer in the flosculinized whorls ranges from 0.15 to 0.21 mm in the equatorial zone. Chamberlets are large and spherical to subspherical in the inner whorls, outward becoming oval to subrectangular and higher than wide.

Range: This species is observed in the Middle–Late Ilerdian of the Sarıbayır, Kışlatepe and Kızılkayatepe sections (Figs. 2–4). The stratigraphic distribution of this species corresponds to the *Alveolina* zones of Hottinger (1960) and Serra-Kiel et al. (1998).

Alveolina dedolia Drobne, 1977

(Figs. 6c and d)

Alveolina dedolia Drobne, 1977, pl.5, Figs. 9–11, text-fig. 15a. – Acar, 1995, pl. 18, Fig. 8.

Description: Test small, spherical to oval with truncated poles. The axial diameter ranges from 2.47 to 3.82 mm while the equatorial diameter ranges from 2.29 to 3.29 mm. The index of elongation ranges from 1.04 to 1.2. Nine to ten whorls are present in an axial diameter of 2.94 mm. The proloculus is spherical to subspherical and its diameter varies from 147 to 352 μm. The first three whorls are regularly coiled. The following two whorls are flosculinized. The thickness of the basal layer in this stage is about 0.11 mm in the equatorial zone. The flosculinized whorls are followed by four to five regularly coiled whorls. Chamberlets are spherical to oval.

Remarks: A. dedolia differs from *A. subpyrenaica* in being less flosculinized, spherical test shape, and regular coiling in the early stage.

Range: A. dedolia is seen from the upper part of the Early Ilerdian to the lower part of the Middle Ilerdian in the Kızılkayatepe section (Fig. 4), but it is defined in the lower part of the Middle Ilerdian (*Alveolina moussoulensis* zone) by Drobne (1977) and Serra-Kiel et al. (1998, Fig. 2). Furthermore, this species was found in the Early Ilerdian of the Polatlı (Central Turkey) region by Acar (1995).

Alveolina subpyrenaica Leymerie, 1846

(Figs. 6f and g)

Alveolina subpyrenaica Leymerie, 1846, pl. 12, Fig. 9a–c. – Dizer, 1964, pl.1, Figs. 8–12. – Sirel, 1976b, pl. V, Figs. 3–8.

Description: The medium test is oval with rounded to truncated poles. The equatorial diameter varies from 2.35 to 3.11 mm. The axial diameter measures between 3.41 and 4.58 mm, with an index of elongation of 1.2 to 1.5. Diameter of spherical megalosphere ranges from 117 to 235 μm. The first two to three whorls are tightly coiled. The chamberlets are small and dense at this stage. The following four to six whorls are coiled relatively loose and the basal layer is thick. The thickness of the basal layer measures between 0.11 and 0.23 mm in the axial zone, 0.05–0.17 mm in the equatorial zone. In the last whorls, the axial thickening of the basal layer gradually decreases. The shape of chamberlets is ovoid or rectangular in these whorls.

Range: This species is found in the Middle Ilerdian of the Sarıbayır and Kızılkaya sections (Figs. 2, 4). The stratigraphic distribution of this species corresponds to

the *Alveolina* zone of Hottinger (1960) and Serra-Kiel et al. (1998).

Alveolina ilerdensis Hottinger, 1960

(Fig. 6h)

Alveolina ilerdensis Hottinger, 1960, p. 119–121, pl. 7, Figs. 14–20, text-fig. 64. – Sirel, 1976b, pl. V, Figs. 10–13. – Acar, 1995, pl. 18, Figs. 5–7.

Description: Megalospheric test of large size, elongated ovoid with rounded poles. The axial diameter is about 4.42 mm and equatorial diameter 2.4 mm. The index of elongation is 1.8. The spherical megalosphere (about 280 μm in diameter) is followed by two to three tightly coiled whorls. This stage is spherical in shape. The later stage exhibits six to seven whorls coiled loosely and elongated. The basal layer in these whorls is thick along the axial zone, but decreases towards the poles of the test. Chamberlets spherical in the inner whorls, later becoming oval, higher than wide.

Remarks: A. ilerdensis is distinguished from *A. subpyrenaica* in possessing an elongated test shape and more chamberlets. Flosculinization is not shown in *A. ilerdensis*.

Range: A. ilerdensis is observed only in the upper part of the Middle Ilerdian of the Sarıbayır and Kışlatepe sections (Figs. 2, 3). However, it was shown in the Middle Ilerdian-Upper Ilerdian by Hottinger (1960) and Serra-Kiel et al. (1998, Fig. 2). Also, *A. ilerdensis* is described in the Middle Ilerdian levels of Haymana-Polatlı (Central Turkey) (Sirel, 1976b; Acar, 1995) and Çıbanköy (Kastamonu) (Özgen, 1998).

Alveolina pisella Drobne, 1977

(Fig. 7a–c)

Alveolina pisella Drobne, 1977, pl. 5, Figs. 17–19, text-fig. 16.

Description: Microspheric test oval, axial diameter 6.2–7.1 mm, equatorial diameter 4.2–5 mm. Index of elongation is 1.4. Twenty-one to twenty-two whorls are counted in an axial diameter of 7.1 mm. The first whorls are very tightly coiled. The following whorls are coiled regularly. The basal layer is very thin, which equals the height of chamberlets. Chamberlets are small, dense and spherical to oval. Megalospheric test has the characteristic spherical form. The axial and equatorial diameters measure between 3.5–4.5 and 4.2–4.5 mm, respectively. The proloculus is spherical or subspherical with a diameter of 200–400 μm. Coiling is tight and regular. The chamberlets are developed similarly as in microspheric form.

Range: A. pisella is found in the Late Ilerdian of the Kızılkayatepe section (Fig. 4). It is shown in the late Ilerdian (*Alveolina trempina* zone) by Drobne (1977) and the upper part of Middle Ilerdian and Late Ilerdian by Serra-Kiel et al. (1998, Fig. 2).

Alveolina decipiens Schwager, 1883

(Fig. 7d)

Alveolina decipiens Schwager, 1883, pl. III (XXIV), Fig. 1. – Hottinger, 1960, pl. 8, Figs. 1–8, text-figs. 66, 70g. – Sirel, 1976b, pl. VI, Figs. 2–5. – Drobne, 1977, p. 35, pl. V, Fig. XX, text-fig. 17.

