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Biostratigraphy and taxonomy of fusulinid foraminifera across the Upper Mississippian (upper Serpukhovian)–Lower Pennsylvanian (Bashkirian) successions from the Hadim Nappe, Central Taurides, southern Turkey

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Abstract.—The Hadim Nappe, which is one of the allochthonous tectonic units in the Tauride Belt, in southern Turkey, includes a continuous stratigraphic succession from the Middle(?)–Late Devonian to Late Cretaceous. A relatively complete succession of the upper Serpukhovian to Bashkirian is exposed in the Central Taurides, where two sections (Yassıpınar and Gölbelen) have been selected for detailed biostratigraphic investigations. The Mississippian-Pennsylvanian boundary in these sections was determined by the first appearance datum of the *Plectostaffella jakhensis* and located in the oolitic limestone facies indicating a shallow-water depositional environment. The uppermost Serpukhovian and regional Bashkirian substages (Syuranian, Akavasian, Askynbashian, and Arkhangelskian) were determined by index taxa, namely *Plectostaffella jakhensis*, *P. bogdanovkensis*, *P. varvariensis*, *Pseudostaffella antiqua*, *Staffellaeformes staffellaeformis*, *Tikhonovichiella tikhonovichi*, and *Verella spicata*. Fifty fusulinid species belonging to fourteen genera were determined in two sections, in which two species are new: *Depratina turani* Akbaş new species and *Tikhonovichiella praetikhonovichi* Akbaş new species. The taxonomic positions of two fusulinid species (*Depratina convoluta* n. comb. and *Staffellaeformes parva robusta* n. comb.) are revised. The studied fusulinid assemblages correlate with fusulinid assemblages from the southern Urals, Russian Platform, Donetz Basin, Darvaz, Spain, central Iran, and some other regions of the Tethyan Realm.

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Introduction

The Carboniferous is formally subdivided into two subseries by the International Commission on Stratigraphy as the Mississippian, comprising the Tournaisian, Visean, and Serpukhovian stages, and the Pennsylvanian with the Bashkirian, Moscovian, Kasimovian, and Gzhelian stages (Richards, 2013; Ogg et al., 2016). The Mississippian-Pennsylvanian boundary corresponds to the lower-middle Carboniferous boundary in the Russian regional chronostratigraphic subdivisions, and according to these subdivisions, the Bashkirian and Moscovian stages are subdivided into regional substages or horizons (see Kagarmanov and Donakova, 1990; Kulagina et al., 2001). The stages/substages or horizons and their boundaries are mainly determined in current studies by using the evolutionary lineages of the certain conodont taxa. The fusulinids have also been extensively evaluated as indices for the Mississippian-Pennsylvanian boundary; however, due to problems of provincialism, conodonts appear to be the best indicators. The fusulinid taxa of the Mississippian-Pennsylvanian boundary in the Eurasian-Arctic Faunal Realm (Ross, 1967) differ from the Midcontinent-Andean Faunal Realm (Ross, 1967) due to the closure of the seaway between Gondwana and Laurussia, which resulted in diachronous development of different phylogenetic lineages (Groves, 1988; Groves et al., 1999). The Mississippian-Pennsylvanian (Serpukhovian-Bashkirian) boundary has a GSSP at Arrow Canyon, Nevada, USA (Lane et al., 1999) and is recognized by the FAD of conodont *Declinognathodus noduliferus* (Ellison and Graves, 1941) (sensu lato) in the *Gnathodus girtyi simplex* Dunn, 1966–*Declinognathodus noduliferus* sensu lato lineage.

The Hadim Nappe successions preserve suitable strata to determine the stage/substages or horizon boundaries by fusulinid assemblages, with an almost continuous succession, including stage/substages or horizons within shallow marine carbonates with some siliciclastic intercalations from the Middle (?)–Late Devonian to Late Cretaceous in the Central Taurides (Özgül, 1976, 1997; Monod, 1977; Turan, 1990). The shallow-marine and carbonate-rich Hadim Nappe successions and their fusulinid assemblages are very similar to those from other regions of the Tethyan Realm (Kalvoda, 1990, 2003), particularly the Russian Platform and the southern Urals. Some studies have established stage boundaries based on fusulinids (Okuyucu, 1997, 2002, 2008, 2009; Dzhenchuraeva and Okuyucu, 2007; Atakul-Özdemir et al., 2011; Demirel and Altıner, 2016) and conodonts (Atakul-Özdemir et al., 2012; Atakul-Özdemir, 2015) corresponding to the Carboniferous units of the Hadim Nappe.

The aims of this study are: (1) to describe and to give the stratigraphic distribution and biostratigraphic characteristics of the fusulinid assemblages of the upper Serpukhovian–Bashkirian successions of the Hadim Nappe, (2) to correlate them with the coeval assemblages in Turkey and other regions, and

(3) to delineate the Mississippian-Pennsylvanian boundary based on the fusulinid fauna. For this purpose, two fusulinid-rich carbonate sections (Yassıpınar and Gölbelen) of the Hadim Nappe were selected for detailed biostratigraphic studies from the Central Taurides, where the Hadim Nappe widely crops out with continuous successions. Two of these are the Yassıpınar (Hadim area) and Gölbelen (Bozkır region) sections in the Central Taurides (Fig. 1).

Geological setting

The Taurides, one of the major units of the Alpine-Himalayan Orogenic Belt, is geographically subdivided into three segments or parts by Özgül (1976, 1984) as: (1) the Eastern Taurides to the east of the Ecemis fault, (2) the Central Taurides between the Kırkkavak fault and the Ecemis fault, and (3) the Western Taurides from the Aegean coast to the Kırkkavak fault. The Tauride Belt is made up of a number of autochthonous and allochthonous units with distinct stratigraphic, structural, and metamorphic features (e.g., Blumenthal, 1944, 1951; Brunn et al., 1971, 1973; Özgül, 1976, 1984, 1997) that have been regarded as nappes (Brunn et al., 1971) or tectonostratigraphic units (Özgül, 1976, 1984) (Fig. 1). Of these, the Beydağları-Anamas-Akseki Unit is autochthonous, whereas the allochthonous units are characterized by the Hadim (Aladağ Unit of Özgül, 1976), Bolkar Dağı, Beyşehir-Hoyran, Antalya, and Alanya nappes (Blumenthal, 1944, 1951; Gutnic et al., 1968, 1979; Brunn et al., 1970, 1971; Monod, 1977; Turan, 1990, 2000, 2010).

The Hadim Nappe, originally established by Blumenthal (1941, 1951) in the Central Taurides, is made up of sedimentary rocks, including shallow-marine platform carbonates with some siliciclastic intercalations that range in age from the Middle (?)–Late Devonian to the Late Cretaceous (Güvenç, 1965, 1977a; Özgül, 1971, 1997; Monod, 1977; Turan, 1990, 2000, 2010) (Fig. 2). The Hadim Nappe corresponds to the "Siyah Aladag Nappe" (Blumenthal, 1941) and Belemedik Paleozoic Window (Blumenthal, 1947) of the Eastern Taurides, the "Aladağ Unit" (Özgül, 1976) and the "Bademli-Camlik Unit" (Monod, 1977) of the Central Taurides, and the Karadag Serie (Graciansky, 1968) of the Western Taurides.

In previous studies, numerous formation names have been used for the Carboniferous deposits of the Hadim Nappe (e.g., Monod, 1977; Güvenç, 1980; Tekeli et al., 1984; Lengeranlı et al., 1986; Okuyucu and Güvenç, 1997; Özgül, 1997). In this study, the lithostratigraphic scheme of Güvenç (1977b, 1980) is adopted, and the name Dikenli is used for the Carboniferous deposits. The Carboniferous Dikenli Formation consists of black shale, siltstone, and carbonates at the base, fusulinid-rich carbonates with sandstone intercalations in the central part, and carbonates and *Girvanella* Limestone facies (sensu Güvenç, 1965) at the top (Fig. 2).

The upper Serpukhovian–Bashkirian successions of the Hadim Nappe from the Central Taurides were studied in two measured stratigraphic sections, namely the Yassıpınar section (UTM: 36S 444515.2mE, 4084999.6mN) to the south of Hadim town (Fig. 3) and the Gölbelen section (UTM: 36S 419446.7mE, 4100126.3mN) to the south of the Bozkır town (Fig. 4). The Mississippian-Pennsylvanian boundary interval was detected only at the Yassıpınar section (Fig. 5). In contrast, the base of the Gölbelen section begins with a base of the Bashkirian Stage (Syuranian Substage) (Fig. 6). The lower part of the Bashkirian Stage in both sections is made up of mainly oolitic limestone with rare quartz arenite sandstone interbeds, indicating a shallow-marine environment (Figs. 5, 6). The oolitic limestone beds are mainly gray- or yellow-colored, thin- to medium-bedded, and represented by the oolitic grainstone microfacies with a poor fauna and flora. Although the oolitic limestone and bioclastic limestone intercalations show continuation to the overlying strata of the Bashkirian Stage (Akavasian–Askynbashian substages) at the Gölbelen section, this interval is represented by yellow-colored and thick-bedded quartz arenite sandstone in the Yassıpınar section, except for 1 m thick limestone strata in the middle part. The upper part of the Bashkirian strata at both sections consists of mainly fusulinid-rich bioclastic limestone without any terrigenous input (Figs. 5, 6). The fusulinid-rich bioclastic limestone beds are gray-colored and medium- to thick-bedded, and characterized dominantly by bioclastic grainstone and locally by bioclastic grainstone-packstone microfacies with an abundant fusulinid fauna, with algae, echinoderms, bryozoans, and rare intraclasts.

Lithostratigraphic properties of the Serpukhovian and Bashkirian stages.—The Serpukhovian strata of the Hadim Nappe are mainly composed of sandstone and rare limestone, with a poor fauna and flora. The lowermost Bashkirian is predominantly represented by oolitic limestone beds indicating a shallow-water depositional environment (Figs. 5, 6). The fusulinids in this interval were only recovered from the central parts of the ooids. The Akavasian and Askynbashian interval of the Yassıpınar section consists dominantly of sandstone without fusulinids. In contrast, at the Gölbelen section, this interval is represented by bioclastic limestone with rich and diversified fusulinid assemblages, and most characteristic fusulinids of the Akavasian-Askynbashian interval have been defined from this section. Although some terrigenous deposits and a poor fusulinid fauna occur in the boundary interval of the two sections, almost all fusulinid assemblages of this interval were recovered precisely based on the studied two sections (Fig. 7).

Biostratigraphy

Biostratigraphy of the Serpukhovian-Bashkirian boundary.—Although the Serpukhovian-Bashkirian boundary is recognized by the FAD of conodont *Declinognathodus noduliferus* at its GSSP at the Arrow Canyon, Nevada, USA (Lane et al., 1999), it is also known that the fusulinid foraminifera allow identification of the boundary. According to previous studies, there are many fusulinid foraminifera to distinguish the boundary between the Serpukhovian and the Bashkirian stages in various regions around the world (Brenckle et al., 1977, 1982, 1997; Skipp et al., 1985; Vachard and Maslo, 1996; Davydov, 1997; Kulagina and Sinitsyna, 1997, 2003; Richards et al., 2002; Atakul-Özdemir et al., 2011; Leven, 2012; Kulagina et al., 2014). Despite many different index foraminiferal taxa and regions, due to the good correlation we

