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GEOBIOS

Geobios 43 (2010) 225–240

Original article

Middle–late Asselian (Early Permian) fusulinid fauna from the post-Variscan cover in NW Anatolia (Turkey): Biostratigraphy and geological implications ☆

Faunes de fusulines de l'Assélien moyen-supérieur (Permien inférieur) de la couverture postvarisque du Nord-Ouest de l'Anatolie (Turquie) : implications biostratigraphiques et géologiques

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Received 9 November 2008; accepted 7 September 2009
Available online 1 February 2010

Abstract

The earliest autochthonous cover of the Variscan basement of the Sakarya Composite Terrane (SCT) in NW Anatolia is represented by basal conglomerates and limestones. The microfacies types of the limestones in ascending order are: (1) bioclastic grainstone/packstone, (2) fusulinid grainstone/packstone, (3) smaller foraminiferal grainstone/packstone, (4) *Anthracoporella* (dasycladale) grainstone/packstone, and (5) wackestones. Twenty-three species assignable to 15 genera of fusulinids were recovered from the studied materials of the Kadirler section; *Quasifusulina guvenci* nov. sp. and *Pseudoschwagerina beedei magna* nov. subsp. are created. Rugosofusulinids, sphaeroschwagerinids, pseudoschwagerinids, occidentoschwagerinids, pseudochusenellids, quasifusulinids, rugosochusenellids and paraschwagerinids are the main faunal elements of the succession, which shows two distinct faunal intervals. *Eoschubertella*, *Schubertella*, *Biwaella*?, *Rugosofusulina stabilis* group, and *Pseudochusenella* correspond to the first interval at the base; the second interval is characterized by the species of *Sphaeroschwagerina*, *Pseudoschwagerina, Occidentoschwagerina*, the *Rugosofusulina latispiralis* group, and diverse quasifusulinids. A biostratigraphic correlation shows that the Kadirler section in the SCT in NW Anatolia shares many common species with Central Asia in the East but especially with the Carnic Alps and Karavanke Mountains in the West. The new data suggest that the close faunal relationship in the Late Carboniferous between eastern Alps, Ural Mountains, NW Turkey and Central Asia also continued during the Asselian.

Keywords: Biostratigraphy; Fusulinids; Asselian; Early Permian; Paleogeography; Turkey

Résumé

Dans la couverture varisque de l'unité tectono-sédimentaire complexe de Sakarya, au Nord-Ouest (NO) de l'Anatolie, les couches autochtones plus anciennes sont des conglomérats basaux et des calcaires. Les microfaciès-types de ceux-ci montrent dans l'ordre ascendant : (1) des *grainstones/packstones* bioclastiques, (2) des *grainstones/packstones* à fusulines, (3) des *grainstones/packstones* à petits foraminifères, (4) des *grainstones/packstones* à dasycladales *Anthracoporella* et (5) des *wackestones*. Vingt-trois espèces de fusulines correspondant à 15 genres sont identifiées dans la coupe de Kadirler ; *Quasifusulina guvenci* nov. sp. et *Pseudoschwagerina beedei magna* nov. subsp. sont créées. Rugosofusulines, sphéroschwagérines, pseudoschwagérines, occidentoschwagérines, pseudochusenelles, quasifusulines, rugosochusenelles et paraschwagérines sont les principaux éléments d'une succession qui montre deux intervalles fauniques distincts. *Eoschubertella*, *Schubertella*, *Biwaella*?, *Rugosofusulina* du groupe *stabilis* et *Pseudochusenella* marquent l'intervalle inférieur, tandis que le second intervalle est caractérisé par *Sphaeroschwagerina*, *Pseudoschwagerina*, *Occidentoschwagerina*, le groupe *Rugosofusulina latispiralis* et des quasifusulines. Une corrélation paléobiogéographique montre que la coupe de Kadirler, dans l'Unité tectono-sédimentaire complexe de Sakarya dans le NO de l'Anatolie, partage

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0016-6995/$ – see front matter
doi:10.1016/j.geobios.2009.09.006

de nombreuses espèces avec l'Asie Centrale, à l'Est, mais surtout avec les Alpes Carniques et les Monts de Karawanken à l'Ouest. Les nouvelles données suggèrent que les relations fauniques étroites, au Carbonifère supérieur, des Alpes Orientales, de l'Oural, du NO de la Turquie et de l'Asie Centrale, se sont poursuivies pendant l'Assélien. De plus, il est évident que l'Unité tectono-sédimentaire complexe de Sakarya se connectait davantage avec le domaine paléobiogéographique de foraminifères du Nord de la Paléotéthys qu'avec celui du Sud de la Paléotéthys. Pendant le Midien, au contraire, les associations de foraminifères avaient plus d'affinités avec celles des Taurides périgondwaniennes.

Mots clés : Biostratigraphie ; Fusulinoïdes ; Assélien ; Permien inférieur ; Paléobiogéographie ; Turquie

1. Introduction

The Sakarya Composite Terrane (SCT; Göncüoğlu et al., 1997) in northern Turkey is one of the several pieces of a very complex mosaic between Gondwana and northerly located mega-terranes or terrane assemblages (e.g., Baltica, Siberia, Avalonia, etc. ; Stampfli and Borel, 2002). It corresponds to the southern part of the Rhodope-Pontide fragment of Sengör et al. (1984) and the Sakarya Zone of Okay et al. (1991). SCT is more than 1000 km long and 120 km wide and comprises an E–W trending alpine continental fragment (Fig. 1). Northward, it is bordered by the Intra-Pontide suture that includes remnants of the Intra-Pontide branch of Neotethys. To the S, the SCT is bounded by the Tauride-Anatolide continental microplate along the mélanges and ophiolites of the Neotethyan Izmir-Ankara-Erzincan suture belt. During the latest Cretaceous closure of the Neotethyan oceanic branches and their subsequent collision, SCT was partly sliced and imbricated. This deformation has widely obscured a very complex pre-Alpine history, including the Variscan and Cimmerian events (e.g., Göncüoğlu et al., 2000).

The Variscan basement comprises arc-type granitoids intruding different metamorphic units: a low-grade metamorphic fore-arc complex (Göncüoğlu et al., 2000), a sedimentary succession with Carboniferous turbidites and limestone interlayers (Turhan et al., 2004), an oceanic island complex and a high-grade metamorphic assemblage of Mid Carboniferous age with amphibolites and meta-ultramafic rocks (Okay et al., 1996; Duru et al., 2004). It is suggested (e.g., Göncüoğlu et al., 2003, 2007; Robertson and Ustaömer, 2009) that it was located on the northern Gondwana-margin in upper-plate position and affected by arc-magmatism during Late Carboniferous southward subduction of Paleotethys.

This basement in places is disconformably overlain by Permian sediments, a part of which is the main topic of the present paper and will be dealt in detail. The Cimmerian rocks mainly include the *mélange* complex (e.g., Okay and Göncüoğlu, 2004) with tectonic slivers of Mid-Triassic E-MORB and OIB-type basalts (Sayit and Göncüoğlu, 2009), high pressure metamorphic rocks of Late Triassic age, olistostromes and debris flows with olistoliths of basalts, Devonian to Permian limestones and Late Triassic arkosic sandstones (Hodul Unit of Okay et al., 1991) intercalated with shales and siltstones. The last one is also unconformable on the Variscan basement and its autochthonous Permian cover. In NW Anatolia, this Cimmerian assemblage is known as the ''Karakaya Complex''. It is commonly accepted (for details, see Okay and Göncüoğlu, 2004) that the mélange complex was formed during the closure of a Paleotethyan marginal basin (e.g., Sengör et al., 1984; Stampfli, 2000). However, the location with respect to SCT, life-span, margins, subduction directions and overall geodynamic evolution of Paleotethys is a

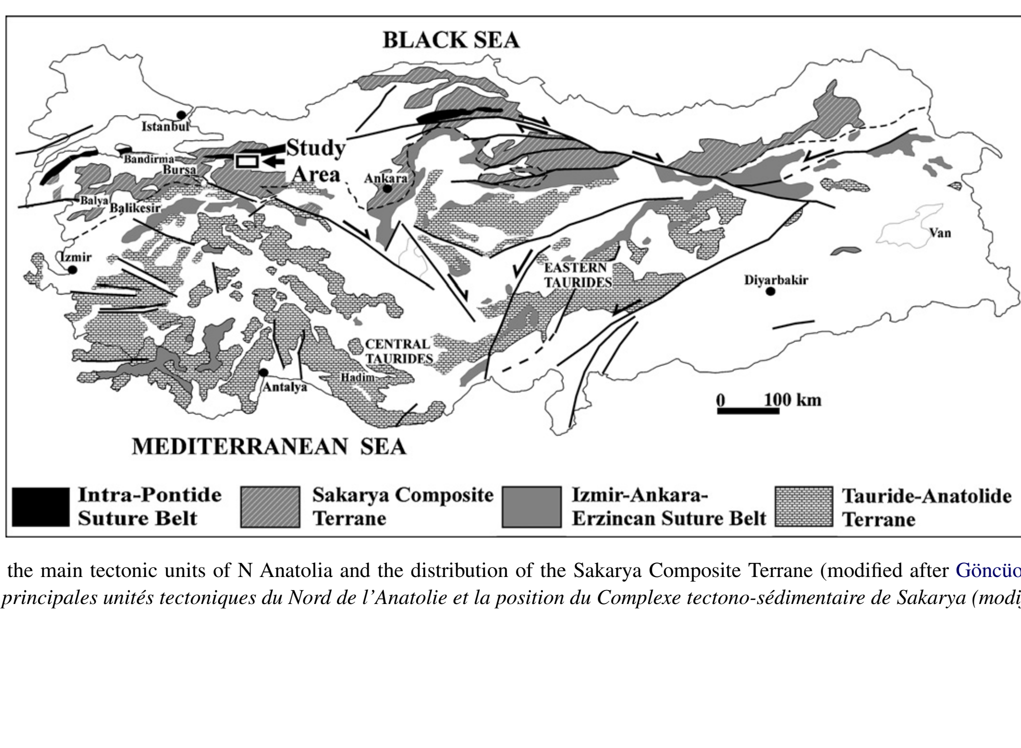

Fig. 1. Turkey with the main tectonic units of N Anatolia and the distribution of the Sakarya Composite Terrane (modified after Göncüoğlu et al., 1997).
La Turquie, avec les principales unités tectoniques du Nord de l'Anatolie et la position du Complexe tectono-sédimentaire de Sakarya (modifié d'après Göncüoğlu et al., 1997).

matter of discussion (for details see Okay and Göncüoğlu, 2004). On the other hand, the paleobiogeographic setting of the very widespread Permian limestones that occur both beneath and within the complex remained problematic as well (e.g., Leven and Okay, 1996; Altiner et al., 2000; Leven and Özkan, 2004; Turhan et al., 2004).

