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CARBONIFEROUS - PERMIAN STRATIGRAPHY AND FUSULINIDS OF EAST IRAN. GZHELIAN AND ASSELIAN DEPOSITS OF THE OZBAK-KUH REGION

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Abstract. Deposits of the Gzhelian-Asselian Stages were recognised by fusulinid occurrences in the upper part of the Sardar Formation (Zaladu Member) of the Ozbak Kuh region, East Iran. These deposits cannot be referred to the Bage-Vang Formation, which contains Bolorian fusulinids of the early Permian and lies at the base of a transgressive carbonate sequence. The results obtained in the Carboniferous-Permian section of East Iran are similar to those of western and southern Tethys. Everywhere the Asselian and, locally, the Sakmarian deposits are closely related to the Upper Carboniferous ones. After the late Sakmarian-Yakhtashian regression, carbonate platforms were formed from the Bolorian time through the Late Permian. The Zaladu Member contains 10 genera - *Rauserites, Kushanella* (?), *Schellwienia, Anderssonites* (?), *Praepseudofusulina, Quasitriticites, Ruzhenzevites, Paraschwagerina, Pseudoschwagerina, Sphaeroschwagerina* (?) and 37 species and subspecies of fusulinids. New species and subspecies are described: *Rauserites infrequentis, R. tabasensis, R. fusoideus, R. inobservabilis, R.* (?) *persicus, Quasitriticites iranicus, Ruzhenzevites zaladuensis zaladuensis, R. zaladuensis brevis,* and *R. ferganensis curtus.*

Riassunto. Rocce dei piani Gzheliano e Asseliano sono state riconosciute in base ai fusulinidi nella parte superiore della Formazione Sardar (Membro Zaladu), nella regione dell'Ozbak Kuh nell'Iran orientale. Questi depositi non possono essere attribuiti alla Formazione Bage-Vang, che contiene fusulinidi Boloriani del Permiano inferiore e si trova alla base di una successione carbonatica trasgressiva. I risultati ottenuti nella sezione Carbonifero-Permiana dell'Iran orientale riproducono i dati della Tetide occidentale e meridionale. Ovunque l'Asseliano e localmente anche i sedimenti del Sakmariano sono strettamente connessi con quelli del Carbonifero superiore. Dopo il tardo Sakmariano-Yakhtashiano, si formarono piattaforme carbonatiche dal Boloriano sino al Permiano superiore. Il membro Zaladu contiene 10 generi di fusulinidi: *Rauserites, Kushanella* (?), *Schellwienia, Anderssonites* (?), *Praepseudofusulina, Quasitriticites, Ruzhenzevites, Paraschwagerina, Pseudoschwagerina, Sphaeroschwagerina* (?) e 37 specie o sottospecie di fusulinidi. Sono descritte le seguenti specie e sottospecie nuove di fusulinidi: *Rauserites infrequentis, R. tabasensis, R. fusoideus, R. inobservabilis, R.* (?) *persicus, Quasitriticites iranicus, Ruzhenzevites zaladuensis zaladuensis, R. zaladuensis brevis,* and *R. ferganensis curtus.*

Introduction

The most complete Carboniferous-Permian sequences of East Iran are exposed in the Ozbak-Kuh and Shirgesht areas (north of Tabas) and in the Kuh-e-Shotori (east and southeast of Tabas) (Stöcklin 1971). The geological development and the Carboniferous-Permian stratigraphy of the region were outlined during the geological mapping in the 1960s and described in a number of publications (Stöcklin et al. 1965; Ruttner et al. 1968, 1970). Later, the data on the Upper Paleozoic stratigraphy were summarized by Stepanov (1971) and in the Stratigraphic Lexicon of Iran (Stöcklin 1971). Partoazar (1995) published a synthesis on the Permian deposits of Iran including the Carboniferous-Permian sequences of the Tabas area. According to these publications, the Carboniferous-Permian section comprises three formations: Shishtu, Sardar and Jamal. The Shishtu Formation is composed mostly of Devonian deposits but its uppermost beds belong to the Tournaisian Stage of the Lower Carboniferous (Mississippian). The Sardar Formation corresponds to the remaining part of the Carboniferous and, probably, basal Permian. The Jamal Formation is entirely Permian in age. Some attempts were made to subdivide the Sardar and Jamal formations. It was suggested to distinguish two members - Sardar 1 and Sardar 2 (Ruttner & Stöcklin 1966). Their mutual boundary is not distinct, but Stepanov (1971) thinks that it coincides approximately with the «Lower-Middle Carboniferous (Dinantian-Silesian) boundary». Partoazar (1995) distinguished the lowermost part of the Jamal Formation as an independent unit, named Bage-Vang, which he referred to the Asselian-Sakmarian.

In the year 2000, Taheri studied two sections, which were thoroughly sampled for microfauna. The Zaladu section is located in the Ozbak-Kuh Mountains (Fig. 1) and the

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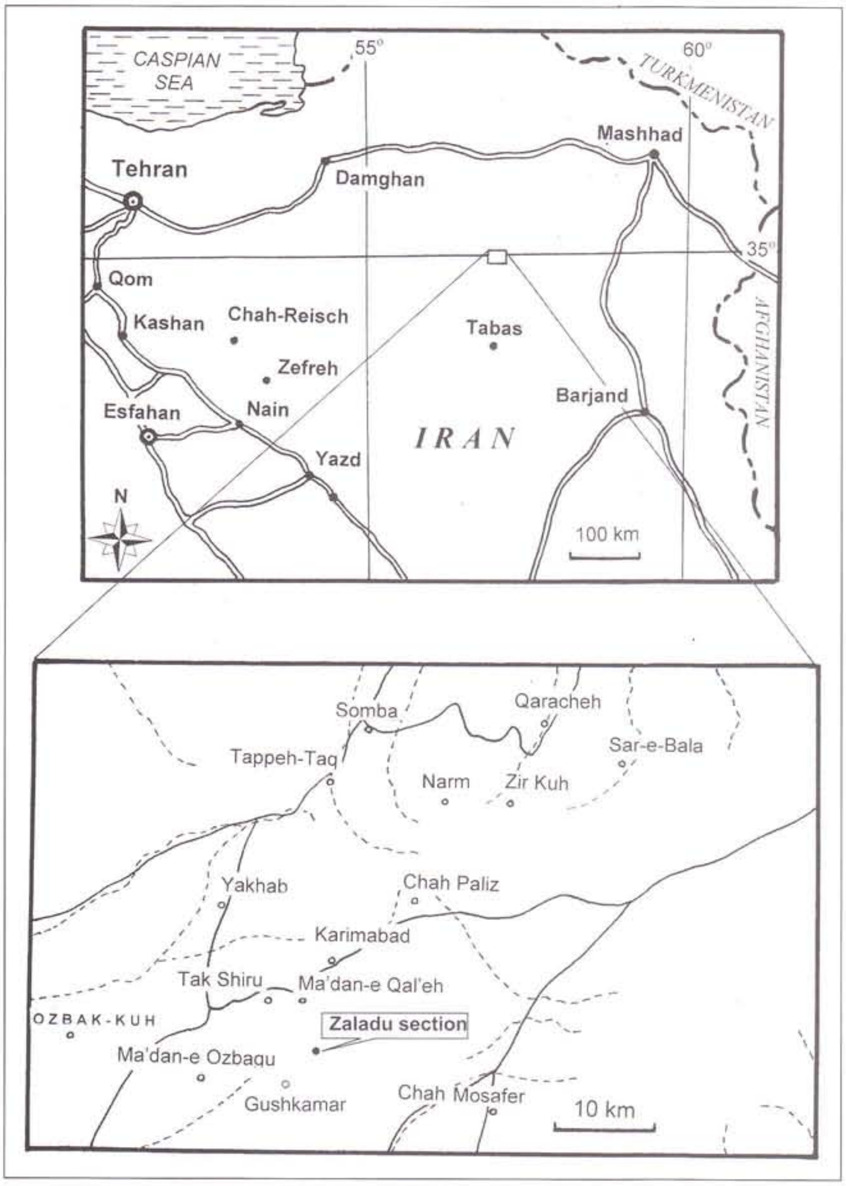