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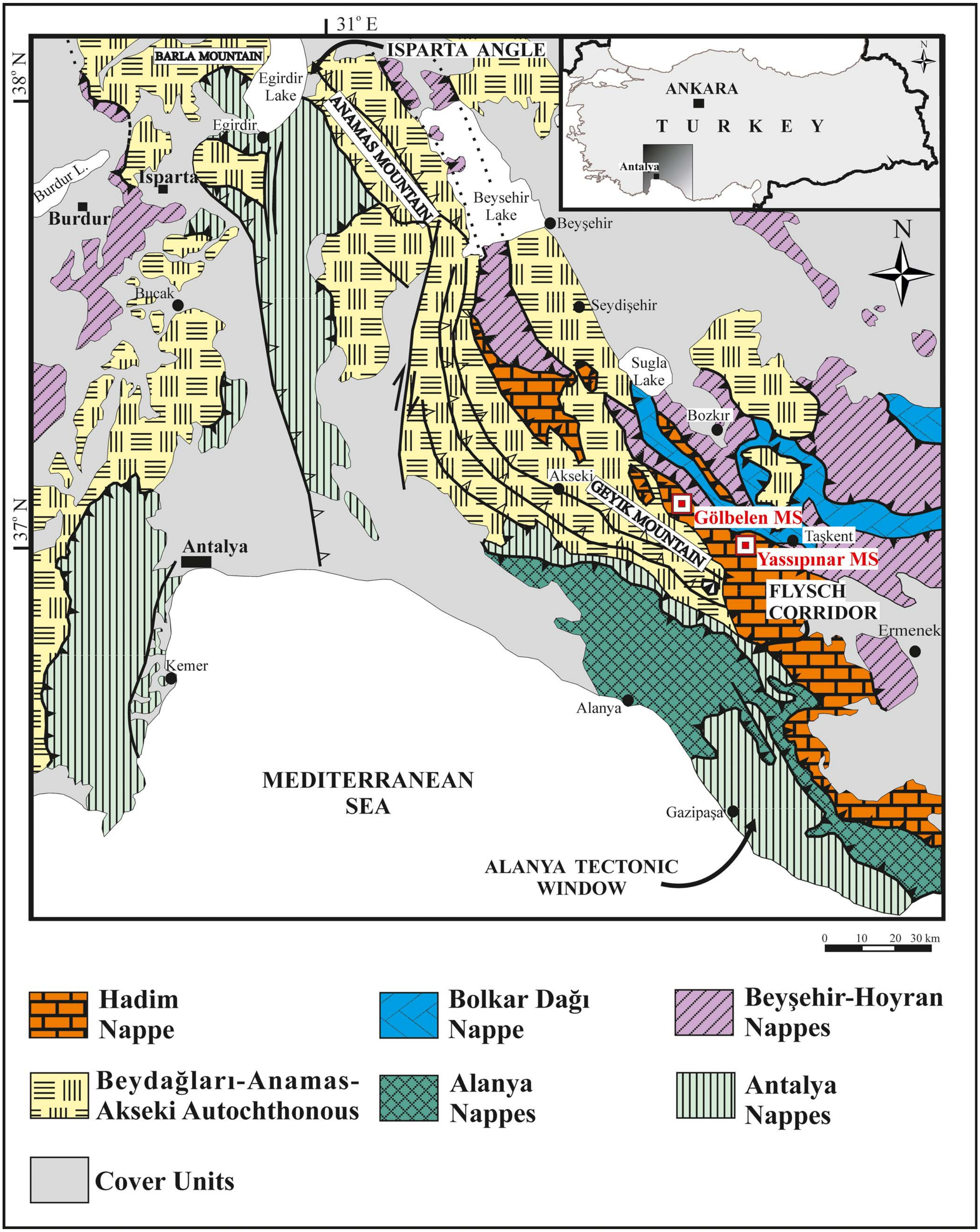

Figure 1. Schematic map showing the distribution of autochthonous and allochthonous sequences in the area between the Western and Central Taurides with the location of the Yassıpınar and Gölbelen measured sections (MS) (simplified and revised after Özgül, 1984).

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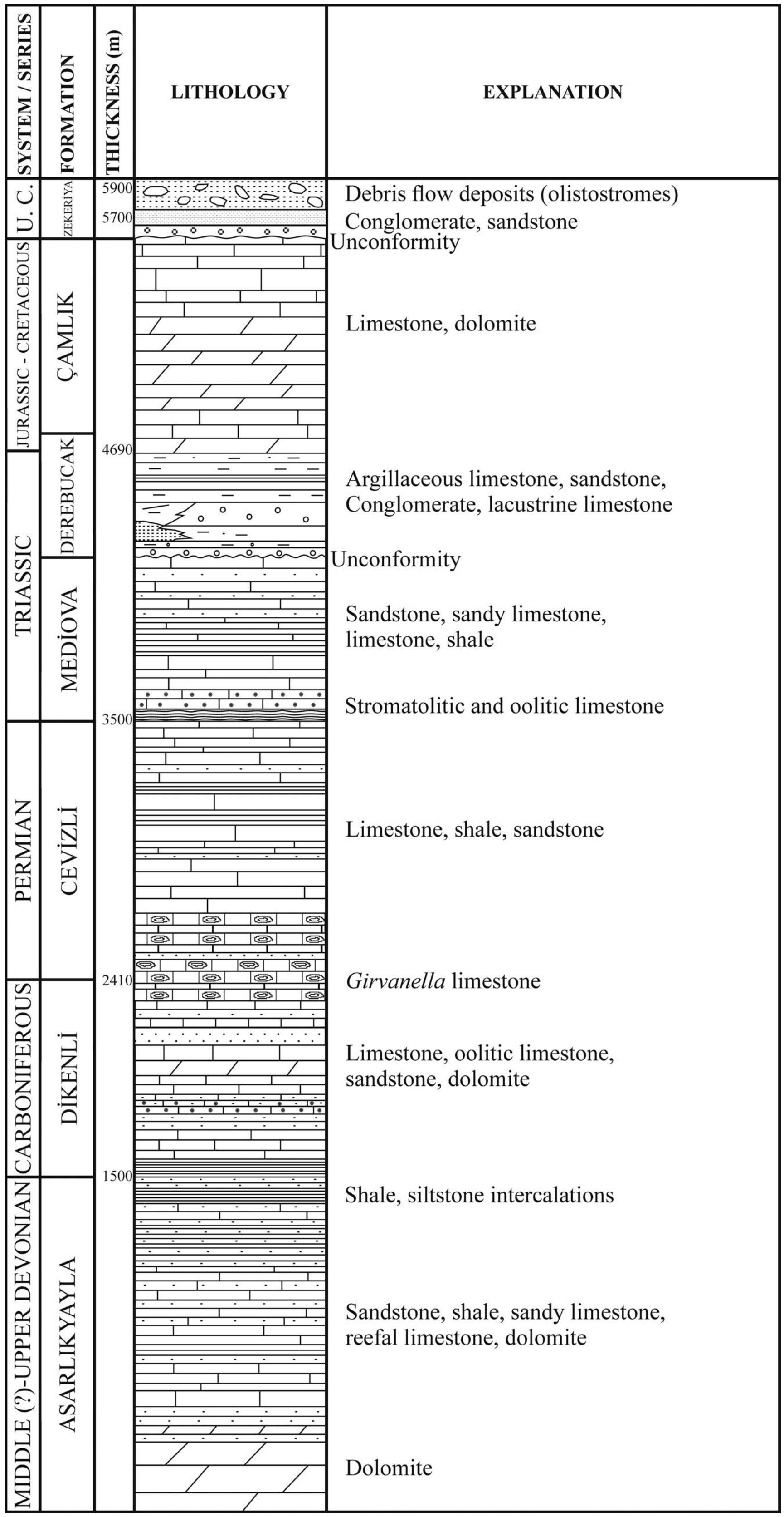

Figure 2. Generalized columnar section of the Hadim Nappe (modified after Monod, 1977; Turan, 1990; Özgül, 1997). Key: U. C., Upper Cretaceous.

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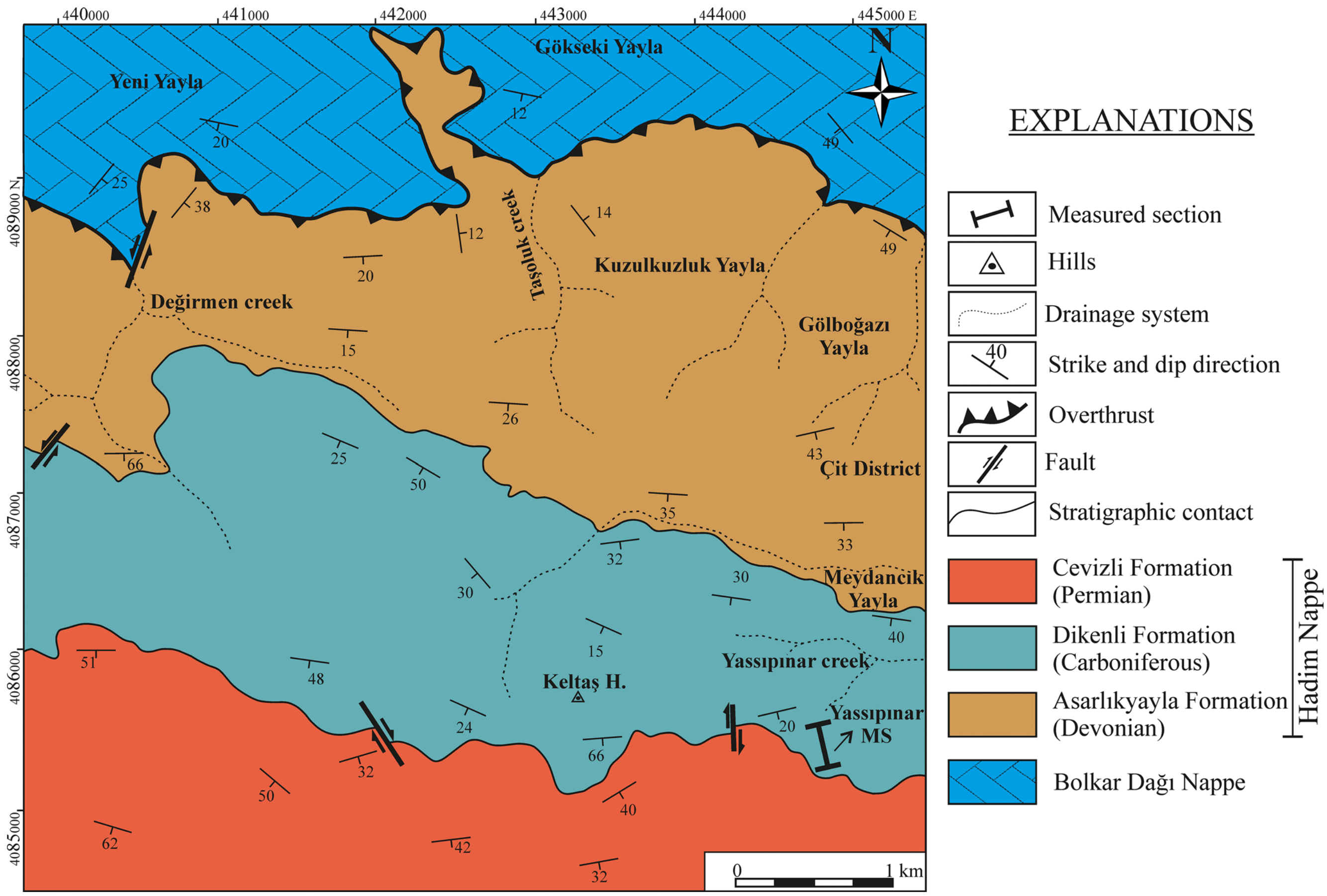

Figure 3. Geological map of the study area showing the location of the Yassıpınar measured section (simplified and revised after Turan, 1990).

prefer to focus on the Tethyan Realm, especially the Russian Platform and the southern Urals. The base of the Bashkirian along the Mississippian-Pennsylvanian transition is determined by the first occurrence of *Plectostaffella jakhensis* (Reitlinger, 1971), which is the one of the index foraminifera in the Russian Platform, southern Urals, Hadim Nappe (Central Taurides, Turkey), and Elburz (Iran) (Einor, 1996; Kulagina and Sinitsyna, 1997; Kulagina et al., 2000, 2001, 2014; Atakul-Özdemir et al., 2011; Leven and Gorgij, 2011). The Serpukhovian-Bashkirian boundary was determined between the *Eostaffella* ex gr. *E. ikensis*-*Eostaffella postmosquensis* Zone and the *Plectostaffella jakhensis*-*Plectostaffella bogdanovkensis* Zone in the Central Taurides based on foraminifers by Atakul-Özdemir et al. (2011). Later, this boundary was studied by Atakul-Özdemir et al. (2012) based on conodonts and the conodont *Declinognathodus noduliferus bernesgae* Sanz-López et al., 2006 is found just below the boundary, with the base of the Bashkirian stage determined by the occurrence of the conodont *Declinognathodus inaequalis* (Higgins, 1975).

The fusulinid assemblages of the upper Serpukhovian and Bashkirian strata permit a fine subdivision and comparison with coeval fusulinid assemblages of other Tethyan regions, such as the Taurides (Turkey), southern Urals, Russian Platform, and Donetz Basin. The biostratigraphic characteristics of the upper Serpukhovian and the Bashkirian stages are as follows:

Serpukhovian Stage, upper substage.—The Serpukhovian interval is represented mainly by siliciclastic rocks and rarely carbonate strata in the Hadim Nappe. In this study, the uppermost part of the Serpukhovian stage has been defined in the Yassıpınar stratigraphic section, and it is characterized by thick sandstone layers with a thin limestone bed that contains *Eostaffella postmosquensis acutiformis* Kireeva in Rauzer-Chernousova et al., 1951 (Figs. 5, 7, 8).

