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Systematic descriptions of alveolinids from the Ilerdian-Cuisian (Ypresian) of Hormak conglomerates of Ghargharook section from north Zahedan, East Iran Belt

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Original Research

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Abstract:

Alveolinids benthic foraminifera, are known as significant biostratigraphic markers, commonly occur in shallow water carbonates of Eocene deposits from Tethyan regions. Twenty-nine species and three subspecies of the genus *Alveolina* are described from carbonate pebbles of the Hormak conglomerates (Ghargharook section) in northeastern Zahedan (Eastern Iran Belt). The Ilerdian and Cuisian chronstratigraphic units of the study area are characterized by perfectly preserved specimens of *Alveolina* species such as *A. archiaci adamsi, A. aramaea, A. canavari, A. corbarica, A. cremae, A. dedolia taneri, A. aff. di-stefanoi, A. ellipsoidalis, A. erki, A. aff. frumentiformis, A. gambaensis, A. globosa, A. globula, A. aff. guidonis, A. haymanaensis, A. himalayensis, A. kayserensis, A. minuta, A. moussoulensis, A. oblonga, A. parva, A. pisiformis, A. reicheli, A. rotundata kazancii, A. ruetimeyeri, A. sakaryaensis, A. schwageri, A. subpyrenaica* and *A. aff. tumida*. These species are found throughout many shallow-water successions of the Tethyan region during the Lower Eocene (subzones 6 – 12). Calcareous pebbles containing *Alveolina* are originated from the northern parts of the mountains of Eastern Iran, mainly Safid Abeh, Bandan, Nehbandan and Birjand areas. These pebbles were parts of the local Zebro, Debil, and Palang formations.

Keywords: Benthic foraminifera; Alveolinids; Lower eocene; Hormak conglomerates; East Iran Belt

1. Introduction

The genus *Alveolina* d'Orbigny (1826) is a larger benthic foraminifer with porcelaneous test, planispirally coiled; it was abundant and diverse especially in the Eocene shallow–water tropical and subtropical carbonate environments. Accurate identification of *Alveolina* species makes it a powerful tool for determining the age of rocks and global biostratigraphy and paleogeographic reconstructions of the Tethyan regions.

The distinction of alveolinid biozones proposed by Hottinger (1960) and Serra-Kiel et al. (1998) are mainly assessed from the Tethyan province. Alveolinids, throughout their evolutionary lineages, exhibit relatively rapid rates of evolution and develop complex structures, which makes them a crucial biostratigraphic index fossil group for the shallow marine environments of the Paleogene. The Eocene alveolinids of the Tethys regions have been described by several researchers (Hottinger, 1960, 1974; carlo, 1966; Sirel, 1976a, 1976b; Drobne, 1977; Rahaghi, 1978, 1980, 1983; Sameeni and Butt, 2004; Vecchio et al., 2007; Erdem, 2008; Erdem et al., 2007; Erdem et al., 2016; Sirel and Acar, 2008; Drobne et al., 2011; Zhang et al., 2013; Deveciler, 2014; Sarkar, 2016, 2019; Babazadeh and Najafabadi, 2015; Papazzoni et al., 2017; Hadi and Vahidnia, 2019; Hadi et al., 2019a; Hadi et al., 2019b; Hadi et al., 2019c; Hadi et al., 2020a; Hadi et al., 2020b; Moezi–Nasab et al., 2018; Bozkurt and Görmüş, 2021; Arjmandzadeh et al., 2021; Rahman et al., 2021; Khan et al., 2021), among others.

In the East Iran Belt, few systematic studies have been carried out on the Eocene alveolinas, for instance Babazadeh

and Alavi (2013) studied the carbonate sequences of south Birjand and identified Early Eocene SBZ5-6 zones of Serra-Kiel et al. (1998) (Fig. 1).
Moezi–Nasab et al. (2018) studied the Hormak conglomerate and they suggested an Early Eocene age for this conglomerate level (Fig. 1).
Hadi et al. (2019a) and Hadi et al. (2019c) studied biostratigraphy of larger foraminiferal and microfacies from two limestones sections of Ypresian (Ilerdian-Cuisian) age of the Sistan Suture Zone (eastern Iran): 1-Chenesht section repotred middle Ilerdian to late Cuisian (SBZ8-12) and; 2-Robiyat section reported middle to late Cuisian (SBZ11-12) (Fig. 1).
Recently, Hadi et al. (2019a) studied marly limestone (16 m in thickness) of the Hormak section located 29° 59′37″N; 60° 51′14″E close to the Ghargharook section. However, there are ambiguities in their study, since, by our field observations, no marly limestone units have been recognized in this area (Fig. 1).
The purpose of this paper is 1) systematic description of *Alveolina* species contained in allochthonous pebbles originated from the eastern belt of Iran. 2) Determining the origin of conglomerate carbonate pebbles based on the identification of alveolinid assemblages. 3) Stratigraphers can use the results of this research to reconstruct the paleogeography of different regions of Tethys.

2. Geological setting and lithostratigraphy

Iran has been subdivided into various sedimentary-structural zones (Fig. 2 a). In the eastern part of central Iran, between the Nehbandan Fault (in the west) and the Hariroud Fault (in the east), with a range of 800 km long and 200 km wide,

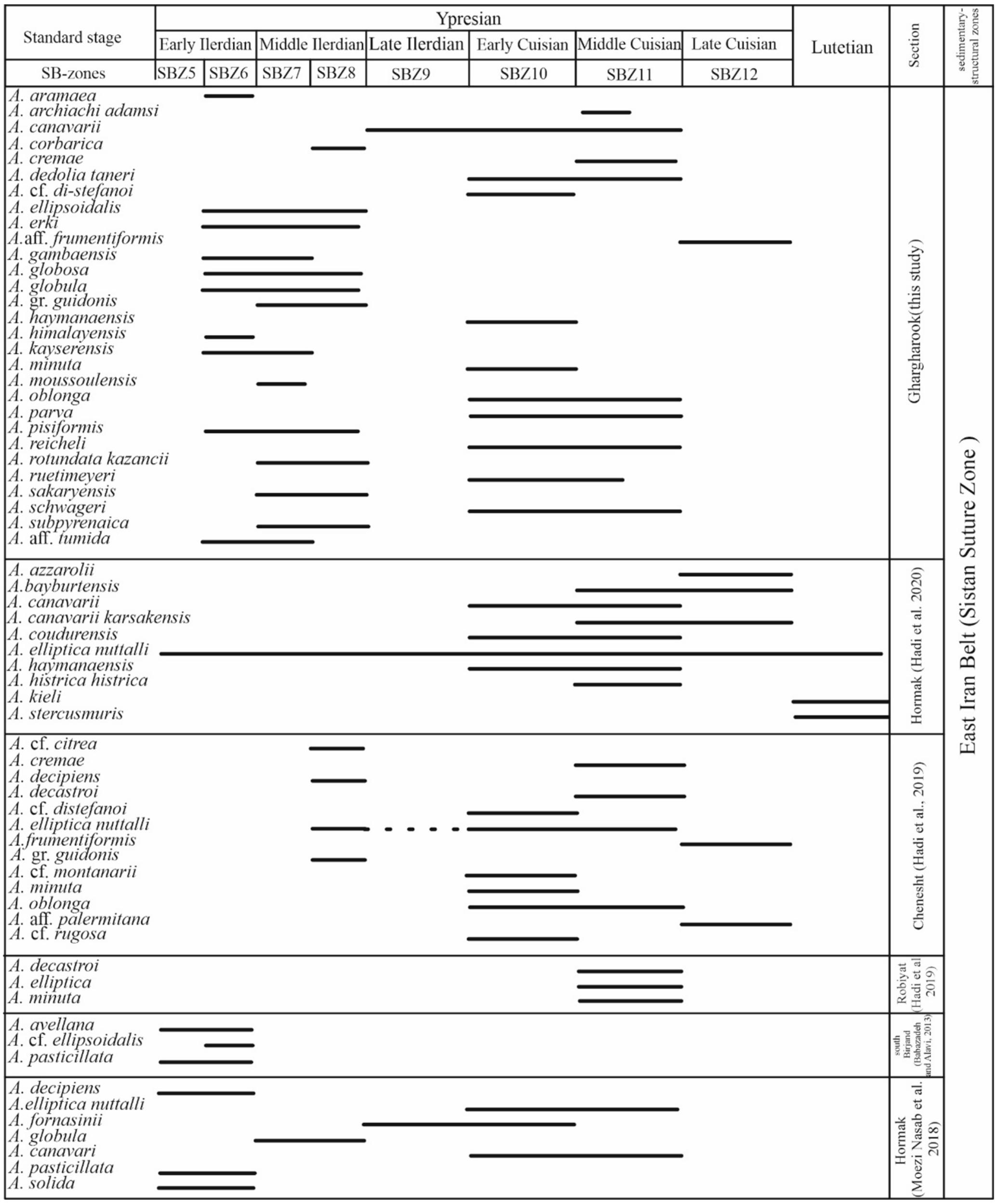

Figure 1. Stratigraphic distributions of the *Alveolina* species in the East Iran Belt, after previous works and this study (Moezi–Nasab et al., 2018; Babazadeh and Alavi, 2013; Hadi et al., 2019a) and (Hadi et al., 2019a).

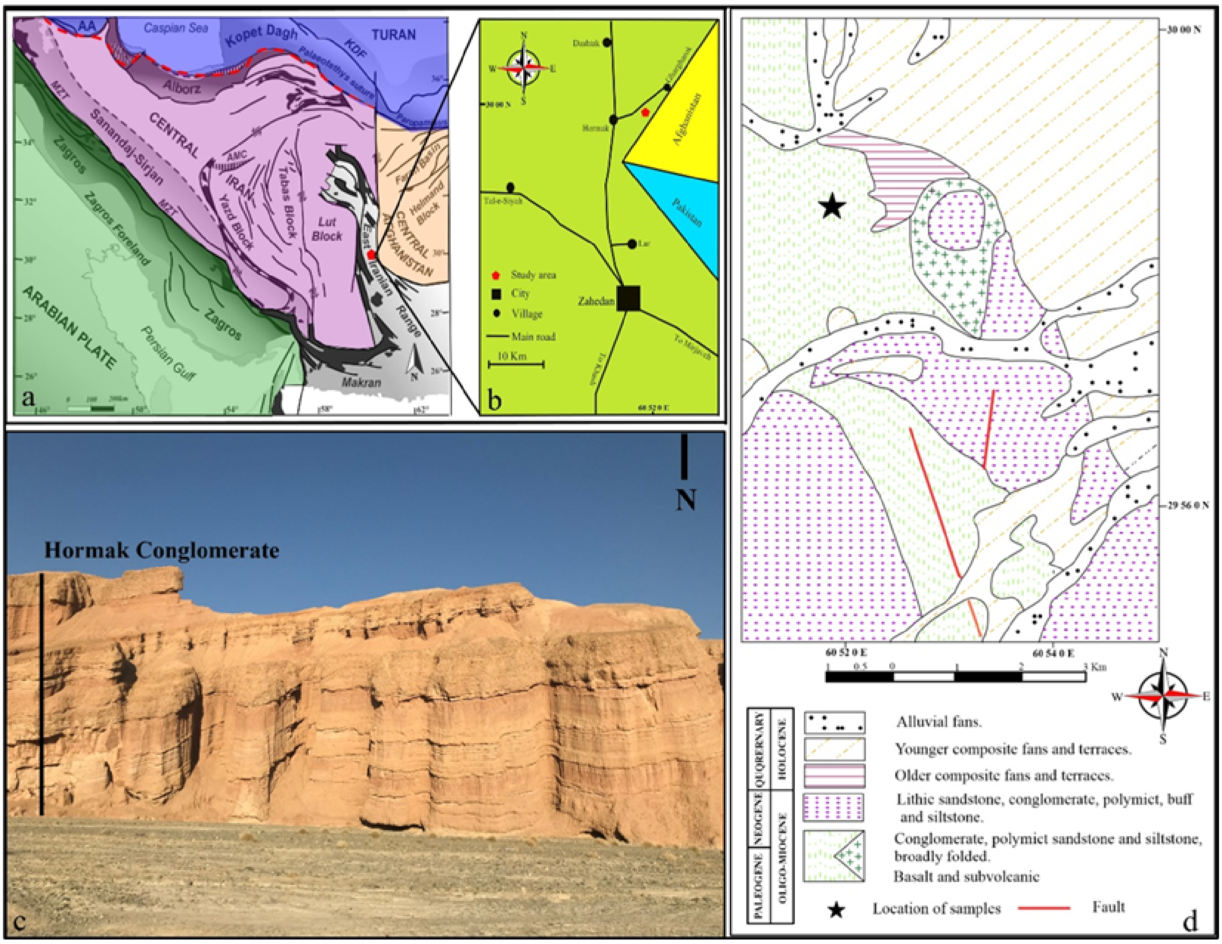

Figure 2. (a) Map of Iran showing the sedimentary-structural zones (modified from (Zanchi et al., 2009)). (b) Geographic position of the studied area, Ghargharouk section. (c) Photographs of the Hormak conglomerate. (d) Geological map and location of the studied section (modified from (Behrozi, 1991)).

there are thick flysch deposits, which contain ophiolitic rocks associated with remains oceanic crust. The mentioned area, which passed the developmental stages from oceanic to continental crust, is one of the derivations of the "Neo-Tethyan" type, called the "East Iran Belt Mountains" (Alavi, 1991). Iranshahr – Birjand Sheared Fault Zone (Samani and Ashtari, 1992) contains Nehbandan-Khash Zone (Nabavi, 1976) Iranshahr-Birjand area (Reyre and Mohafez, 1972) and Sistan Suture Zone (Tirrul et al., 1983).