Description: Test subcylindrical with poles slightly depressed inward. The axial diameter is 4.11 mm, equatorial diameter 2.41 mm and index of elongation 1.7. Proloculus is spherical and its diameter is about 176 μm. One to two tightly coiled whorls are followed by six elongated whorls. The basal layer of elongated whorls is very thick along the axial zone. In the last three whorls, axial thickness of the basal layer decreases. Chamberlets are small and spherical in the first whorls, ovoid in the last whorls.

Range: A. decipiens is found in the Late Ilerdian of the Kızılkayatepe section (Fig. 4). This species was shown in the Middle Ilerdian by Hottinger (1960) and Serra-Kiel et al. (1998, Fig. 2). In addition, this species has been found in the Late Ilerdian levels of the Polatlı (Ankara) region by Sirel (1976b).

Alveolina laxa Hottinger, 1960

(Fig. 7e, Fig. 8a)

Alveolina laxa Hottinger, 1960, pl. 8, Fig. 1, text-figs. 68f, g. – Sirel, 1976b, pl. 4, Fig. 11. – Drobne, 1977, p. 35, 36; pl. 6, Figs. 1–4, text-figs. 18.

Description: Megalospheric test of medium size, ovoid with rounded to slightly truncated poles. The axial and equatorial diameters are 4 and 3 mm, respectively. The index of elongation is 1.3. The proloculus is spherical to ovoid with a diameter of 205 μm. The juvenile stage consists of three tightly coiled whorls. Spire is loosely coiled from fourth whorls and basal layer in these whorls is very thick along axial and equatorial zones. Maximum thickness of the basal layer measures from 0.29 to 0.35 mm in the axial zone; 0.17–0.23 mm in the equatorial zone. Chamberlets are spherical in the tight inner whorls and spherical to oval, higher than wide in the outer whorls. Microspheric test is ovoid. The first five to six whorls are tightly coiled. Following are evenly flosculinized whorls. Chamberlets are developed similar to the megalospheric form.

Remarks: This species differs from *A. bayburtensis* by having tightly coiled whorls in the early stage.

Range: This species is observed in the Middle Ilerdian of all sections from the study area (Figs. 2–4). The stratigraphic distribution of *A. laxa* resembles the *Alveolina* zones of Hottinger (1960) and Serra-Kiel et al., 1998.

Alveolina citrea Drobne, 1977

(Fig. 8b)

Alveolina citrea Drobne, 1977, p. 36–38, pl. 6, Figs. 5–9; text-figs. 19a–c. – Acar, 1995, pl. 21, Figs. 1–4.

Description: Test oval with rounded to truncated poles. The axial diameter is about 4.44 mm, equatorial diameter 3.11 mm, index of elongation 1.4. Proloculus is spherical with a diameter of 165–250 μm. First two whorls are tightly coiled, followed by four to five looser coils and up to five relatively tight coils. Axial thickening of the basal layer varies between 0.11–0.27 mm in the elongated whorls, but the equatorial thickening of the basal layer is less. The maximum thickness of the basal layer in the equatorial zone measures 0.11 mm. Chamberlets are spherical in the inner whorls, oval to subrectangular in the outer whorls.