Bashkirian Stage, Syuranian Substage.—Due to extensive tectonic deformation, the base of the Gölbelen section is bounded by a fault and the lower Bashkirian (lowermost part of the Syuranian Substage) succession could not be determined (Fig. 6). However, the basal part of the section includes some characteristic fusulinid faunas of the Syuranian Substage (lower Bashkirian) (Figs. 6, 7). In the Yassıpınar section, which has a continuous succession from Serpukhovian to Bashkirian, the base of the Bashkirian Stage is determined by the FAD of *Plectostaffella jakhensis*, and occurrence of the *Plectostaffella bogdanovkensis* Reitlinger, 1980 and *Plectostaffella varvariensis* (Brazhnikova and Potievskaya, 1948) from the above beds (Figs. 5, 7).

The Syuranian Substage of the Bashkirian Stage includes abundant and diverse fusulinid assemblages in the Hadim Nappe sections. These fusulinid assemblages are composed of *Plectostaffella bogdanovkensis*, *P. jakhensis*, *P. varvariensis*,

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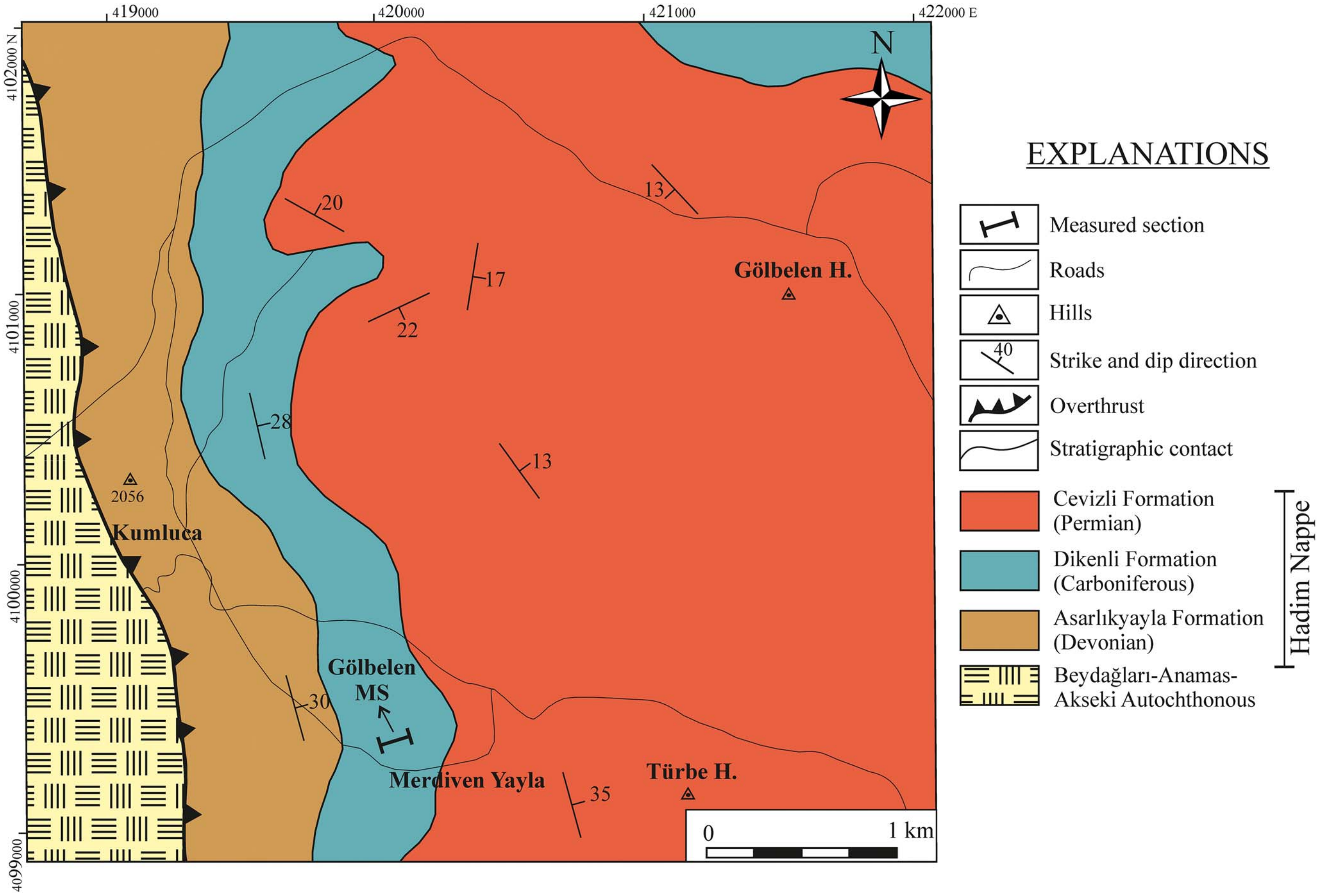

Figure 4. Geological map of the study area showing the location of the Gölbelen measured section (simplified and revised after Metin, 1994).

Semistaffella minuscilaria (Reitlinger, 1971), and *Semistaffella variabilis* (Reitlinger, 1961), which are important index taxa for the Syuranian Substage (Figs. 8, 9).

Plectostaffella jakhensis was originally described by Reitlinger (1971) from the South Urals (Jakhino village, Berdyaush River), and has been defined in coeval strata by many authors (Groves, 1988; Kulagina and Sinitsyna, 1997, 2003; Kulagina et al., 2000, 2001; Leven et al., 2006; Atakul-Özdemir et al., 2011; Leven and Gorgij, 2011; Leven, 2012). *Plectostaffella bogdanovkensis*, which is one of the most important taxa of this interval, was first described from the Bogdanovkian horizon of the Bashkirian Stage by Reitlinger (1980), and then determined in coeval strata (Kulagina and Sinitsyna, 1997; Kulagina et al., 2000, 2001, 2014; Atakul-Özdemir et al., 2011; Leven and Gorgij, 2011) or from the upper substages of the Bashkirian Stage (Dzhenchuraeva and Okuyucu, 2007; Leven, 2012). The other characteristic taxon of this interval, *Plectostaffella varvariensis*, was determined at the base of the lower Bashkirian succession in Donbas (Ukraine) by Brazhnikova and Potievskaya (1948). *Plectostaffella varvariensis*, widely distributed in the Tethyan Realm, is known in the southern Urals (Kulagina and Sinitsyna, 1997, 2003; Kulagina et al., 2000, 2001), Elburz Mountains (Iran) and central Iran (Leven et al., 2006; Leven and Gorgij, 2011), Pamir Mountains (Tajikistan) (Leven, 2012), and Taurides (Dzhenchuraeva and Okuyucu, 2007; Atakul-Özdemir et al., 2011) during the Syuranian–Askynbashian interval. The diverse fusulinid assemblages of the Syuranian Substage also comprise *Eostaffella postmosquensis postmosquensis* Kireeva in Rauzer-Chernousova et al., 1951; *E. postmosquensis acutiformis* Kireeva in Rauzer-Chernousova et al., 1951; *E. designata* (Zeller, 1953); *E. ovoidea* (Rauzer-Chernousova, 1948); *E.* ex gr. *E. pseudostruvei pseudostruvei* (Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936); *E. pseudostruvei angusta* Kireeva in Rauzer-Chernousova et al., 1951; *Plectostaffella* cf. *P. evolutica* (Rumyantseva, 1970); *Semistaffella primitiva* (Reitlinger, 1961); *Varistaffella eostaffellaeformis* (Rumyantseva, 1970); *V. ziganica* (Sinitsyna in Grozdilova et al., 1975); and *Pseudostaffella uralica* Kireeva in Rauzer-Chernousova et al., 1951 (Fig. 7). The characteristic early Bashkirian fusulinids, including *Eostaffella ovoidea*, *Semistaffella minuscilaria*, *S. variabilis*, and *Pseudostaffella uralica* are also described within the Akavasian Substage of the Bashkirian in the Yassıpınar section (Figs. 5, 7).

Bashkirian Stage, Akavasian Substage.—Besides the abundant and diverse fusulinid assemblages, advanced species of the genus *Pseudostaffella* Thompson, 1942 first appear in the Akavasian Substage of the Bashkirian Stage in the studied sections. The strata of the Akavasian Substage contain quite abundant fusulinid assemblages with *Eostaffella postmosquensis postmosquensis* Kireeva in Rauzer-Chernousova et al., 1951;

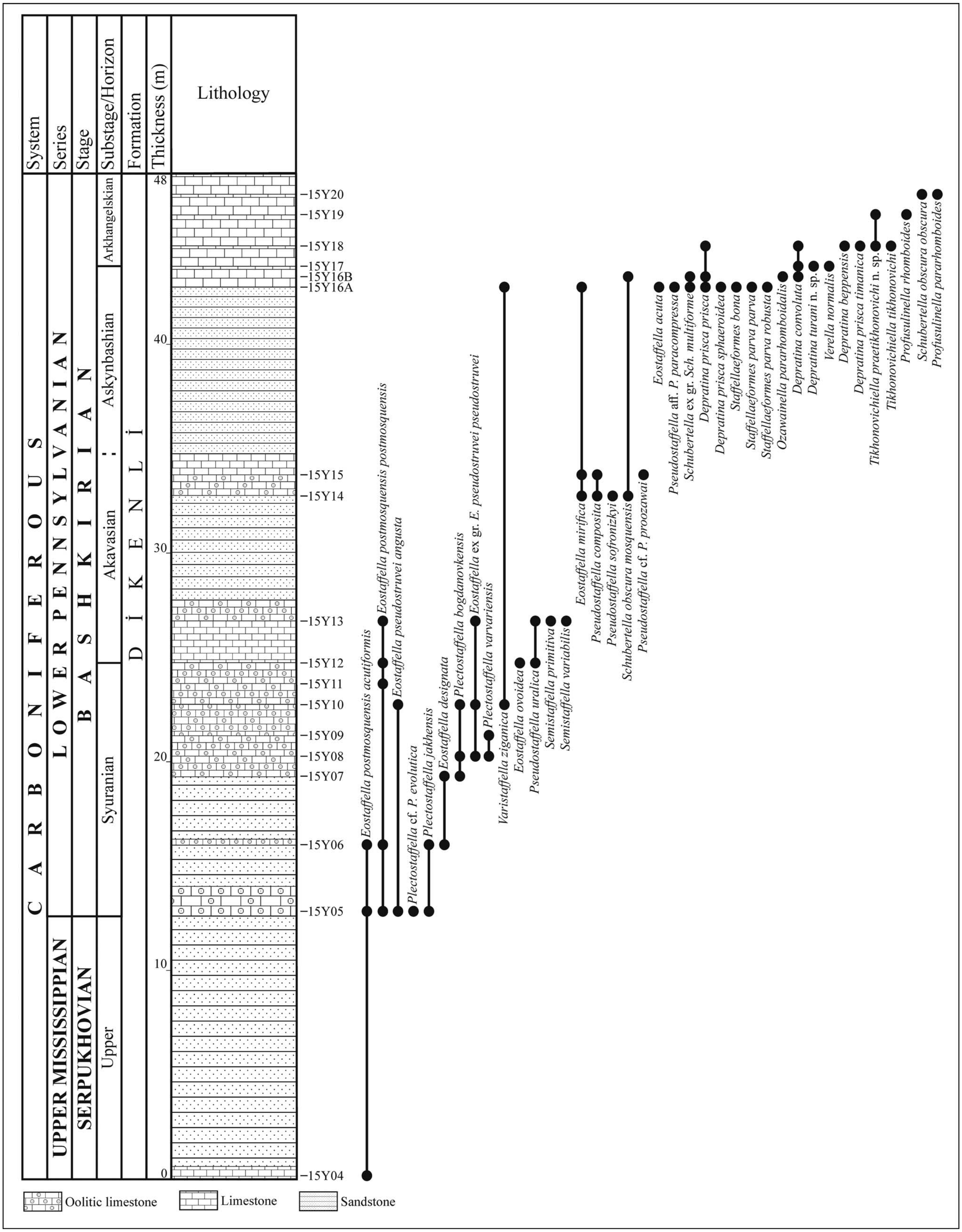

Figure 5. Lithostratigraphy and fusulinid distribution in the Yassıpınar section.