The ophiolite-flysch range of the East Iran Belt Mountains includes several intensely deformed tectonic units consisting of volcanic and volcanoclastic rocks, siliceous pelagic sediments (cherts and radiolarites), and calcareous rocks (deep marine, platform), while in some other parts there are outcrops of terrigenous turbidites.

The study area is located between Nosrat Abad and Kahourak faults in the east of Iran (Aghanabati, 2004). Based on the mechanism of these faults, it seems that the evolution of the sedimentary basin in the study area was different from the main zone of the Sistan Suture and the evolution of sedimentary and igneous facies from the Late Cretaceous (Aghanabati, 2004). In this region, from the east (Nosrat Abad Fault) to the west (Kahourak Fault), sedimentary rocks along with igneous rocks (gabbro and pillow lava) were deposited during the Late Cretaceous, although Eocene ignimbrite, tuff, and rhyolitic tuffs discontinuously overlie the whole strata. In the study area, there are outcrops of conglomerates of 1 to 300 meters in thickness near Ghargharook village. The study stratigraphic section is composed of alternation of oligomictic conglomerate bearing calcareous pebbles, isolated corals and pebbly chert, sandstone, red shale, andesite, basalt, and rhyolitic tuff pebbles (Fig. 3).

3. Material and methods

The alveolinids described here are included in samples collected from a stratigraphical section located 7 km to the east of the village of Ghargharook, located 50 km north of the Zahedan city (Figs. 2 b-d). The selected site for the fieldwork shows perfectly preserved foraminifera specimens and is located 60°51′39.48″E latitude, 29°58′35.41″N longitude, respectively.

The alveolinids were found in limestone pebble of the Hormak conglomerate (Samples GH 1 – 46). The authors performed taxonomic investigations on 120 thin sections using a Nikon eclipse E200 microscope. Photomicrographs were taken using Superior Statistical analysis Pro (with version 9.0 of LIMDEP 2008). The material is housed at the Islamic Azad University of Zahedan.

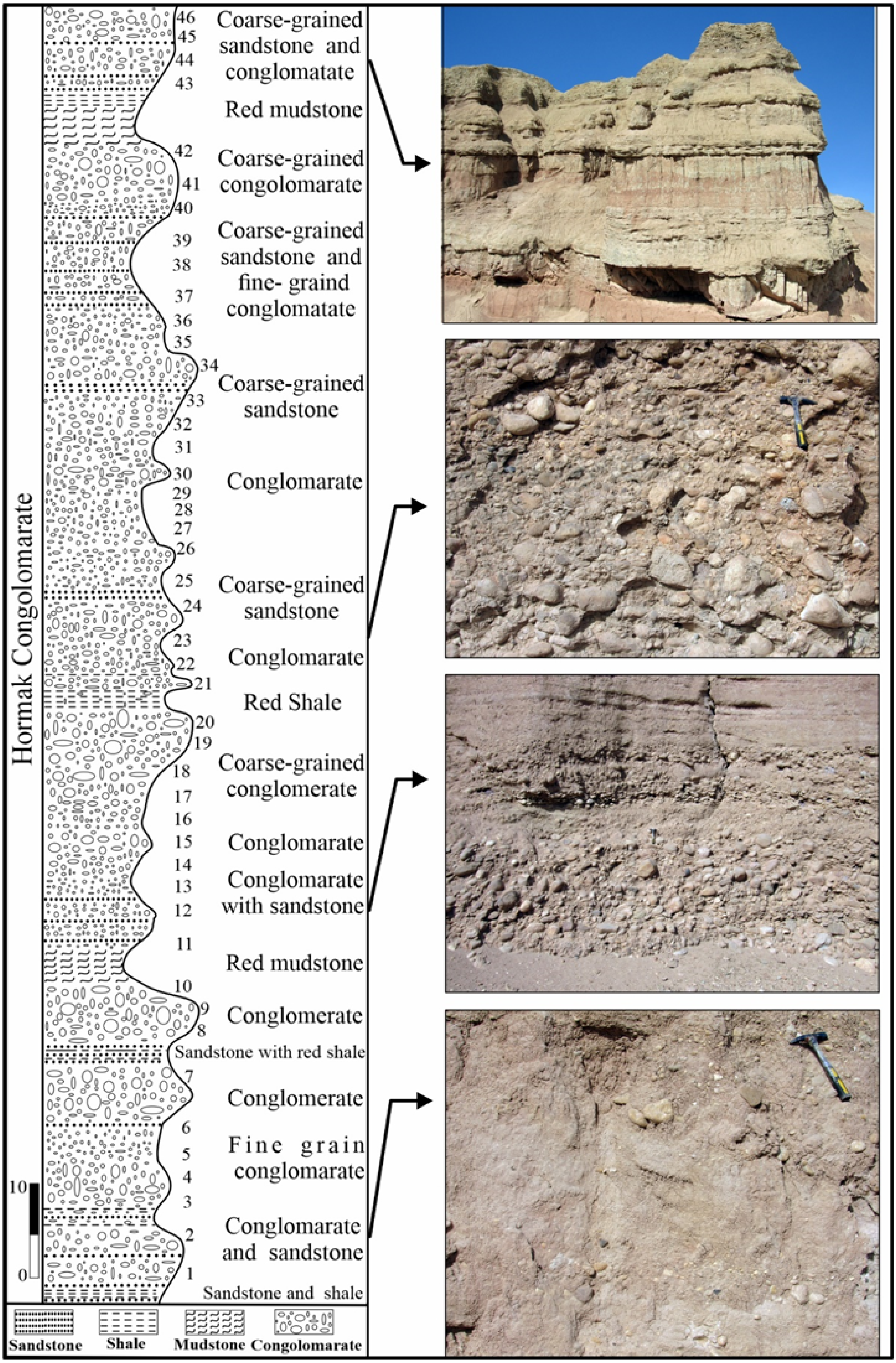

Figure 3. Lithostratigraphic column and photographs of the Hormak conglomerate.

4. Systematic paleontology

The description of morphological features and stratigraphic distribution follows the terms employed by (Hottinger, 1960; Serra-Kiel et al., 1998; Erdem et al., 2007) and (Sirel and Acar, 2008) (with discussions and references there in). The suprageneric classification follows Loeblich and Tappan (1987). The description of biozones was mainly conducted based on the Tethyan province.

Phlum Foraminifera (d'Orbigny, 1826)
Order Miliolida (Delage and Hérouard, 1896)
Superfamily Alveolinoidea (Ehrenberg, 1839)
Family Alveolinidae (Ehrenberg, 1839)
Genus Alveolina (d'Orbigny, 1826)

***Alveolina globosa* (Leymerie, 1846)** (Plate 1. Fig. 1)
1846 *Alveolina subpyrenaica* var. *globosa pars*. Leymerie, pl. 8, Figs. 10 a-c.
1960 *Alveolina globosa* Leymerie; Hottinger, p. 80-82, pl. 3, Figs. 15-20; text Figs. 10, 22i, 40.
2008 *Alveolina globosa* Leymerie; Sirel and Acar, pl. 5, Figs. 8, 9; pl. 8, Figs. 1-7.

Description: The small test is spherical to sub-spherical. The axial and equatorial diameters are 2.5 mm and 2.1 mm, respectively. The index of elongation is 1.19 mm. Proloculus is spherical with a diameter of 0.32 mm. It is followed by tightly coiled 2 whorls of nepionic stage. The latter 4 – 5 whorls are flosculinized. The thickness of the basal layer is 3 – 4 times larger than the height of the chamberlets in the flosculinized period. Whorls that adult and senile sateges are coiled loosely. The cross-sections of the chamberlets are generally circular. Chamberlets turn into slightly oval in the last whorls.
Range: *A. globosa* was described in Sinjar Formation aged Upper Paleocene, northern Iraq by Al-Hashimi and Amer (1985). It was reported in the middle Ilerdian (SBZ7, 8) of Sakarya, Turkey (Sirel and Acar, 2008).

***Alveolina pisiformis* Hottinger (1960)** (Plate 1. Figs. 2, 3)
1960 *Alveolina pisiformis* Hottinger, p. 85, pl. 4, Figs. 1-6; text Figs. 43 b, f.
1977 *Alveolina pisiformis* Hottinger; Drobne, p. 24, pl. 3, Figs. 14-15, text Fig. 11 b.
1995 *AIveolina pisiformis* Hottinger; Acar, p. 54, pl. I, Fig. 4.
2008 *AIveolina pisiformis* Hottinger; Sirel and Acar, pl. 6, Figs. 6-8; pl. 7, Figs. 1-6

Plate 1

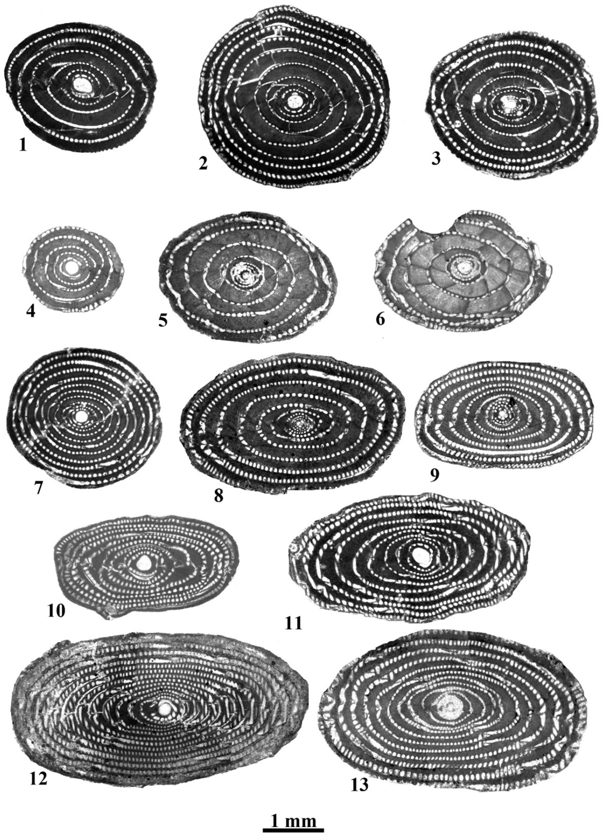

Figure 4. 1) *Alveolina globosa* Leymerie (1846) sample number H 24; 2-3). *A. pisiformis* Hottinger (1960) sample number H 24; 4). *A. aramaea* Hottinger (1960) sample number H 24; 5-6). *A.parva* Hottinger (1960) sample number H31; 7). *A. globula* Hottinger (1960) sample number H24; 8-9). *A. subpyrenaica* Leymerie (1846) sample number 8:H 27. 9:H 12; 10-11. *A. reicheli* Sirel and Acar (2008) sample number 10: H 1, 11: H 32; 12. *A.* aff. *guidonis* Drobne (1977) sample number H 3; 13. *A. sakaryaensis* Sirel (1976b) sample number H 10. All figures belong to axial sections.