Fig. 1 - Index map of studied area with the localities of the Zaladu section.

Bage-Vang section is situated to the south, in the Shirgesht area. The samples from both sections were processed in the Geological Institute of the Russian Academy of Sciences (Moscow), where about 600 oriented thin sections were prepared. The thin sections contain abundant fusulinids and small foraminifera. Their analysis allows unambiguous dating of the Jamal Fm. and the upper part of the Sardar Fm. The fusulinid collection from the Zaladu section is stored in the Geological Institute (GIN) of the Russian Academy of Sciences, collection number GIN 4773.

This article presents the results of investigations of the upper part of the Sardar Formation of the Zaladu section, which yielded abundant fusulinid assemblages, characteristic of the uppermost Carboniferous and the Asselian Stage of the Lower Permian. We called Zaladu Member this part of the Sardar Formation and we describe its type-section.

General characteristics of the Zaladu section

The section is located on the Tigh-Madanu mountain, near the village of Gushkamar, in the Ozbak-Kuh region (Fig. 1). It is a key section for establishing the upper limit of the Sardar Fm. The type section of the formation, located in the Kuh-e-Shotori Range (Stöcklin et al. 1965), is composed mainly of shallow-water shales and sandstones with rare thin limestone interbeds. The latter noticeably increase in frequency in the Zaladu section. According to Partoazar (1995), the Sardar Formation is divisible into three parts corresponding to three sedimentary cycles. The first cycle begins with reddish brown sandstones and quartzites, which are abruptly replaced by organogenic limestones (beds 1-4 of Partoazar; not considered in this paper); the second cycle is marked by thin conglomerates replaced upward by green shales with thin interbeds of sandstones and limestones (bed 5 of Partoazar); the third cycle starts again with red conglomerates passing upwards to sandstones, shales and fusulinid limestones (beds 6 and 7 of Partoazar). According to Partoazar, the first and second cycles embrace the interval from the Visean to the Moscovian. The deposits of the third cycle were related to the Asselian-Sakmarian interval of the Early Permian. As shown below, this dating of the uppermost part of the Sardar Formation was correct, although Partoazar's inference was based on the wrong prerequisites: he correlated this part of the section to the Bage-Vang Formation on the basis of incorrect dating of fusulinids from this formation as Asselian-Sakmarian. However, Kahler (1974) found previously in the same location the fusulinids *Misellina*, *Chalaroschwagerina* and others forms, which indicated the Bolorian age of the Bage-Vang Fm. in its type section.

So, neither the data of Partoazar (1995) nor the earlier data of Stöcklin et al. (1965), Ruttner et al. (1968, 1970), Stepanov (1971), and Kahler (1974) can define the age of the upper limit of the Sardar Fm. Except for the beds correlated with the Bage-Vang Fm., Partoazar determined the Sardar Fm. to be not younger than the Moscovian Stage. On the contrary, according to Kahler (1974), the Sardar Fm. spans not only the entire Carboniferous, but also the Lower Permian, up to the Artinskian