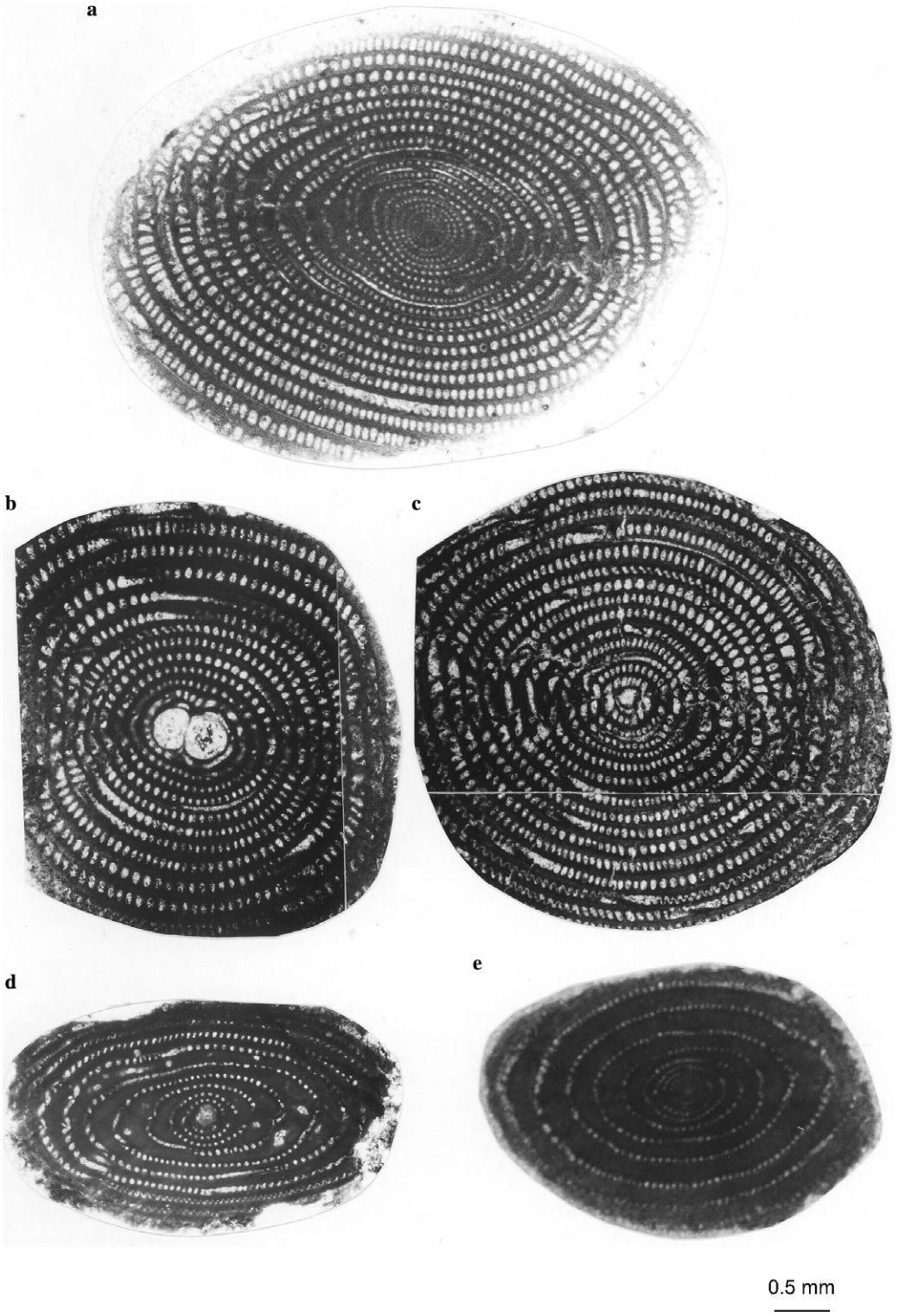


Fig. 7. *A. pisella* Drobne (a) Axial section of microspheric specimen, Kızılkayatepe section (Kz.22). (b) Axial section of megalospheric specimen, twinned, Kızılkayatepe section (Kz.23). (c) Subaxial section of megalospheric specimen, Kızılkayatepe section (Kz.23). (d) *A. decipiens* Schwager, axial section of megalospheric specimen, Kızılkayatepe section (Kz.23). (e) *A. laxa* Hottinger, axial section of juvenil form, microspheric specimen, Kızılkayatepe section (Kz.12). All enlarged ×20.

Remarks: A. citrea is distinguished from *A. laxa* by having relatively tight coiled whorls. In addition, flosculinization is clearly shown in *A. laxa*.

Range: This species is defined in the Late Ilerdian of the Kışlatepe section (Fig. 3). The stratigraphic distribution of *A. citrea* resembles Drobne (1977) and Serra-Kiel et al. (1998).

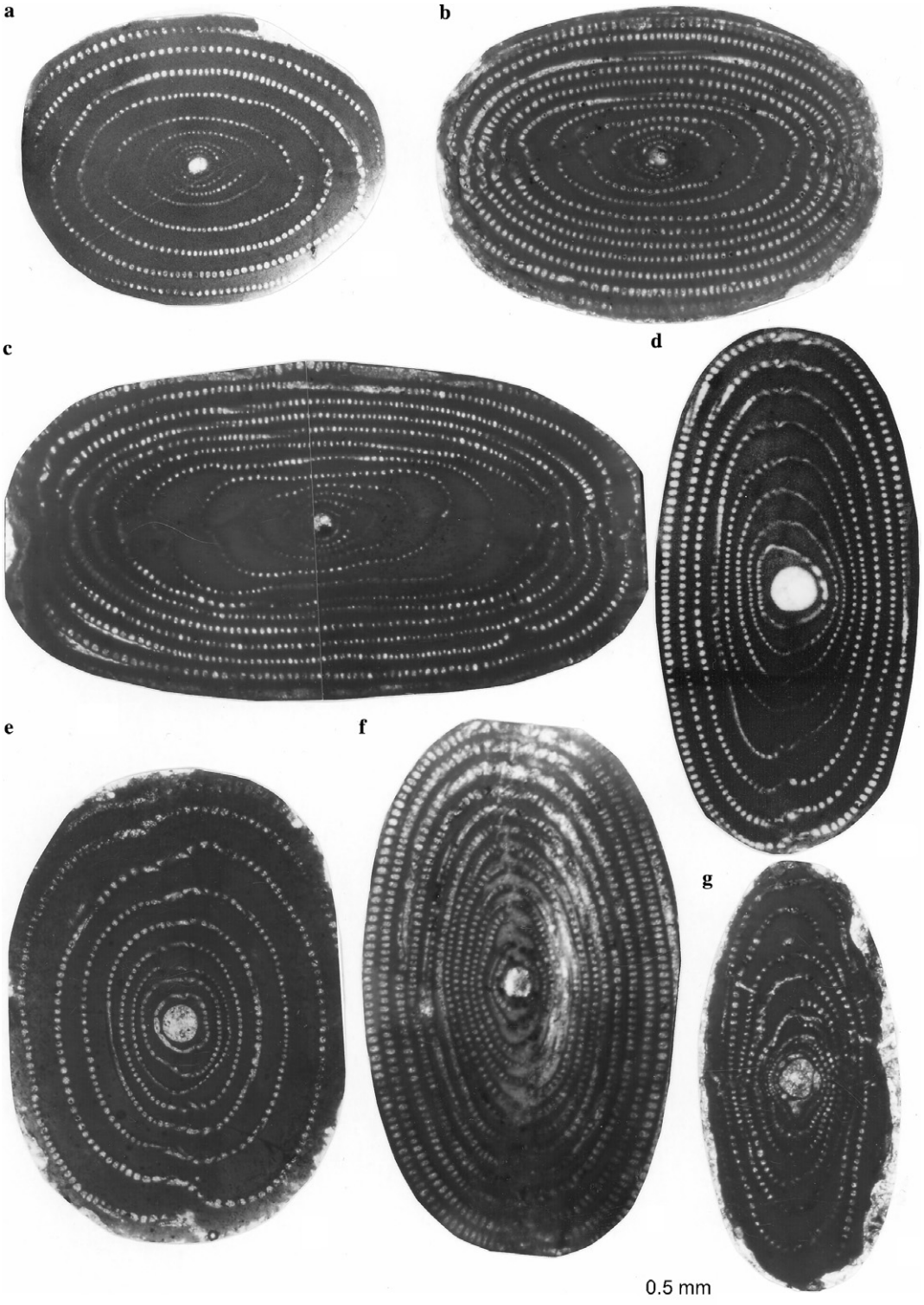


Fig. 8. (a) *A. laxa* Hottinger, axial section of megalospheric specimen, Kızılkayatepe section (Kz.12). (b) *A. citrea* Drobne, axial section of megalospheric specimen, Kıslatepe section (Ks.21). (c–d) *A. canavarii* Checchia-Rispoli, axial sections of megalospheric specimens, c – Kıslatepe section (Ks.24), d – Sarıbayır section (S.25). (e) *A. bayburtensis* Sirel, axial section of megalospheric specimen, Kıslatepe section (Ks.31). (f) *A. oblonga* d'Orbigny, axial section of megalospheric specimen, Kıslatepe section (Ks.27). (g) *A. vredenburgi* Davies & Pinfold, axial section of megalospheric specimen, Kıslatepe section (Ks.4). All enlarged ×20.