2015 *AIveolina pisiformis* Hottinger; Hadi et al., pl. 1, Fig. d.
2016 *AIveolina pisiformis* Hottinger; (Hadi et al., 2016), p. 226, text-Fig. 9e.
2019c *AIveolina pisiformis* Hottinger; Hadi et al., Fig. 5.2.

Description: The test is spherical to sub-spherical. The axial diameter varies between 2.7 and 3.2 mm. The axial and equatorial diameters are 2.5 mm and 2.8 mm, respectively. The index of elongation is 1.1. The proloculus is spherical with a diameter of 0.18 – 0.28 mm and followed by two whorls are tightly coiled in the early stage. The adult stage has three or four flosculinized whorls. The thickness of the basal layer is 3 – 4 times larger than the height of the chamberlets. In the senile (final) stages, 3 – 4 whorls are coiled slightly tight. While the basal layer increases in the adult stage, it decreases towards the final stage. The cross-sections of the chamberlets are circular turn into an upright oval form in the last whorls.
Range: Serra-Kiel et al. (1998) reported the occurrence of this species in the upper part of SBZ6 to SBZ7. It was found in the lower Ilerdian of the Sakarya, Turkey (Sirel and Acar, 2008) and reported in the SBZ7–SBZ8 biozones of the Adriatic carbonate platform by Drobne et al. (2011). According to Hadi et al. (2019c), the species indicates a middle Ilerdian (SBZ7–8) age of sedimentary successions of the Western Alborz and Eastern Iran.

***Alveolina aramaea* (Hottinger, 1960)** (Plate 1. Fig. 4)
1960 *Alveolina aramaea* Hottinger, p. 72, p 1.3, Figs. 4-7; text-Fig. 36.
1972 *Alveolina aramaea* Hottinger; Sirel, p. 278, pl. 1, Fig. 4.
2008 *Alveolina aramaea* Hottinger; Sirel and Acar, pl. 11, Figs. 5-7.

Description: The megalospheric generation has a small-sized, slightly nautiloid to spherical form. The axial and equatorial diameters are 1.6 mm and 1.5 mm, respectively. The index of elongation is 1.06 mm. The large proloculus (0.2 mm in diameter) is followed by 4 – 5 subspheric whorls of the flosculinized period. Thickening of the basal layer increases gradually towards the last whorls. Chamberlets are small and circular in the inner whorls, larger and ovoid in the outer whorls.
Range: This species was reported in the lower llerdian limestone beds of the Kars area, northeastern Turkey (Sirel and Acar, 2008). Drobne (1977) described rare specimens of this species in association with common *Alveolina aramaea* from outcrops close to Kozina (Slovinia).

***Alveolina parva* (Hottinger, 1960)** (Plate 1. Figs. 5, 6)
1960 *Alveolina parva* Hottinger, p. 98, pl. 5, Figs. 3, 4; text-Figs. 51 h-1.
2008 *Alveolina parva* Hottinger; Sirel and Acar, pl. 17, Figs. 1-7.

Description: The small megalospheric test is sub-spheric to slightly ovoid shape. The axial and equatorial diameters are 3 mm and 2.2 mm respectively. The index of elongation is 1.43 mm. The spheric proloculus (0.1 mm diameter) is followed by tightly coiled 3 – 4 subspheric whorls of the nepionic stage. In the following three flosculinized whorls, the basal layer is 5 – 6 times greater than the height of the chamberlets. The last stage is composed of tightly 1 – 2 whorls. The cross-sections of chamberlets are circular in the early stage. They can be seen in the oval form in the flosculinized whorls.
Range: The species was reported from the lower Cuisian sediments of Şarlak Dere section in Niğde region and in the lower to middle Cuisian limestone of the Darende area, West Malatya, Turkey (Sirel and Acar, 2008).

***Alveolina globula* (Hottinger, 1960)** (Plate 1. Fig. 7)
1960 *Alveolina globula* Hottinger, p. 77, pl. 3, Figs. 10, 11; text-Figs. 38 c-e, 39.
1972 *Alveolina globula* Hottinger; Sirel, p. 278, pl. 1, Figs. 1, 2.
2008 *AIveolina globula* Hottinger; Sirel and Acar, pl. 18, Figs. 11, 12; pl. 19, Figs. 1-3.

Description: The test is small and spheric or slightly subspherical shape. The axial and equatorial diameters are 2.5 mm and 2.3 mm, respectively. The elongation index is 1.08 mm. The spheric megalosphere (0.22 mm in diameter) is followed by 2 – 3 subspherical-slightly ovoid whorls. In the following eight whorls, the thickening of the basal layer increases marginally. The size of the chamberlets increases slightly toward the outer whorls. The cross-sections of the chamberlets are small and spheric.
Range: The species was found in the lower Ilerdian deposits of the Kars, eastern Turkey and in the uppermost lower middle Ilerdian limestone of the Sakarya section, Ankara central Turkey (Sirel and Acar, 2008).

***Alveolina subpyrenaica* (Leymerie, 1846)** (Plate 1. Figs. 8, 9)
1846 *Alveolina subpyrenaica* Leymerie, pl. 12, Figs. 9 a–c.
1965 *Alveolina subpyrenaica* Leymerie; (Dizer, 1965), pl. 1, Figs. 8–12.
1976b *Alveolina subpyrenaica* Leymerie; Sirel, pl. 5, Figs. 3–8.
2007 *Alveolina subpyrenaica* Leymerie; Özgen-Erdem et al., Figs. 6 f, g.
2008 *Alveolina subpyrenaica* Leymerie; Sirel and Acar, pl. 22, Figs. 6, 7.
2015 *Alveolina subpyrenaica* Leymerie; Hadi et al., pl. 1, Fig. b.
2016 *Alveolina subpyrenaica* Leymerie; Hadi et al., p. 226, text-Fig. 9 b.
2020b *Alveolina subpyrenaica* Leymerie; Hadi et al., Figs. 4.8–9.

Description: The test is an elongated oval with an axial diameter varies between 3.0 – 3.6 mm and equatorial diameter between 1.8 – 2.3 mm. The index of elongation is 1.6 mm. The proloculus is spheric and small (0.1 mm in diameter). The early stage has tightly coiled 2 – 3 spheric whorls. The following 6–7 elongated ovoid whorls are coiled loosely along with the axial and equatorial directions. The size of the small chamberlets increases from the first to the last whorl. The shape of chamberlets is spheric or subspheric in the early stage, then become upright-oval shape in the last whorls.

Range: The species was found in the middle Ilerdian (SBZ8) deposits of the Sakarya section (Sirel and Acar, 2008) and Eskişehir (Erdem et al., 2007) from central Turkey. It was also reported in the lower part of the middle Ilerdian (SBZ7) from the Gheynarjeh section and the middle Ilerdian (SBZ7–SBZ8) deposits in the Baghdareh section by Hadi et al. (2020b) and described in the Ziarat Formation from Soltanieh Mountains (Western Alborz) by Hadi et al. (2015).

***Alveolina reicheli* (Sirel and Acar, 2008)** (Plate 1. Figs. 10, 11)
2008 *AIveolina reicheli* Sirel and Acar, pl. 24, Figs. 1-6.

Description: The medium-sized test is slightly elongated ovoid shape. The axial diameter varies between 2.9 – 4.0 mm. The equatorial diameter is approximately 1.6 to 2.1 mm and the index of elongation is 1.85 mm. The spherical to subspherical proloculus has 0.28 – 0.3 mm diameter. It is followed by tightly coiled 1 – 2 ovoid whorls of the nepionic stage. The latter 4 – 5 elongated whorls are coiled loosely in the axial direction. The latest 3 – 4 whorls are coiled tightly. The size of the chamberlets increases gradually from the early stage to the final stage.

Range: According to Sirel and Acar (2008), this species indicates an early-middle Cuisian age (SBZ10-11) in central Turkey.

***Alveolina* aff. *guidonis* (Drobne, 1977)** (Plate 1. Fig. 12)
1977 *Alveolina guidonis* Drobne, p. 60, pl. 15, Figs. 6-12.
2008 *AIveolina guidonis* Drobne; Sirel and Acar, pl. 30, Figs. 1-4.
2019a *AIveolina guidonis* Drobne; Hadi et al., Fig. 6.3.

Description: The medium-sized test is elongated ovoid shape. The axial and equatorial diameters are 5.0 mm and 2.5 mm, respectively. The index of elongation is 2 mm. There are 14 whorls in an axial section that measures 5.0 mm in diameter. The proloculus (0.2 mm in diameter) is spherical. The spheric proloculus is followed by regularly coiled elongated ovoid whorls. The size of the chamberlets increases gradually from the early stage to the last whorl. The cross-sections of the chamberlets are subcircular in the early whorls, however, they become upright oval in the last whorls.

Range: this species was restricted to the middle Ilerdian (SBZ7, 8) in the Sakarya section central Turkey (Sirel and Acar, 2008) and the Keçiborlu area (Isparta) in SW Turkey (Bozkurt and Görmüş, 2021). According to Hadi et al. (2019a) *Alveolina* gr. *guidonis* indicates the middle Ilerdian (SBZ8) age in the Chenesht section from Iran.

***Alveolina sakaryaensis* (Sirel, 1976b)** (Plate 1. Fig. 13)
1976b *Alveolina sakaryaensis* Sirel, p. 21, pl. 11, Fig. 5; pl. 111, Fig. 4.
2004 *Alveolina sakaryaensis* Sirel; (Erdem, 2004), p. 30, pl. 29, Fig. 5; pl. 31, Fig. 4; Fig. 13.
2008 *Alveolina sakaryensis* Sirel; Sirel and Acar, pl. 29, Figs. 1-4.
2020b *Alveolina* aff. *sakaryensis* Sirel; Hadi et al., Fig. 4.12.

Description: The test is medium-sized and ovoid with axial diameter of 4.5 mm and equatorial diameter of 2.6 mm. The index of elongation is 1.73 mm. The spherical and large proloculus (0.4 mm in diameter) is followed by 1 – 2 tightly coiled subspherical whorls of the nepionic stage. The following 5 – 6 elongated whorls are coiled loosely along the axial direction. The axial thickening of the basal layer is 3 – 4 times thicker than the height of chamberlets. In the senile stage, the 3 – 4 whorls are coiled tightly and the axial thickening of the basal layer is decreased. The chamberlets are circular and small in the early stages, then become slightly larger and upright oval in the last whorls.

Range: This species was found in the middle Ilerdian (SBZ7-8) of the Sakarya section in central Turkey (Sirel and Acar, 2008). It was documented among the assemblage of *Glomalveolina lepidula*, *A. ellipsoidalis*, *A. pisiformis*, and *A. subpyrenaica* in the upper part of the middle Ilerdian (SBZ8) in the Baghdareh section, Iran (Hadi et al., 2020b).

***Alveolina* aff. *tumida* (Hottinger, 1960)** (Plate 2. Fig. 1)
1960 *Alveolina tumida* Hottinger, p. 139, text-Fig. 71 b.
1977 *Alveolina tumida* Hottinger; Drobne, pl. 7, Figs. 4–6.
1998 *Alveolina tumida* Hottinger; (Gietl, 1998), pl. 4, Fig. 7.
2015 *Alveolina tumida* Hottinger; Hadi et al., pl.2, Fig. b.
2016 *Alveolina tumida* Hottinger; Hadi et al., p. 226, text-Fig. 9 d.
2020b *Alveolina tumida* Hottinger; Hadi et al., Figs. 4.10-11.