The first biostratigraphical studies related to fusulinids and other small foraminifers from Permian blocks within the Karakaya Complex were carried out by Erk (1942) and Aygen (1956) in the Bursa and Balya regions. Later, Lys (1971), Kahler and Kahler (1979), Leven and Okay (1996), Altiner (1999), Altiner and Özkan-Altiner (2001), Leven and Özkan (2004) and Okuyucu (2007) described several new genera, species and faunal compositions of the blocks from the Balya, Bergama, Kinik, Bandirma and Orhaniye regions (northwestern Turkey). Fusulinids of autochthonous Midian (Late Permian) units, on the other hand, were reported by Göncüoğlu et al. (1987) and Turhan et al. (2004).

In this study, the fusulinid fauna from the Early Permian sequence (Kadirler algal limestone member of the Cambazkaya Formation), which is the oldest unconformable cover above the Variscan basement rocks of the Karakaya Complex is studied: (1) to present its faunal distribution, (2) to describe the facies and depositional environment, (3) to discuss the stratigraphic importance of this sequence, (4) to give biostratigraphic correlation of this sequence with the other Tethyan Late Paleozoic units, and overall (5) to discuss the geological significance of a Permian carbonate platform above the Variscan basement, and the opening of a basin that produced the Karakaya Complex.

2. Geological setting

The studied section is located in the pre-Liassic core of an E-W-trending anticline to the S of Geyve of SCT, where the basement rocks crop out (Fig. 2). To the N, the anticline is bounded by the southern strands of the N Anatolian Fault Zone and to the S by the Taraklı-Orhaneli Tertiary Basin. On both margins of the anticline, the Upper Cretaceous-Lower Tertiary succession (Gölpazari Group; Saner, 1978) unconformably overlies the Karakaya Complex with its pre-Late Permian basement (Fig. 2) and the Liassic-Early Cretaceous cover (Turhan et al., 2004).

In the Geyve area, the Karakaya Complex includes the ‘‘arkosic sandstone unit’’ of latest Permian (Changhsingian)–Middle Triassic age with olistoliths of Permian limestones and the ‘‘pillow basalt–limestone association’’ of Middle Triassic age (Göncüoğlu et al., 2004; Turhan et al., 2004). The ‘‘arkosic sandstone unit’’ is an internally disrupted unit with dominating arkoses and arkosic sandstones; it includes bands and lenses of conglomerates, feldspathic siltstones and mudstones. The clasts are dominated by slightly deformed granitic-rhyolitic rocks, quartz-micaschists, and black cherts, which are the principal lithologies of the basement. Limestone olistoliths of centimeters to hundreds of meters in size are embedded in the ‘‘arkosic sandstone unit’’. Their age ranges from Late Carboniferous to Early Triassic in the Kadirler area (Turhan et al., 2004). The ‘‘pillow basalt–limestone unit’’ rests on the arkosic sandstone unit with a tectonic contact and comprises gray to pink, cherty, micritic limestones associated with basaltic lava flows.

The low-grade metamorphic igneous and sedimentary rocks as well as their autochthonous Permian cover are considered as the ‘‘basement’’ of the Karakaya Complex. The contact between the basement and the ‘‘arkosic sandstone unit’’ of the Karakaya Complex is a normal fault in the Kadirler area. However, it is commonly accepted (e.g., Okay and Göncüoğlu, 2004) that this clastic member of the complex disconformably rests on the basement and that its clasts were mainly derived from the same.

The pre-Permian basement includes a highly disrupted metasedimentary succession with slates, phyllites, metasandstones, black quartz-schists, muscovite-biotite schists and black recrystallized limestones, alternating with felsic metatuffs and metarhyolites. Black cherts with deformed radiolarians occur as disrupted bands, up to 2 m thick. Limestones within the basement are black, fine medium-bedded and occur as 3 to 5 m thick bands, which alternate with the surrounding metapelites and metacherts. Metafelsic rocks within this succession are either interbedded with the metasediments or display cross-

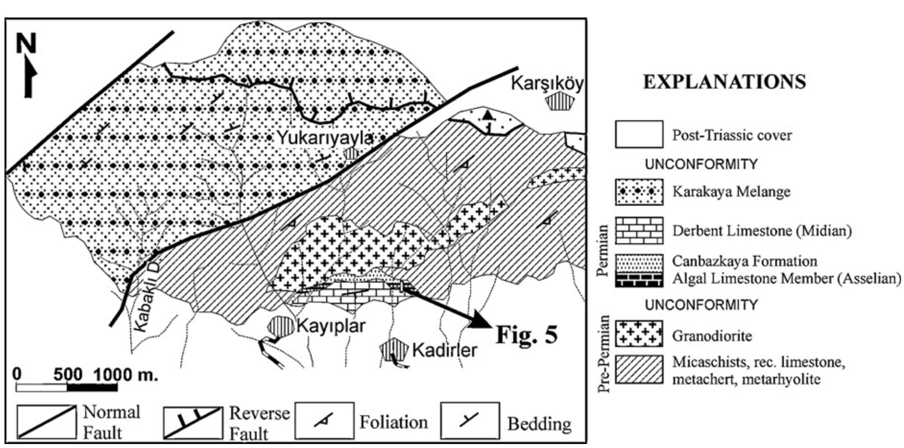

Fig. 2. Geological map of the Geyve-Kadirler area (after Göncüoğlu et al., 2004).
Carte géologique de la région de Geyve-Kadirler (d'après Göncüoğlu et al., 2004).

Fig. 3. Field view of the sphaeroschwagerinid and rugosofusulinid rich parts of the section.
Vues de terrain des couches riches en sphéroschwagérines et rugosofusulines.

cutting relations. The metasedimentary succession is intruded by a medium-grained porphyritic granitoid with a 5 to 6 m wide contact metamorphic zone. In the Sogut area to the E of Kadirler, the granitoids were dated isotopically as Late Carboniferous (Cogulu and Krummenacher, 1965). The metasediments and the granitoid are cut by meter-scaled, weakly foliated diabase dikes.

Fig. 4. Field view of the crinoid rich parts of the section.
Vues de terrain des couches riches en crinoïdes.

This crystalline basement is disconformably overlain by a Permian cover (Göncüoğlu et al., 1987; Turhan et al., 2004) whose lower part is the main topic of this study. The basal part of the section is characterized by yellowish-brown, medium-bedded quartz sandstones and conglomerates. It was named as the Cambazkaya Formation by Saner (1978). Both pebbles of the conglomerates and clasts of the sandstones include medium to well-rounded grains of mylonitic granodiorite, metarhyolite, pelitic hornfels (contact metamorphic slate), muscovite-schist, metachert as well as clasts of strained quartz, muscovite, plagioclase, tourmaline and zircon. The matrix is clayey and with very fine-grained sericite. It grades into thick-bedded to massive yellowish-gray thin to medium-bedded quartz sandstone with violet shale interlayers. The upper part of the quartz-sandstones is carbonate-cemented and gray in color. The overlying carbonate-rich part is composed of dark grey-black, thin to medium-bedded limestones with grey shale alternations, very rich in fossils (Figs. 3 and 4). They are followed by dark grey-black, thin to medium-bedded clayey limestones and occasionally thick limestone-shale alternations. The upper part of section is made up of grey-green thin to medium-bedded shale and clayey quartz-sandstone alternation. The uppermost

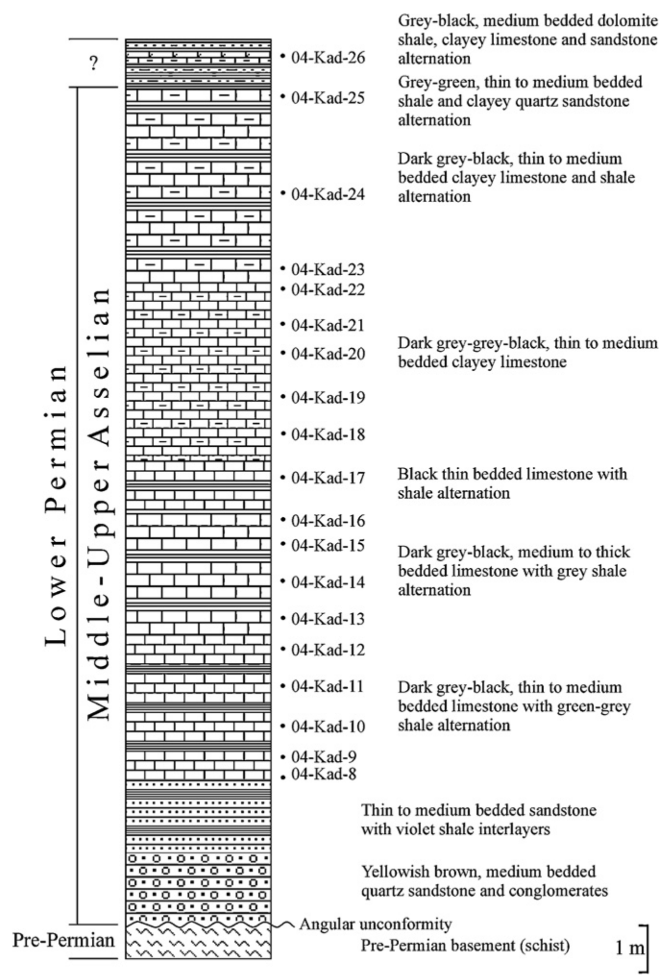

Fig. 5. Measured columnar section of the Kadirler Algal Limestone Member.
Colonne stratigraphique des calcaires à algues de la coupe de Kadirler.

part of the section consists of grey-black medium-bedded dolomite, shale, clayey limestone and sandstone. This limestone-bearing succession is informally named herein as ‘‘Kadirler algal limestone member’’ of the Cambazkaya Formation.