Alveolina canavarii Checchia-Rispoli, 1905
(Figs. 8c and d)

Alveolina canavarii Checchia-rispoli, 1905, pl.12, Figs. 19–21, 25. – Hottinger, 1960, pl. 8, Figs. 15–18, text-figs. 21e, 22g, 68a–d, 69. – Dizer, 1964, pl.1, Figs. 15–19; pl. 2, Figs. 1–5, text-fig. 2.

Description: Megalospheric test of medium size, cylindrical to subcylindrical with rounded or truncated poles. Axial

diameter ranges between 4.23 and 6.38 mm, equatorial diameter between 2.76 and 3.38 mm and index of elongation between 1.6 and 1.9. Proloculus ranges from 147 to 630 μm in diameter and is spherical to subspherical in shape. Coiling is loose in the first six to eight whorls. Axial thickening of the basal layer increases from the first whorls, but decreases in the last four to five whorls. Maximum thickness of the basal layer measures between 0.29 and 0.5 mm in the axial zone. The whorls in the equatorial zone are more tightly coiled than the axial zone. Maximum thickness of the basal layer in the equatorial zone measures 0.17 mm. Chamberlets are spherical in the inner whorls, oval in the outer whorls.

Remarks: A. canavarii differs from *A. oblonga* by its less spires and loosely coiled whorls.

Range: A. canavarii is found in the upper part of the Late Ilerdian to Middle Cuisian of the Sarıbayır and Kışlatepe sections (Figs. 2, 3), but it is shown in the Early-Middle Cuisian by Hottinger (1960) and in the Early Cuisian by Serra-Kiel et al. (1998, Fig. 2). Also, this species is found in the Early–Late Cuisian levels of the Haymana-Polatlı region (Sirel, 1976b; Sirel and Gündüz, 1976).

Alveolina bayburtensis Sirel 1976

(Fig. 8e)

Alveolina bayburtensis Sirel, 1976a, pl. I, Figs. 1–3. – Sirel and Gündüz, 1976, pl. XIV, Figs. 3–5. – Acar, 1995, pl. 29, Figs. 3–5; pl. 30, Fig. 1.

Description: Test is cylindrical with poles fairly depressed inward. The axial diameter ranges between 3.8 and 5.1 mm and equatorial diameter between 3.1 and 3.5 mm. The index of elongation changes between 1.25 and 1.56. 9 whorls are counted in an axial diameter of 4.6 mm. The spherical megalosphere (390–562 μm in diameter) is very large and followed by flosculinized whorls. The thickness of the basal layer in all the whorls is high along axial and equatorial zones. Chamberlets are very small and dense. They are spherical in the inner whorls, later becoming oval, higher than wide.

Range: This species is observed in the Middle Cuisian of the Sarıbayır and Kışlatepe sections (Figs. 2, 3). Its stratigraphic distribution corresponds to Serra-Kiel et al. (1998), but is defined in the Middle–Late Cuisian by Sirel (1976a).

Alveolina vredenburgi Davies and Pinfold, 1937

(Fig. 8g)

Alveolina vredenburgi Davies and Pinfold, 1937, pl. V, Fig. 25.

Alveolina cucumiformis Hottinger, 1960, p.135, text-figs. 26, 29/1, 2, 71c and d, 72, 73. – Sirel, 1976b, pl. II, Figs. 1–4. – Drobne, 1977, p. 40.

Alveolina vredenburgi Hottinger et al., 1998, pl.1, Figs. 1–9; pl.2, Figs. 1–10; pl. 3, Figs. 3–10.

Description: Test are small and elongated oval with rounded poles. The axial and equatorial diameters range between 3.22 and 4.16 mm and 1.71 and 1.82 mm, respectively. The index of elongation ranges from 1.8 to 2.2. The diameter of the spherical proloculus ranges between 165 and 380 μm. The first two whorls are tightly coiled when the test is spherical. The following six whorls are elongated and the basal layer is thickened along axial zone. Axial thicknesses is measure between 0.11 and 0.38 mm. Chamberlets are small and spherical in the inner whorls, upright oval. The size of chamberlets gradually increases toward the outer whorls.

Range: This species is found in the Early Ilerdian of the Sarıbayır, Kışlatepe and Kızılkayatepe sections (Figs. 2–4). It is characterized by the *Alveolina cucumiformis* zone in the lower part of the Early Ilerdian (Hottinger, 1960). The stratigraphic distribution of this species is also similar to Serra-Kiel et al. (1998).

Alveolina oblonga d'Orbigny, 1826

(Fig. 8f)

Alveolina oblonga d'Orbigny, 1826, Figs. 28, 30, and 31. – Hottinger, 1960, pl. 9, Figs. 4–16, text-figs. 5, 10, 12, Figs. 16, 17, 22k, 75, 76. – Dizer, 1964, pl. 2, Figs. 7–9, text-fig. 2. – Sirel, 1976b, pl. VI, Figs. 7–11.

Description: Test are cylindrical with rounded poles. The axial and equatorial diameters are 5.5 and 3.2 mm, respectively. The index of elongation is 1.7. The proloculus is subspherical with a diameter of 280 μm. The first five to six whorls are loosely coiled. The maximum thickness of the basal layer ranges from 0.1 to 0.15 mm along the axial zone. The following seven whorls are coiled tightly and the basal layer is very thin. Chamberlets are spherical to subspherical in the loose inner whorls and oval to subrectangular in the outer whorls.

Range: A. oblonga is observed in the Early Cuisian of the Kışlatepe section (Fig. 3). This species was defined as the *Alveolina oblonga* zone in the Early Cuisian by Hottinger (1960), but described to the Early–Middle Cuisian by Serra-Kiel et al. (1998).

Alveolina aff. ***coudurensis*** Hottinger, 1960

(Fig. 9a)

Alveolina coudurensis Hottinger, 1960, p. 144–146, pl. 9, Figs. 19 and 20, text-fig. 77a.