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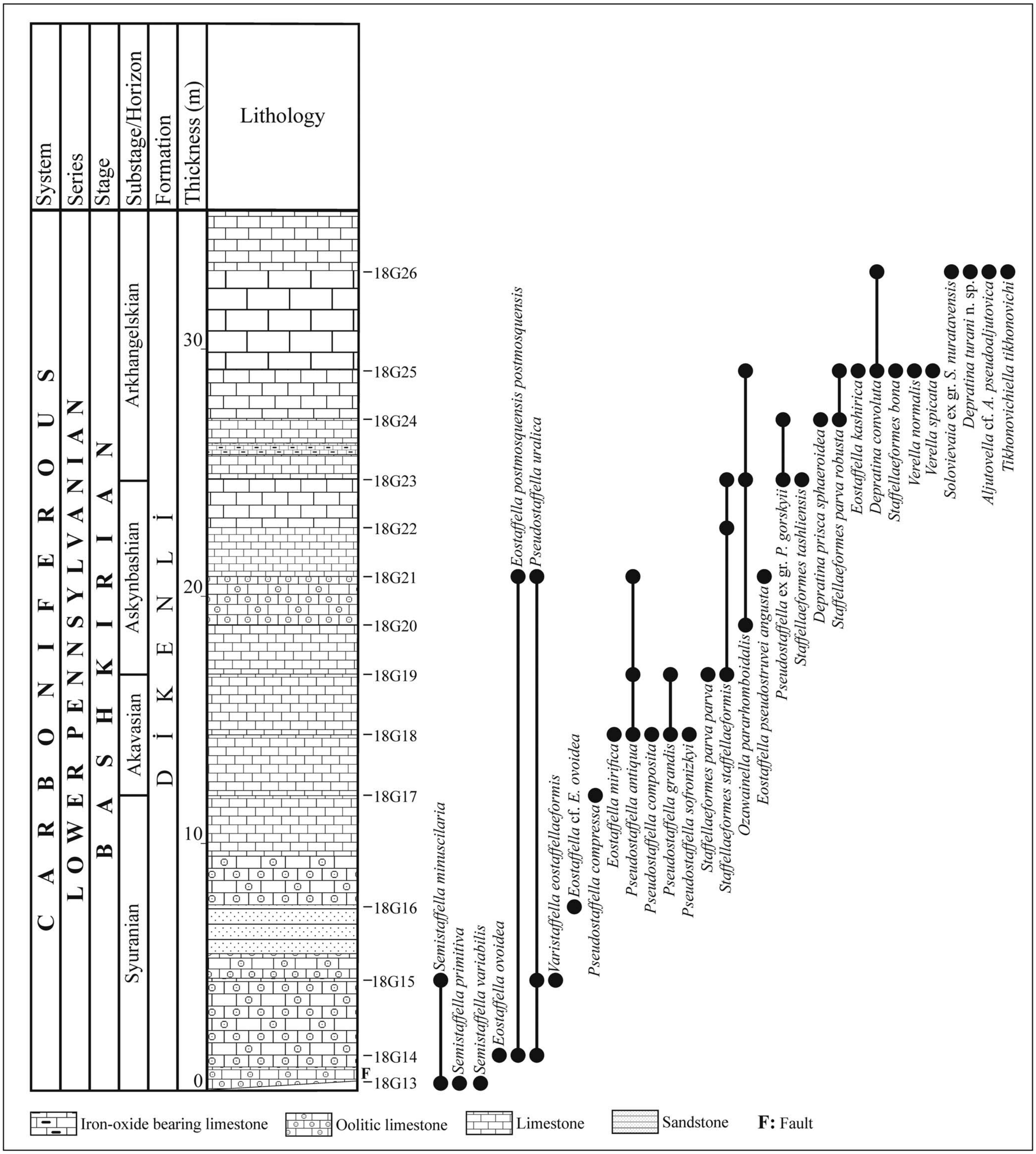

Figure 6. Lithostratigraphy and fusulinid distribution in the Gölbelen section.

E. ex gr. *E. pseudostruvei pseudostruvei* (Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936); *E. mirifica* Brazhnikova in Brazhnikova et al., 1967; *E. ovoidea* (Rauzer-Chernousova, 1948); *Semistaffella primitiva* (Reitlinger, 1961); *S*. *variabilis* (Reitlinger, 1961); *Pseudostaffella antiqua* (Dutkevich, 1934); *P. composita* Grozdilova and Lebedeva, 1950; *P. compressa* (Rauzer-Chernousova, 1938); *P. grandis* (Shlykova in Grozdilova and Lebedeva, 1950); *P.* cf. *P. proozawai* Kireeva in Rauzer-Chernousova et al., 1951; *P. sofronizkyi* Safonova in Rauzer-Chernousova et al., 1951; *P. uralica* Kireeva in Rauzer-Chernousova et al., 1951; and *Schubertella obscura mosquensis* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951 (Fig. 7). The species *Pseudostaffella antiqua*, which is the index taxon of the

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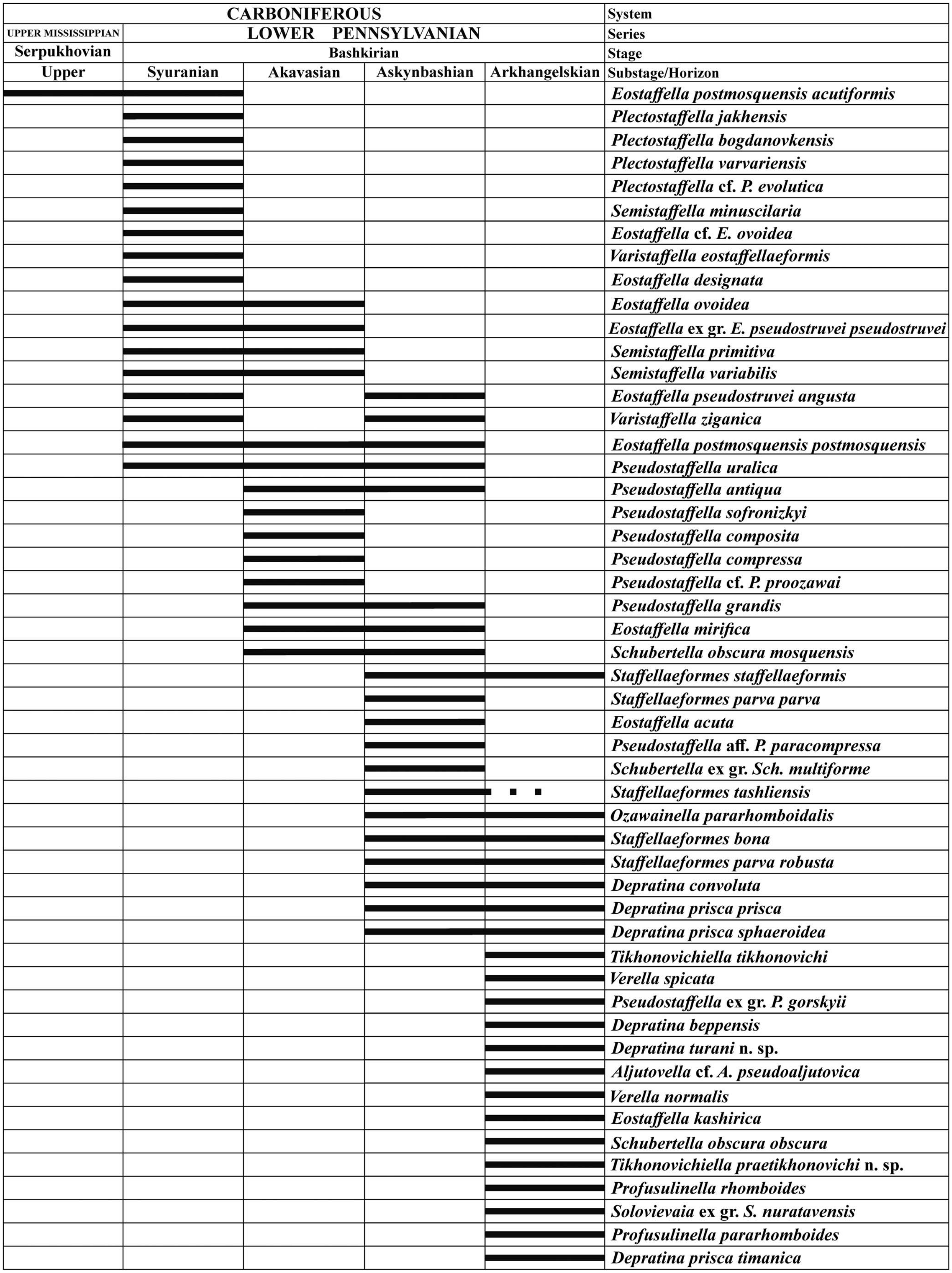

Figure 7. Total stratigraphic distribution of fusulinids from the upper Serpukhovian to Bashkirian in this study.

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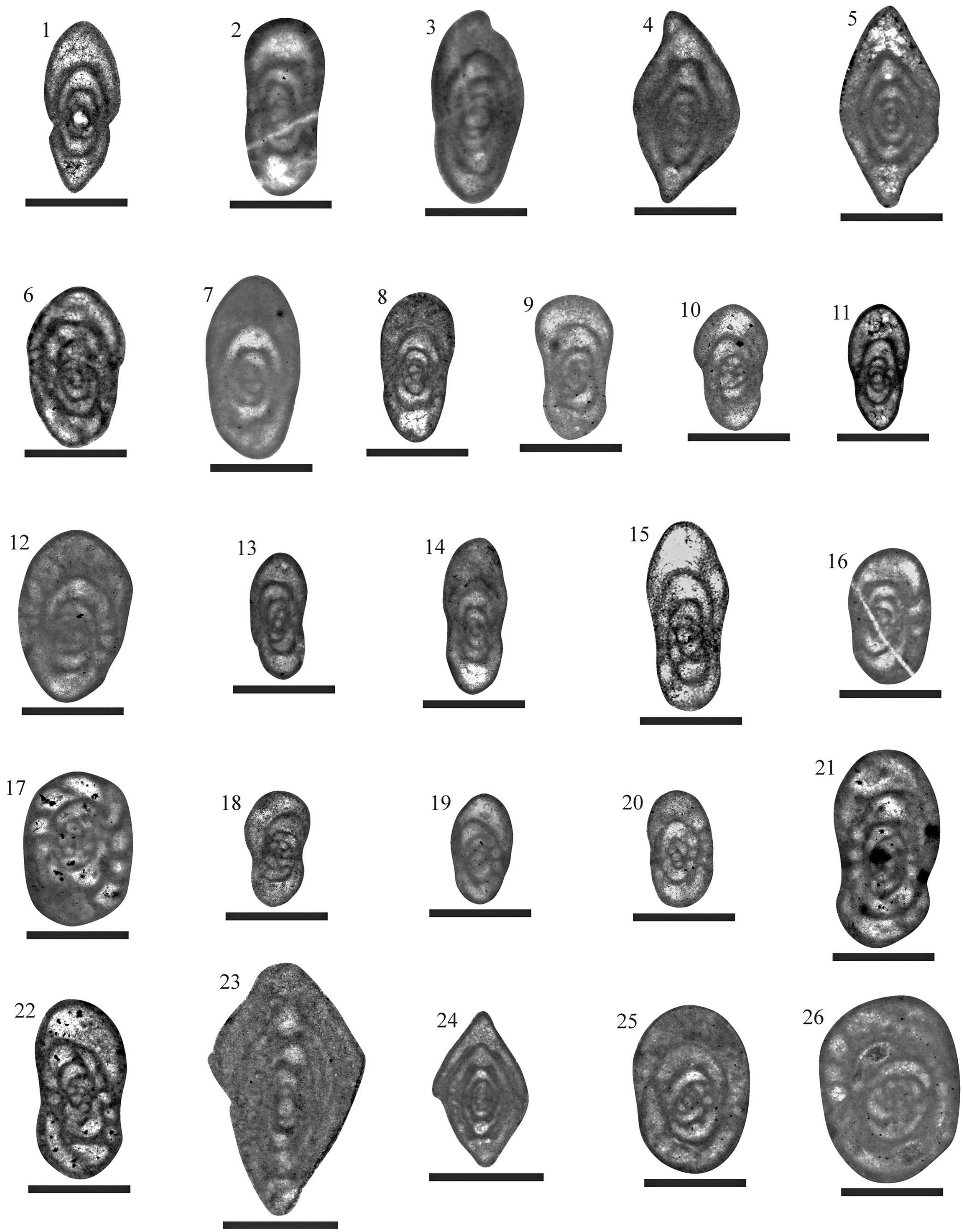
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Figure 8. Thin-section photomicrographs of the fusulinid assemblages of the Yassıpınar (YS) and Gölbelen (GS) sections. (**1**) *Eostaffella acuta* Grozdilova and Lebedeva, 1950, axial section, 15Y16A.08.02, YS. (**2**) *Eostaffella designata* (Zeller, 1953), subaxial section, 15Y07.04.02, YS. (**3**) *Eostaffella kashirica* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951, axial section, 18G25.12, GS. (**4, 5**) *Eostaffella mirifica* Brazhnikova in Brazhnikova et al., 1967, (**4**) axial section, 15Y15.05, YS; (**5**) axial section, 18G18.11.02, GS. (**6, 7**) *Eostaffella ovoidea* (Rauzer-Chernousova, 1948), (**6**) axial section, 15Y12.08, YS; (**7**) axial section, 18G14.03.01, GS. (**8, 9**) *Eostaffella postmosquensis postmosquensis* Kireeva in Rauzer-Chernousova et al., 1951, (**8**) axial section, 15Y05.03.02, YS; (**9**) subaxial section, 18G21.04.03, GS. (**10, 11**) *Eostaffella postmosquensis acutiformis* Kireeva in Rauzer-Chernousova et al., 1951, (**10**) axial section, 15Y05.05.01, YS; (**11**) axial section, 15Y04.01.01, YS. (**12**) *Eostaffella* cf. *E. ovoidea* (Rauzer-Chernousova, 1948), subaxial section, 18G16.03, GS. (**13**) *Eostaffella* ex gr. *E. pseudostruvei pseudostruvei* (Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936), axial section, 15Y10.05.01, YS. (**14, 15**) *Eostaffella pseudostruvei angusta* Kireeva in Rauzer-Chernousova et al., 1951, (**14**) axial section, 15Y05.06.01, YS; (**15**) axial section, 18G21.04.01, GS. (**16, 17**) *Plectostaffella bogdanovkensis* Reitlinger, 1980, subaxial sections, (**16**) 15Y07.04.01, YS; (**17**) 15Y08.02, YS. (**18**) *Plectostaffella* cf. *P. evolutica* (Rumyantseva, 1970), axial section, 15Y05.04.01, YS. (**19, 20**) *Plectostaffella jakhensis* (Reitlinger, 1971), (**19**) axial section, 15Y05.03.01, YS; (**20**) subaxial section, 15Y05.06.02, YS. (**21, 22**) *Plectostaffella varvariensis* (Brazhnikova and Potievskaya, 1948), axial sections, (**21**) 15Y08.03, YS; (**22**) 15Y08.06.02, YS. (**23, 24**) *Ozawainella pararhomboidalis* Manukalova, 1950, axial sections, (**23**) 15Y16B.07, YS; (**24**) 18G20.04, GS. (**25, 26**) *Semistaffella minuscilaria* Reitlinger, 1971, axial sections, (**25**) 18G13.03, GS; (**26**) 18G15.05, GS. Scale bars = 250 μm (**1–22, 25, 26**); = 500 μm (**23, 24**).