After an intervening 8 m thick conglomeratic sandstone package, the main body of the Derbent Limestone starts with an alternation of black sandy dolomites and carbonate-cemented quartz-sandstones and grades into a 40 m thick carbonate succession. This lagoon-type limestone with a rich foraminifer fauna (*Neoschwagerina haydeni* Dutkevitch and Khabakov, *Neoschwagerina* ex gr. *ventricosa* Skinner, *Charliella rossae* Altiner and Özkan-Altiner, *Hemigordiopsis renzi* Reichel, *Yabeina* sp., *Pseudokahlerina* sp. and *Kahlerina* sp.) had been recently studied in detail by Turhan et al. (2004) and dated as Midian. Hence, it will not be handled in this study. However, the ‘‘algal limestone member’’ and its fossil content is a novelty for NW Anatolia and will be evaluated hereafter.

3. Facies description of the algal limestone member

The limestones of the Kadirler Member are well-bedded limestones, mainly separated by grey shale partings (Fig. 5). They are composed of different types of wackestones, and five microfacies types are recognized:

- Bioclastic grainstone/packstone;
- Fusulinid grainstone/packstone;
- Smaller foraminiferal grainstone/packstone;
- *Anthracoporella* (dasycladale) grainstone/packstone;
- Wackestone.

The bioclastic grainstone/packstone is the most abundant facies type and contains a diverse biota, including fragments derived from ostracods, brachiopods, gastropods, echinoderms, fusulinids, smaller foraminifers and numerous calcareous algae. The fusulinid grainstone/packstone consists of abundant fusulinid tests with some other small foraminifers. Individual

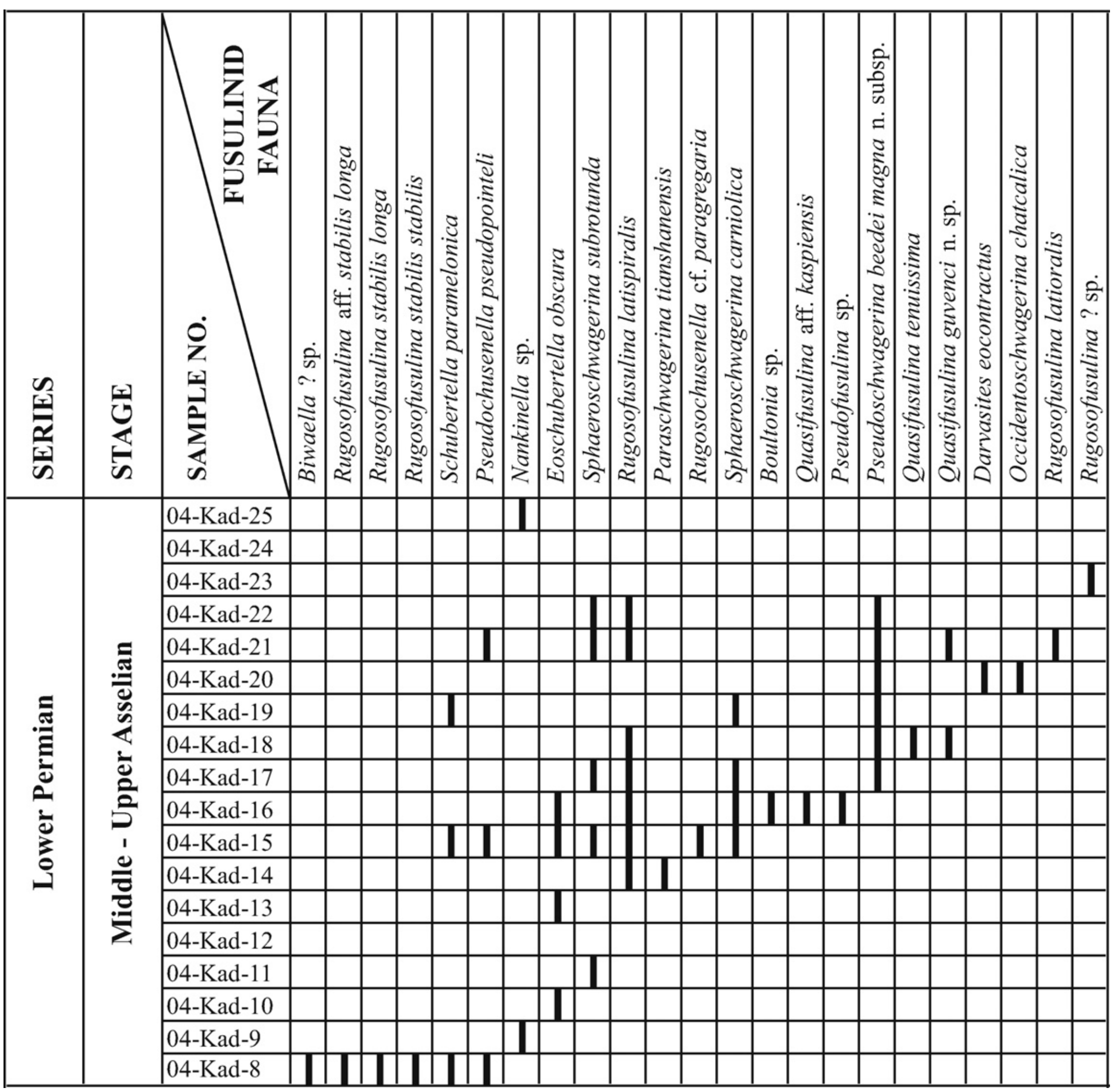

Fig. 6. Distribution of the fusulinid fauna in the studied samples of the Kadirler section.
Répartition des faunes de fusulines dans les échantillons étudiés de la coupe de Kadirler.

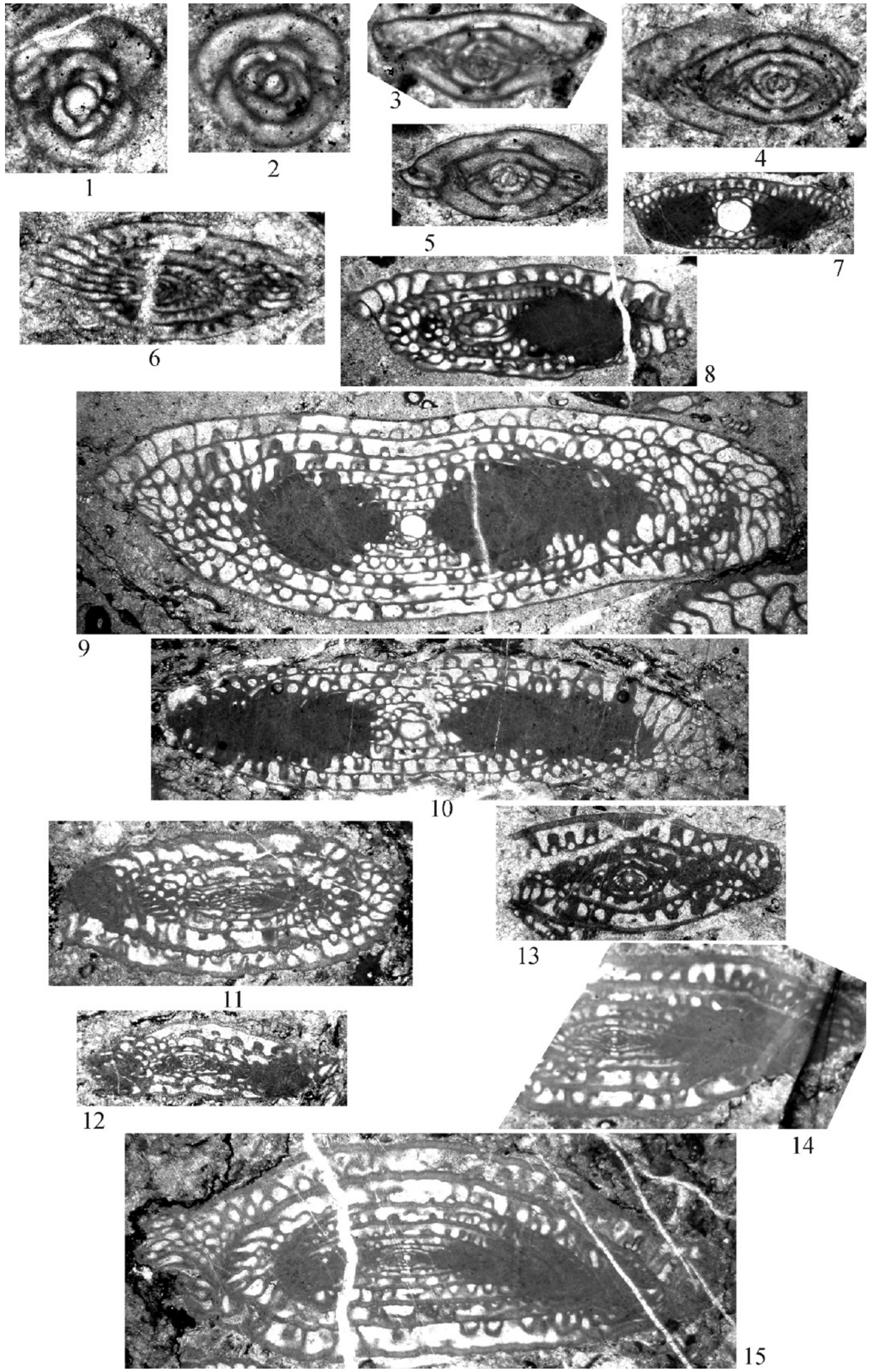

Fig. 7. Photomicrographs of the middle–late Asselian fusulinid fauna from the Kadirler section. **1, 2**. *Eoschubertella obscura* (Lee and Chen.), axial sections, × 100; 1, sample 04-Kad-15-1-1; 2, 04-Kad-15-1-4. **3–5**. *Schubertella paramelonica* Suleimanov, axial sections, × 40; 3, sample 04-Kad-8-9-1; 4, sample 04-Kad-8-10-2; 5, sample 04-Kad-15-17-1. **6**. *Boultonia* sp., slightly oblique axial section, sample 04-Kad-16-3-3, × 40. **7, 8**. *Quasifusulina guvenci* nov. sp., × 15; 7, holotype, axial section, sample 04-Kad-21-19-4; 8, slightly oblique axial section, sample 04-Kad-18-13-3. **9**. *Quasifusulina tenuissima* (Schellwien), axial section, sample 04-Kad-18-28-1, × 15. **10**. *Quasifusulina* aff. *kaspiensis* (Shcherbovich), axial section, sample 04-Kad-16-1-6, × 15. **11, 12**. *Rugosochusenella* cf. *paragregaria* (Rauzer-Chernousova), × 15; 11, subaxial section, sample 04-Kad-15-4-3; 12, axial section, sample 04-Kad-15-6-1. **13**. *Darvasites eocontractus* Leven and Shcherbovich,