Alveolina aff. *coudurensis* Hottinger, Drobne, 1977, p. 43, pl. 7, Figs. 14 and 15.

Alveolina cf. *coudurensis* Hottinger, Acar, 1995, pl. 26, Fig. 5; pl. 27, Figs. 3 and 8.

Description: Test cylindrical with poles fairly depressed inward. The axial diameter is 5.88 mm, equatorial diameter 2.82 mm and index of elongation 2.08. The proloculus is subspherical and its diameter is 294 μm. It is followed by three tightly coiled whorls. Coiling is loose from the fourth whorl and the basal layer is very thick in the axial zone. The thickness of the basal layer is between 0.17 and 0.58 mm in the axial zone and 0.08–0.29 mm in the equatorial zone. Chamberlets are generally spherical to oval.

Remarks: In *A. coudurensis* Hottinger, coiling is loose from the first whorl and the index of elongation ranges from 2.2 to 3.1. However, our specimen has three tightly coiled whorls in the early stage and its index of elongation is smaller than the type species.

Range: Early Cuisian, Kışlatepe section (Fig. 3).

Alveolina haymanensis Sirel 1976

(Fig. 9b)

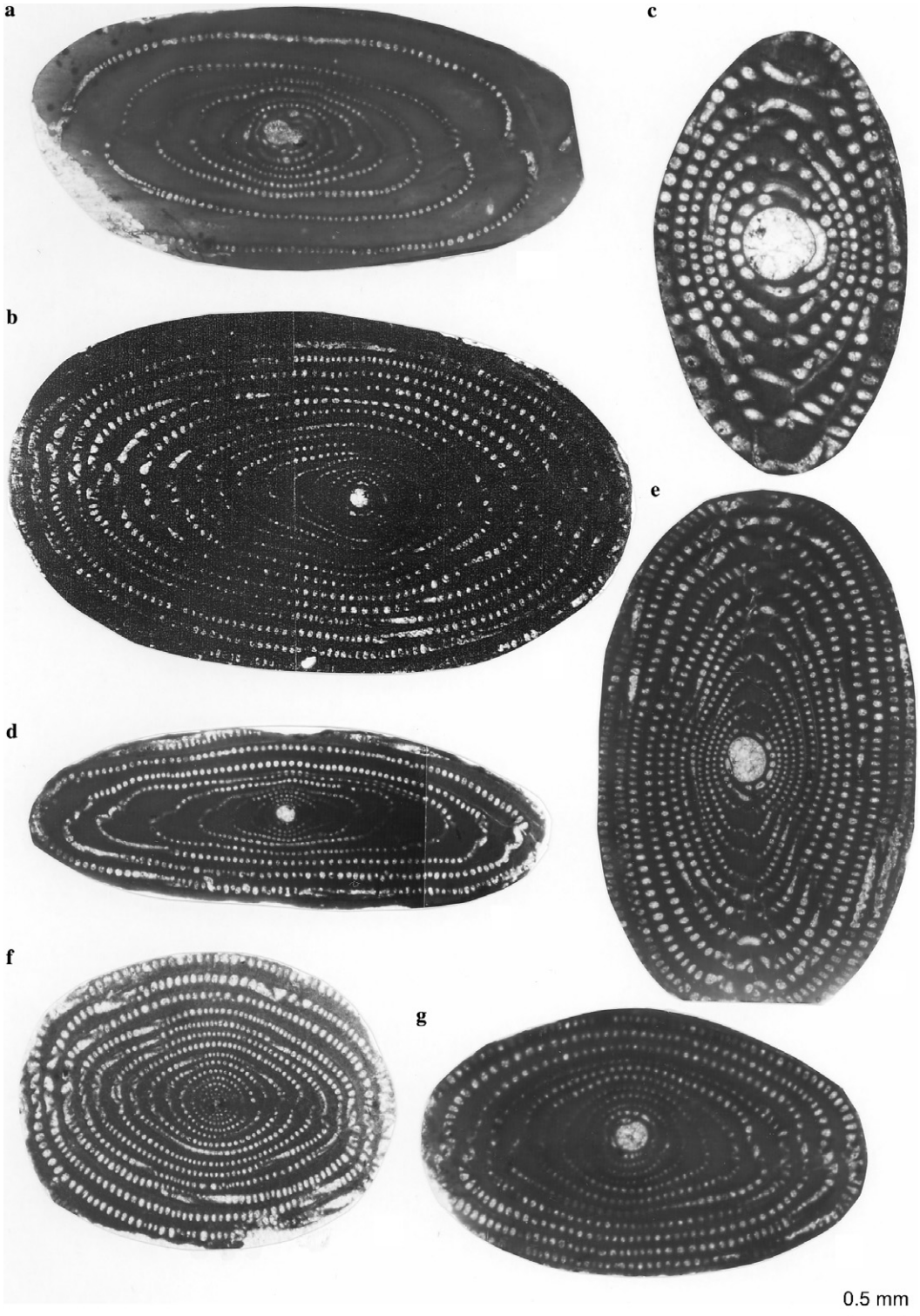


Fig. 9. (a) *A.* aff. *coudurensis* Hottinger, axial section of megalospheric specimen, Kıslatepe section (Ks.26). (b) *A. haymanensis* Sirel, axial section of megalospheric specimen, Kıslatepe section (Ks.27). (c) *A. cremae* Checchia-Rispoli, axial section of megalospheric specimen, Sarıbayır section (S.29). (d) *A. ruetimeyeri* Hottinger, axial section of megalospheric specimen, Sarıbayır section (S.23). (e) *A. lehneri* Hottinger, axial section of megalospheric specimen, Kıslatepe section (Ks.33). (f) *A. varians* Hottinger, axial section of megalospheric specimen, Kızılkayatepe section (Kz.12). (g) *A. schwageri* Checchia-Rispoli, axial section of megalospheric specimen, Kıslatepe section (Ks.25). All enlarged ×20.

Alveolina haymanensis Sirel, 1976a, pl. II, Fig. 2; pl. III, Figs. 1–3. – Acar, 1995, pl. 25, Figs. 1, 2, and 5; pl. 26, Fig. 1; pl. 27, Figs. 1 and 2.