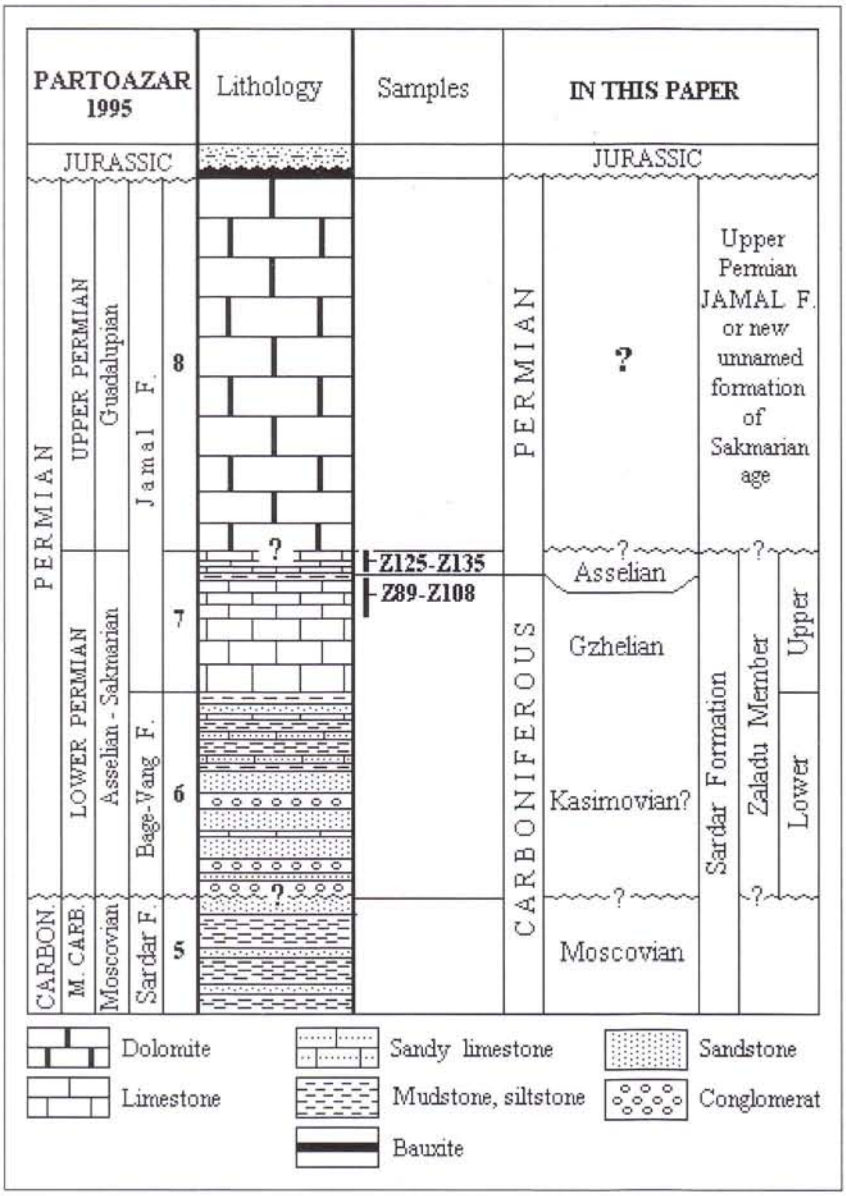

Fig. 2 - Zaladu section with the location of studied samples.

Stage. In order to elucidate the problem, we studied the deposits of the third sedimentary cycle (Fig. 2), whose lower part was correlated by Partoazar to the Bage-Vang Formation. These deposits are recognized by us as the Zaladu Member.

The Zaladu Member, 85 m thick, consists of two parts (Fig. 2). The lower part (50 m thick) is composed of an alternation of conglomerates and sandstones, and reddish brown and light green mudstones and siltstones, which increase in abundance upsection. Thin sandy limestones, which grade into fine-bedded bioclastic deposits, appear at the top. The limestones contain fragments of brachiopod shells and crinoid columnals. No fusulinids were found.

The predominantly carbonate upper part of the Zaladu Member (35 m thick) is made of limestones that are thick bedded at the base and medium and fine bedded towards the top, where they are bioconstructed and bioclastic, locally ferruginous, and reddish colored. At the top there are thin shale interbeds. The limestones yielded remains of brachiopods, corals, bryozoans, crinoids, and algae. Abundant fusulinids are locally rock-forming.

The relatioships of the Zaladu Member with the underlying deposits is unclear. Partoazar (1995) supposed a significant unconformity and a hiatus corresponding to the entire Kasimovian and Gzhelian. He did not present any paleontological evidence, but his hypothesis looks very probable due to the presence of basal conglomerates and generally transgressive lithological changes along the section. An indirect evidence is provided by a fusulinid-proved hiatus corresponding to the Kasimovian and most part of Gzhelian stages in a section in the Anorak area, 300 km to the south-west of the section under consideration (unpublished data).

The Zaladu Member is covered by thick-bedded and massive dolomites, which are usually referred to the Jamal Fm. According to Partoazar (1995), the upper carbonate part of what we define as Zaladu Member belongs also to the Jamal Fm. This issue will be considered in detail below.

Fusulinid assemblages and age of the Zaladu Member

We found fusulinids in the upper 15 m of the Zaladu Member. Sixteen samples (Z89-Z133) were collected at one-meter intervals and 260 oriented thin sections were prepared. The fusulinids found form three assemblages. The oldest assemblage (*Rauserites-Ruzhenzevites*) characterizes the largest part of this portion of the section (samples Z89-Z108) (Fig. 2). The second assemblage is very poor and recognized in sample Z125. The third assemblage (*Pseudoschwagerina*) is confined to the uppermost five meters (samples Z126-Z133). A complete list of species and their stratigraphic ranges are given in Table 1.

The most characteristic forms of the first assemblage (*Rauserites-Ruzhenzevites*) are diverse and abundant species of the genus *Rauserites* and abundant, but less diverse, representatives of the genus *Ruzhenzevites*. The latter is dominated by the typical species *Ruzhen-*

Fusulinids	Gzhelian	Asselian	
	Z89-Z108	Z125	Z126-Z133
Rauserites			
primitivus (Rozovskaya)	+		
variabilis Rozovskaya	+		
immutabilis (Scherbovich)	+		
elongatissimus (Rozovskaya)	+		
jucundus Leven	+		
lucidus (Rauser-Chernousova)	+		
postarcticus (Rauser-Chernousova)	+		
ishimbaji (Rozovskaya)	+		
quentillus (Zolotova)	+		
exilis Rozovskaya	+		
aff. *pseudolaxus* (Igo)	+		
samaricus (Rauser-Chernousova)	+		
aff. *samaricus* (Rauser-Chernousova)	+		
infrequentis n. sp.	+		
tabasensis n. sp.	+		
inobservabilis n. sp.	+		
fusoides n. sp.	+		
sp. 1	+		
sp.2	+		
Rauserites (?)			
persicus persicus sp. et subsp. nov.	+		
persicus compactus sp. et subsp. nov.	+		
Kushanella (?) sp.	+		
Anderssonites (?)			
aff. *anderssoni simplex* (Konovalova)	+		
Schellwienia			
orenburgensis (Dobrokhotova)	+		
aff. *dissimilis* (Scherbovich)	+		
aff. *modesta* (Scherbovich)	+		
Praepseudofusulina			
ikensis (Dobrokhotova)		+	
Pseudofusulina (?)			
macilenta Leven			+
aff. *macilenta* Leven			+
Quasitriticites			
iranicus n. sp.		+	
Ruzhenzevites			
ferganensis ferganensis (Dutkevitch)	+		+
ferganensis curtus n. subsp.	+		
subcylindricus (Bensh)		+	+
parasolidus (Bensh)		+	
zaladuensis zaladuensis sp. et subsp.nov.		+	+
zaladuensis brevis sp. et subsp. nov.		+	+
Paraschwagerina			
cf. *tianshnensis* (Chang)			+
Pseudoschwagerina			
velebitica Kochansky-Devide			+
parabeedei Ross			+
uddeni (Beede et Kniker)			+
Sphaeroschwagerina (?) sp.			+

Tab. 1 - List of fusulinids from the studied section.

zevites ferganensis (Dutkevich), which is widespread in the Tethyan region from the Carnic Alps in the west to South China in the east, and characteristic of the uppermost Carboniferous deposits. Beds with *R. ferganensis* of southern Fergana and Darvaz, which are recognized as an independent zone, are correlative with the *Daixina sokensis* Zone of the Gzhelian Stage of East European platform, according to Bensh (1972) and Davydov (in Chuvashov et al. 1986). Although *Ruzhenzevites* were not found in the platform sections, such forms as *Daixina, Rugosofusulina, Dutkevitchia, Triticites, Rauserites, Schellwienia, Quasifusulina,* are similar to the fusulinids of the *Ruzhenzevites ferganensis* Zone of Central Asia. Except for *Rauserites* and *Schellwienia,* the genera listed were not found in the Zaladu section. This imparts to this assemblage a peculiar, probably provincial, habit.