fusulinid tests are also found in other microfacies types. The foraminiferal grainstone/packstone is another type of microfacies and it is characterized by calcareous, tubular and chambered species which are represented by mostly *Ammovertella*, *Calcivertella*, *Calcitornella*, *Endothyra*, *Bradyina, Eotuberitina*, *Climacammina* and *Tetrataxis.* Calcareous algae, especially *Tubiphytes,* are the constant element in these facies like in other facies. The *Anthracoporella* (dasycladale) grainstone/packstone occurs especially in the upper part of the section and is characterized by mainly large fragments of *Anthracoporella.* This microfacies type shows very similar macroscopic and microscopic characteristics with the *Anthracoporella* wackestone/packstone microfacies type in ''well bedded limestone facies (intermound facies)'' (Krainer, 1995) of the Late Carboniferous Auernig Group in the Carnic Alps (Austria). Foraminifers and other bioclasts are small and very rare in this microfacies type. The wackestone microfacies type is recognized only at the last limestone bed in the section; it is characterized by very rare foraminifers that are represented mainly by hemigordiopsid and lagenid forms. Rare ostracod and brachiopod fragments are other bioclasts of this last microfacies type.

Taxonomic diversity of biota and a normal marine fauna such as brachiopods, ostracods, crinoids, fusulinids, small foraminifers and especially the presence of calcareous algae points to deposition within the photic zone (maximum water depth no more than a few tens of meters) under a very shallow marine environment.

4. Biostratigraphy

Twenty-three species assignable to fifteen genera of fusulinids were recovered from the studied materials of the Kadirler section (Figs. 6–10). Main faunal elements of the succession are the rugosofusulinids, sphaeroschwagerinids, pseudoschwagerinids, occidentoschwagerinids, pseudochusenellids, quasifusulinids, rugosochusenellids and paraschwagerinids. The fusulinid faunal composition in the Kadirler section makes it possible to correlate this fauna with the different Paleotethyan faunal realms (Fig. 11).

The Kadirler section can be subdivided into two distinct faunal intervals (Figs. 5 and 6). The base of the Kadirler section is characterized by the occurrences of *Eoschubertella*, *Schubertella*, *Biwaella*?, the *Rugosofusulina stabilis* group, and *Pseudochusenella* and unidentified species of *Nankinella*. In this interval, the *Rugosofusulina stabilis* group is represented by *Rugosofusulina stabilis stabilis, Rugosofusulina stabilis longa* and *Rugosofusulina* aff. *stabilis longa.* This association appears together with *Schubertella paramelonica*, *Pseudochusenella pseudopointeli* and *Biwaella*? sp., *Eoschubertella obscura* and *Nankinella* occur in the uppermost part of this interval and they are more common in the second interval.

The second faunal interval yields several stratigraphically important species of the genera *Sphaeroschwagerina*, *Pseudoschwagerina* and *Occidentoschwagerina,* the *Rugosofusulina latispiralis* group and diverse quasifusulinids. Many stratigraphically important species exist in this interval. It is marked by the first appearance datum (FAD) of inflated schwagerinid species such as *Sphaeroschwagerina subrotunda*. *Rugosofusulina latispiralis* and *R. latioralis* are the representatives of the *Rugosofusulina latispiralis* group in this interval. New subspecies of *Pseudoschwagerina beedei* Dunbar and Skinner, *Pseudoschwagerina beedei magna* nov. subsp. and the new species *Quasifusulina guvenci* nov. sp. first and abundantly occur in the middle part of this zone. Diversity and abundance of fusulinid fauna decrease in the uppermost part of this zone, where only two taxa described as unidentified species of *Rugosofusulina*? and *Nankinella* occur in this part.

5. Regional correlation and age

Biostratigraphic correlation of the Kadirler section is restricted only to the fusulinid faunas. The studied interval is very rich in fossil algae. The content and paleobiogeographic evaluation of this flora will be the subject of another study in preparation. Correlation of the Lower Permian sequences of the Kadirler section with important standard and reference sections of the Central Asia, the southern Urals and the Europe are shown in Fig. 11.

5.1. Biochronostratigraphy of the Kadirler section

Fusulinid faunas of the lowermost part of the succession are represented by *Schubertella paramelonica* Suleimanov, *Pseudochusenella pseudopointeli* (Rauzer-Chernousova)*, Biwaella*? sp. and the *Rugosofusulina stabilis* group. Subspecies of the *Rugosofusulina stabilis* group [*Rugosofusulina stabilis stabilis* (Rauzer-Chernousova) and *Rugosofusulina stabilis longa* (Rauzer-Chernousova)] are very common in the *Daixina* (*Bosbytauella*) *bosbytauensis*-*Daixina robusta* Zone (Latest Carboniferous) in Central Asia, southern Fergana, Pre-Caspian Basin, and southern Urals; their stratigraphic range extends up to the Asselian (Rauzer-Chernousova, 1938; Shcherbovich, 1969; Isakova and Nazarov, 1986; Forke et al., 1998; Forke,

axial section, sample 04-Kad-20-8-1, × 15. **14, 15**. *Pseudochusenella pseudopointeli* (Rauzer-Chernousova), axial sections, × 15; 14, sample 04-Kad-8-8-1; 15, sample 04-Kad-15-14-1.

Microphotographies des faunes de fusulines de l'Assélien moyen-supérieur de la coupe de Kadirler. **1, 2**. Eoschubertella obscura *(Lee et Chen.), deux sections axiales, × 100 ; 1, échantillon 04-Kad-15-1-1 ; 2, 04-Kad-15-1-4.* **3–5**. Schubertella paramelonica *Suleimanov, sections axiales, × 40 ; 3, échantillon 04-Kad-8-9-1 ; 4, échantillon 04-Kad-8-10-2 ; 5, échantillon 04-Kad-15-17-1.* **6**. Boultonia *sp., section axiale légèrement oblique, échantillon 04-Kad-16-3-3, × 40.* **7, 8**. Quasifusulina guvenci *nov. sp., × 15 ; 7, holotype, section axiale, échantillon 04-Kad-21-19-4 ; 8, section axiale légèrement oblique, échantillon 04-Kad-18-13-3.* **9**. Quasifusulina tenuissima (Schellwien*), section axiale, échantillon 04-Kad-18-28-1, × 15.* **10**. Quasifusulina *aff.* kaspiensis *(Shcherbovich), section axiale, échantillon 04-Kad-16-1-6, × 15.* **11, 12**. Rugosochusenella *cf.* paragregaria *(Rauzer-Chernousova), × 15 ; 11, section subaxiale, échantillon 04-Kad-15-4-3 ; 12, section axiale, échantillon 04-Kad-15-6-1.* **13**. Darvasites eocontractus *Leven et Shcherbovich, section axiale, échantillon 04-Kad-20-8-1, × 15.* **14, 15**. Pseudochusenella pseudopointeli *(Rauzer-Chernousova), sections axiales, × 15 ; 14, échantillon 04-Kad-8-8-1 ; 15, échantillon 04-Kad-15-14-1.*