Description: Megalospheric test is large and oval. Axial diameter is 6.22 mm, equatorial diameter 3.6 mm and index of elongation is 1.7. The spherical megalosphere

(200 μm in diameter) is followed by two tightly coiled whorls. Axial thickening of the basal layer is thin in these whorls. The following 9–10 whorls are coiled loosely along axial zone. Axial thickening of the basal layer is two to three times thicker than the height of the chamberlets. In the last four to five whorls, axial thickening of the basal layer becomes decreases and chamberlets are subrectangular in shape.

Remarks: This species differs from *A. oblonga* by its ovoid shape in the adult stage and tightly coiled whorls in the earliest stage.

Range: This species is found in the Early Cuisian of the Kışlatepe section (Fig. 3). It was defined in the Early Cuisian (*Alveolina oblonga* zone) by Sirel (1976a). The stratigraphic distribution of *A. haymanensis* resembles the *Alveolina* zones Serra-Kiel et al. (1998).

Alveolina cremae Checchia-Rispoli, 1905

(Fig. 9c)

Alveolina cremae Checchia-Rispoli, 1905, pl. 12, Figs. 3–5. – Hottinger, 1960, p.152, pl.10, Figs. 8–10, pl. 11, Figs. 4–8; pl. 14, Fig. 8. – Acar, 1995, pl. 32, Fig. 7; pl. 33, Fig. 1.

Description: Test is fusiform to oval with axial and equatorial diameters about 4.15 and 2.25 mm, respectively. Index of elongation is 1.8. Proloculus is spherical and very large with a diameter of approximately 650 μm. Coiling is loose and the basal layer is thick along the axial zone. Maximum thickness of the basal layer is between 0.25 and 0.3 mm. Number of whorls is few. Chamberlets are very large with a greater width than height in the first whorl, spherical to oval in the last whorls.

Remarks: A. cremae is distinguished from *A. ellipsoidalis* in possesing a large proloculus and chamberlets and fewer whorls.

Range: This species is found in the Middle Cuisian of the Sarıbayır section (Fig. 2). Its stratigraphic distribution is shown as the Middle Cuisian by Hottinger (1960) and Serra-Kiel et al. (1998).

Alveolina schwageri Checchia-Rispoli, 1905

(Fig. 9g)

Alveolina schwageri Checchia-Rispoli, 1905, pl. 12, Figs. 11–14. – Hottinger, 1960, p. 155, pl. 10, Figs. 5–7; pl. 11, Fig. 3. – Drobne, 1977, Fig. 39a, pl. 15, Figs. 13–16.

Description: Test is small and fusiform. The equatorial diameter varies between 2.52 and 2.67 mm, axial diameter measures from 4.1 to 4.5 mm. Index of elongation between 1.6 and 1.7. The proloculus is spherical with a diameter of 330 μm. The first two whorls are spherical and encircled by five or six whorls that are elongated along axial zone. In this stage, the test is fusiform in shape. The axial thickening of the basal layer ranges from 0.11 to 0.22 mm in the elongated whorls. In the external whorls, the thickness of the basal layer decreases (0.08–0.16 mm).

Remarks: A. schwageri differs from other *Alveolina* genus in the Early Cuisian by its fusiform test shape and spherical early whorls.

Range: This species is defined in the Early Cuisian of the Kışlatepe section (Fig. 3). The stratigraphic distribution of *A. schwageri* resembles *Alveolina* zones of Hottinger (1960) and Serra-Kiel et al. (1998).

Alveolina lehneri Hottinger, 1960

(Fig. 9e)

Alveolina lehneri Hottinger, 1960, pl. 13, Figs. 7–9, text-figs. 83f and g.

Description: Test is large, elongated oval with slightly truncated poles. The axial diameter ranges from 5.2 to 6.1 mm, equatorial diameter from 3 to 3.42 mm and index of elongation from 1.6 to 1.8. Proloculus is spherical to subspherical and its diameter is from 220 to 450 μm. Coiling is relatively loose. Basal layer along zone of coiling is thickened from the third whorl to eighth-ninth whorls followed by up to four to six whorls that lack axial thickening. Maximum thickness of the basal layer measured in the axial zone is from 0.22 to 0.27 mm. The shape of the test in the first growth stage is fusiform, but in the last stage its shape becomes oval to subcylindrical.

Remarks: A. lehneri differs from *A. oblonga* by having a fusiform test shape in the early stage and oval shape in the last stage.

Range: This species is found in the Middle Cuisian of the Kışlatepe section (Fig. 3). Its stratigraphic distribution corresponds to the *Alveolina* zones of Hottinger (1960) and Serra-Kiel et al. (1998).

Alveolina ruetimeyeri Hottinger, 1960

(Fig. 9d)

Alveolina ruetimeyeri Hottinger, 1960, pl. 9, Figs. 17–18; pl. 11, Figs. 13–15; pl. 14, Figs. 20–22. – Dizer, 1964, pl. 3, Figs. 6–8, text-fig. 4. – Drobne, 1977, pl. 17, Figs. 2–5.

Description: Test is elongated and cylindrical to subcylindrical. Poles are rounded or depressed inward. The equatorial diameter varies from 1.61 to 2.1 mm. The axial diameter measures from 3.97 to 5.2 mm with an index of elongation of 2.4–3. The proloculus is spherical to subspherical and has a diameter from 165 to 230 μm. Coiling is looser from the first whorl. Axial thickening of the basal layer is very thick and the maximum thickness ranges from 0.32 to 0.52 mm. In the last whorls, thickening gradually decreases.

Remarks: This species is distinguished from *A. oblonga* by its loosely coiled whorls and greater axial thickening of the basal layer.

Range: This species is found in the Early–Middle Cuisian of the Sarıbayır and Kışlatepe sections (Figs. 2, 3). The stratigraphic distribution of *A. ruetimeyeri* resembles Serra-Kiel et al. (1998), but was shown in the Early Cuisian (*Alveolina oblonga* zone) by Hottinger (1960).

Alveolina varians Hottinger, 1960

(Fig. 9f)

Alveolina varians Hottinger, 1960, pl. 8, Figs. 9–12, text-figs. 12, 65. – Sirel, 1976b, pl. IV, Figs. 17–18; pl. VII, Figs. 6–7.