Abundant fusulinids (mostly *Rauserites*) associated with *Ruzhenzevites* indicate the Late Pennsylvanian age of the enclosing beds, but the association of the Zaladu section is more archaic than that of the *Ruzhenzevites ferganensis* Zone of Darvaz and Fergana. This is evidenced, first of all, by the absence of relatively advanced genera, such as *Daixina, Rugosofusulina, Dutkevitchia,* and *Jigulites.* In addition, among the *Rauserites* species, there are three species - *R. variabilis* Rozovskaya, *R. exilis* Rozovskaya, and *R. samaricus* (Rauzer-Chernousova) of Kasimovian age and five species, i.e. *R. elongatissimus* (Rozovskaya), *R. lucidus* Leven, *R. postarcticus* (Rauzer-Chernousova), and *R. ishimbaji* (Rozovskaya) characteristic of the lower half of the Gzhelian Stage. Only *R. immutabilis* (Scherbovich) was described earlier from the upper Gzhelian deposits (Beds with *Pseudofusulina* of the Caspian region) (Scherbovich 1969). Other species of the genus *Rauserites* are new or cannot be identified exactly. It is worth noting the presence of a single form similar to the Kasimovian *Kushanella* in association with *Rauserites.*

Thus, because of *Rauserites,* this assemblage can be dated as early Gzhelian, assuming that *Ruzhenzevites* appeared there earlier than the commonly considered time. However, because the beds with the *Rauserites-Ruzhenzevites* assemblage lie directly under the beds with Asselian fusulinids, they are more likely of late Gzhelian age. *Rauserites* seems to bear the archaic character probably because the Iranian species of this genus have not been adequately studied so far, which hampers their correlation to the species from East European standard sections. This is confirmed by the fact that *Rauserites* were accompanied by forms similar to the late Gzhelian *Schellwienia modesta* (Scherbovich) and *Anderssonites anserssoni simplex* (Konovalova) and by forms with outlined axial filling (such as *Rauserites ? persicus* n. sp.), which are not characteristic of beds older than the late Gzhelian.

The second assemblage (sample Z125) sharply differs from the *Rauserites-Ruzhenzevites* assemblage. The previously dominating species of *Rauserites* are absent and the genus *Ruzhenzevites* is represented by forms with more intensive septal fluting than that of *Ruzhenzevites ferganensis* (Dutkevich). These forms are identified as *Ruzhenzevites zaladuensis* n. sp. The assemblage contains abundant *Praepseudofusulina ikensis* (Dobrokhotova), which characterize the uppermost Gzhelian (the *Daixina bosbytauensis* Zone) and the basal Asselian of the East European platform and Darvaz. The transitional forms between *Triticites* and *Pseudoschwagerina* also appear. Similar forms were described from the Gzhelian-Asselian boundary beds of South China and distinguished as the genus *Quasitriticites* (Zhuang, 1984). Thus, this assemblage seems to be transitional Gzhelian-Asselian, but more likely it is of early Asselian age because the overlying deposits contain *Pseudoschwagerina* species previously unknown in beds older than the middle Asselian.

The third (*Pseudoschwagerina*) assemblage (samples Z126-Z131) is the typical Asselian (middle Asselian) association, as evidenced by the presence of widespread species, such as *Pseudoschwagerina parabeedei* Ross, *P. uddeni* (Beede & Kniker) and *P. velebitica* Kochansky-Devidé. These forms are associated with abundant *Ruzhenzevites* represented by the new species *R. zaladuensis* n. sp., as well as by *R. parasolidus* (Bensh). The latter is known from the Asselian beds of Fergana. The presence of typical *Paraschwagerina* and *Sphaeroschwagerina* (?) is not in disagreement with the Asselian age of the enclosing deposits.

Contrary to the Gzhelian-Asselian dating of the upper part of the Zaladu Member, the age of its lower part cannot be defined with certainty. Most likely, the lower boundary of the Zaladu Member does not lie below the base of the Kasimovian deposits. A likely interruption in sedimentation prior to the accumulation of the basal sandstones and conglomerates suggests the possibility that the Kasimovian Stage is missing entirely or partly from the section. Until this issue is clarified, the Zaladu Member should be considered to be Kasimovian (?) -Asselian in age.

The age of the dolomites crowning the Zaladu section is not well defined. If we suppose that they lie conformably on the middle Asselian beds of the Zaladu Member, they should be dated as late Asselian-Sakmarian. In this case, they cannot belong to the Jamal Fm. because the basal Bage-Vang Member of the Jamal Formation is of Bolorian age, i. e. much younger than Asselian-Sakmarian. However, there may be a latent stratigraphic hiatus between the dolomites and the Zaladu Member. This justifies referring the dolomites of the Zaladu section to the Jamal Fm., which elsewhere has an unconformable erosional contact with the underlying deposits. In this case the age of the dolomites can be considered Late Permian, or, possibly, Bolorian- Late Permian.

Correlation

We have no data to recognize the Zaladu Member outside the section under consideration. According to Stöcklin (1971), the uppermost limestone of the Sardar Formation occurs only in the northern Tabas area, where the Zaladu section is located. To the south, the upper part of the formation is composed of sandy-shaly facies. Because the latter cannot be dated exactly, it is unclear whether the carbonate facies are replaced southward by the sandy-shaly deposits or they are cut off by the unconformity that separates the Sardar and Jamal formations. This hypothesis is supported by the presence, in some sections, of coal-bearing interbeds at the boundary between these formations (Stöcklin 1971). This suggests a temporary uplift of this region and some interruption in sedimentation.