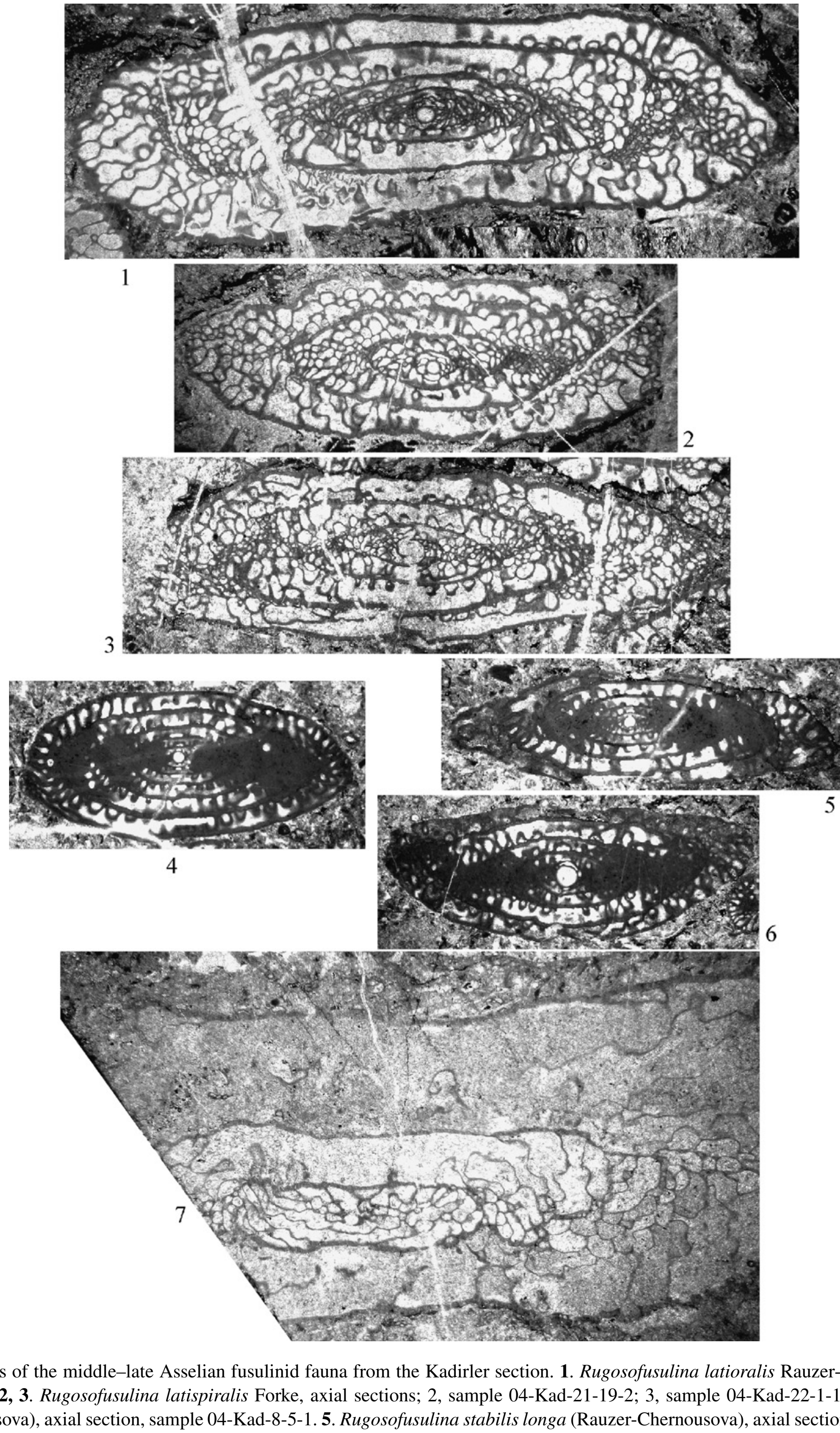

Fig. 8. Photomicrographs of the middle–late Asselian fusulinid fauna from the Kadirler section. **1**. *Rugosofusulina latioralis* Rauzer-Chernousova, axial section, sample 04-Kad-21-17-1. **2, 3**. *Rugosofusulina latispiralis* Forke, axial sections; 2, sample 04-Kad-21-19-2; 3, sample 04-Kad-22-1-1. **4**. *Rugosofusulina stabilis stabilis* (Rauzer-Chernousova), axial section, sample 04-Kad-8-5-1. **5**. *Rugosofusulina stabilis longa* (Rauzer-Chernousova), axial section, sample 04-Kad-8-13-1. **6**. *Rugosofusulina* aff. *stabilis longa* (Rauzer-Chernousova), axial section, sample 04-Kad-8-12-1. **7**. *Rugosofusulina*? sp., tangential section, sample 04-Kad-23-3-2. Magnification for all figures : × 10.

Microphotographies des faunes de fusulines de l'Assélien moyen-supérieur de la coupe de Kadirler. **1**. Rugosofusulina latioralis *Rauzer-Chernousova, section axiale, échantillon 04-Kad-21-17-1.* **2, 3**. Rugosofusulina latispiralis *Forke, sections axiales ; 2, échantillon 04-Kad-21-19-2 ; 3, échantillon 04-Kad-22-1-1.* **4**. Rugosofusulina stabilis stabilis *(Rauzer-Chernousova), section axiale, échantillon 04-Kad-8-5-1.* **5**. Rugosofusulina stabilis longa *(Rauzer-Chernousova), section axiale, échantillon 04-Kad-8-13-1.* **6**. Rugosofusulina *aff.* stabilis longa *(Rauzer-Chernousova), section axiale, échantillon 04-Kad-8-12-1.* **7**. Rugosofusulina *? sp., section tangentielle, échantillon 04-Kad-23-3-2. Grossissement pour toutes les figures : × 10.*

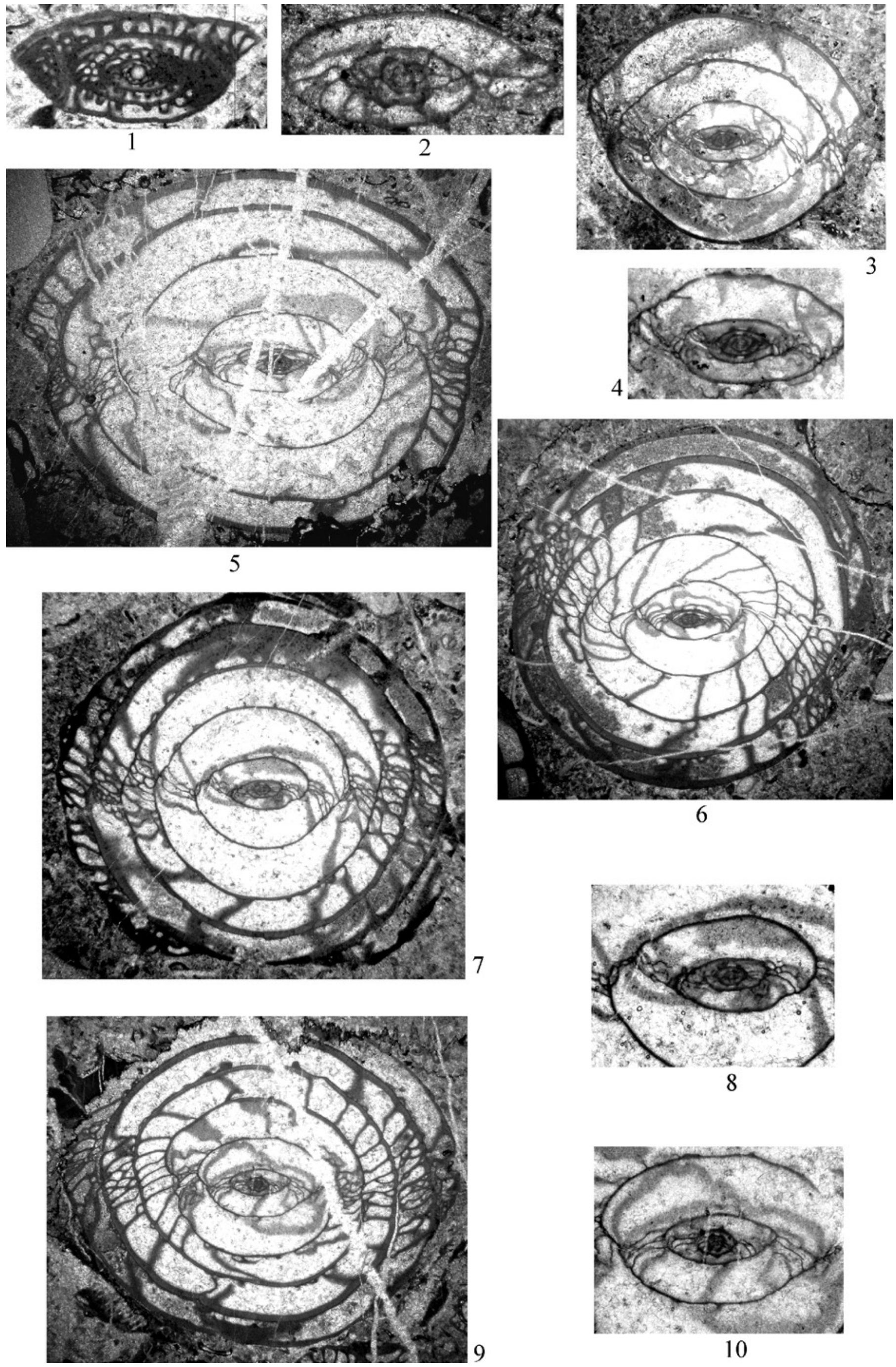

Fig. 9. Photomicrographs of the middle–late Asselian fusulinid fauna from the Kadirler section. **1**. *Pseudofusulina* sp., slightly oblique axial section, sample 04-Kad-16-7-1, × 15. **2**. *Biwaella*? sp., slightly oblique axial section, sample 04-Kad-8-1-1, × 40. **3–5**. *Sphaeroschwagerina carniolica* (Kahler and Kahler), axial sections, × 10 ; 3, sample 04-Kad-17-6-2 ; 4, enlargement of the juvenarium of the Fig. 3, × 20 ; 5, sample 04-Kad-1-4-1. **6–10**. *Sphaeroschwagerina subrotunda* (Ciry), axial sections, × 10 ; 6, sample 04-Kad-15-7-3 ; 7, sample 04-Kad-21-11-1 ; 8, enlargement of the juvenarium of the Fig. 7, × 20 ; 9, sample 04-Kad-22-10-2 ; 10, enlargement of the juvenarium of the Fig. 9, × 20.

Microphotographies des faunes de fusulines de l'Assélien moyen-supérieur de la coupe de Kadirler. **1**. Pseudofusulina *sp., section axiale légèrement oblique, échantillon 04-Kad-16-7-1, × 15.* **2**. Biwaella*? sp., section axiale légèrement oblique, échantillon 04-Kad-8-1-1, × 40.* **3–5**. Sphaeroschwagerina carniolica *(Kahler et Kahler), sections axiales, × 10 ; 3, échantillon 04-Kad-17-6-2 ; 4, vue détaillée du juvénarium de la Fig. 3, × 20 ; 5, échantillon 04-Kad-1-4-1.* **6–10**. Sphaeroschwagerina subrotunda *(Ciry), sections axiales, × 10 ; 6, échantillon 04-Kad-15-7-3 ; 7, échantillon 04-Kad-21-11-1 ; 8, vue détaillée du juvénarium de la Fig. 7, × 20 ; 9, échantillon 04-Kad-22-10-2 ; 10, vue détaillée du juvénarium de la Fig. 9, × 20.*

2002; Novak, 2007). The acme zone of *Rugosofusulina stabilis stabilis* (Rauzer-Chernousova) and *Rugosofusulina stabilis longa* (Rauzer-Chernousova) in the cited regions is mainly middle–late Asselian in age. *Schubertella paramelonica* Suleimanov was originally described from the Asselian-Artinskian interval in the southern Urals; it has a constant stratigraphic range in this interval (Suleimanov, 1949). It is known from the Zweikofel Formation (Upper "*Pseudoschwa-*