Description: The test is a small-sized and elongated oval with poles rounded. The axial and equatorial diameters are 3.0 mm and 1.5 mm, respectively. The index of elongation is 2 mm. The spherical proloculus has a diameter of about 0.2 mm. It is followed by 2 – 3 tightly coiled subspherical whorls in the early stage. The later seven elongated whorls are coiled loosely in the axial direction. The thickness of the basal layer is 3 – 4 times larger than the chamberlets height in this stage. The chamberlets are small and circular in the early stages and their size increases gradually from the early stage to the final stage.

Range: This species was reported from the lower Ilerdian and early middle Ilerdian (SBZ6 to SBZ7) deposits of the Tethyan Province by Serra-Kiel et al. (1998). It was also found in the lower part of the middle Ilerdian (SBZ7) from the Gheynarjeh and Baghdareh sections of the western Alborz zone, Iran (Hadi et al., 2020b).

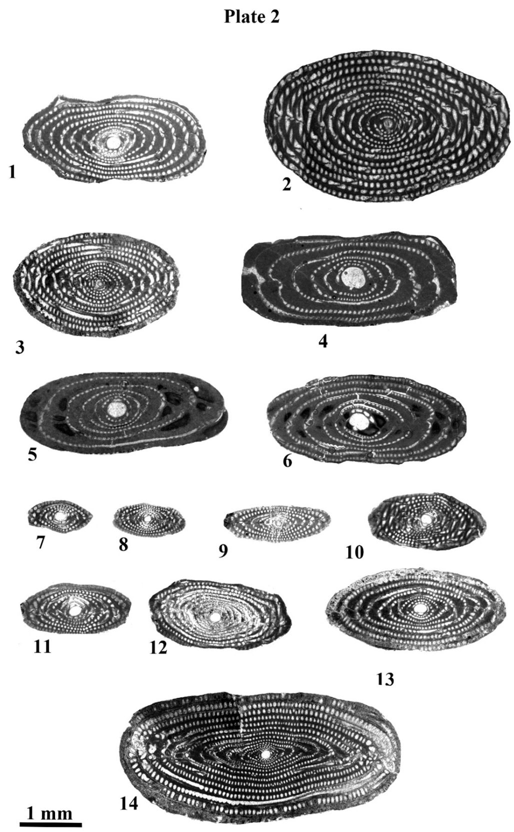

Figure 5. 1) *Alveolina* aff. *tumida* Hottinger (1960) sample number H 25; 2-3). *A. ellipsoidalis* Schwager, 1883 sample number 2:H27, 3: H6; 4-6). *A. rotundata kazancii* Sirel and Acar (2008) sample number 4: H 25, 5: H43, 6: H43; 7). *A. erki* Acar (1995) sample number H16; 8-9). *A. gambaensis* Ho et al. (1976) sample number 8:H 22, 9: H 8; 10-12. *A. himalayensis* Ho et al. (1976) sample number 10: H 34, 11: H 22, 12: H 16; 13) *A. corbarica* Hottinger (1960) sample number H 18; 14). *A. kayserensis* Sirel and Acar (2008) sample number H 20; all figures belong to axial sections.

***Alveolina ellipsoidalis* (Schwager, 1883)** (Plate 2. Figs. 2, 3)

1883 *Alveolina ellipsoidalis* Schwager, p. 96, pl. 25, Figs. 1–2.

1960 *Alveolina ellipsoidalis* Schwager; Hottinger, p. 64, pl. 2, Figs. 1–8, text-Figs. 20c, 33 a, b.

1964 *Alveolina ellipsoidalis* Schwager; (Devoto, 1964), pl. 2, Fig. 2.

1974 *Alveolina (Alveolina) ellipsoidalis* Schwager; Hottinger, p.41, pl.33, Figs. 1-7.

1976b *Alveolina ellipsoidalis* Schwager; Sirel, p. 92, pl. 2, Figs. 5, 6, 8–11; pl. 6, Fig. 6.

1977 *Alveolina ellipsoidalis* Schwager; Drobne, p.16, pl.1, Figs. 1–3.

1998 *Alveolina ellipsoidalis* Schwager; (Accordi et al., 1998), , pl. 18, Fig. 1.

2007 *Alveolina ellipsoidalis* Schwager; Özgen-Erdem et al., Figs. 5 e, f.

2008 *Alveolina ellipsoidalis* Schwager; Sirel and Acar, pl. 21, Figs. 1–4.

2009 *Alveolina ellipsoidalis* Schwager; (Scheibner and Speijer, 2009), p. 209, text-Fig. 10 L.

2011 *Alveolina ellipsoidalis* Schwager; Drobne et al. p. 747, pl. 1.

2013 *Alveolina ellipsoidalis* Schwager; Zhang et al., text-Fig. 8/4.

2015 *Alveolina ellipsoidalis* Schwager; Hadi et al., pl. 1, Fig. a.

2016 *Alveolina ellipsoidalis* Schwager; Hadi et al., p. 226, text-Fig. 9 c.

2020b *Alveolina ellipsoidalis* Schwager; Hadi et al., Figs. 4.5–6.

Description: The test is medium-sized and ellipsoidal to elongated oval. The axial diameter varies between 2.8 mm and 4.0 mm. The equatorial diameter varies from 1.7 mm to 2.5 mm. The index of elongation is 1.64 mm. The small spherical proloculus (0.1 – 0.12 mm in diameter) is followed by tightly coiled 3 – 4 subspherical whorls. The following whorls are coiled regular and oval. The basal layer is thin. The cross-sections of the chamberlets are sub-circular in the early stage then become oval. Their size increases gradually from the early stage to the final stage.

Range: *A. ellipsoidalis* is defined in the upper parts of early Ilerdian of Spain by Hottinger (1960). Similarly, Serra-Kiel et al. (1998), Fig. 2 showed that the species range in the same stratigraphic levels as indicated by Hottinger (1960).

Hadi et al. (2020b). reported that this species indicates the middle Ilerdian (SBZ7–SBZ8) of the Gheynarjeh and Baghdareh sections (Western Alborz-Iran). Bozkurt and Görmüş (2021) found it in the same levels (SBZ7-8) of the Isparta region in Turkey. This species has also been recognized from the early–middle Ilerdian (SBZ5–SBZ8) deposits in Turkey by Erdem et al. (2007) and is recorded in Tibet in SBZ6–SBZ8 by Zhang et al. (2013).

Alveolina rotundata kazancii **(Sirel and Acar, 2008)** (Plate 2. Figs. 4-6)
2008 *Alveolina rotundata kazancii* Sirel and Acar, pl. 34, Figs. 1-8.

Description: The test is small-medium sized and elongated oval-shaped. The axial diameter varies between 3.2 mm and 3.5 mm. The equatorial diameter varies from 1.4 mm to 1.5 mm and the index of elongation is 2.2 mm. Spherical proloculus (0.3 – 0.4 mm in diameter) is followed by tightly coiled 1 – 2 subspheric whorls of the nepionic period. The latter 5 – 6 elongated ovoid whorls of the adult stage are coiled loosely in the axial direction. The axial thickening of the basal layer is 3 – 4 times greater than the basal layer in an equatorial spiral. The cross-sections of the chamberlets are circular. They can be seen upright oval-shaped in the last whorl.
Range: This species was first introduced from the middle Ilerdian (SBZ7-8) successions of the Sakarya section in central Turkey (Sirel and Acar, 2008). Similarly, it was found in the middle Ilerdian of Isparta (Bozkurt and Görmüş, 2021) and Kastamonu regions (Erdem et al., 2016).

Alveolina erki **(Acar, 1995)** (Plate 2. Fig. 7)
1995 *Alveolina erki* Acar, p. 35, pl. 3, Figs. 10-13.
2008 *AIveolina erki* Acar; Sirel and Acar, pl. 36, Figs. 1-3.

Description: The test is small-sized and lenticular to ovoid. The axial and equatorial diameters are 1.0 mm and 0.6 mm, respectively. The index of elongation is 1.6 mm. Subspherical proloculus (0.2 mm in diameter) is followed by tightly coiled 3 ovoid whorls. The latter two whorls are elongated. Basal layer, in the axial direction, thickens marginally towards the last two whorls. The cross-sections of the chamberlets are circular or subcircular.
Range: The species is defined in the middle-upper Ilerdian (SBZ7-9) deposits of the Sakarya section, SW Ankara, central Turkey (Sirel and Acar, 2008). It was found in the lowermost lower Ilerdian of the Kayseri, central Turkey (Sirel and Acar, 2008). *Alveolina erki* was also found in the early to middle Ilerdian (SBZ5-8) carbonates of Isparta region, SW Turkey by Bozkurt and Görmüş (2021).

Alveolina gambaensis **Sheng and Zhang, in (Ho et al., 1976)** (Plate 2. Figs. 8, 9)
1976 *Fasciolites gambaensis* Sheng and Zhang, p. 38, pl. XVII, Figs. 1-5.
2008 *AIveolina gambaensis* Sheng and Zhang; Sirel and Acar, pl. 36, Figs. 6-1 1.

Description: The elongated-fusiform test is small-sized with axial diameter of 1.2 – 1.7 mm and equatorial diameter of 0.5 – 0.6 mm. The index of elongation is 2.6 mm. The spheric prolocus has an 0.1 mm diameter. It is followed by 2 – 3 ovoid whorls of the nepionic stage. In the last whorls, the axial thickening of the basal layer becomes rather thick as opposed to the basal layer of the equatorial spirals. The cross-sections of chamberlets are circular in the early stage and oval in the last stage. The size of the chamberlets increases gradually from inner to the outer whorls.
Range: The species was found in the uppermost lower Ilerdian to lowermost middle Ilerdian-middle Ilerdian limestone of the Kayseri, central Turkey (Sirel and Acar, 2008).

Alveolina himalayensis **Sheng and Zhang, in (Ho et al., 1976)** (Plate 2. Figs. 10-12)
1976 *Fasciolites himalayensis* Sheng and Zhang, p. 39, p. 1. XVII, Figs. 6-9.
2008 *AIveolina himalayensis* Sheng and Zhang; Sirel and Acar, pl. 36, Figs. 12-15.

Description: The megalospheric form has a small-sized, elongated test, with axial and equatorial diameters are 1.8 – 2.4 mm and 0.8 – 1.2 mm, respectively. The index of elongation is 2 mm. The proloculus is spherical or sometimes subspherical and its diameter varies from 0.15 to 0.2 mm. The early stage is composed of tightly coiled 3 – 4 ovoid whorls. The last whorls are elongated, and the axial thickening of the basal layer in these whorls is thicker in comparison with the basal layer of the equatorial direction. The cross-sections of the small chamberlets are circular in the early whorls and upright oval in the last whorls.
Range: The species was found in the uppermost lower Ilerdian (SBZ6) deposits of the Korumazdag in Turkey (Sirel and Acar, 2008).

Alveolina corbarica **(Hottinger, 1960)** (Plate 2. Fig. 13)
1960 *Alveolina corbarica* Hottinger, p. 68, pl. 2, Figs. 20-24; texte-Figs. 6 a, 35-g.
1976a *Alveolina corbarica* Hottinger; Sirel, p. 94, pl. 5, Figs. 1, 2.
2008 *Alveolina corbarica* Hottinger; Sirel and Acar, pl. 38, Figs. 1-7.

Description: The test is elongated. The axial and equatorial diameters are 3.0 mm and 2.3 mm, respectively. The index of elongation is 1.3 mm. The subspherical proloculus (0.2 mm in diameter) is followed by 2 or 3 tightly coiled whorls. The following 6 – 7 elongated ovoid whorls are coiled loosely at the axial direction. The thickness of the basal layer is twice the height of chamberlets in the axial region. The cross-sections of chamberlets are circular in the early stage and oval in the last stage. The size of the chamberlets increases gradually from inner to the outer whorls.
Range: Hottinger (1960) described the stratigraphic distribution of this species as upper part of middle

Ilerdian, Serra-Kiel et al. (1998) considered *A. corbarica* as a marker of SBZ8. BouDagher-Fadel et al. (2015) reported this species from the same stratigraphic levels in Tibet. The species was found in the middle Ilerdian beds (SBZ7-8) of the Korumazdag section, Kayseri and Sakarya section-Ankara, central Turkey (Sirel and Acar, 2008) and in Isparta region, SW Turkey (Bozkurt and Görmüş, 2021).