Outside East Iran, the Zaladu Member approximately corresponds in age and stratigraphic position to the Vazhnan Formation of the Abadeh region (Central Iran) and Dorud Formation of Central Alborz (Fig. 3). According to the data of Baghbani (1993, 1997), the Vazhnan Formation, formed by alternating sandstones, shales, and limestones rests on the erosional surface of fusulinid-bearing beds of the Moscovian stage. The formation is overlain by transgressive limestones of the Surmaq Formation with basal coarse-grained sandstones (Taraz 1974; Iranian-Japanese Group 1981). The presence of *Pseudoschwagerina* and *Robustoschwagerina*(?) in the middle and upper parts of the Vazhnan Formation indicates the Asselian-Sakmarian age, but its lower part may belong to the Gzhelian Stage. Fusulinids of the lowermost beds of the Surmaq Formation (*Pamirina, Misellina, Chalaroschwagerina, Darvasites*) (Taraz 1974; Kobayashi & Ishii 2001) are represented by the same forms present in the bottom part of the Jamal Formation (Bage-Vang Member) of East Iran. They are

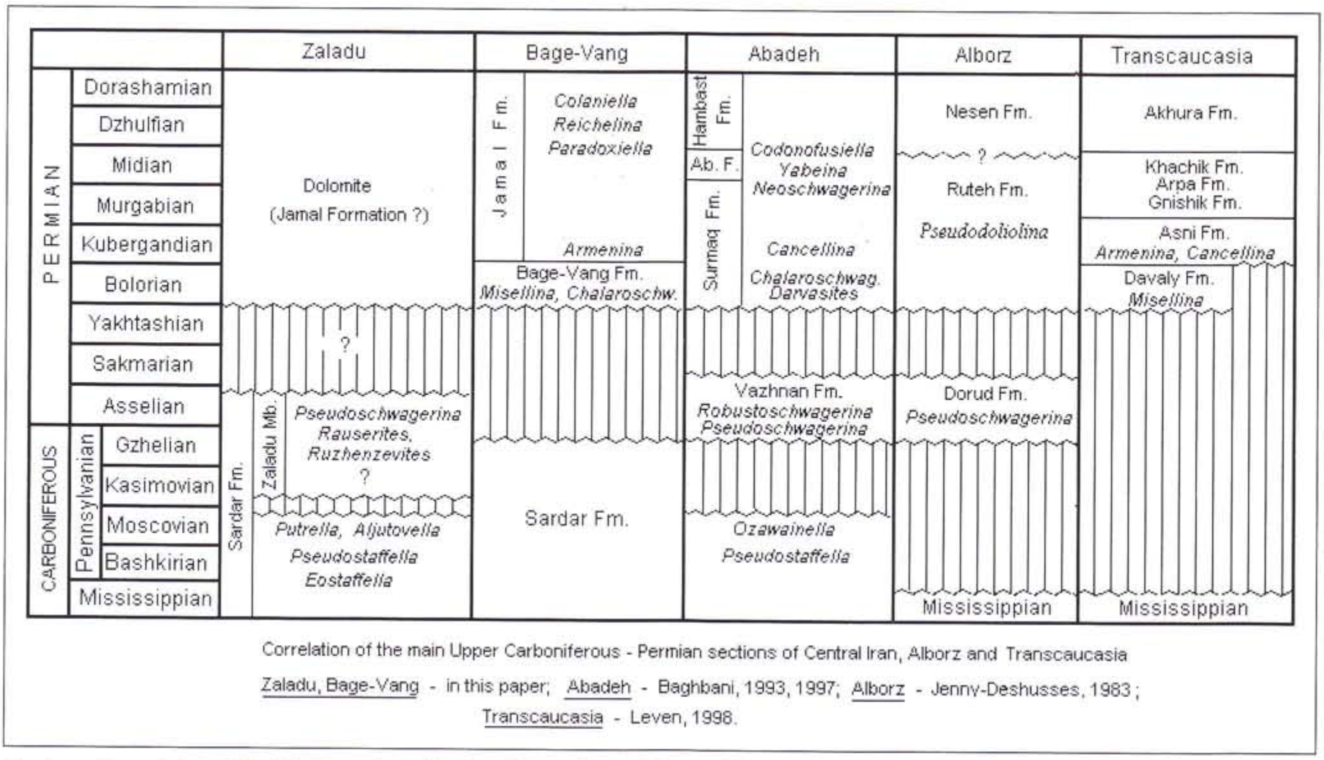

Fig. 3 - Correlation of the Zaladu section with the other sections of Iran and Transcaucasia.

characteristic of the Bolorian stage of the Lower Permian. The Yakhtashian stage is missing, similarly to the Zaladu section of the region under consideration.

Like the Zaladu Member, the Dorud Formation of Central Alborz is composed of basal red-brown sandstones and variegated shales, which pass upward to bioclastic limestones containing Asselian *Pseudoschwagerina* (Fig. 3). The limestones are overlain by quartzitic sandstones, locally with conglomerates at the base. The Dorud Formation lies transgressively on the Mississippian limestones of the Mobarak Formation and older deposits, and is overlain by limestones of the Ruteh Formation (Assereto 1963; Stöcklin 1971; Bozorgnia 1973; Kahler 1974; Jenny-Deshusses 1983; Vachard 1996). The limestones with *Pseudoschwagerina* and the underlying sandstones and shales correlate well with the Zaladu Member.

The East Iran, Central Iran and Alborz sections are relatively similar. The Zaladu Member, Vazhnan and Dorud formations correspond to the single, large, latest Carboniferous-Early Permian (Asselian-Sakmarian) cycle of sedimentation induced by an extensive transgression. Prior to this time the Iranian region was above sea-level, which may have resulted in the absence of the Kasimovian and locally Moscovian and Bashkirian deposits, as demonstrated by the Alborz sections. Everywhere the cycle began with the accumulation of frequently red and variegated clastic deposits and ended with the deposition of carbonates, mainly shallow-water bioconstructed and bioclastic limestones.

After the late Sakmarian-Yakhtashian regression, East Iran, Central Iran and Alborz were again above sea-level. As in many regions of the Tethys, a new transgression began there in Bolorian time, when thick carbonate platforms began to form (Leven 1994, 1997). These are the formations of Jamal of the Tabas area, Surmaq of the Abadeh region, and Ruteh of Alborz. At the bases of the carbonates there are conglomerates and sandstones of varying thickness in combination with bioclastic limestones with abundant fusulinids. Locally, these beds can be easily distinguished as independent stratigraphic units, e.g. the Bage-Vang Member. The transgression expanded in the early Kubergandian time of the Late Permian. As a result, in many places the Kubergandian limestones lie on the erosional surface of deposits older than the Bolorian units. For example, in Transcaucasia, Bolorian deposits occur only in the section of Davali (Leven 1998). They are missing in all the other sections, and the Kubergandian limestones, including frequent basal bauxites, lie on the Mississippian and Devonian deposits (Leven 1998). Similar patterns are characteristic of many sections of South Afghanistan, South China, and Japan (Leven 1994, 1997). This is probably true also for the carbonate formations of Central Iran and Alborz, such as the Surmaq, Ruteh and Jamal formations.

Conclusions

1. The study of fusulinids revealed that the upper part of the Zaladu Member at the top of the Sardar Formation comprises deposits of both the Gzhelian Stage of the Upper Carboniferous (Pennsylvanian) and the Asselian Stage of the Lower Permian (Cisuralian).

2. The basal beds of the Jamal Formation (the Bage-Vang Formation according to Partoazar 1995) were proved to be of Bolorian age. So, the Zaladu Member cannot be assigned to those beds.