Description: Test is medium sized and oval. Axial diameter varies between 3.76 and 4.12 mm. Equatorial diameter ranges from 2.64 to 3.62 mm and the index of elongation ranges from 1.1 to 1.4. Proloculus is spherical and has a diameter ranging from 65 to 200 μm. Coiling is irregular

and tight in the early stages and relatively loose in the last stage. The basal layer is very thin in the first three to five whorls and the test is spherical in this stage. In later whorls, the thickness of the basal layer increases irregularly. The shape of the test becomes inflated fusiform with slightly pointed poles. In the last growth stage, the test is oval with slightly truncated poles. Chamberlets are numerous and spherical in the juvenile stage, becoming oval in the adult stage.

Remarks: A. varians differs from *A. subpyrenaica* and *A. aragonensis* by having a fusiform test shape in the juvenile stage, ovoid test with truncated poles in the adult stage and relatively loose coiling.

Range: A. varians is found in the Middle Ilerdian of the Kışlatepe and Kızılkayatepe sections (Figs. 3, 4). Its stratigraphic distribution is shown in the Middle Ilerdian levels of the Polatlı region by Sirel (1976b). However, this species is defined in the lower part of the Early Ilerdian (*Alveolina cucumiformis* zone) by Hottinger (1960) and Serra-Kiel et al. (1998) [Fig. 2].

5. Biostratigraphic interpretation and discussion

Eight *Alveolina* biozones were described in the Ilerdian and Cuisian interval by Hottinger (1960). The other zonation study, which described twenty shallow benthic zones (SB1–20) based on alveolinid, nummulitid, orthophragminid and the other foraminiferal species in Paleocene–Eocene sediments, was carried out by Serra-Kiel et al. (1998). These two zonation studies were mainly based on data from the Tethyan province.

The stratigraphic distributions of *Alveolina* species described in this study have been correlated with those described previously in different localities of the Tethyan province, including Turkey (Hottinger, 1960; Sirel, 1976a,b, 1998; Sirel and Gündüz, 1976; Drobne, 1977; Acar, 1995; Serra-Kiel et al., 1998). These data are given in the systematic paleontology part under the title of "Range".

In this part, stratigraphic distributions and assemblages of *Alveolina* species, which are defined in the study area, are presented in chronostratigraphical order. In addition, their positions in the original *Alveolina* biozones (Hottinger, 1960) and shallow benthic biozones (Serra-Kiel et al., 1998) are explained (Figs. 2–4).

The lower part of the Early Ilerdian has been described as the *Alveolina cucumiformis* (*vredenburgi*) zone by Hottinger (1960) or as the shallow benthic (5) zone by Serra-Kiel et al. (1998). This interval is represented by the first and the last occurrence of *Alveolina vredenburgi* in the three sections of the studied area. In addition, *Alveolina* assemblages such as *Glomalveolina lepidula*, *A. ellipsoidalis* and *A. avellana* in the Sarıbayır section (Fig. 2); *G. lepidula*, *G. karsica* and *A. ellipsoidalis* in the Kışlatepe section (Fig. 3) and *A. ellipsoidalis* and *A. avellana* in the Kızılkayatepe section (Fig. 4) have been recognized together with *A. vredenburgi* in this interval.

The upper part of the Early Ilerdian is described as the *Alveolina ellipsoidalis* zone by Hottinger (1960) or the shallow benthic (6) zone by Serra-Kiel et al. (1998). However, a biostratigraphic range of *A. ellipsoidalis* has not been recognized in this interval in the study area. The first occurrence of *G. minutula* and *A.* aff. *minervensis*, or the last occurrence of *A. vredenburgi* define the lower boundary of this interval in the Sarıbayır section (Fig. 2). The upper boundary of this interval, on the other hand, is defined by the first occurrence of *A. moussoulensis, A. aragonensis*, *A. subpyrenaica* and *A. laxa*. In the Kışlatepe section (Fig. 3), the last occurrence of *A. vredenburgi* and *G. karsica* determines the lower and upper boundaries of this interval, respectively. In addition, the first occurrences of *A. moussoulensis*, *A. aragonensis*, *A. laxa* and *A. varians* help define the upper boundary of this interval in this section (Fig. 3). In the Kızılkayatepe section, the first appearance of *A. dedolia* defines the lower boundary of this interval. The upper boundary is represented by the first occurrence of *A. moussoulensis*, *A. aragonensis*, *A. subpyrenaica*, *A. laxa* and *A. varians* in this section (Fig. 4). The *Alveolina* species such as *G. lepidula*, *G. minutula*, *A. ellipsoidalis*, *A. avellana* and *A. aff. minervensis* in the Sarıbayır section; *G. lepidula*, *G. karsica* and *A. ellipsoidalis* in the Kışlatepe section and *A. dedolia*, *A. ellipsoidalis* and *A. avellana* in the Kızılkayatepe section constitute assemblages in this interval.

The lower part of the Middle Ilerdian, described as the *Alveolina moussoulensis* zone by Hottinger (1960) or as the shallow benthic (7) zone by Serra-Kiel et al. (1998), is represented by the first and the last occurrence of *A. moussoulensis* and *A. laxa* in all sections (Figs. 2–4). The *Alveolina* species such as *G. lepidula*, *G. minutula*, *A. ellipsoidalis*, *A. avellana*,*A. subpyrenaica*, *A. aff. minervensis* and *A. aragonensis* in the Sarıbayır section; *G. lepidula*, *A. ellipsoidalis*, *A. aragonensis*, *A. varians* in the Kışlatepe section and *A. dedolia*, *A. ellipsoidalis*, *A. aragonensis*, *A. varians*, *A. subpyrenaica* and *A. avellana* in the Kızılkayatepe section form assemblages in this interval.