Alveolina kayserensis **(Sirel and Acar, 2008)** (Plate 2. Fig. 14)
2008 *Alveolina kayserensis* Sirel and Acar, pl. 40, Figs. 1-4.

Description: The test is medium-sized and subcylindrical in shape. The axial and equatorial diameters are 4.6 mm and 2.1 mm, respectively. The index of elongation is 2.1 mm. The spherical proloculus (0.12 mm in diameter) is followed by tightly coiled 2 – 3 elongated whorls of the nepionic stage. In the last 6 – 7 subcylindrical whorls, the axial thickening of the basal layer is thicker than that of the equatorial direction. The last 3 – 4 whorls are coiled tightly. The size of the chamberlets increases gradually from the first to the last whorls. Their cross-sections are circular in the early whorls and upright oval in the last whorls. The size of the chamberlets increases gradually from inner to the outer whorls.
Range: The species was found in the uppermost lower Ilerdian to the lowermost middle Ilerdian (SBZ6-7) deposits of the Korumazdag section, Turkey (Sirel and Acar, 2008).

Alveolina moussoulensis **(Hottinger, 1960)** (Plate 3. Figs. 1, 2)
1960 *Alveolina moussoulensis* Hottinger, p. 65, pl. 2, Figs. 10–16, text-Figs. 20 d, 24, 34.
1976b *Alveolina moussoulensis* Hottinger; Sirel, pl. IV, Fig. 9.
2005 *Alveolina moussoulensis* Hottinger; (Erdem et al., 2005), p. 413, text-Fig. 10 f.
2007 *Alveolina moussoulensis* Hottinger; Özgen-Erdem et al., Fig. 5 g.
2008 *Alveolina moussoulensis* Hottinger; Sirel and Acar, pl. 29, Figs. 1–3.
2011 *Alveolina moussoulensis* Hottinger; Drobne et al. p. 747, pl. 1.
2013 *Alveolina moussoulensis* Hottinger; Zhang et al., text-Fig. 8.7.
2016 *Alveolina moussoulensis* Hottinger, (Özcan et al., 2016), text-Fig. 20.2.
2020b *Alveolina moussoulensis* Hottinger; Hadi et al.,

Plate 3

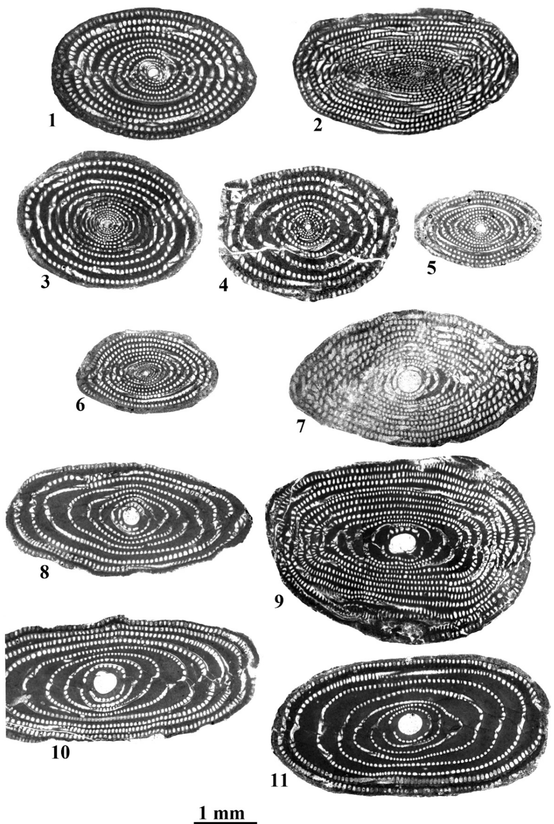

Figure 6. 1-2) *Alveolina moussoulensis* Hottinger (1960) sample number 1:H 2, 2: H 46; 3-4. *A*). *dedolia taneri* Sirel and Acar (2008) sample number 3:H 32, 4:H11), 5-6). *A. minuta* Checchia-Rispoli (1905) sample number 5:H 11, 6:H 9 7). *A.archiaci adamsi* Sirel and Acar (2008) sample number H 18; 8). *A. cremae* Checchia-Rispoli (1905) sample number H 14 9). *A. haymanaensis* Sirel (1976a) sample number H25; 10-11). *A. canavarii* Checchia-Rispoli (1905) sample number 10:H 1, 11:H 26. All figures belong to axial sections.

Fig. 4.7.

Description: The test is medium-sized and ovoid with rounded poles. The axial and equatorial diameters are 3.4 – 3.6 mm and 2.1 – 2.2 mm, respectively. The index of elongation is 1.6 mm. Proloculus is spherical and its diameter is 0.2 mm. The first 3 to 4 whorls are tightly coiled and subspherical. The last 5 whorls are coiled relatively loose. The axial thickening of the basal layer is of less thick than the basal layer of the other whorls. The last 4 – 5 whorls are coiled tightly. In this stage, the basal layer is thin. The size of the chamberlets increases gradually from the first to the last whorls. Their cross-sections are circular in the first whorls and oval in the last whorls. The microspheric test is medium sized and subcylindrical. Elongated whorls are coiled tightly and irregularly. The size of the chamberlets increases gradually from inner to the outer whorls.
Range: This species was found in the lower part of the middle Ilerdian successions from Spain (Hottinger, 1960) Eskişehir and Turkey (Erdem et al., 2007). It was also identified in early to middle Ilerdian deposits of the Isparta region in Turkey (Bozkurt and Görmüş, 2021). BouDagher-Fadel et al. (2015) recorded this species in SBZ7 to SBZ9 in Tibet. Hadi et al. (2020b) reported it as an index of the SBZ7 of middle Ilerdian of the Gheynarjeh and Baghdareh sections (western Alborz, Iran).

Alveolina dedolia taneri **(Sirel and Acar, 2008)**
(Plate 3. Figs. 3, 4)
2008 *AIveolina dedolia taneri* Sirel and Acar, pl. 44, Figs. 1-8.
2019 *AIveolina dedolia taneri* Sirel and Acar; Hadi and Vahidinia, Figs. 3.3, 3.4.

Description: The test has a small-medium size, ovoid form with axial and equatorial diameters of 3.0 mm and 2.2 mm, respectively. The index of elongation is 1.36 mm. The small spherical proloculus (0.1 mm in diameter) is followed by tightly coiled 4 – 5 spheric-subspheric whorls of the nepionic stage. The last 7 – 8 ovoid whorls are coiled slightly loose and regular. The thickening of the basal layer is twice the height of the chamberlets. The size of the chamberlets increases gradually from the beginning to the end of the spire. The cross-sections of the chamberlets are circular to subcircular in the early whorls. and become upright oval in the last whorls.
Range: *A. dedolia taneri* was reported in the lower Cuisian (SBZ10) deposits, in central Turkey (Sirel and Acar, 2008). but Hadi and Vahidnia (2019) documented it in the middle Cuisian (SBZ11) successions of Central Iran.

Alveolina minuta **(Checchia-Rispoli, 1907)** (Plate 3. Figs. 5, 6)
1907 *Alveolina minuta* Checchia-Rispoli, p. 160, p 1.3, Fig. 7.
2008 *AIveolina minuta* Checchia-Rispoli; Sirel and Acar, p. 1.45, Figs. 9-14.
2019a *AIveolina*cf. *minuta* Checchia-Rispoli; Hadi et al., Fig. 7.2.

Description: The test has a small size, slightly elongated ovoid. The axial diameter varies between 2.0 mm and 2.3 mm. The equatorial diameter ranges between 1.3 mm and 1.4 mm. The index of elongation is 1.58 mm. Small proloculus is spherical to subspherical with a diameter ranges between 0.1 mm and 0.2 mm. It is followed by tightly coiled 3 – 4 subspheric whorls of the early stage. In the following elongated ovoid whorls, the axial thickening of the basal layer is slightly thick. The chamberlets are small in the early stage and their size increases toward the outer whorls.
Range: The specie was determined in the lower-middle Cuisian limestone beds of the Safranbolu and Malatya, areas,Turkey (Sirel and Acar, 2008). According to Hadi et al. (2019a), this species can be found in the lower Cuisian (SBZ10) successions of the Chenesht section-Iran.

Alveolina archiachi adamsi **(Sirel and Acar, 2008)**
(Plate 3. Fig. 7)
2008 *Alveolina archiaci adamsi* Sirel and Acar, pl. 46, Figs. 7-10.

Description: The medium test has an ovoid shape. The axial and equatorial diameters are 4.1 mm and 2.3 mm, respectively. The index of elongation is 1.78 mm. Proloculus is large and of 0.4 mm in diameter. It is followed by 1-2 spheric whorls in the early stage. and 10 – 11 ovoid whorls of the adult stage. The poles of these whorls are pointed in the early stage, then become rounded in the following stages. The cross-sections of the chamberlets are subspheric in the early whorls and upright oval in the last whorls.
Range: The specie was defined in the lowermost middle Cuisian limestone of the Belendiz section, Konya, central Turkey (Sirel and Acar, 2008).

Alveolina cremae **(Checchia-Rispoli, 1905)**
(Plate 3. Fig. 8)
1905 *Alveolina cremae* Checchia-Rispoli, pl. 12, Figs. 3–5.
2007 *Alveolina cremae* Checchia-Rispoli; Özgen-Erdem et al., Fig. 9 c
2008 *Alveolina cremae* Checchia-Rispoli; Sirel and Acar, pl. 48, Figs. 1-6.
2010 *Alveolina cremae* Checchia-Rispoli; (Dicarlo et al., 2010), pl. 7, Fig. 11.
2011 *Alveolina cremae* Checchia-Rispoli; Drobne et al., p. 749, pl. 2.
2011 *Alveolina cremae* Checchia-Rispoli; Benedetti et al., p. 703, text-Figs. 2 c–f.
2017 *Alveolina cremae* Checchia-Rispoli; Papazzoni et al. p. 12, text-Fig. 5 a.
2020b *Alveolina cremae* Checchia-Rispoli; Hadi et al., Fig. 7.1.

Description: The medium test is slightly elongated ovoid with rounded poles. The axial and equatorial diameters are about 4.0 mm and 1.8 mm, respectively.

The index of elongation is 2.22 mm. The large, spherical proloculus (0.3 mm in diameter) is followed by $1-2$ subspheric whorls. In the last $6-7$ whorls, the axial thickening of the basal layer is greater than the basal layer of the equatorial direction. The cross-sections of the chamberlets are subspheric at the early stage and upright oval or uneven in the last whorls.

Range: This species is a marker of SBZ11 (Serra-Kiel et al., 1998). Its stratigraphic range in the middle Cuisian is known in Spain (Hottinger, 1960), Turkey, (Erdem, 1998), and Italy (Benedetti et al., 2011), It was also found in the middle Cuisian (SBZ11) deposits of the Gheynarjeh section, Iran (Hadi et al., 2020b).

***Alveolina haymanaensis* (Sirel, 1976a)** (Plate 3. Fig. 9)

1976a *Alveolina haymanaensis* Sirel, pl. II, Fig. 2; pl. III, Figs. 1–3.

2007 *Alveolina haymanensis* Sirel; Özgen-Erdem et al. Fig. 9 b.

2019b *Alveolina haymanensis* Sirel; Hadi et al. Fig. 7.9.

Description: The test has a medium-size, inflated ovoid-elongated. The axial and equatorial diameters are 4.5 mm and 3.1 mm, In turn. the index of elongation is 1.45 mm. The subspheric large proloculus (0.4 mm in diameter) is followed by one subspheric whorls of the nepionic stage. The following $5-6$ elongated whorl are coiled loosely at the axial direction and the axial thickenings of the basal layer in this stage are $2-3$ times greater than the height of the chamberlets. The last stage is composed of $6-7$ tightly coiled whorls. The axial thickening of the basal layer becomes narrower in the last whorls. The cross-sections of the chamberlets are spheric to subspheric in the early stage and upright oval in the last whorls.