3. The results obtained show that the Carboniferous-Permian sections of East Iran are similar in general structural peculiarities to other coeval sections of Central Iran and Alborz. All Gzhelian - Sakmarian deposits are delimited by unconformities due to breaks, sometimes long, in sedimentation caused by emersions. The Bolorian transgression induced everywhere the formation of carbonate platforms; the underlying Carboniferous-Lower Permian deposits are predominantly terrigenous.

Description of the new species of fusulinids

Order **Schwagerinida** Solovieva, 1985

Family Triticitidae Davydov, 1986

Genus *Rauserites* Rozovskaya, 1950

Type species: *Triticites stuckenbergi* Rauzer-Chernousova, 1938

Remarks. The systematics of the Order Schwagerinida, especially its early representatives, family Triticitidae, is very complicated. There is a limited number of features that can be used in systematic studies. Therefore we estimate their quantitative characteristics: a degree of development of chomata, weak, moderate or strong septal fluting, and so on. Such estimations cannot help being subjective. This is true for the genus *Rauserites* that shows indistinct and ambiguously interpreted differences from the genus *Triticites*. Rozovskaya (1950) established *Rauserites* as a subgenus of *Triticites*. However, these taxa were referred to different phylogenetic lines which branch off from the subgenus *Montiparus*. Davydov (1990) suggested still farther genetic relationships between *Rauserites* and *Triticites*: the former genus was proposed to be descendant of *Montiparus*, and the latter one, of *Protriticites*. Bensh (in Rauzer-Chernousova et al. 1996) united the forms referred by Davydov to the genus *Triticites* into an independent genus *Schwageriniformis*. Now V. Davydov (pers. comm.) considers *Triticites* to be the only American genus equivalent of *Rauserites* from the East European and Tethyan sections. Although questionable, this view was accepted in this paper.

Rauserites infrequentis Leven, n. sp.

Pl. 1, fig. 4, 5, 8, 9; Pl. 2, fig. 13

Holotype. GIN 4773/3. Subaxial section; Iran, Zaladu, Zaladu Member; sample Z108; late Carboniferous (Pennsylvanian), Gzhelian (Pl. 1, fig 8).

Etymology. From *infrequens* (lat.) - infrequently occurring; not common.

Material. 2 axial, 3 subaxial and 2 tangential sections.

Description. Shell of moderate size, fusiform to thickly subcylindrical, with slightly convex lateral slopes and bluntly pointed poles. Adult individuals have 5 to 6 volutions and measure 5.3 to 7.0 mm in length and 1.49 to 2.0 mm in diameter; form ratio 3.4 to 3.5. First 3 to 3.5 whorls constituting not very tightly coiled juvenarium, followed into loosely coiled adult stage. Spirotheca composed of tectum and fine-alveolar keriotheca; thickness in fifth whorl 0.04 to 0.05 mm Septa wavy across middle of shell, becoming irregularly fluted toward poles. Proloculus relatively small, its outside diameter 0.125 to 0.200 mm. Tunnel narrow in the juvenarium, significantly widening outwards. Weak chomata present only in juvenarium.

Discussion. *Rauserites infrequentis* n. sp. is closely similar to *Rauserites jucundus* Leven & Davydov from Darvaz, but differs in its less intensively septal fluting and sharp widening of the spiral of two last whorls. From *R. tabasensis* n. sp. this species differs in relatively longer test and tightly coiled spiral of the first 3-3.5 whorls.

Occurrence and age. Zaladu section, upper part of Zaladu Member, sample Z101, Z102 and Z108; Late Carboniferous (Pennsylvanian), Gzhelian.

Rauserites tabasensis Leven n. sp.

Pl. 2, fig. 10-12

Holotype. GIN 4773/24. Axial section; Iran, Zaladu, Zaladu Member, sample Z99; late Carboniferous (Pennsylvanian), Gzhelian (Pl. 2, fig. 10).

Etymology. From Tabas (Iran).

Material. 2 axial and 3 subaxial sections.

Description. Shell of moderate size, elongate fusiform, with bluntly rounded poles. Mature specimens have 4.5 to 5 volutions and measure 6.5 mm in length and 1.7 to 2.1 mm in diameter; form ratio 2.5 to 3.2. Spirotheca composed of tectum and fine alveolar keriotheca. Thickness of spirotheca in last volution is 0.08 to 1.0 mm. Septa irregularly and wavy fluted from pole to pole. Proloculus spherical; its outside diameter is 0.18 to 0.25 mm. Early 2 volutions coiled more tightly than succeeding volutions. Tunnel low and narrow in the first two volutions and wide in following volutions. Weak but clear chomata occur on proloculus and early 3 volutions.

Discussion. *Rauserites tabasensis* n. sp. is closely similar to *Rauserites immutabilis* (Scherbovich) but the shell of later is inflated in its middle part.

Occurrence and age. Zaladu section, upper part of Zaladu Member, samples Z99 and Z100; late Carboniferous (Pennsylvanian), Gzhelian.

Rauserites fusoideus Leven, n. sp.

Pl. 2, fig. 19, 20

Holotype. GIN 4773/4. Axial section; Iran, Zaladu, Zaladu Member, sample Z101; late Carboniferous (Pennsylvanian), Gzhelian (Pl. 2, fig.19).

Etymology. From *fusoideus* (lat.) - fusiform.

Material. 2 axial and 4 subaxial sections.

Description. Shell of moderate size, fusiform to elongate fusiform with slightly convex lateral slopes and bluntly pointed poles. Adult individuals have 4.5 to 5.5 volutions and measure 5.0 to 5.2 mm in length and 1.3 to 1.45 mm in diameter; form ratio 3.6 to 3.9. Spirotheca composed of tectum and fine-textured keriotheca; thickness in fifth whorl 0.056 to 0.06 mm Septa thin and irregularly and wavy fluted from pole to pole. Proloculus medium in size, its outside diameter 0.19 mm Tunnel low and narrow in early volutions gradually widening throughout. Small and narrow chomata developed only in early 2 volutions.

Discussion. *Rauserites fusoideus* n. sp. is very similar to *R. concinnus* Leven & Davydov from Darvaz, but differs in its smaller and shorter shell and slightly less intensive septal fluting. Described species differs from *Rauserites infrequentis* n. sp. in regular coiling of the spiral of all whorls, including two last ones.

Occurrence and age. Zaladu section, upper part of Zaladu Member, samples Z101 and Z103; Late Carboniferous (Pennsylvanian), Gzhelian.

Rauserites inobservabilis Leven, n. sp.

Pl. 2, fig. 17, 18

Holotype. GIN 4773/29. Axial section; Iran, Zaladu, Zaladu Member, sample Z100; late Carboniferous (Pennsylvanian), Gzhelian (Pl. 2, fig. 17).