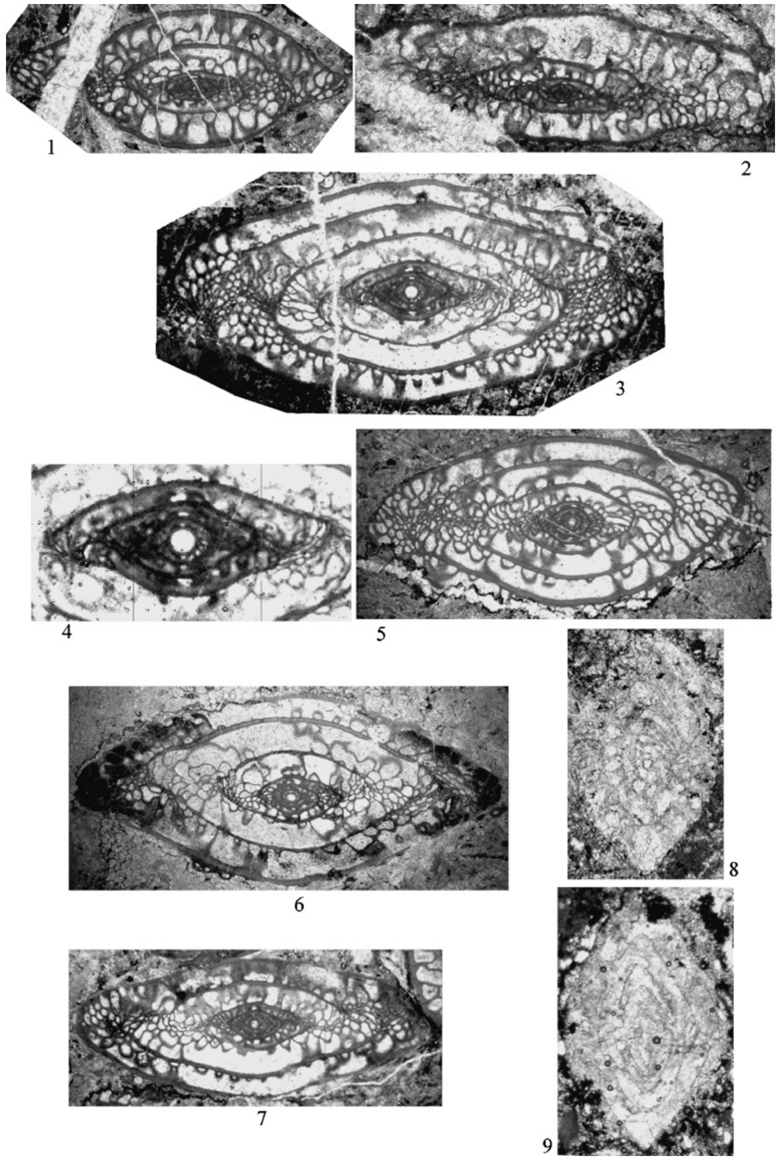

Fig. 10. Photomicrographs of the middle–late Asselian fusulinid fauna from the Kadirler section. **1**. *Occidentoschwagerina chatcalica* Bensh, axial section, sample 04-Kad-20-5-1, × 15. **2**. *Paraschwagerina tianshanensis* (Chang), axial section, sample 04-Kad-14-6-1, × 15. **3–7**. *Pseudoschwagerina beedei magna* nov. subsp., axial sections, × 10; 3, holotype, sample 04-Kad-21-20-1; 4, enlargement of the juvenarium of the holotype, × 20; 5, sample 04-Kad-19-10-1; 6, sample 04-Kad-17-10-1; 7, sample 04-Kad-22-4-1. **8, 9**. *Nankinella* sp., subaxial sections, × 40; 8, sample 04-Kad-9-1-1; 9, sample 04-Kad-25-3-2.

Microphotographies des faunes de fusulines de l'Assélien moyen-supérieur de la coupe de Kadirler. **1**. Occidentoschwagerina chatcalica *Bensh, section axiale, échantillon 04-Kad-20-5-1, × 15.* **2**. Paraschwagerina tianshanensis *(Chang), section axiale, échantillon 04-Kad-14-6-1, × 15.* **3–7**. Pseudoschwagerina beedei magna *nov. subsp., sections axiales, × 10 ; 3, holotype, échantillon 04-Kad-21-20-1 ; 4, vue détaillée du juvénarium de l'holotype, × 20 ; 5, échantillon 04-Kad-19-10-1 ; 6, échantillon 04-Kad-17-10-1 ; 7, sample 04-Kad-22-4-1.* **8, 9**. Nankinella *sp., sections subaxiales, × 40 ; 8, échantillon 04-Kad-9-1-1 ; 9, échantillon 04-Kad-25-3-2.*

gerina'' Limestone) and Trogkofel Limestone of the Carnic Alps (Sakmarian-Artinskian) and in the Dolzanova Soteska Formation of the Karavanke Mountains (mainly middle Asselian; Forke, 2002; Fig. 11).

Pseudochusenella pseudopointeli (Rauzer-Chernousova) is one of the important species of the lowermost part of the section. It also occurs in the middle part of the section. It is very common in the Carnic Alps, Karavanke Mountains, Darvas, southern Fergana, southern Urals and Pre-Caspian Basin and is stratigraphically found in middle–upper Asselian successions (Shcherbovich, 1969; Bensh, 1972; Leven and Shcherbovich, 1978; Isakova and Nazarov, 1986; Chuvashov et al., 1990; Forke, 2002; Novak, 2007) (Fig. 11).

Only one unidentified species of *Biwaella*? sp. was described from the basal part of the Kadirler section, together with the middle–upper Asselian fusulinids association. Stratigraphically, the genus *Biwaella* is generally known in younger deposits, but its occurrence in Asselian strata is also reported (Leven and Gorgij, 2006; Okuyucu, 2008).

Two unidentified species of *Nankinella* are recovered from the base and uppermost part of the Kadirler section. From the base of section, *Nankinella* appears together with typical

SYSTEM	STAGE	Series	MOSCOW SYNECLISE Rauser-Chernoussova et al. 1979; Ivanova et al. 1979 Fusulinid zones	S FERGANA Bensh 1972 Fusulinid zones	Horizon	SOUTHERN URALS Davydov et al. 1997 Fusulinid zones	Horizon	DONETS BASIN Davydov 1990; Davydov et al. 1992; Davydov and Leven, 2003 Fusulinid zones	Lithostratigraphy	SOUTHERN ALPS (Carnic Alps, Karavanke Mts.) Forke 2002 Fusulinid zones	KARAKAYA COMPLEX (Kadirler section) This study Selected fusulinid fauna
PERMIAN	Sakmarian	Upper	*Pseudofusulina urdalensis* *Pseudofusulina plicatissama*	*Robustoschwagerina schellwieni*	Sterlitam.	*Zigarella urdalensis* *Zigarella plicatissima*			UPL	*Robustoschwagerina geyeri, Zellia heritschi, Paraschwagerina nitida, "Pseudofusulina" spp.*	?
		Lower	*Pseudofusulina verneuili*		Tastubian	*Schwagerina verneuili*				*Sphaeroschwagerina asiatica, Paraschwagerina paranitida, Zellia praeheritschi*	
			Pseudofusulina moelleri			*Schwagerina moelleri* *Darvasites eocontractus*					
	Asselian	Upper	*"Schwagerina" sphaerica* *Pseudofusulina firma*	*Sphaeroschwagerina glomoresa*	Shikhanian	*Schwagerina firma* *Sphaeroschwagerina sphaerica*	Slavyan.	*Sphaeroschagerina sphaerica gigas*	GF, BF	*Paraschwagerina mukhamedjarovica Pseudoschwagerina muongthensis*	*Occideoschwagerina chatcalica* *Pseudoschwageriana beedei magna* *Rugosochusenella* cf. *paragregaria* *Rugosofusulina latispiralis* *Pseudochusenella pseudopointeli* *Sphaeroschwagerina subrotunda* *Paraschwagerina tianshanensis* *Sphaeroschwagerina carniolica*
		Middle	*"Schwagerina" moelleri* *Pseudofusulina fecunda*	*"Schwagerina" moelleri* *Pseudofusulina fecunda*	Uskalykian	*Schwagerina fecunda* *Pseudoschwagerina robusta*	Nikitovsk.	*Sphaeroschwagerina moelleri*	GF, DSF	*Pseudoschwagerina* aff. *uddeni* *Paraschwagerina pseudomira*	
						Paraschwagerina ishimbajica				*Sphaeroschwagerina carniolica* *Pseudoschwagerina extensa*	
		Lower	*"Schwagerina" vulgaris* *"Schwagerina" fusiformis*	*"Schwagerina" vulgaris* *"Schwagerina" fusiformis*	Sjurenian	*Sphaeroschwagerina fusiformis*	Kartamysh.	*Occidentoschwagerina "fusulinoides"*			?
						Sphaeroschwagerina vulgaris aktjubensis				*Schwagerina versabilis*	

Fig. 11. Biostratigraphic correlation of standard fusulinid zones of Moscow Syneclise and southern Urals with the other important regions and the Karakaya Complex (Kadirler section).
Corrélation biostratigraphique des zones classiques de fusulines de la Synéclise de Moscou et de l'Oural du Sud avec d'autres régions importantes et le Complexe de Karakaya (coupe de Kadirler).

representatives of *Eoschubertella obscura* (Lee and Chen.), which is mainly described from the Upper Carboniferous but also known in Lower Permian deposits of different Tethyan regions (Toriyama, 1958; Grozdilova and Lebedeva, 1960; van Ginkel, 1965; Villa, 1995; Leven, 1998; Yang et al., 2005; Fohrer et al., 2007). The species *obscura* was originally described under the genus *Schubertella* by Lee and Chen in Lee et al. (1930). In this study, the species described are assigned to the genus *Eoschubertella* according to the wall structure. The main difference between *Eoschubertella* and *Schubertella* is related to their wall structures and the morphologic limit between these two genera is still under discussion (Groves, 1991; Fohrer et al., 2007).