Range: This species can be considered as an early Cuisian indicator in Ankara and Eskişehir areas, Turkey (Sirel, 1976a; Erdem et al., 2007). The stratigraphic distribution of *A. haymanensis* resembles the Tethyan Alveolina zones of Serra-Kiel et al. (1998).

***Alveolina canavarii* (Checchia-Rispoli, 1905)** (Plate 3. Figs. 10, 11)

1905 *Alveolina canavarii* Checchia-Rispoli, pl. 12, Figs. 19–21, 25.

1960 *Alveolina canavarii* Checchia-Rispoli; Hottinger, pl. 8, Figs. 15–18, text-Figs. 21 e, 22 g, 68 a–d, 69.

2007 *Alveolina canavarii* Checchia-Rispoli; Özgen-Erdem et al. p. 921, text-Figs. 8 c, d.

2008 *Alveolina canavarii* Checchia-Rispoli; Sirel and Acar, pl. 57, Figs. 1–6; pl. 58, Figs. 1–3.

2011 *Alveolina canavarii* Checchia-Rispoli; Drobne et al. p. 749, pl. 2.

2015 *Alveolina canavarii* Checchia-Rispoli; Hadi et al. pl. 2, Fig. f.

2020b *Alveolina canavarii* Checchia-Rispoli; Hadi et al., Figs. 7.3-5.

Description: The test is medium-sized and cylindrical to subcylindrical with rounded poles. The axial and equatorial diameters are $4.2-4.6$ mm and $2-2.3$ mm, respectively. The index of elongation is 2 mm. Proloculus is spherical and has a 0.38 mm diameter. It is followed by $5-6$ elongated whorls coiled loosely. The axial thickening of the basal layer is $4-5$ times greater than the height of chamberlets in these whorls. The last 3 whorls are coiled tightly. The cross-sections of the chamberlets are small and subcircular in the early whorls, they become upright oval in the last whorls.

Range: This species was reported the lower Cuisian (SBZ10) of the peri-Mediterranean region (Hottinger and Drobne, 1988; Serra-Kiel et al., 1998; Drobne et al., 2011). It was defined in the early-middle Cuisian (SBZ10-SBZ11) by Hottinger (1960) and Sirel and Acar (2008). Also, some authors (Erdem et al., 2007; Hadi et al., 2015) introduced the first appearance of this species from the upper Ilerdian deposits (SBZ9) of Turkey and Iran. This species was observed in the middle Cuisian (SBZ11) of the Gheynarjeh section in Iran (Hadi et al., 2020b).

***Alveolina oblonga* (d'Orbigny, 1826)** (Plate 4. Fig. 1)

1826 *Alveolina oblonga* d'Orbigny, Figs. 28, 30 and 31.

2007 *Alveolina oblonga* d'Orbigny; Özgen-Erdem et al., Fig. 8 f.

2008 *Alveolina oblonga* d'Orbigny; Sirel and Acar, pl. 63, Figs. 1-5; pl. 64, Figs. 1-4.

2019a *Alveolina oblonga* d'Orbigny; Hadi et al., Figs. 7.6-7.

Description: The test is cylindrical with rounded poles and medium-sized. The axial and equatorial diameters are 5.8 mm and 2.4 mm, respectively. The index of elongation is 2.41 mm. The proloculus is subspherical with a diameter of 0.18 mm. The first $6-7$ ovoid whorls are coiled loosely along the axial direction by the equatorial line. In the following subcylindrical whorls of the last stage, the thickening of the basal layer narrows. The cross-sections of chamberlets are circular in the ovoid whorls and upright oval in the cylindrical whorls.

Range: This species was defined in the *Alveolina oblonga* Zone by Hottinger (1960) which corresponds to the early Cuisian, and was found in the same levels by Erdem et al. (2007). However, the species was introduced as an indicator of the early–middle Cuisian for Tethyan Province by Serra-Kiel et al. (1998). Hadi et al. (2019a) found this species in the lower-middle Cuisian (SBZ10-11) deposits of the Chenesht and Baghdareh sections in Iran.

***Alveolina* aff. *distefanoi* (Checchia-Rispoli, 1905)** (Plate 4. Fig. 2)

1905 *Alveolina di-stefanoi* Checchia-Rispoli, p. 163, pl. 12, Fig. 9.

2019a *Alveolina* cf. *di-stefanoi* Checchia-Rispoli; Hadi et al., Figs. 6.6-7.

Description: The test is medium-sized and elongated subcylindric. The axial and equatorial diameters are 4.5 mm and 1.4 mm, respectively. The index of elongation is 3.2 mm. The spheric proloculus is small (about 0.1 mm in diameter) and is followed by tightly coiled $1-2$

Plate 4

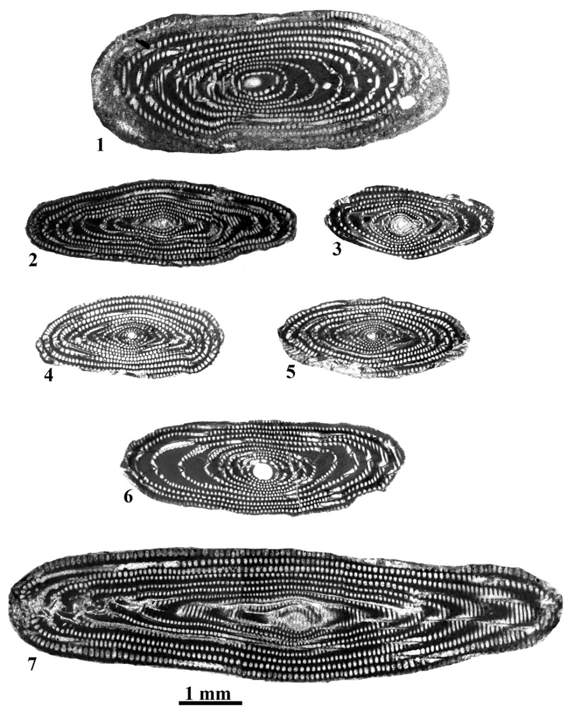

Figure 7. 1) *Alveolina oblonga* d'Orbigny (1826) sample number H 18; 2). *A*. aff. *di-stefanoi* Checchia-Rispoli (1905) sample number H 23; 3-5). *A*. schwageri Checchia-Rispoli (1905) sample number 3: H 6, 4-5: H 11; 6. *A*. *ruetimeyeri* Hottinger (1960) sample number H 6; 7. *A*. aff. *frumentiformis* Schwager (1883) sample number H 10. All figures belong to axial sections.

elongated ovoid whorls. In the following 7 – 8 elongated whorls, the axial thickening of the basal layer becomes greater. The cross-sections of the chamberlets are circular to subcircular-oval from inner to outer whorls.
Range: The species was observed in the lower to middle Cuisian deposits of the Darende, eastern Turkey (Sirel and Acar, 2008) Safranbolu area, NW Turkey (Okur and Kutluk, 2020) Central-Southern Italy (Benedetti et al., 2011). According to Hadi et al. (2019a) this species indicates an early Cuisian (SBZ10) age of the Chenesht section from Iran.

***Alveolina schwageri* (Checchia-Rispoli, 1905)** (Plate 4. Figures 3-5)
1905 *Alveolina schwageri* Checchia-Rispoli, pl. 12, Figs. 11–14.
1960 *Alveolina schwageri* Checchia-Rispoli; Hottinger, p. 155, pl. 10, Figs. 5–7; pl. 11, Fig. 3.
1977 *Alveolina schwageri* Checchia-Rispoli; Drobne, Fig. 39 a, pl. 15, Figs. 13–16.
2007 *Alveolina schwageri* Checchia-Rispoli; Özgen-Erdem et al., Fig. 9 g.

Description: The test is small-sized and elongated ovoid shape. The axial diameter varies between 2.7 mm and 3.0 mm. The equatorial diameter measures 1.2 to 1.4 mm. The index of elongation is 2.2 mm. The proloculus is spherical with a diameter of 0.15 – 0.18 mm. It is followed by tightly coiled 3 – 4 ovoid whorls of the nepionic stage. The axial thickening of the basal layer in the last 5 – 7 of elongated ovoid whorls, is thicker than the basal layer in the equatorial direction. The chamberlets are spheric or ovoid.
Range: This species was observed in the lower Cuisian deposits of Eskişehir, Turkey (Erdem et al., 2007). It was observed in the early-middle Cuisian of central and eastern Turkey (Sirel and Acar, 2008). It was also found in the Lower Eocene beds corresponding to SBZ10 in NE India, by (Sarkar, 2019).

***Alveolina ruetimeyeri* (Hottinger, 1960)** (Plate 4. Fig. 6)
1960 *Alveolina ruetimeyeri* Hottinger, pl. 9, Figs. 17–18; pl. 11, Figs. 13–15; pl. 14, Figs. 20–22.
1977 *Alveolina ruetimeyeri* Hottinger; Drobne, pl. 17, Figs. 2–5.
2007 *Alveolina ruetimeyeri* Hottinger; Özgen-Erdem et al., Fig. 9 g.
2008 *Alveolina ruetimeyeri* Hottinger; Sirel and Acar, pl. 64, Figs. 5, 6; pl. 65, Figs. 1-7.

Description: The test is medium-sized, elongated with rounded poles. The axial and equatorial diameters are 4.5 mm and 1.5 mm, respectively. The index of elongation is 3 mm. The large proloculus (0.3 mm in diameter) is spherical and is followed by $1-2$ subspherical whorls of the early stage and by elongated whorls of the adult stage. The axial thickening of the basal layer is thicker in the last elongated whorls. The cross-sections of the chamberlets are generally circular or subcircular in shape.
Range: The species was introduced as an early Cuisian indicator (*Alveolina oblonga* Zone) by Hottinger (1960). It was also reported in the lower-middle Cuisian successions of the Eskişehir and Safranbolu, Turkey (Erdem et al., 2007; Sirel and Acar, 2008). and from the lower Cuisian of NE India (Sarkar, 2019).

***Alveolina* aff. *frumentiformis* (Schwager, 1883)** (Plate 4. Fig. 7)
1983 *Alveolina frumentiformis* Schwager, p. 100, pl. 2, Fig. 4.
1960 *Alveolina frumentiformis* Schwager; Hottinger, pl. 10, Figs. 15–18; pl. 16, Figs. 1–7, text-Figs. 8e, f, Fig. 21f, Fig. 82.
1974 *Alveolina frumentiformis* Schwager; Hottinger, pl. 83, Figs. 3–4; pl. 84.
1977 *Alveolina frumentiformis* Schwager; Drobne, pl. 12, Figs. 1–6.
2019a *Alveolina frumentiformis* Schwager; Hadi et al., Figs. 8.4-6.

Description: The test is large sized, elongated and subcylindrical. The axial and equatorial diameters are 9.0 mm and 2.2 mm. The index of elongation is 4.09 mm. The early whorls are elongated ovoids. The last four whorls are fusiform and loosely coiled. The last whorls are elongated with truncated poles and are coiled slightly tightly and the axial thickening of the basal layer narrower. The chamberlets are small, circular in the inner whorls, becoming larger and oval in the outer whorls.
Range: This species is documented the upper Cuisian-early Lutetian (SBZ12, 13) of the Tethyan Province by Serra-Kiel et al. (1998). However, Hadi and Vahidnia (2019) reported *A. frumentiformis* from the middle Cuisian (SBZ11) in central Iran. Besides, this species was defined in the upper Cuisian (SBZ12) of the Chenesht section in Iran by Hadi et al. (2019a).