Etymology. From *inobservabilis* (lat.) - imperceptible

Material. 2 axial and several tangential sections.

Description. Shell small, subcylindrical, with bluntly rounded poles. Mature specimens have 4 to 5 volutions and measure 3.2 to 4.5 mm in length and 1.1 to 1.3 mm in diameter; form ratio 2.9 to 3.4. Spirotheca composed of tectum and fine alveolar keriotheca. Thickness of spirotheca in last volutions 0.04 mm. Septa wavy or irregular fluted across middle of shell, becoming moderately folded toward poles. Proloculus medium, its outside diameter 0.15 to 0.16 mm. Tunnel half as high as chambers, narrow in inner 3 volutions, significantly widening outwards. Small and narrow chomata developed in early 3 volutions.

Discussion. *Rauserites inobservabilis* n. sp. resembles *R. fusoideus* n. sp. but differ in its subcylindrical and shorter shape of shell with rounded poles.

Occurrence and age. Zaladu section, upper part of Zaladu Member, sample Z100; Late Carboniferous (Pennsylvanian), Gzhelian.

Rauserites sp. 1

Pl. 1, fig. 16, 17

Material. 2 subaxial sections.

Remarks. *Rauserites* sp. 1 is similar to *Rauserites infrequentis* n. sp. and to *R. fusoideus* n. sp., but differs in its more compact and regularly coiled spiral.

Occurrence and age. Zaladu section, upper part of Zaladu Member, samples Z103 and Z108; Late Carboniferous (Pennsylvanian), Gzhelian.

Rauserites sp. 2

Pl. 3, fig. 6

Material. 1 axial section.

Discussion. *Rauserites* sp. 2 has a slight similarity to *R. inobservabilis* n. sp., but it differs from the latter in its larger size, more intensive septal folding and more developed chomata.

Occurrence and age. Zaladu section, upper part of Zaladu Member, sample Z100; Late Carboniferous (Pennsylvanian), Gzhelian.

Rauserites (?) persicus Leven, n. sp.

Pl. 2, fig. 22; Pl. 3, fig. 1-5

Holotype. GIN 4773/35. Axial section; Iran, Zaladu, Zaladu Member, sample Z108; late Carboniferous (Pennsylvanian), Gzhelian (Pl. 3, fig. 1).

Etymology. From Persia - the ancient name of Iran.

Material. 7 axial and 2 subaxial sections.

Remarks. The generic assignment of this species can be a subject of dispute because the true *Rauserites* have more developed chomata and different structure of inner whorls. The weak septal fluting indicating its relatively primitive character prevents refering this species to the genus *Schellwienia*.

Description. Shell of moderate to large size, fusiform, with straight to slightly concave lateral slopes and rather bluntly rounded poles. Mature individuals have 4.0 to 6.5 mm in length and 1.3 to 2.1 mm in diameter; form ratio 2.5 to 3.6. Early 2.5 to 3.5 volutions constitute tightly coiled juvenarium, which followed by abrupt expansion into loosely coiled adult stage. Spirotheca composed of tectum and fine alveolar keriotheca. Thickness of spirotheca in last volution is 0.05 to 0.06 mm. Septa wavy across middle of shell, becoming irregularly fluted toward poles. Proloculus relatively small, its outside diameter 0.15 mm. Tunnel narrow in the juvenarium, significantly widening outwards. Weak chomata present only on proloculus. Axial filling occur in the polar areas of tightly coiled juvenarium.

Discussion. Described species differs from other species of genus *Rauserites* in tightly coiled juvenarium with axial filling.

Occurrence and age. Zaladu section, upper part of Zaladu Member, samples Z103 and Z108; Late Carboniferous (Pennsylvanian), Gzhelian.

Genus *Quasitriticites* Zhuang, 1984

Type species: *Quasitriticites guizhouensis* Zhuang, 1984

Quasitriticites iranicus Leven, n. sp.
Pl. 4, fig. 16-18

Holotype. GIN 4773/64. Axial section; Iran, Zaladu, Zaladu Member, sample Z125; late Carboniferous (Pennsylvanian), late Gzhelian - early Permian (Cisuralian), early Asselian (Pl. 4, fig. 17).
Material. 6 axial and subaxial sections.

Description. Shell moderately large, fusiform, with straight to slightly convex slopes and bluntly pointed poles. Mature shells possess 4.5 to 5 volutions, with first 2.5 or 3 tightly coiled; loosely coiled adult stage. Shells measure 4 to 6.7 mm in length and 1.5 to 2.8 mm in diameter; form ratio 2.1 to 2.8. Spirotheca composed of tectum and fine-textured keriotheca; thickness in last whorl 0.07 to 0.1 mm. Septa strongly fluted in juvenarium and weak fluted in next whorls. Proloculus moderately size; its outside diameter 0.2 to 0.3 mm. Tunnel low and rather narrow. Small but clear chomata present in juvenarium.

Discussion. The described species differs from *Quasitriticites guizhouensis* Zhuang and *Q. machangensis* Zhuang in its more elongate and larger shell. Like other representatives of the genus *Quasitriticites*, this species is intermediate between the genera *Triticites* and *Pseudoschwagerina*. But from *Triticites* it differs in sharply changed volution of the spiral of juvenarium and subsequent whorls. True *Pseudoschwagerina* are characterized by more distinct change in the volutions.

Occurrence and age. Zaladu, Zaladu Member, samples Z102 and Z125; Late Carboniferous (Pennsylvanian), late Gzhelian – Early Permian (Cisuralian), early Asselian.

Genus *Ruzhenzevites* Davydov, 1986

Type species: *Schwagerina pailensis* var. *ferganensis* Dutkevitch, 1939.

Remarks. The genus with the type species *Schwagerina pailensis* var. *ferganensis* Dutkevitch, 1939 was distinguished by Davydov (in Chuvashov et al. 1986) from the Upper Carboniferous of Fergana. Bensh (1987) considered it as a synonym of the genus *Eoparafusulina* Coogan. This is not correct, in our opinion. *Ruzhenzevites* well differs from true *Eoparafusulina* of California in its larger size, larger proloculus, wider volution, especially of inner whorls, absence of chomata, and poorly pronounced pseudochomata observable frequently only in one or two inner volutions. The genus under consideration is very similar to the genus *Monodiexodina* Sosnina. However, true *Monodiexodina* show more regularly and lower folded and more developed cuniculi. In addition, they are younger. It seems *Eoparafusulina, Ruzhenzevites* and *Monodiexodina* were originated in different times and had different ancestors.