The upper part of the Middle Ilerdian, described as the *Alveolina corbarica* zone by Hottinger (1960) or as the shallow benthic (8) zone by Serra-Kiel et al. (1998) is, represented by the first and the last occurrence of *A. ilerdensis* in the Sarıbayır and Kışlatepe sections (Figs. 2, 3). In the Kızılkaya section (Fig. 4), the last appearance of *A. moussoulensis*, *A. subpyrenaica*, *A. laxa*, *A. dedolia* and *A. avellana* designates the lower boundary of this interval. The upper boundary is defined by the last occurrence of *A. ellipsoidalis* and *A. varians* and the first appearance of *A. pisella* and *A. decipiens.* The *Alveolina* assemblages of this interval are *G. lepidula*, *G. minutula*, *A. ilerdensis*, *A. ellipsoidalis*, *A. aff. minervensis* and *A. aragonensis* in the Sarıbayır section; *G. lepidula*, *A. ilerdensis*, *A. ellipsoidalis*, *A. aragonensis* and *A. varians* in the Kışlatepe section and *A. ellipsoidalis*, *A. aragonensis* and *A. varians* in the Kızılkayatepe section.

The Late Ilerdian, described as the *Alveolina trempina* zone by Hottinger (1960) or the shallow benthic (9) zone

by Serra-Kiel et al. (1998), is represented by the first and the last appearance of *A. trempina* in the Sarıbayır section. The first and the last appearance of *A. citrea* define the lower and upper boundaries of this interval in the Kışlatepe section, respectively. In the Kızılkayatepe section, this interval is defined by the first and the last occurrence of *A. pisella* and *A.decipiens*. The *Alveolina* assemblages of the Late Ilerdian are *G. lepidula*, *G. minutula*, *A. trempina* and *A. aragonensis* in the Sarıbayır section; *G. lepidula*, *A. citrea* and *A. aragonensis* in the Kışlatepe section and *A. pisella*,*A. decipiens* and *A. aragonensis* in the Kızılkayatepe section.

The Early Cuisian, described as the *Alveolina oblonga* zone by Hottinger (1960) or the shallow benthic (10) zone by Serra-Kiel et al. (1998), is represented by the first and the last appearances of *A. haymanensis*, *A. schwageri*, *A. oblonga* and *A.* aff. *coudurensis* in the Kışlatepe section. In the Sarıbayır section, the first occurrence of *A. ruetimeyeri* and the last occurrences of *G. lepidula*, *A. trempina* and *A. aragonensis* define the lower boundary of this interval. The upper boundary is represented by the last occurrence of *G. minutula* and the first occurrences of *A. bayburtensis* and *A. cremae*. In the Kızılkaya section, the last appearances of *A. aragonensis*, *A. pisella* and *A. decipiens* mark the lower boundary of this interval. *A. muscatensis* is observed only in this interval. The *Alveolina* species such as *G. minutula*, *A. canavarii* and *A. ruetimeyeri* in the Sarıbayır section; *A. oblonga*, *A. aff. coudurensis*, *A. haymanensis*, *A. schwageri*, *A. canavarii* and *A. ruetimeyeri* in the Kışlatepe section constitute assemblages in this interval.

The Middle Cuisian, described as the *Alveolina dainellii* zone by Hottinger (1960) or as the shallow benthic (11) zone by Serra-Kiel et al. (1998), is represented by the first and the last occurrences of *A. cremae* and *A. bayburtensis* in the Sarıbayır section (Fig. 2). In the Kışlatepe section, the first and the last appearance of *A. lehneri* and *A. bayburtensis* mark the lower and upper boundaries of this interval, respectively. In addition, the last occurrences of *A. canavarii* and *A. ruetimeyeri* define the upper boundary of this interval in both sections. This interval is not observed in the Kızılkayatepe section (Fig. 4). The *Alveolina* assemblages in the Middle Cuisian consist of *A. bayburtensis*, *A. cremae*, *A. canavarii* and *A. ruetimeyeri* in the Sarıbayır section and *A. bayburtensis*, *A. lehneri*, *A. canavarii* and *A. ruetimeyeri* in the Kışlatepe section.

6. Conclusions

In this study, 28 *Alveolina* species are defined from the Ilerdian–Middle Cuisian unit of the study area. *Alveolina* assemblages of the Seyitgazi (Eskişehir) region have close affinity to several previously studied Ilerdian–Cuisian *Alveolina* fauna from the Tethyan province (Hottinger, 1960; Drobne, 1977; Serra-Kiel et al., 1998). However, stratigraphic ranges of *G. minutula*, *A. ellipsoidalis*, *A. dedolia*, *A. varians*, *A. ilerdensis*, *A. decipiens* and *A. canavarii*, which are described in the study area, exhibit differences compared to their equivalents in the Tethyan province. This observation is supported by several studies conducted in various localities of Turkey (Sirel, 1976a,b; Sirel and Gündüz, 1976; Sirel, 1998; and Acar, 1995). The stratigraphic range of *G. minutula* is Early Ilerdian–Early Cuisian. *A. ellipsoidalis* and *A. dedolia* are observed in the Early–Middle Ilerdian. The age of *A. varians* and *A. ilerdensis* is Middle Ilerdian. *A. decipiens* and *A. canavarii* are found in the Late Ilerdian and Late Ilerdian–Middle Cuisian, respectively.

The characteristic *Alveolina* assemblages of the Seyitgazi region are presented in chronostratigraphical order as follows:

The Early Ilerdian is characterized by the presence of mainly *A. vredenburgi*, *A. ellipsoidalis*, *A. avellana*, *A.* aff. *minervensis*, *A. dedolia, G. lepidula*, *G. minutula* and *G. karsica.*

The Middle Ilerdian is represented by *A. moussoulensis*, *A. subpyrenaica*, *A. laxa*, *A. ellipsoidalis*, *A. avellana*, *A.* aff. *minervensis*, *A. aragonensis, A. varians*, *A. ilerdensis*, *G. lepidula* and *G. minutula.*

The Late Ilerdian is characterized by the occurrence of *A. trempina*, *A. citrea*, *A. pisella*, *A. decipiens*, *A. aragonensis*, *G. lepidula* and *G. minutula.*

The Early Cuisian is mainly represented by the presence of *A. oblonga*, *A. schwageri*, *A. haymanensis*, *A. canavarii*, *A.* aff. *coudurensis*, *A. ruetimeyeri*, *A. muscatensis* and *G. minutula.*

The Middle Cuisian is characterized by the occurrence of *A. cremae*, *A. bayburtensis*, *A. lehneri*, *A. canavarii* and *A. ruetimeyeri.*

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