Akavasian Substage, is only found in the Gölbelen section (Figs. 6, 9). This characteristic species was originally described by Dutkevich (1934) in the lower Moscovian successions of the Urals. Later, it was also determined throughout the Bashkirian–lower Moscovian successions in the Russian Platform, Kolva-Vishera (Russia), Cantabrian Mountains (Spain), and the Nagaiwa Formation (Japan) (Rauzer-Chernousova et al., 1951; Grozdilova and Lebedeva, 1954; Ginkel, 1965; Kobayashi, 1973). *Pseudostaffella antiqua* is widely distributed and is known in the southern Urals (Russia) (Kulagina and Sinitsyna, 1997, 2003; Kulagina et al., 2000, 2001; Kulagina, 2003), Elburz Mountains (Iran) and central Iran (Leven et al., 2006; Leven and Gorgij, 2011), Pamir Mountains (Tajikistan) (Leven, 2012), and Hadim Nappe. The other common taxa of the Akavasian Substage comprise *Eostaffella mirifica*, *Pseudostaffella composita*, and *Pseudostaffella sofronizkyi*, which are present in the Yassıpınar and Gölbelen sections of the Hadim Nappe (Figs. 5, 6).

Bashkirian Stage, Askynbashian Substage.—The fusulinid assemblages of this substage are more abundant and more diverse than in the previous one, and the advanced fusulinid genus *Depratina* Solovieva in Rauzer-Chernousova et al., 1996 first appears (Fig. 10) with other fusulinid genera (*Ozawainella* Thompson, 1935, *Staffellaeformes* Solovieva, 1986, and *Schubertella* Staff and Wedekind, 1910) in the Yassıpınar and Gölbelen sections (Figs. 5, 6). The species *Staffellaeformes staffellaeformis* (Kireeva in Rauzer-Chernousova et al., 1951), index taxon of the base of the Askynbashian substage of the Bashkirian, is identified only in the Gölbelen section (Fig. 6). The Yassıpınar section also includes different species belonging to the genus *Staffellaeformes* (Fig. 5). *Staffellaeformes staffellaeformis* was first described from the Russian Platform by Kireeva (in Rauzer-Chernousova et al., 1951) in lower Moscovian units, later described from the Alai (Turkmenistan) (Dzhenchuraeva, 1979) and the Cantabrian Mountains (Villa, 1995) in the upper Bashkirian–lower Moscovian successions. In accordance with this study, *Staffellaeformes staffellaeformis* was determined in coeval strata of the Bashkirian successions of the southern Urals (Russia) (Kulagina et al., 2001; Kulagina, 2003, 2008, 2009), Elburz Mountains (Iran) and central Iran (Leven and Gorgij, 2011), Pamir Mountains (Tajikistan) (Leven, 2012), and Hadim Nappe (Dzhenchuraeva and Okuyucu, 2007). The entire fusulinid assemblage of this interval contains *Eostaffella acuta* Grozdilova and Lebedeva, 1950; *E. mirifica* Brazhnikova in Brazhnikova et al., 1967; *E. postmosquensis postmosquensis* Kireeva in Rauzer-Chernousova et al., 1951; *E. pseudostruvei angusta* Kireeva in Rauzer-Chernousova et al., 1951; *Ozawainella pararhomboidalis* Manukalova, 1950; *Varistaffella ziganica* (Sinitsyna in Grozdilova et al., 1975); *Pseudostaffella antiqua* (Dutkevich, 1934); *P. grandis* (Shlykova in Grozdilova and Lebedeva, 1950); *P.* aff. *P. paracompressa* Safonova in Rauzer-Chernousova et al., 1951; *P. uralica* Kireeva in Rauzer-Chernousova et al., 1951; *Schubertella* ex gr. *Sch. multiforme* Villa in Villa and Merino-Tomé, 2016; *Sch. obscura mosquensis* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951; *Depratina convoluta* (Lee and Chen in Lee et al., 1930) n. comb.; *D. prisca prisca* (Deprat, 1912); *D. prisca sphaeroidea* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951); *Staffellaeformes bona* (Grozdilova and Lebedeva, 1954); *S. parva parva* (Lee and Chen in Lee et al., 1930); *S. parva robusta* (Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936) n. comb.; and *S. staffellaeformis* (Kireeva in Rauzer-Chernousova et al., 1951) (Fig. 7). Although the Yassıpınar section is characterized by more diverse and abundant fusulinid assemblages, the Gölbelen stratigraphic section includes index taxa of the Askynbashian Substage. Furthermore, despite the fact that two sections contain the same generic taxa, only two species, *Ozawainella pararhomboidalis* and *Staffellaeformes parva parva*, are mutual species.

Bashkirian Stage, Arkhangelskian Substage.—The Arkhangelskian has an enormous diversity of fusulinid assemblages in the Hadim Nappe sections. In the studied sections, in addition to the previously noted genera, advanced fusulinids such as *Solovievaia* Vachard and Le Coze, 2018; *Aljutovella* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951; *Tikhonovichiella* Solovieva in Rauzer-Chernousova et al., 1996; and *Verella* Dalmatskaya, 1951 first appear in the Arkhangelskian Substage. The species of the latter two genera, *Tikhonovichiella tikhonovichi* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951) and *Verella spicata* Dalmatskaya, 1951, are the index taxa of the Arkhangelskian Substage. Although the species *Tikhonovichiella tikhonovichi* is present in both the Yassıpınar and Gölbelen sections, the species *Verella spicata* is only found in the Gölbelen section (Figs. 5, 6). One of the characteristic taxon of the Bashkirian-Moscovian boundary, *Tikhonovichiella tikhonovichi*, was described by Rauzer-Chernousova (in Rauzer-Chernousova et al., 1951) from the lower Moscovian succession of the Russian Platform. Subsequently, it has been reported in the

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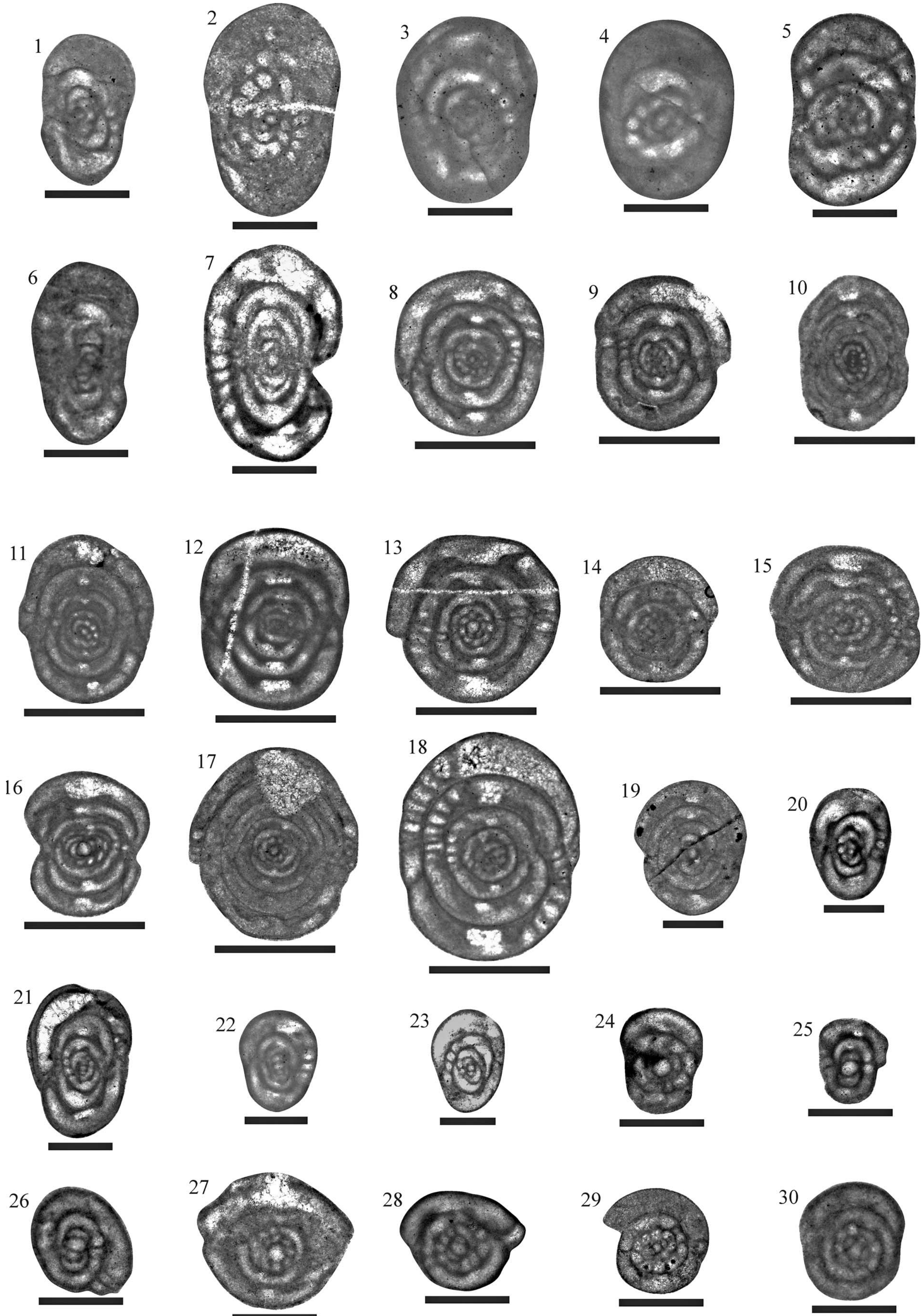