The beginning of the middle part of the section (Figs. 5 and 6) is characterized by the first occurrences of the age-diagnostic schwagerinid species *Sphaeroschwagerina subrotunda* (Ciry) which is very common in the middle part of the Kadirler section and very important for a precise biostratigraphic correlation. The species *subrotunda* was originally described under the genus name *Pseudoschwagerina* by Ciry (1943) but, according to its morphologic characteristics, it is undoubtedly assigned to the genus *Sphaeroschwagerina* in this study. It was described by Ciry (1943) from limestone blocks within the Karakaya Complex near Ankara. *Sphaeroschwagerina subrotunda* (Ciry) is commonly known in Lower Permian successions of the Tethyan faunal province; its uppermost stratigraphic occurrences were reported from China in the Sakmarian (Yang et al., 2005). The associated fusulinid fauna [*Rugosofusulina latispiralis* Forke, *Sphaeroschwagerina carniolica* (Kahler and Kahler), etc.] clearly indicates that the stratigraphic distribution of *Sphaeroschwagerina subrotunda* (Ciry) is middle–late Asselian in the Kadirler section. *Rugosofusulina latispiralis* Forke is one of the important species for the middle part of the section (Fig. 5); it appears together with the middle–late Asselian index species *Paraschwagerina tianshanensis* (Chang) which is very characteristic for this time interval in the Karavanke Mountains, southern Fergana, Akiyoshi Limestone Group in Japan and China (Chang, 1963; Bensh, 1972; Ozawa et al., 1990; Forke, 2002). *Rugosofusulina latispiralis* Forke was originally described from the base of Born Formation in Karavanke Mountains by Forke (2002). This species is very typical for the middle–upper Asselian Dolzanova Soteska and the Born Formations in the Karavanke Mountains (Forke, 2002; Novak, 2007). The fusulinid fauna of the Born Formation in the Karavanke Mountains shows very close affinities with the fauna of the Kadirler section. One rugosochusenellid, *Rugosochusenella* cf. *paragregaria* (Rauzer-Chernousova) was determined only in one sample in the middle part of the section. It was recognized between middle Asselian to Sakmarian in Darvaz, southern Fergana, southern Urals and the Carnic Alps (Rauzer-Chernousova, 1940, 1965; Bensh, 1972; Leven and Shcherbovich, 1978; Isakova and Nazarov, 1986; Forke, 2002). *Rugosochusenella* cf. *paragregaria* (Rauzer-Chernousova) and other associated fusulinid fauna in the Kadirler section share many common species with the Carnic Alps. *Sphaeroschwagerina carniolica* (Kahler and Kahler) is one of the main age-diagnostic faunal elements in the middle part of the section. It was first time described from the Lower Permian Dolzanova Soteska Formation in the Karavanke Mountains (Slovenia) by Kahler and Kahler (1937). Recent studies of Forke (2002) and Novak (2007) indicate that *Sphaeroschwagerina carniolica* (Kahler and Kahler) first occurs in the basal Grenzland Formation of the Carnic Alps (Asselian) and Dolzanova Soteska and Born Formations in the

Karavanke Mountains (middle–late Asselian; Fig. 11). The occurrences of *Sphaeroschwagerina carniolica* (Kahler and Kahler) are mainly restricted to the Carnic Alps and Karavanke Mountains, but its presence in the middle Asselian of southern Urals was indicated by Rauzer-Chernousova (1965). First quasifusulinids occur in the middle part of the section. *Quasifusulina* aff. *kaspiensis* (Shcherbovich) is the first representative and its stratigraphic range is in the interval between late Gzhelian to Asselian in the Carnic Alps, southern Urals, the Arctic region (Spitsbergen) and Pre-Caspian Basin (Shcherbovich, 1969; Nilsson and Davydov, 1997; Krainer and Davydov, 1998; Forke, 2002). Two unidentified species of *Boultonia* and *Pseudofusulina* are found in the same level. *Pseudoschwagerina beedei magna* nov. subsp. is determined for the first time in this study as a very distinct subspecies because of its morphological structure. *Pseudoschwagerina beedei* Dunbar and Skinner was originally determined in the Permian succession of the Hueco Formation (Texas) in North America by Dunbar and Skinner (1937). It is very difficult to utilize faunal connections and the morphological evolution of species between Midcontinent-Andean and Tethyan faunal provinces, but we know that some specimens are very close to each other. Due to the morphological similarity of the pseudoschwagerinid fauna in these two different provinces, some specimens were described under subspecies names of *Pseudoschwagerina uddeni* (Beede and Kniker) (*Pseudoschwagerina uddeni russiensis* Rauzer-Chernousova and Shcherbovich) and *Pseudoschwagerina beedei* Dunbar and Skinner (*Pseudoschwagerina beedei uralensis* Rauzer-Chernousova) by Rauzer-Chernousova and Shcherbovich (1949); later on, many specimens were recognized in the middle Asselian deposits of the Tethyan faunal province as subspecies of these species (Shcherbovich, 1969; Bensh, 1972; Leven and Shcherbovich, 1978; Isakova and Nazarov, 1986; Chuvashov et al., 1990). *Quasifusulina tenuissima* (Schellwien) and *Quasifusulina guvenci* nov. sp. are the other described species of quasifusulinids in the section. The former first appears in the late Gzhelian and extends up to the middle Sakmarian in S China, the Karavanke Mountains and the Carnic Alps (Forke, 2002; Yang et al., 2005; Novak, 2007). *Quasifusulina guvenci* nov. sp. was originally illustrated under the name *Quasifusulina tauridiana* from the Upper Carboniferous (Kasimovian) deposits of the Hadim Nappe (Central Taurides) by Güvenç (1965) in an unpublished Ph.D. thesis. Later on, this species was determined in different sections of the Hadim Nappe from the Upper Carboniferous (Kasimovian)–Lower Permian (Asselian) deposits by Okuyucu (1997). Two new genera appear together for the first time in the upper levels of the middle part of the section: *Occidentoschwagerina chatcalica* Bensh and *Darvasites eocontractus* Leven and Shcherbovich. The former was originally described from the middle Asselian of southern Fergana (Bensh, 1962) and its other occurrences are known from the early Asselian of Spitsbergen (Nilsson and Davydov, 1997) and middle Asselian of S China (Yang et al., 2005). *Darvasites eocontractus* has been originally described from the Sakmarian deposits in Darvaz by Leven and Shcherbovich (1980). It was also recognized in the different lower Sakmarian sections of the Urals and Central Asia (Davydov et al., 1997; Forke, 2002; Fig. 11) and Yakhtashian of northwestern Turkey (Leven and Okay, 1996), but similar specimens were recently reported from the middle Asselian in the Karavanke Mountains (Forke, 2002; Novak, 2007).

The uppermost part of the Kadirler section (Figs. 5 and 6) is characterized by a very poor fusulinid fauna and only three species, *Rugosofusulina latioralis*, *Rugosofusulina*? sp. and *Nankinella* sp. were determined in this interval. Only one specimen of *Rugosofusulina latioralis* Rauzer-Chernousova has been described in this part; its stratigraphic distribution in the Tethyan region changes from Asselian to Artinskian (Rauzer-Chernousova, 1937; Kahler and Krainer, 1993; Leven, 1995; Yang et al., 2005). The unidentified *Rugosofusulina* species does not show typical rugosity in the wall and it is characterized by cylindrical shell shape with increased chamber height in outer volutions. *Nankinella* sp. is the last representatives of fusulinid species in the Kadirler section, where it occurs in the uppermost part.

5.2. Regional correlations

The subdivision of the Lower Permian is based principally on conodonts and fusulinid biostratigraphy of the stratotype sections in Moscow Basin and southern Urals (Rauzer-Chernousova et al., 1979; Ivanova et al., 1979; Davydov et al., 1997). The widely accepted three-fold subdivision of the Asselian stage (Fig. 11), which is commonly used in Moscow Basin and southern Urals on the basis of morphologic evolution of the inflated schwagerinid genus "*Schwagerina*", cannot be precisely determined in the Kadirler section. However, many common genera (*Sphaeroschwagerina*, *Pseudoschwagerina*, etc.) and their species are very useful for biostratigraphic correlation of the Asselian with other Tethyan areas (Fig. 11). There is no evidence for the presence of Sakmarian (*Zellia*, some species of *Robustoschwagerina*, etc.) or younger strata in our studied section.

To summarize the biostratigraphic correlation and age, the fusulinid fauna of the Kadirler section shares many common species with Central Asia in the E, but especially with the Carnic Alps and Karavanke Mountains in the W. This faunal composition can be best correlated with the middle–late Asselian and their fusulinid zones along the Laurasian margin of the Paleotethys (Fig. 12). A similar paleogeographic correlation was already suggested for the Gzhelian based on fusulinid assemblages (Leven and Okay, 1996) from the Permian blocks within the Karakaya Complex of the SCT. A correlation of the Late Carboniferous fauna between the N-Paleotethys affiliated SCT and the Peri-Gondwanan Tauride-Anatolide terranes also provided a similar result (Leven and Okay, 1996; Altiner et al., 2000; Leven and Özkan, 2004; Kobayashi and Altiner, 2008).

The Asselian and Sakmarian successions in the Taurides are restricted to the Aladag Unit of Özgül (1984) and its equivalents from the different regions of the Taurides. Very limited data can be obtained from these successions in terms of faunal composition, especially for the Asselian. According to the

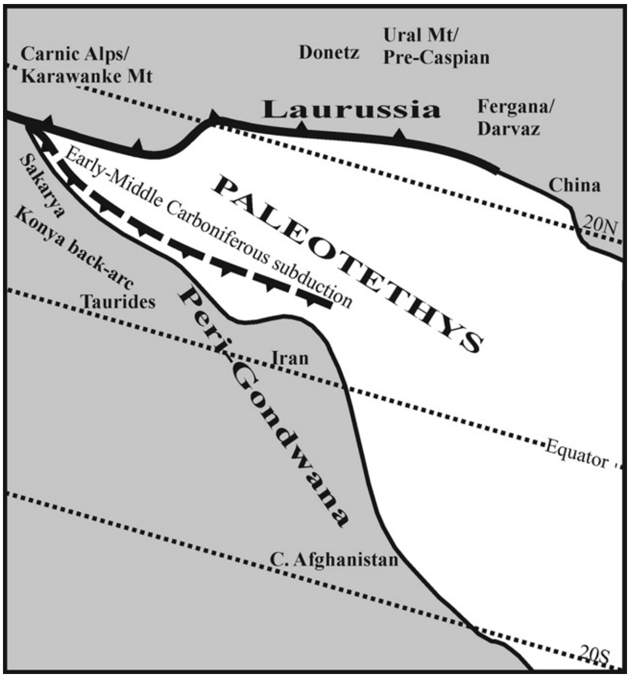

Fig. 12. Paleogeographic setting of the Sakarya Composite Terrane during the Late Carboniferous and Early Permian within the Paleotethys and inferred positions of the correlated localities. C: Central; Mt: Mountains. Paleo- and Neotethys are linked for the commodity of the scheme.