5. Discussion

5.1 Biostratigraphic interpretation

Two foraminiferal biozonal schemes have been established based on data from the Tethyan province: 1) a biozonation based on the genus *Alveolina* and composed of eight biozones, were proposed by Hottinger (1960) for the Ilerdian and Cuisian interval, 2) a biozonation based on shallow large benthic foraminifera with Twenty zones (SBZ1–20) have been proposed by Serra-Kiel et al. (1998) for the Paleocene – Eocene interval. The stratigraphic distributions of the *Alveolina* species described in the present study can be characterized by taking into account their distributions given by previous authors (Hottinger, 1960; Sirel, 1976a, 1976b; Drobne, 1977; Rahaghi, 1983; Sameeni and Butt, 2004; Vecchio et al., 2007; Erdem, 2008; Erdem et al., 2007; Erdem et al., 2016; Sirel and Acar, 2008; Drobne et al., 2011; Deveciler, 2014; Sarkar, 2019; Papazzoni et al., 2017; Hadi and Vahidnia, 2019; Hadi et al., 2019a; Hadi et al., 2019b; Hadi et al., 2019c; Hadi et al., 2020a). Stratigraphic distributions and assemblage of *Alveolina* species, identified in the study area, are given in stratigraphic order (from older to younger) according to their vertical positions in the biozones of Hottinger (1960) and shallow benthic foraminifer according to biozones of Serra-Kiel et al. (1998).
The upper part of the early Ilerdian is indicated by the *Alveolina ellipsoidalis* Zone of Hottinger (1960), which equivalent to the shallow benthic zone (SBZ 6) of Serra-Kiel et al. (1998). This interval is defined by pebbles containing *Alveolina ellipsoidalis Alveolina himalayensis A. aramaea*. In addition, in the study pebbles, *Alveolina ellipsoidalis* is found associated with *Alveolina erki*, *A. pisiformis*, *A. kayserensis*, *A. globula*, *A. globosa*, *A. gambaensis*.
The lower part of the middle Ilerdian corresponds to the *Alveolina moussoulensis* Zone of Hottinger (1960) or the shallow benthic zone (7) of Serra-Kiel et al. (1998). This interval is represented by the first and the last occurrence of *Alveolina moussoulensis*. In the studied area, Ghargharook section, *Alveolina moussoulensis*, is found in pebbles associated with *A. ellipsoidalis*, *A. erki*, *A. gambaensis*, *A. globosa*, *A. globula*, *A.* gr. *guidonis*, *kayserensis*, *A. pisiformis*, *A. rotundata kazancii*, *A. sakaryensis*, *A. subpyrenaica* and *A.* aff. *tumida*.
The upper part of the middle Ilerdian, described as the *Alveolina corbarica* Zone by Hottinger (1960) or the zone (SBZ 8) of shallow benthic by Serra-Kiel et al. (1998) is defined by the first and the last occurrence of *A. corbarica*. In the Ghargharook section, SBZ 8 is observed by pebbles containing *A. moussoulensis*, *A.* aff. *tumida*, *A. kayserensis* and *A. gambaensis*, *A. ellipsoidalis*, *A. erki*, *A. globosa*, *A. globula*, *A.* gr. *guidonis*, *A. pisiformis*, *A. rotundata kazancii*, *A. sakaryensis* and *A. subpyrenaica*.
The late Ilerdian, is defined into the *Alveolina trempina* Zone by Hottinger (1960) or the zone (SBZ 9) of shallow benthic by Serra-Kiel et al. (1998). In the studied section, the biostratigraphic range of *A. trempina* has not been recognized but it can be represented *Alveolina canavarii*.
by pebbles containing *A. corbarica*, *A. ellipsoidalis*, *A. erki*, *A. globosa*, *A. globula*, *A.* gr. *guidonis*, *A. pisiformis*, *A. rotundata kazancii*, *A. sakaryensis* and *A. subpyrenaica A. oblonga*, *A. dedolia taneri*, *A.* cf. *di-stefanoi*, *A. haymanaensis*, *A. minuta*, *A. parva*, *A. reicheli*, *A. ruetimeyer* and *A. schwageri*.
The early Cuisian is defined as the *Alveolina oblonga* Zone by Hottinger (1960) or the zone (10) of shallow benthic by Serra-Kiel et al. (1998). In the Ghargharook section this interval is represented by pebbles containing *A. oblonga*, *A. dedolia taneri*, *A.* cf. *di-stefanoi*, *A. haymanaensis*, *A. minuta*, *A. parva*, *A. reicheli*, *A. ruetimeyer* and *A. schwageri* and the last occurrence of *A.* cf. *di-stefanoi*, *A. haymanaensis* and *A. minuta*. This interval also contains *A. canavarii*.
The middle Cuisian, defined as the *Alveolina dainellii* Zone

by Hottinger (1960) or zone (11) of shallow benthic by Serra-Kiel et al. (1998) is represented in the Ghargharook section by pebbles containing *A. cremae* and *A. archiachi adamsi* and *A. canavarii*, *A. dedolia taneri*, *A. oblonga*, *A. parva*, *A. reicheli*, *A. ruetimeyeri* and *A. schwageri*.
The late Cuisian, described as the *Alveolina violae* Zone by Hottinger (1960) or zone (12) of shallow benthic by Serra-Kiel et al. (1998) is represented in the Ghargharook section by pebbles containing of *A. canavarii*, *A. cremae*, *A. erki*, *A. dedolia taneri*, *A. oblonga*, *A.* gr. *parva*, *A. reicheli* and *A. schwageri*

5.2 Origin of carbonate pebbles of the study conglomerate

In the eastern belt of Iran (or Sistan Suture Zone), Eocene carbonate deposits have not been well studied, consequently, the lithostratigraphic formations of this structural-sedimentary zone have been named partially.
In recent years, some paleontological works, including Moezi–Nasab et al. (2018), Hadi et al. (2019a), Hadi et al. (2020a), Hadi et al. (2020b), and Gorgij and Mirzaei (2019) have studied the foraminifera assemblages of this structural zone and introduced three local formations Debil, Zibro, and Panlang. It seems that the pebbles of the study conglomerate in the Harmak section originated from these formations.

6. Conclusion

The micropaleontological analysis and regional correlation allow.
1- to characterize and described in the carbonate pebbles of the Hormak conglomerate of the north Zahedan a rich *Alveolina* fauna composed of 29 species and 3 subspecies. This allows reliable dating and correlation of *Alveolina* assemblages with those form other sections, both in Iran and beyond.
2- that conglomerate pebbles containing *Alveolina* are mostly originated from the local Zebro, Debil and Palang formations of the northern parts of the Eastern Iran.
3- the *Alveolina* assemblages described in the present article represent typical components for the SBZ 6 (lower Ilerdian) to SBZ 12 (late Cuisian) by comparing the available biostratigraphic information coming from reference sections of the Tethyan region.

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Authors Contributions
HY conceived and planned the idea of this study and did the Field work, preparation of thin sections, microscopic photography, designed the figures and plates, performed the morphologic measurements of the specimens and initial draft of the article. DS wrote the systematic description of the specimens. All authors read and approved the final manuscript.

Availability of Data and Materials
Data is available on request from the authors. The data supporting this study's findings are available from the corresponding author, upon reasonable request.

Conflict of Interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Acar S. (1995) Türkiye'deki değişik bölgelerinin bazı alveolin cinslerinin alveolina, borelis ve praebulalveolina sistemlerinin tanımı ve stratigrafilerinin dağılımı [description and stratigraphic distribution of alveolina, borelis and praebulalveolina systems of some alveolina genus from different localities of turkey]. *Selçuk University, PhD Thesis* 106 in Turkish

Accordi G., Carbone F., Pignatti J. (1998) Depositional history of a paleogene carbonate ramp (western cephalonia, ionian islands, greece). *Geologica Romana* 34:131–205.

Aghanabati A. (2004) Geology of Iran. *Ministry of Industry and Mines, Geological Survey of Iran, Tehran.* 582 in Persian.

Al-Hashimi H. A. J., Amer R. M. (1985) Tertiary microfacies of iraq. *Directorate General for Geological Survey and Mineral Investigation.* 56

Alavi M. (1991) Sedimentary and structural characteristics of the paleo-tethys remnants in northeastern Iran. *Geological Society of America Bulletin* 103:983–992. https://doi.org/10.1130/0016-7606(1991)103\%3C0983:SASCOT\%3E2.3.CO;2

Arjmandzadeh R., Teshnizi E. Sharifi, Ahmadi A. A., Mahdavi A., Tavsoli S., Dabiri R. (2021) The mineralogy, geochemistry and genesis of aghol-messi sedimentary copper-uranium deposit, tabas block, central Iran. *Researches in Earth Sciences* 11 (4): 47–70. https://doi.org/10.52547/esrj.11.4.47

Babazadeh S. A., Alavi M. (2013) Paleoenvironmental model for early eocene larger benthic foraminiferal deposits from south birjand region, east Iran. *Revue de Paléobiologie* 32 (1): 223–233.

Babazadeh S. A., Najafabadi M. Soltani (2015) Biostratigraphy of eocene sedimentary rocks based on alveolinids in the east of lut block, Iran. *Kharazmi Journal of Earth Sciences* 1 (1): 20. https://doi.org/10.29252/gnf.1.1.1

Behrozi A. (1991) Zahedan geological map (1:125,000). *Ministry of Industry and Mines, Geological Survey of Iran.*

Benedetti A., Carlo M. Di, Pignatti J. (2011) New late ypresian (cuisian) rotaliids (foraminiferida) from central and southern italy and their biostratigraphic potential. *Turkish Journal of Earth Sciences* 20:701–719. https://doi.org/10.3906/yer-0910-47

BouDagher-Fadel M. K., Price G. D., Hu X., Li J. (2015) Late cretaceous to early paleogene foraminiferal biozones in the tibetan himalayas, and a pan-tethyan foraminiferal correlation scheme. *Stratigraphy* 12:67–91.

Bozkurt A., Görmüş M. (2021) Systematics, biostratigraphy and paleoenvironmental investigation of early ypresian alveolina assemblages in the northern part of isparta angle (keçiborlu, isparta, sw turkey). *Bulletin of the Mineral Research and Exploration* 164:183–229. https://doi.org/10.19111/bulletinofmre.740944

carlo B. Scotto di (1966) Le alveoline del gargano nordorientale. *Palaeontographia Italica* 61:65–73.

Checchia-Rispoli G. (1907) Nota preventiva sulla serie nummulitica dei dintorni di bagheria e di termini-imerese in provincia di palermo. *Giornale di scienze naturali ed economiche.* 26:156–188.

——— (1905) Sopra alcune alveoline eoceniche della sicilia. *Palaeontographia Italica* 11:147–167.

Delage Y., Hérouard E. (1896) Traité de zoologie concrète. *La Cellule et les Protozoaires, Paris* 1

Deveciler A. (2014) Description of larger benthic foraminifera speciesfrom the bartonian of yakacikmemlik region (n ankara, central turkey). *Bulletin of the Earth Science Application and Research Center of Hacettepe University* 35 (2): 137–150.

Devoto G. (1964) Zone ad alveolinidae nel cretaceo e paleocene del lazio ed abruzzo centro meridionali. *Geologica Romana* 3:405–414.

Dicarlo M., Accordi G., Carbone F., Pignatti J. (2010) Biostratigraphic analysis of paleogene lowstand wedge conglomerates of a tectonically active platform margin (zakynthos island, greece). *Journal of Mediterranean Earth Sciences* 2:31–92. https://doi.org/10.3304/JMES.2010.004

Dizer A. (1965) Sur quelques alvéolines de l'eocène de turquie. *Revue de Micropaléontologie.* 7 (4): 265–279.

Drobne K. (1977) Alvéolines paléogènes de la slovénie et de l'istrie. phd thesis. *Mémoires Suisses de Paléontologie.* 99:1–132.

Drobne K., Cosovic V., Moro A., Buckovic D. (2011) The role of the palaeogene adriatic carbonate platform in the spatial distribution of alveolinids. *Turkish Journal of Earth Sciences* 20:721–751. https://doi.org/10.3906/yer-0911-76

d'Orbigny A. D. (1826) Tableau méthodique de la classe des céphalopodes. *Annales des Sciences Naturelles* 1 (7): 96–314.