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Figure 9. Thin-section photomicrographs of the fusulinid assemblages of the Yassıpınar (YS) and Gölbelen (GS) sections. (**1, 2**) *Semistaffella primitiva* (Reitlinger, 1961), (**1**) subaxial section, 15Y13.03, YS; (**2**) axial section, 18G13.04.01, GS. (**3, 4**) *Semistaffella variabilis* (Reitlinger, 1961), (**3**) subaxial section, 15Y13.08.01; YS; (**4**) axial section, 18G13.04.02, GS. (**5**) *Varistaffella eostaffellaeformis* (Rumyantseva, 1970), subaxial section, 18G15.03, GS. (**6, 7**) *Varistaffella ziganica* (Sinitsyna in Grozdilova et al., 1975), (**6**) subaxial section, 15Y10.04.01, YS; (**7**) axial section, 15Y16A.10, YS. (**8, 9**) *Pseudostaffella antiqua* (Dutkevich, 1934), (**8**) axial section, 18G18.08, GS; (**9**) subaxial section, 18G19.06, GS. (**10, 11**) *Pseudostaffella composita* Grozdilova and Lebedeva, 1950, axial sections, (**10**) 15Y15.04, GS; (**11**) 18G18.06, GS. (**12**) *Pseudostaffella compressa* (Rauzer-Chernousova, 1938), axial section, 18G17.04, GS. (**13**) *Pseudostaffella* ex gr. *P. gorskyii* Dutkevich in Grozdilova and Lebedeva, 1950, axial section, 18G23.06, GS. (**14, 15**) *Pseudostaffella grandis* (Shlykova in Grozdilova and Lebedeva, 1950), axial sections, (**14**) 18G18.07.01, GS; (**15**) 18G19.03, GS. (**16**) *Pseudostaffella* aff. *P. paracompressa* Safonova in Rauzer-Chernousova et al., 1951, axial section, 15Y16A.08.01, GS. (**17**) *Pseudostaffella* cf. *P. proozawai* Kireeva in Rauzer-Chernousova et al., 1951, axial section, 15Y15.03, YS. (**18, 19**) *Pseudostaffella sofronizkyi* Safonova in Rauzer-Chernousova et al., 1951, (**18**) subaxial section, 18G18.09, GS; (**19**) axial section, 15Y14.06, YS. (**20–23**) *Pseudostaffella uralica* Kireeva in Rauzer-Chernousova et al., 1951, axial sections, (**20**) 15Y12.03, YS; (**21**) 15Y12.07, YS; (**22**) 18G14.03.02, GS; (**23**) 18G21.03, GS. (**24–26**) *Schubertella* ex gr. *Sch. multiforme* Villa in Villa and Merino-Tomé, 2016, axial sections, (**24**) 15Y16A.07, YS; (**25**) 15Y16A.27, YS; (**26**) 15Y16B.05, YS. (**27, 28**) *Schubertella obscura obscura* Lee and Chen in Lee et al., 1930, axial sections, (**27**) 15Y20.04, YS; (**28**) 15Y22.03.02, YS. (**29, 30**) *Schubertella obscura mosquensis* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951, (**29**) subaxial section, 15Y14.04, YS; (**30**) axial section, 15Y16B.08, YS. Scale bars = 250 µm (**1–7, 19–30**); = 500 µm (**8–18**).

Urals (Russia) (Grozdilova et al., 1975; Kulagina et al., 2001; Kulagina, 2003, 2008), Pamir Mountains (Tajikistan) (Leven, 2012), and in the Hadim Nappe (Dzhenchuraeva and Okuyucu, 2007) successions. The other characteristic taxon of this interval, *Verella spicata*, was originally described by Dalmatskaya (1951) at the base of the Moscovian Stage of the Russian Platform, then was reported in the upper Bashkirian successions of the South Gissar (Bensh, 1969; Saltovskaya, 1974), Alai (Turkmenistan) (Dzhenchuraeva, 1979), Cantabrian Mountains (Villa, 1995), Pamir Mountains (Tajikistan) (Leven, 2012), and Hadim Nappe (Dzhenchuraeva and Okuyucu, 2007). Except these two index species, the Arkhangelskian Substage in the Hadim Nappe sections contains following diverse fusulinid species; *Eostaffella kashirica* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951; *Ozawainella pararhomboidalis* Manukalova, 1950; *Pseudostaffella* ex gr. *P. gorskyii* Dutkevich in Grozdilova and Lebedeva, 1950; *Schubertella obscura obscura* Lee and Chen in Lee et al., 1930; *Profusulinella pararhomboides* Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936; *P. rhomboides* (Lee and Chen in Lee et al., 1930); *Solovievaia* ex gr. *S. nuratavensis* (Solovieva, 1977); *Depratina beppensis* (Toriyama, 1958); *D. convoluta* (Lee and Chen in Lee et al., 1930); *D. prisca prisca* (Deprat, 1912); *D. prisca sphaeroidea* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951); *D. prisca timanica* (Kireeva in Rauzer-Chernousova et al., 1951); *D. turani* Akbaş n. sp.; *Staffellaeformes bona* (Grozdilova and Lebedeva, 1954); *S. parva robusta* (Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936) n. comb.; *S. staffellaeformis* (Kireeva in Rauzer-Chernousova et al., 1951); *S. tashliensis* (Lebedeva in Grozdilova et al., 1975); *Aljutovella* cf. *A. pseudoaljutovica* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951; *Tikhonovichiella praetikhonovichi* Akbaş n. sp.; *T. tikhonovichi* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951); *Verella normalis* Rumyantseva, 1962; and *V. spicata* Dalmatskaya, 1951 (Fig. 7).

Biostratigraphic correlation.—Plectostaffella jakhensis, one of the important taxon for indication of the Mississippian-Pennsylvanian boundary, was reported by Reitlinger (1971) for the first time in the lower Bashkirian strata of southern Urals. Later, it was reported in the southern Urals (Kulagina and Sinitsyna, 1997, 2003; Kulagina et al., 2000, 2001) and Taurides (Atakul-Özdemir et al., 2011). In this study, the first appearance of *Plectostaffella jakhensis* is in the strata below the appearance of *Plectostaffella bogdanovkensis* and *Plectostaffella varvariensis*, at the base of the Bashkirian (Fig. 5). This is very typical and widespread at the Serpukhovian-Bashkirian boundary strata and makes it easier to correlate this boundary with other regions.

The Syuranian Substage of the Bashkirian Stage is characterized by *Plectostaffella bogdanovkensis*, *P. jakhensis*, and *P. varvariensis* in the southern Urals (Kulagina and Sinitsyna, 1997, 2003; Kulagina et al., 2000, 2001, 2014), Elburz Mountains (Leven and Gorgij, 2011), and Taurides (Atakul-Özdemir et al., 2011). In this study, the Serpukhovian-Bashkirian boundary is also recognized by the occurrence of these index taxa, which is similar to the southern Urals based on similar fusulinid assemblages and oolitic facies (Kulagina et al., 2018; Kulagina and Gorozhanina, 2019). The Akavasian Substage of the Bashkirian Stage is represented by the appearance of diverse species of the genera *Pseudostaffella* Thompson, 1942 and *Varistaffella* Kulagina and Sinitsyna, 2003 with a distinct three-layered wall structure (Kulagina and Sinitsyna, 2003), and its base is characterized by FAD of the *Pseudostaffella antiqua* in the southern Urals (Kulagina and Sinitsyna, 1997, 2003). In the Hadim Nappe sections, the Akavasian Substage shows close similarity to the southern Urals fusulinid fauna in terms of the diversity and abundance of the *Pseudostaffella* assemblage, and the appearance of *Pseudostaffella antiqua* at the base of this substage. The Askynbashian Substage is characterized by the appearance of more advanced fusulinids with distinct chomata, three-layered wall, and subspherical or short inflated fusiform test, such as in the genera *Staffellaeformes* (at the base of this substage) and *Depratina* (at the top of this substage) in the Bashkirian successions of the Hadim Nappe (Fig. 7). The base of the Askynbashian Substage in this study is determined by the FAD of the species *Staffellaeformes staffellaeformis*, which is known in the coeval interval in the southern Urals (Kulagina et al., 2001; Kulagina, 2003, 2008, 2009), Elburz Mountains (Leven and Gorgij, 2011), Pamir Mountains (Leven, 2012), and Taurides (Dzhenchuraeva and Okuyucu, 2007). *Tikhonovichiella tikhonovichi* and *Verella spicata* indicate the uppermost Bashkirian (Arkhangelskian Substage) in the Bashkirian–Moscovian transition. The former is determined in the lower part, and latter is in the upper part of the Arkhangelskian Substage in the Hadim Nappe sections. *Tikhonovichiella tikhonovichi* is recognized in the uppermost Bashkirian successions of the Urals (Grozdilova et al., 1975; Kulagina et al., 2001; Kulagina, 2003, 2008), Pamir Mountains (Leven, 2012), and Taurides

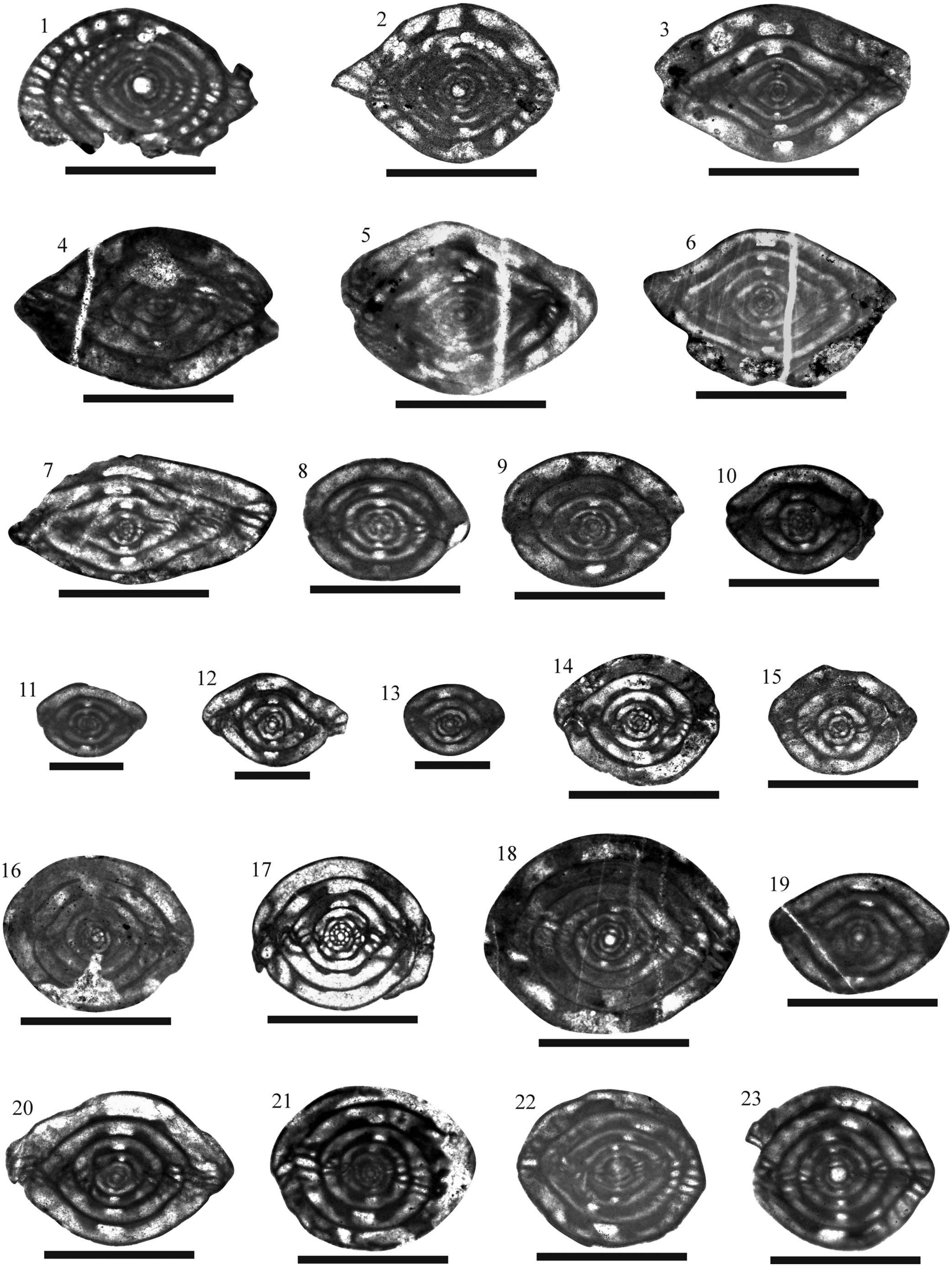

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Figure 10. Thin-section photomicrographs of the fusulinid assemblages of the Yassıpınar (YS) and Gölbelen (GS) sections. (**1–3**) *Profusulinella pararhomboides* Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936, subaxial sections, (**1**) 15Y20.03, YS; (**2**) 15Y26.03, YS; (**3**) axial section, 18G27.12, GS. (**4–6**) *Profusulinella rhomboides* (Lee and Chen in Lee et al., 1930), (**4**) subaxial section 15Y19.06, YS; axial sections, (**5**) 15Y26.04, YS; (**6**) 18G31.07, GS. (**7**) *Solovievaia* ex gr. *S. nuratavensis* (Solovieva, 1977), axial section, 18G26.07, GS. (**8, 9**) *Depratina beppensis* (Toriyama, 1958), axial sections, (**8**) 15Y18.12, YS; (**9**) 15Y18.21, YS. (**10–13**) *Depratina convoluta* (Lee and Chen in Lee et al., 1930) n. comb., axial sections, (**10**) 15Y17.04, YS; (**11**) 15Y18.03, YS; (**12**) 15Y23.09, YS; (**13**) 18G26.09, GS. (**14, 15**) *Depratina prisca prisca* (Deprat, 1912), axial sections, (**14**) 15Y16A.19.01, YS; (**15**) 15Y18.13, YS. (**16–18**) *Depratina prisca sphaeroidea* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951), axial sections, (**16**) 15Y16A.12, YS; (**17**) 15Y16A.17, YS; (**18**) 18G24.03, GS. (**19, 20**) *Depratina prisca timanica* (Kireeva in Rauzer-Chernousova et al., 1951), axial sections, (**19**) 15Y18.11, YS; (**20**) 15Y21.13, YS. (**21–23**) *Depratina turani* Akbaş n. sp., (**21**) axial section, 15Y17.03, YS; (**22**) subaxial section, 15Y17.06, YS; (**23**) axial section, 15Y17.08 (holotype), YS. Scale bars = 500 µm (**11–13**); = 1 mm (**1–10, 14–23**).