Position paléogéographique du Complexe de Sakarya à l'intérieur de la Paléotéthys, avec les emplacements supposés des autres régions évoquées dans le texte. C : central ; Mt : montagnes. Paléo- et Néotéthys sont réunies pour la facilité du dessin.

recent studies of Okuyucu (2008) and Kobayashi and Altiner (2008), the base of the Asselian and its faunal content could not be determined. The middle and late Asselian successions in the Central Taurides were divided into two zones by Kobayashi and Altiner (2008) as *Paraschwagerina* sp. (middle Asselian) and *Dutkevitchia complicata* Zones (late Asselian) in the central Taurides. The former zone is characterized mainly by *Paraschwagerina* and *Pseudoschwagerina* species and the latter by *Rugosochusenella* and *Dutkevitchia* species. The age of the *Dutkevitchia complicata* Zone was suggested as late Asselian but a possible early Sakmarian age was also indicated by the authors. The described fauna for middle–late Asselian zones is not similar with that of the Kadirler section.

The Early Permian successions of the central and eastern Taurides were studied in terms of fusulinid fauna and one fusulinid zone was determined for the late Asselian–early Sakmarian deposits by Okuyucu (2008). The main abundant faunal elements of this zone are *Pseudofusulinoides*, *Pseudochusenella*, *Paraschwagerina*, *Zellia*, *Darvasites*, *Quasifusulina* and *Sphaeroschwagerina.* The fusulinid fauna determined by Okuyucu (2008) for the late Asselian–early Sakmarian time interval does not share any common genera and species with the Kadirler section. In fact, there are some differences between the faunal composition encountered by Okuyucu (2008) and Kobayashi and Altiner (2008). The most critical ones are:

- The abundance of *Pseudofusulinoides* taxa in the material of Okuyucu (2008), where they are completely absent in the material of Kobayashi and Altiner (2008);
- The presence of age diagnostic genus *Sphaeroschwagerina* which allows biostratigraphic correlation with the stratotype of the Asselian (southern Urals) in Okuyucu's (2008) material.

The fusulinid fauna of the late Asselian–early Sakmarian Peri-Gondwanan Tauride-Anatolide Platform (Okuyucu, 2008) also shows close similarities to Central Asia, the Carnic Alps and Karavanke Mountains as it is the case with the fauna of the Kadirler section. But the specific diversity and the abundance of fusulinid fauna in the Kadirler section during middle–late Asselian are more pronounced (Figs. 7–10). In brief, during the Asselian, the faunal assemblages, and especially the occurrence of *Rugosochusenella* cf. *paragregaria*, *Sphaeroschwagerina carniolica*, *Quasifusulina* aff. *kaspiensis*, *Occidentoschwagerina chatcalica*, *Pseudoschwagerina* ex gr. *beedei*, etc. in the SCT (Kadirler section) indicate a closer relation to the N Paleotethyan faunal assemblage than to the Peri-Gondwanan faunal assemblage, which would indicate still limited faunal exchange between the SCT and the Tauride-Anatolide Platform. This, in turn, may suggest that SCT (Kadirler section) and Peri-Gondwanan Tauride-Anatolide Platform were in relatively different paleogeographic or tectonic positions within the Paleotethys during the Asselian. The Early Permian fusulinid assemblage from the limestone blocks in the Karakaya Complex of the SCT is also well correlated with the fauna along the northern periphery of the Paleotethyan Ocean, as noticed by Leven and Özkan (2004).

The faunal exchange between these two units seems to be restored during the Midian as confirmed by the increasing number of common fusulinid fauna. Paleogeographically, this would indicate that the Midian transgression (Izart et al., 2003) facilitated the N Peri-Gondwanan fauna to enter the SCT (Altiner et al., 2000; Turhan et al., 2004; Leven and Özkan, 2004).

6. Conclusions

The Kadirler algal limestone member represents the earliest autochthonous cover of the Variscan basement of the SCT. The member is represented by mainly grainstone/packstone microfacies types with diverse biota which is composed of brachiopods, ostracods, crinoids, fusulinids, smaller foraminifers and numerous calcareous algae. Litho- and biofacies characteristics of the limestones in the member correspond to a warm-water platform (tropical) with rich carbonate production under a shallow marine environment. Two faunal intervals were observed in the algal limestone member: a first one characterized by *Eoschubertella*, *Schubertella*, *Biwaella*?, *Rugosofusulina stabilis* group, and *Pseudochusenella*, at the base, and a second one with *Sphaeroschwagerina*, *Pseudoschwagerina*, *Occidentoschwagerina*, the *Rugosofusulina latispiralis* group and diverse quasifusulinids. Two new taxa, *Quasifusulina guvenci* nov. sp. and *Pseudoschwagerina beedei* *magna* nov. subsp. are newly described due to their distinct morphological structures. The fusulinid fauna of the Kadirler algal limestone member correlates with the Moscow Basin and southern Urals. It includes many common species with Darvaz, southern Fergana, Pre-Caspian Basin and Central Asia, and also with the Carnic Alps and Karavanke Mountains in eastern Europe. This faunal composition can be best correlated with the middle–late Asselian and their fusulinid zones from the northern Paleotethyan faunal province. A comparison of the Late Carboniferous to Middle Permian faunal assemblages of the Kadirler section as well as the blocks within the Karakaya Complex of the SCT with the Peri-Gondwanan Tauride-Anatolide Platform suggests that these two terranes were loosely linked. The faunal connexion could have been re-established after the regional Midian transgression in both terranes.

7. Systematic paleontology (by C. Okuyucu)

Order FORAMINIFERIDA Eichwald, 1830
Suborder FUSULININA Wedekind, 1937
Superfamily FUSULINACEA von Möller, 1878
Family FUSULINIDAE von Möller, 1878
Subfamily FUSULININAE von Möller, 1878
Genus ***Quasifusulina*** Chen, 1934
Type species: *Fusulina longissima* von Möller, 1878

Quasifusulina guvenci Okuyucu nov. sp.
Fig. 7(7, 8)

1965. *Quasifusulina tauridiana* nov. sp. - Güvenç, pp. 131–132, pl. F6, Figs. 11 and 12.
1997. *Quasifusulina tauridiana* Güvenç, - Okuyucu, pp. 84–85, pl. 9, Fig. 1.
1997. *Quasifusulina* sp. A - Okuyucu, pp. 86–87, pl. 9, Figs. 2 and 3.

Etymology: Dedicated to Prof. Dr. T. Güvenç, who first illustrated the species.

Material: 1 axial and 1 slightly oblique axial section.
Holotype: 04-Kad-21-19-4 (Fig. 7(7)).
Paratype: 04-Kad-18-13-3 (Fig. 7(8)).

Type Locality: Northwest of Kadirler village, S of Geyve district, Sakarya, NW Turkey.

Age: Late Carboniferous (Kasimovian)–Early Permian (Asselian).

Diagnosis: *Quasifusulina* with smaller size, less volutions, larger proloculus and regular septal folding.

Description: Test small, subcylindrical with blunt poles. Coiling of the spiral regular with low increase in the height of volution. Species with two and a half volutions to five volutions; 2.57 to 4.40 mm in length and 0.87 to 1.50 mm in width, form ratio of 2.40–3.30. Proloculus large and slightly irregular in shape, with outside diameter of 230 to 385 μm. Two-layered thin wall with tectum and finely porous lower layer. Septa thin, relatively intense and regularly folded. Chomata absent. Heavy axial fillings developed on both sides of the test and ending at the penultimate whorl.

Remarks: *Quasifusulina guvenci* Okuyucu nov. sp. differs from the other species of *Quasifusulina* by a smaller size of the test, less volutions, larger proloculus and regular septal folding.

Family SCHWAGERINIDAE Dunbar and Henbest, 1930
Subfamily PSEUDOSCHWAGERININAE Chang, 1963
Genus ***Pseudoschwagerina*** Dunbar and Skinner, 1936
Type species: *Schwagerina uddeni* Beede and Kniker, 1924

Pseudoschwagerina beedei magna Okuyucu nov. subsp.
Fig. 10(3–7)
Etymology: From the latin word magnus - large.
Material: 6 axial sections and 1 subaxial section.
Holotype: 04-Kad-21-20-1 (Fig. 10(3)).
Paratypes: 04-Kad-17-10-1, 04-Kad-18-10-2, 04-Kad-18-24-1, 04-Kad-19-10-1, 04-Kad-20-4-1, 04-Kad-22-4-1.
Type Locality: Northwest of Kadirler village, S of Geyve district, Sakarya, NW Turkey.
Age: Early Permian, middle–late Asselian.

Diagnosis: *Pseudoschwagerina beedei* with larger size, L/D ratio and proloculus, massive chomata in juvenarium, thicker wall and intense septal fluting in final volutions.

Description: Test large, inflated fusiform with slightly pointed polar ends. The inner three or three and a half volutions are tightly coiled, followed by an abrupt increase in height of the chambers in the succeeding volutions. Species with six to six and a half volutions; 8.25 to 10.60 mm in length and 4.0 to 4.50 mm in width, form ratio of 2.0–2.40. Proloculus spherical and medium in size with outside diameter of 200 to 315 μm. The keriothecal wall, relatively thin in the inner volutions, thickens markedly in the outer volutions and reaches up to 0.15 mm in thickness. Septa thin and moderately folded in the tightly coiled juvenarium, but thick and strongly folded in the outer part of the shell. Massive chomata present on the proloculus and in the juvenarium lacking in the later volutions. Tunnel is narrow and well-defined in the inner volutions.

Remarks: *Pseudoschwagerina beedei magna* Okuyucu nov. subsp. differs from the other subspecies of *Pseudoschwagerina beedei* by a larger size of the test, more volutions, higher L/D ratio, more pointed polar ends, relatively larger proloculus and intensive septal fluting in the axial regions of the outer volutions.

Acknowledgements

The authors gratefully acknowledge Necati Turhan and U. Kagan Tekin (Hacettepe University) for their contributions during the fieldwork. We thank the reviewers D. Vachard and H.C. Forke for their constructive remarks and corrections.

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