Ehrenberg C. G. (1839) Über die bildung dei kreidefelsen und des kreidemergels durch unsichtbare organismen. *Physikalische Abhandlungen der königlichen Akademie der Wissenschaften zu Berlin* 59-147

Erdem N. Özgen (2008) Biostratigraphy of thanethian-ilerdian benthic foraminifera in the akçatas–cebeci (nw tosya- se kastamonu) region. *Mineral Research Exploration Bulletin* 137:49–59.

——— (1998) Paleocene-eocene benthic foraminifera assemblages in the western pontids. *Geological Bulletin of Turkey* 41 (2): 63–78.

——— (2004) Türkiye'nin mesozoyik ve senozoyik yeni bentik foraminiferleri. *TMMOB Jeoloji Mühendisleri Odası (Emeğin Bilimsel Sentezi Özel Sayı 1).* 84:1–219.

Erdem N. Özgen, Akyazi M., Karabaşoğlu A. (2007) Biostratigraphic interpretation and systematics of alveolina assemblages from the ilerdian–cuisian limestones of southern eskişehir, central turkey. *Journal of Asian Earth Sciences* 29:911–927. https://doi.org/10.1016/j.jseaes.2006.05.010

Erdem N. Özgen, Canbolat M. Y., Sinanoglu D. (2016) Shallow marine benthic foraminifera assemblage of the early eocene succession in the northern araç (kastamonu) and paleoecological interpretation. *Türkiye Jeoloji Bülteni* 59 (3): 259–273. In Turkish, https://doi.org/10.25288/tjb.298029

Erdem N. Özgen, İnan N., Akyazı M., Tunoğlu C. (2005) Benthonic foraminiferal assemblages and microfacies analysis of paleocene–eocene carbonate rocks in the kastamonu region, northern turkey. *Journal of Asian Earth Sciences* 25 (3): 403–417. https://doi.org/10.1016/j.jseaes.2004.04.005

Gietl R. (1998) Biostratigraphie und sedimentationsmuster einer nordostägyptischen karbonatrampe unter berücksichtigung der alveolinen-faunen. *Fachbereich 5 der Universität Bremen* 129

Gorgij M. N., Mirzaei S. Shahraki (2019) Micropaleontology and systematic determination of miscellaneidae family in the middle paleocene–lower eocene deposits in the north of zahedan, padagi stratigraphic sections. *Journal of Stratigraphy and Sedimentology Researches.* 35 (3): 79–98. https://doi.org/10.22108/JSSR.2019.116539.1097

Hadi M., Consorti L., Vahidinia M. (2020a) Upper ypresian to lower lutetian (sbz 10 to 13) alveolina stratigraphic horizons from the hormak section, zahedan district, sistan suture zone, eastern Iran. *Micropaleontology* 66 (4): 317–337. https://doi.org/10.47894/mpal.66.4.04

Hadi M., Erdem N. Özgen, Sinanoglu D., Sarkar S., Zareh A. Azam (2020b) Distribution of alveolina assemblages in the ypresian (ilerdian-cuisian) successions from Iran and turkey (central and western tethys). *biostratigraphic implications for regional correlation. Micropaleontology* 66 (1): 51–74. https://doi.org/10.47894/mpal.66.1.02

Hadi M., Less G., Vahidnia M. (2019b) Eocene larger benthic foraminifera (alveolinids, nummulitids, and orthophragmines) from the eastern Alborz region (ne Iran): taxonomy and biostratigraphy implications. *Revue de Micropaléontologie* 63:65–84. https://doi.org/10.1016/j.revmic.2019.01.001

Hadi M., Mosaddegh H., Abbassi N. (2015) Biostratigraphic interpretation and systematics of alveolina assemblages in the ziarat formation from soltanieh mountains (western Alborz). *Geological Journal* 95:39–44. https://doi.org/10.22071/gsj.2015.42254

——— (2016) Microfacies and biofabric of nummulite accumulations (bank) from the eocene deposits of western Alborz (nw Iran). *Journal of African Earth Sciences* 124:216–233. https://doi.org/10.1016/j.jafrearsci.2016.09.012

Hadi M., Vahidinia M., Juraj H. (2019a) Larger foraminiferal biostratigraphy and microfacies analysis from the ypresian (ilerdian-cuisian) limestones in the sistan suture zone (eastern Iran). *Turkish Journal of Earth Sciences* 28:122–145. https://doi.org/10.3906/yer-1802-10

Hadi M., Vahidnia M. (2019) Biostratigraphy of larger benthic foraminifera from cuisian and bartonian limestones from the torbat-e-heydarieh region (central Iran). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen.* 291 (3): 299–315. https://doi.org/10.1127/njgpa/2019/0803

Hadi M., Vahidnia M., Abbassi N. (2019c) Ilerdian-cuisian alveolinids from the western Alborz and eastern Iran zones: systematic and biostratigrapic implications. *Journal of Foraminiferal Research* 49:141–162. https://doi.org/10.2113/gsjfr.49.2.141

Ho Y., Zhang B. G., Hu L. Y., Sheng J. Z. (1976) Mesozoic and cenozoic foraminifera from the mount jolmo lungma region. *Palaeontology* 1966–1968 (2): 1–76.

Hottinger L. (1974) Alveolinids, cretaceous-tertiary larger forminifera. *Esso Production Research European Labiratories* 84

——— (1960) Recherches sur les alvéolines du paléocène et de l'eocène. *Mémoires Suisses de Paléontologie* 243

Hottinger L., Drobne K. (1988) Alvéolines tertiaires: quelques problèmes liés à la conception de l'espèce. *Revue de Paléobiologie* 2:665–681. https://doi.org/10.1002/gj.4119

Khan M. Jehangir, Ghazi S., Mehmood M., Yazdi A., Naseem A. A., Serwar U., Zaheer A., Ullah H. (2021) Sedimentological and provenance analysis of the cretaceous moro formation rakhi gorge, eastern sulaiman range. *Iranian Journal of Earth Sciences* 13 (4): 252–266. https://doi.org/10.30495/ijes.2021.1917721.1564

Leymerie A. (1846) Mémoire sur le terrain à nummulites (épicrétacé) des corbières et de la montagne noire. *Mémoires de la Société géologique de France.* 2 (1): 337–372.

Loeblich A. R., Tappan H. (1987) Foraminiferal genera and their classification. *Van Nostrand Reinhold Company, New York.* 970 https://doi.org/10.1007/978-1-4899-5760-3

Moezi–Nasab R., Gorgij M. N., Bakhshi-Mohebbi M. R. (2018) Systematic paleontology of alveolinids in the red continental- clastic hormak formation, south eastern of Iran, north of zahedan, hormak section. *Geoscience Journal* 28:229–236. in Persian, https://doi.org/10.22071/gsj.2017.81959.1084

Nabavi M. H. (1976) A preface to Iran's geology. *Geology Survey & Mineral Exploration of Iran* 109

Okur K., Kutluk H. (2020) Benthic foraminiferal assemblages from the safranbolu formation (cuisian, eocene), northwest anatolia, turkey. *Journal of Palaeogeography* 9 (6) https://doi.org/10.1186/s42501-020-0054-2

Papazzoni C. A., Fofnaciari E., Giusberti L., Vescogni A., Fornaciari B. (2017) Integrating shallow benthic and calcareous nannofossil zones: the lower eocene of the monte postlate section (northern italy). *Palaios* 32:6–17. https://doi.org/10.2110/palo.2016.014

Rahaghi A. (1978) Paleogene biostratigraphy of some parts of Iran. national Iranian oil company. *Geological Laboratories* 164

Rahaghi A. (1983) Stratigraphy and faunal assemblage of paleocene-lower eocene in Iran. *National Iran Oil Company* 73 (23): 505–527.

——— (1980) Tertiary faunal assemblage of qum-kashan, sabzewar and jahrum areas. national Iranian oil company. *Geological Laboratories* 64

Rahman M., Hanif M., Jiang T. Tao, Wahid S. (2021) Alveolinids from the lower indus basin, Pakistan (eastern neo-tethys): systematic and biostratigraphic implications. *Geological Journal* 56 (7): 3644–3671. https://doi.org/10.1002/gj.4119

Reyre D., Mohafez S. (1972) A first contribution of the niocerap agreements to the knowledge of Iranian geology. *Edition Technip*

Samani B., Ashtari S. (1992) Geological evolution of sistan and baluchestan area. *Journal of Earth Sciences 4. Geological survey of Iran.*

Sameeni J. J., Butt A. A. (2004) Alveolinid biostratigraphy of the salt range succession, northern Pakistan. *Revue de Paléobiologie* 23 (2): 505–527.

Sarkar S. (2019) Alveolina-dominated assemblages in the early eocene carbonates of jaintia hills, ne india: biostratigraphic and palaeoenvironmental implications. *Comptes Rendus Paleovol* 18 (8): 949–966. https://doi.org/10.1016/j.crpv.2019.10.006

——— (2016) Early eocene calcareous algae and benthic foraminifera from meghalaya, ne india: a new record of microfacies and palaeoenvironment. *Journal of the Geological Society of India* 88:281–294. https://doi.org/10.1007/s12594-016-0491-9

Scheibner C., Speijer R. P. (2009) Recalibration of the tethyan shallow-benthic zonation across the paleocene-eocene boundary: the egyptian record. *Geologica Acta* 7 (1-2): 195–214.

Schwager C. (1883) Die foraminiferen aus den eocaenablagerungen der lybischen wüste und aegyptens. *Palaeontographica* 30:79–154.

Serra-Kiel J., Hottinger L., Caus E., Drobne K., Ferrandez C., Jauhri A. K., Less G., et al. (1998) Larger foraminiferal biostratigraphy of the tethyan paleocene and eocene. *Bulletin Société Géologique France* 169 (2): 281–299.

Sirel E. (1976a) Description of six new species of the alveolina found in the south of polatlı (sw ankara) region. *Bulletin of the Geological Society of Turkey* 19:19–22.

——— (1976b) Systematic study of thesome species of the genera alveolina, nummulites, ranikothalia and assilina in the south of polatlı. *Bulletin of Geological Society of Turkey* 19:89–102.

Sirel E., Acar Ş. (2008) Description and biostratigraphy of the thanetian-bartonian glomalveolinids and alveolinids of turkey. *TMMOB Jeoloji Mühendisleri Odası* 264

Tirrul R., Bell I. R., Griffis R. J., Camp V. E. (1983) The sistan suture zone of eastern Iran. *Geological Society of America Bulletin* 94:134–150. https://doi.org/10.1130/0016-7606(1983)94$⟨$134:TSSZOE$⟩$2.0.CO;2

Vecchio E., Barattolo F., Hottinger L. (2007) Alveolina horizons in the trentinara formation (southern apennines, italy): stratigraphic and paleogeographic implications. *Rivista Italiana di Paleontologia e Stratigrafia (Research in Paleontology and Stratigraphy)* 113:509–533. https://doi.org/10.13130/2039-4942/6356

Zanchi A., Zanchetta S., Garzanti E., Balini M., Berra F., Mattei M., Muttoni G. (2009) The cimmerian evolution of the nakhlak–anarak area, central Iran, and its bearing for the reconstruction of the history of the eurasian margin. in M. -F. Brunet, M. Wilmsen, and j. w. granath (eds.), south caspian to central Iran basins. *Geological Society of London Special Publications* 312:261–286. https://doi.org/10.1144/SP312.13

Zhang Q., Willems H., Ding L. (2013) Evolution of the paleocene-early eocene larger benthic foraminifera in the tethyan himalaya of tibet, china. *International Journal of Earth Sciences* 102:1427–1445. https://doi.org/10.1007/s00531-012-0856-2

Özcan E., İftikhar, Abbasi I. A., Drobne K., Govindan A., Jovane L., Boukhalfa K. (2016) Early eocene orthophragminids and alveolinids from the jafnayn formation, n oman: significance of nemkovella stockari Less and Özcan, 2007 in tethys. *Geodinamica Acta* 28 (3): 160–184. https://doi.org/10.1080/09853111.2015.1107437