(Dzhenchuraeva and Okuyucu, 2007). The other important taxon, *Verella spicata*, is detected in this interval and occurs in coeval successions of the South Gissar and Zerafshan (Bensh, 1969; Saltovskaya, 1974), Alai (Dzhenchuraeva, 1979), Cantabrian Mountains (Villa, 1995), Pamir Mountains (Leven, 2012), and Taurides (Dzhenchuraeva and Okuyucu, 2007).

The faunas of the studied Hadim Nappe sections share many common species, mainly with southern Urals and other Tethyan regions.

Materials and methods

We studied a total of 31 limestone samples from the Yassıpınar and Gölbelen sections, analyzing two randomly oriented thin sections per sample and >300 oriented thin sections. A transmitted light microscope was used for examination of the thin sections and taking microphotographs of the fusulinids.

In this study, the systematic and taxonomic descriptions of fusulinids follow the handbook on taxonomy of the Paleozoic foraminifera proposed by Rauzer-Chernousova et al. (1996), with addition of the genus *Varistaffella* Kulagina and Sinitsyna, 2003 proposed by Kulagina and Sinitsyna (2003).

Repository and institutional abbreviation.—All holotypes and paratypes are reposited in the collection of the MA-(HY15) at the Faculty of Engineering and Natural Sciences, Department of Geological Engineering, Konya Technical University, Turkey.

Systematic paleontology

Class Foraminifera d'Orbigny, 1826
Superorder Fusulinoidea Fursenko, 1958
Order Fusulinida Fursenko, 1958
Family Profusulinellidae Solovieva in Rauzer-Chernousova et al., 1996
Genus *Depratina* Solovieva in Rauzer-Chernousova et al., 1996

Type species.—*Schwagerina prisca* Deprat, 1912, from China (Indochina), eastern Yun–Nan.

Remarks.—The dominantly small-sized and nearly globular or short-inflated, fusiform-shaped *Profusulinella* group was originally determined as the "prisca group" by Rauzer-Chernousova et al. (1951). Later, Rauzer-Chernousova et al. (1996) assigned the "prisca group" to the genus *Depratina*. The species belonging to this genus differ from species of the genus *Profusulinella*, which have relatively globular or short-inflated fusiform tests, smaller L/D ratio, and poorly developed chomata. Hence, in this study, the species belonging to the "prisca" group (Rauzer-Chernousova et al., 1951) and the species that have the same features are assembled under the genus *Depratina*.

Depratina convoluta (Lee and Chen in Lee et al., 1930) new combination
Figure 10.10–10.13

1930 *Fusulinella* (*Neofusulinella*) *parva convoluta* Lee and Chen in Lee et al., p. 119, pl. 7, figs. 1, 2.
1951 *Profusulinella convoluta*; Safonova and Rauzer-Chernousova in Rauzer-Chernousova et al., p. 160, pl. 13, figs. 10, 11.
1969 *Profusulinella convoluta*; Bensh, p. 112, pl. 2, figs. 9, 10.
1979 *Profusulinella convoluta*; Dzhenchuraeva, pl. 11, fig. 3.
1998 *Profusulinella convoluta*; Leven, p. 17, pl. 1, fig. 44.
2006 *Profusulinella convoluta*; Leven et al., fig. 12.6.
?2006 *Profusulinella* ex gr. *P. convoluta*; Leven et al., fig. 12.14.
2007 *Profusulinella convoluta*; Dzhenchuraeva and Okuyucu, pl. 3, figs. 2, 3, pl. 4, fig. 5.
2007 *Profusulinella convoluta*; Fohrer et al., p. 43, fig. 23.1–23.10.
?2007 *Profusulinella* cf. *P. convoluta*; Fohrer et al., p. 43, fig. 23.11.
?2011 *Profusulinella* (*Profusulinella*) ex gr. *P. convoluta*; Leven and Gorgij, pl. 4, fig. 11.

Holotype.—From the Huanglung Limestone, China (Lee and Chen in Lee et al., 1930, p. 119, pl. 7, fig. 1).

Occurrence.—The Yassıpınar and Gölbelen sections of the Hadim Nappe (Hadim/Konya, Bozkır/Konya, Central Taurides), late Bashkirian–early Moscovian (Askynbashian–Vereian substages).

Description.—Test small and inflated-fusiform in shape. Proloculus globular and small, with 28–60 µm external diameter. Length of test (L) 0.79–1.13 mm; diameter (D) 0.53–0.78 mm; L/D ratio 1.31–1.49. Adult tests have 4.5–5 volutions. The three-layered microgranular wall consists of thin and dark tectum, and thin lower tectorium and upper tectorium. Septa weak and plane in the middle part, and slightly fluted at the poles. Chomata asymmetrical and relatively massive.

Materials.—Four axial sections (15Y17.04, 15Y18.03, 15Y23.09, and 18G26.09), all are reposited in the collection of the MA-HY15.

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Remarks.—This species was first described by Lee and Chen in Lee et al. (1930) under the name *Fusulinella* (*Neofusulinella*) *parva convoluta*, and then included in the "parva group" of Rauzer-Chernousova et al. (1951) under the genus *Profusulinella* as *Profusulinella convoluta*. In this study, according to the systematics proposed by Rauzer-Chernousova et al. (1996), this species is assigned as the genus *Depratina* based on its short-inflated fusiform test and weak chomata compared to the genus *Profusulinella*. This systematic revision is also supported by the correlation graph between the L/D ratio of the type species of *Depratina* and *Profusulinella*, and L/D ratio of *Depratina convoluta* n. comb. (Fig. 12).

Depratina turani Akbaş new species
Figures 10.21–10.23, 11.1–11.3

Holotype.—15Y17.08 (axial section), from Dikenli Formation of the Hadim Nappe, southern Turkey, reposited in the Faculty of Engineering and Natural Sciences, Department of Geological Engineering, Konya Technical University, Turkey (collection number: MA-HY15/15Y17.08).

Diagnosis.—Species of *Depratina* with small and sub-spherical test, low L/D ratio, and asymmetrical chomata.

Occurrence.—The Yassıpınar and Gölbelen stratigraphic sections of the Hadim Nappe in Central Taurides (Konya, Turkey). Carboniferous, late Bashkirian, Arkhangelskian Substage.

Description.—Test small and sub-spherical in shape. The middle part of the test is inflated and widely rounded. The lateral sides are convex and peripheries narrowly arched in shape. The initial one or two volutions are spherical, the latter sub-spherical due to slightly elongate, with 90° change in axis of coiling in some individuals. The progress of the test is gradual with tight coiling. The proloculus small- to medium-sized, with 50–110 µm external diameter. Length of test (L) 1.35–1.42 mm; diameter (D) 1.11–1.20 mm; L/D ratio 1.17–1.28. Adult tests have 5.5–6.5 volutions. Wall calcareous, thin, microgranular, three-layered with a distinct dark tectum, dark lower and upper tectorium. Septa weak and plane. Chomata massive, asymmetrical, and dominantly rounded in shape, but sub-ribbon in initial volutions of some individuals, and the thickness relatively decreases toward the poles.

Etymology.—This species is named after Dr. Ahmet Turan, Konya Technical University, Konya, Turkey, in honor of his contributions to the geology of the Taurides.

Materials.—Two axial sections (15Y17.03, 15Y17.08) and two subaxial sections (15Y17.06, 18G26.08), all are reposited in collection number MA-HY15.

Remarks.—The described new species is most similar to the *Depratina prisca sphaeroidea* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951) based on the shape of the test and wall structure, but differs from it by tighter coiling, asymmetrical and dominantly rounded chomata, which became thinner toward the poles.

Genus *Staffellaeformes* Solovieva, 1986

Type species.—*Profusulinella staffellaeformis* Kireeva in Rauzer-Chernousova et al., 1951, from Russian Platform, Russia.

Remarks.—*Staffellaeformes staffellaeformis*, which was originally described in the composition of the genus *Profusulinella* under the "parva group" (Rauzer-Chernousova et al., 1951), is assigned to the genus *Staffellaeformes*, which was described by Solovieva (1986) with *Profusulinella staffellaeformis* Kireeva in Rauzer-Chernousova et al., 1951 as the type species. Later, the original form in Solovieva's (1986) description of the *Staffellaeformes* was included in the systematics of Rauzer-Chernousova et al. (1996) as a separate genus. In this study, the validity and characteristics of the genus *Staffellaeformes* are accepted in the sense of the systematics of Rauzer-Chernousova et al. (1996). The species belonging to the genus *Staffellaeformes* differ easily from the species of the genus *Profusulinella* based on their sub-spherical or nautiloid tests, almost equal length and diameter, weak developed septa, and types of chomata.

Staffellaeformes parva robusta (Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936) new combination
Figure 11.8, 11.9

1936 *Profusulinella parva robusta* Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., p. 178, pl. 1, fig. 4.
1951 *Profusulinella parva robusta*; Safonova in Rauzer-Chernousova et al., p. 158, pl. 13, fig. 7.
2007 *Profusulinella parva robusta*; Dzhenchuraeva and Okuyucu, pl. 2, fig. 26.

Holotype.—From upper Paleozoic deposits of the Pechora region, Russia (Rauzer-Chernousova et al., 1936, p. 178–179, pl. 1, fig. 4).

Occurrence.—The Yassıpınar and Gölbelen sections of the Hadim Nappe (Hadim/Konya, Bozkır/Konya, Central Taurides), late Bashkirian (Askynbashian–Arkhangelskian substages).

Description.—Test small and subspherical to ovoid in shape with early spherical volutions. Proloculus globular and small, with 50–60 µm external diameter. The length of test (L) 1.25–1.30 mm; diameter (D) 0.84–0.98 mm; L/D ratio 1.33–1.49. Adult tests have 4–5 volutions. The three layered microgranular wall consists of a thin and dark tectum, lower tectorium, and thin upper tectorium. Septa weak and plane in the middle part, and slightly fluted at the poles. Chomata massive and rounded in shape.

Materials.—Two axial sections (15Y16A.06 and 18G24.04), all reposited in the collection number MA-HY15.

Remarks.—This species was described by Rauzer-Chernousova and Belyaev (in Rauzer-Chernousova et al., 1936) as a species

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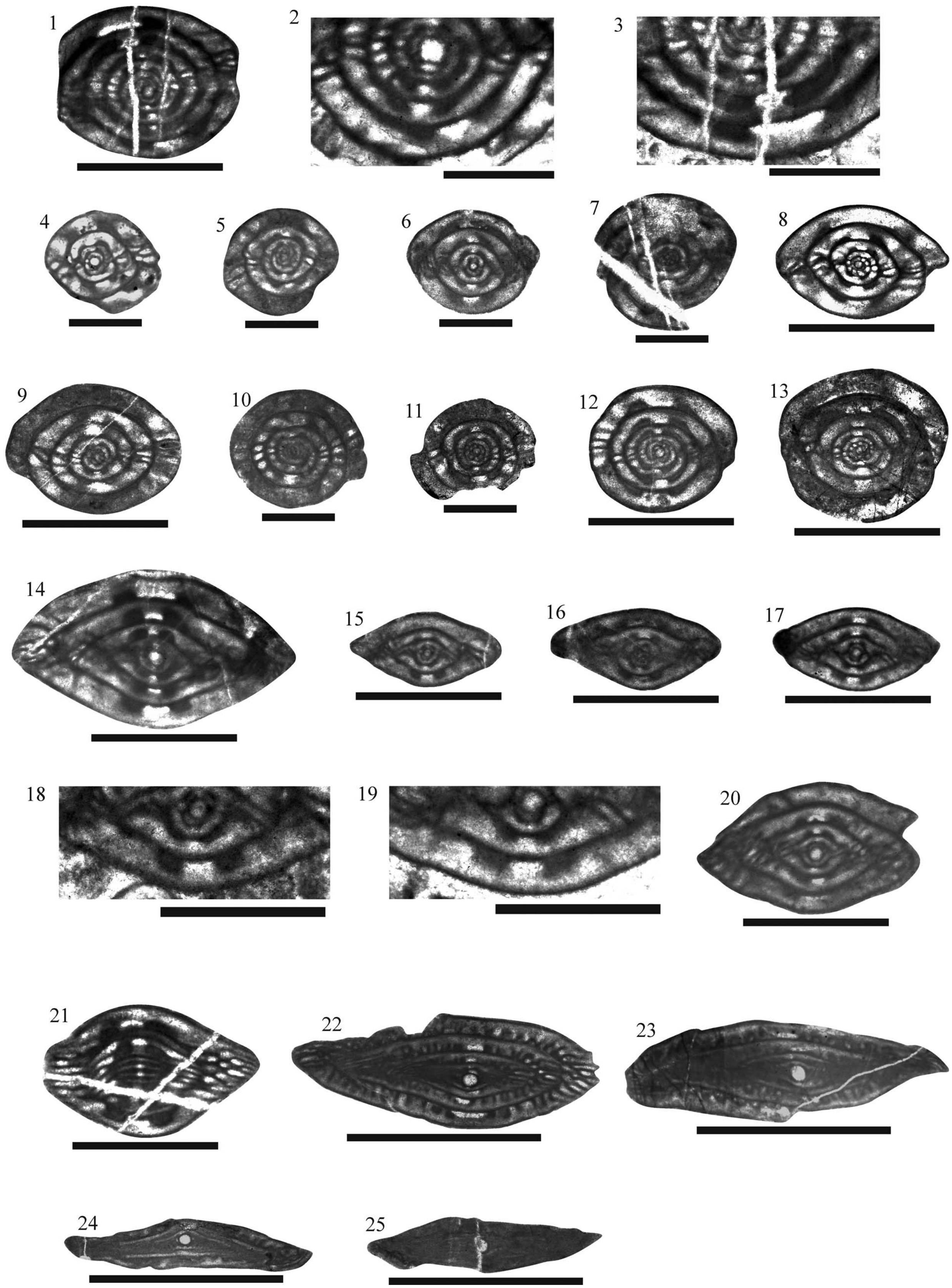

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Figure 11. Thin-section photomicrographs of the fusulinid assemblages of the Yassıpınar (YS) and Gölbelen (GS) sections. (**1–3**) *Depratina turani* Akbaş n. sp., (**1**) subaxial section, 18G26.08, GS, (**2, 3**) detail view of the wall structure of the *Depratina turani* Akbaş n. sp., (**2**) 15Y17.08 (holotype); (**3**) 18G26.08 (three-layered wall including tectum, lower and upper tectorium). (**4, 5**) *Staffellaeformes bona* (Grozdilova and Lebedeva, 1954), axial sections, (**4**) 15Y16A.19.02, YS; (**5**) 18G25.08, GS. (**6, 7**) *Staffellaeformes parva parva* (Lee and Chen in Lee et al., 1930), axial sections, (**6**) 15Y16A.04, YS; (**7**) 18G19.04.01, GS. (**8, 9**) *Staffellaeformes parva robusta* (Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936) n. comb., axial sections, (**8**) 15Y16A.06, YS; (**9**) 18G24.04, GS. (**10–12**) *Staffellaeformes staffellaeformis* (Kireeva in Rauzer-Chernousova et al., 1951), (**10**) subaxial section, 18G19.08.01, GS; axial sections, (**11**) 18G22.03, GS; (**12**) 18G23.07, GS. (**13**) *Staffellaeformes tashliensis* (Lebedeva in Grozdilova et al., 1975), axial section, 18G23.12, GS. (**14**) *Aljutovella* cf. *A. pseudoaljutovica* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951, axial section, 18G26.05, GS. (**15–19**) *Tikhonovichiella praetikhonovichi* Akbaş n. sp., axial sections, (**15**) 15Y18.05 (holotype), YS; (**16**) 15Y19.07, YS; (**17**) 15Y21.38, YS; (**18, 19**) detail view of the wall structure of the *Tikhonovichiella praetikhonovichi* Akbaş n. sp., (**18**) 15Y18.05 (holotype); (**19**) 15Y21.38 (three-layered wall including tectum, lower and upper tectorium). (**20, 21**) *Tikhonovichiella tikhonovichi* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951), (**20**) axial section, 15Y18.09, YS; (**21**) tangential section, 18G26.10, GS. (**22, 23**) *Verella normalis* Rumyantseva, 1962, axial sections, (**22**) 15Y17.07, YS; (**23**) 18G25.07, GS. (**24, 25**) *Verella spicata* Dalmatskaya, 1951, axial sections, (**24**) 18G25.05, GS; (**25**) 18G25.14, GS. Scale bars = 500 µm (**2–7, 10, 11, 18, 19**); = 1 mm (**1, 8, 9, 12–17, 20, 21**); = 2 mm (**22–25**).

of the genus *Profusulinella*, but with its subspherical to ovoid test and weakly developed septa, it is included in the genus *Staffellaeformes* Solovieva, 1986 in this study. This systematic revision is also supported by the correlation graph between the L/D ratio of the type species of *Staffellaeformes* and *Profusulinella*, and L/D ratio of *Staffellaeformes parva robusta* n. comb. (Fig. 13).

Family Aljutovellidae Solovieva in Rauzer-Chernousova et al., 1996

Genus *Tikhonovichiella* Solovieva in Rauzer-Chernousova et al., 1996

Type species.—*Aljutovella tikhonovichi* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951, from the Russian Platform, Russia.

Tikhonovichiella praetikhonovichi Akbaş new species
Figure 11.15–11.19

Holotype.—15Y18.05 (axial section), from Dikenli Formation of the Hadim Nappe, southern Turkey, reposited in the Faculty of Engineering and Natural Sciences, Department of Geological Engineering, Konya Technical University, Turkey (collection number: MA-HY15/15Y18.05).

Diagnosis.—Species of *Tikhonovichiella* with small and inflated fusiform test and weakly developed septa and chomata.

Occurrence.—The Yassıpınar section of the Hadim Nappe in Central Taurides (Konya, Turkey). Carboniferous, late Bashkirian–early Moscovian, Arkhangelskian–Vereian substages.

Description.—Test small and fusiform to inflated fusiform in shape, with nautiloid early volutions. The middle part of the test is narrowly rounded. Lateral sides straight and the poles arched to slightly pointed. Proloculus globular and small in size with 32–60 µm external diameter. Length of test (L) 1.10–1.25 mm; diameter (D) 0.55–0.61 mm; L/D ratio 1.93–2.08. Adult tests have four volutions. The three-layered microgranular wall consists of a thin and dark tectum, distinct lower tectorium, and thin upper tectorium. Septa weak and plane in the middle part, and slightly fluted at the poles. Chomata massive and squared in shape.

Etymology.—Latin *prae*, previous, similarity with *Tikhonovichiella tikhonovichi* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951).

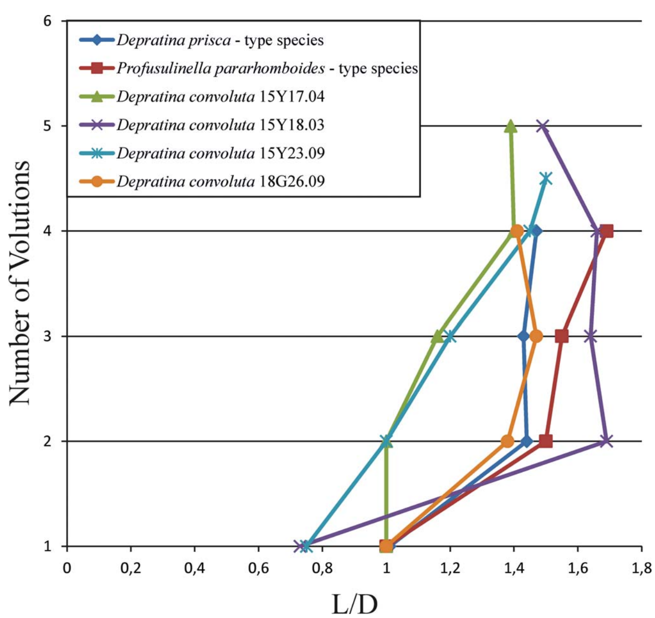

Figure 12. L/D Correlation graph between the type species of the *Depratina* and *Profusulinella*, and L/D ratio of *Depratina convoluta* n. comb.

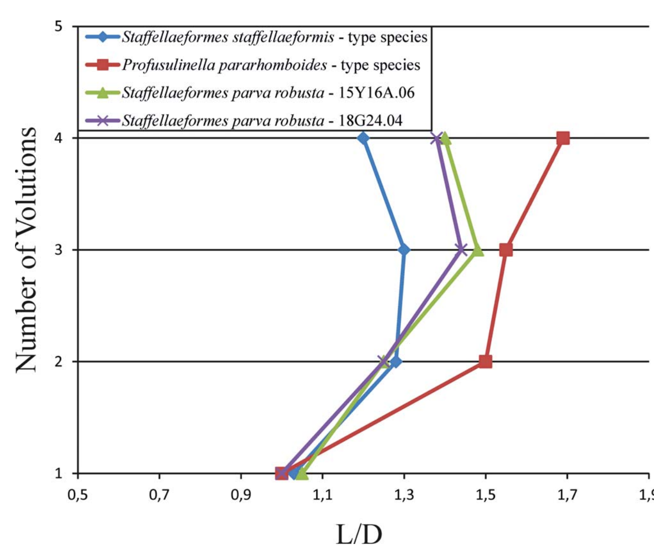

Figure 13. L/D Correlation graph between the type species of the *Staffellaeformes* and *Profusulinella*, and L/D ratio of *Staffellaeformes parva robusta* n. comb.

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Materials.—Three axial sections (15Y18.05, 15Y19.07, 15Y21.38) and one tangential section, all are reposited in collection number MA-HY15.

Remarks.—*Tikhonovichiella praetikhonovichi* Akbaş n. sp. is very close to *Tikhonovichiella tikhonovichi* (Rauzer-Chernousova in Rauzer-Chernousova et al., 1951) based on small sizes and shape of chomata, but differs by more elongate test and higher L/D ratio. Although *Tikhonovichiella tikhonovichi* is known as a primitive representative of the genus *Tikhonovichiella*, this new species is more primitive than the former based on development of the chomata and septa.

Conclusions

This study concerns two sections (Yassıpınar and Gölbelen) of the upper Serpukhovian–Bashkirian succession of the Hadim Nappe in the Central Taurides. The Mississippian-Pennsylvanian boundary beds consist mainly of oolitic grainstone with rare siliciclastic intercalations at both sections. Whereas the lower Bashkirian is represented by quartz arenite sandstone at the Yassıpınar section, the coeval interval at the Gölbelen section is composed of bioclastic grainstone or bioclastic grainstone-packstone with diverse and abundant fauna and flora. The upper part of each section is characterized by medium-thick bedded, bioclastic grainstone, rarely packstone-bearing abundant fusulinid assemblages associated with a rich fauna and flora.

The fusulinid-based biostratigraphy of the two studied stratigraphic sections from the Hadim Nappe in the Central Taurides of Turkey has resulted in the definition of the upper Serpukhovian and Bashkirian (Syuranian, Akavasian, Askynbashian, and Arkhangelskian substages). The Mississippian-Pennsylvanian (Serpukhovian-Bashkirian) boundary is defined by the first appearance of the fusulinid *Plectostaffella jakhensis* in the Yassıpınar section. Due to extensive tectonic deformation, this boundary could not be determined in the Gölbelen section.

Based on the systematics proposed by Rauzer-Chernousova et al. (1996) and this study, the taxonomic position of two fusulinid species (*Depratina convoluta* n. comb. and *Staffellaeformes parva robusta* n. comb.) have been revised.

Depratina turani Akbaş n. sp. and *Tikhonovichiella praetikhonovichi* Akbaş n. sp. are described for the first time from the upper Bashkirian (Arkhangelskian Substage) successions of the Hadim Nappe.

The upper Serpukhovian–Bashkirian fusulinid assemblages found in the studied sections of Hadim Nappe display very similar compositions at the genus and species levels to their counterparts from the other parts of the Tethyan Realm, including the Russian Platform, Donetz Basin, Pamir Mountains (Darvaz), Spain, central Iran, and especially the southern Urals.

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