Ruzhenzevites ferganensis (Dutkevitch) subsp. **curtus** Leven, n. subsp.
Pl. 4, fig. 8

Holotype. GIN 4773/55. Axial section; Iran, Zaladu; Zaladu Member, sample Z102; Late Carboniferous (Pennsylvanian), Gzhelian (Pl. 4, fig. 8).
Etymology. From *curtus* (lat.) - short.
Material. 5 axial and 7 tangential sections.

Description. Shell moderately large, fusiform to elongate fusiform, with bluntly rounded poles and slightly concave lateral slopes. Mature specimens have 5 to 5.5 volutions and measure 6 to 7.5 mm in length and 2 to 2.35 mm in diameter; form ratio 2.9 to 3.1. Spirotheca composed of tectum and thin alveolar keriotheca; thickness in last volution 0.07 to 0.075 mm. Septa thin and more or less regularly folded at basal margins. Septal loops are semicircular in outline. Cuniculi well developed. Narrow band of secondary material follows axis, except last volution. Proloculus moderate in size, its outside diameter 0.2 to 0.35 mm. Tunnel low and fairly wide. Weak chomata present on proloculus.

Discussion. The described subspecies differs from *Ruzhenzevites ferganensis ferganensis* (Dutkevitch) in its shorter and fusiform shell.

Ruzhenzevites zaladuensis Leven, n. sp.

Two subspecies can be recognized in this species - *Ruzhenzevites zaladuensis zaladuensis* n. subsp. with elongate fusiform shell and *R. zaladuensis brevis* n. subsp., shell of which is shorter.

Ruzhenzevites zaladuensis zaladuensis Leven, n. subsp.

Pl. 4, fig. 12, 13; Pl. 5, fig. 3

Holotype. GIN 4773/59. Axial section; Iran, Zaladu; Zaladu Member, sample Z125; early Permian (Cisuralian), Asselian (Pl. 4, fig. 12).

Etymology. From Zaladu valley, Iran.

Material. 8 axial sections.

Description. Shell moderately large, fusiform to elongate fusiform, with bluntly rounded poles and straight to slightly concave lateral slopes. Mature specimens have 5.5 to 6 volutions and measure 10 to 11 mm in length and 2.5 to 2.7 mm in diameter; form ratio 3.9 to 4. Spirotheca composed of tectum and keriotheca; thickness in last two volutions 0.08 to 0.1 mm. Septa regularly fluted throughout shell. Septal folds are about half as high as chambers; low cuniculi present in outer volutions. Proloculus medium, its outside diameter 0.25 to 0.4 mm. Tunnel low and wide. Chomata weak, present only on proloculus. Weak and interrupted secondary deposit present along axis.

Discussion. *Ruzhenzevites zaladuensis zaladuensis* n. sp. and subsp. is close similar to *Ruzhenzevites parasolidus* (Bensh) but differs in more gradual elongation of shell from first to last volutions. It is distinguished from *Ruzhenzevites ferganensis* (Dutkevitch) by its more intensive and regular septal fluting.

Occurrence and age. Zaladu, Zaladu Member, samples Z125, Z127, Z129 and Z131; early Permian (Cisuralian), Asselian.

Ruzhenzevites zaladuensis brevis Leven n. subsp.

Pl. 5, fig. 1, 4-7

Holotype. GIN 4773/66. Axial section; Iran, Zaladu, Zaladu Member, sample Z129; early Permian, (Cisuralian), Asselian (Pl. 5, fig. 1).

Etymology. From *brevis* (lat.) - short.

Material. 5 axial sections.

Description. Shell moderately size, fusiform, with rounded or bluntly pointed poles and straight to slightly concave lateral slopes. Mature specimens have 5 to 6.5 volutions aand measure 6.9 to 8.5 mm in length and 2 to 2.5 mm in diameter; form ratio 3 to 3.6. Spirotheca composed of tectum and keriotheca; thickness in last voluton 0.07 to 0.08 mm. Septa regularly fluted from pole to pole. Septal folds are about half as high as chamber; low cuniculi present in most volutions. Proloculus medium, its outside diameter 2 to 3 mm. Tunnel low and wide. Weak chomata present only on proloculus. Axial filling present in first 3 to 4 volutions but absent in outer ones.

Discussion. *Ruzhenzevites zaladuensis brevis* n. subsp. differs from *R. zaladuensis zaladuensis* n. subsp. in its shorter shell and more developed axial filling.

Occurrence and age. Zaladu, Zaladu Member, samples Z127, Z129 and Z131; Early Permian (Cisuralian), Asselian.

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PLATE 1
All x 15

Fig. 1-3 - *Rauserites immutabilis* (Scherbovich). Axial sections, GIN 4773/1, GIN 4773/2 and GIN 4773/3; Zaladu Member; samples Z99, Z100 and 102.
Fig. 4, 5, 8, 9 - *Rauserites infrequentis* Leven n. sp. 4) subaxial section, GIN 4773/4, sample Z101; 5) axial section GIN 4773/5, sample Z102; 8) subaxial section of the holotype, GIN 4773/8, sample Z108; 9) subaxial section GIN 4773/8, sample Z108.
Fig. 6, 7 - *Rauserites elongatissimus* (Rozovskaya). Axial sections, GIN 4773/6 and GIN 4773/7; Zaladu Member, sample Z89.
Fig. 10 - *Rauserites postarcticus* (Rauzer-Chernousova). Axial section, GIN 4773/9; Zaladu Member, sample Z100.
Fig. 11-13 - *Rauserites primitivus* (Rozovskaya). Axial sections, GIN 4773/10, GIN 4773/11 and GIN 4773/2; Zaladu Member, samples Z89, Z103 and Z100.
Fig. 14, 15 - *Rauserites variabilis* Rozovskaya. Subaxial sections, GIN 4773/12 and GIN 4773/3; Zaladu Member, sample Z103.
Fig. 16, 17 - *Rauserites* sp. 1. Subaxial sections, GIN 4773/13 and GIN 4773/14; Zaladu Member, samples Z103 and Z101.
Fig. 18 - *Rauserites lucidus* (Rauzer-Chernousova). Subaxial section, GIN 4773/15; Zaladu Member, sample Z102.

PLATE 2
All x 15

Fig. 1-3 - *Rauserites ishimbaji* (Rozovskaya). Axial and subaxial sections, GIN 4773/16, GIN 4773/17 and GIN 4773/18; Zaladu Member, samples Z105, Z100 and Z103.
Fig. 4-7 - *Rauserites quentillus* (Zolotova). Axial sections, GIN 4773/19, GIN 4773/20, GIN 4773/21 and GIN 4773/8; Zaladu Member, samples Z101, Z100, Z102 and Z108.
Fig. 8, 9 - *Rauserites exilis* Rozovskaya. Axial sections, GIN 4773/22 and GIN 4773/23; Zaladu Member, sample Z100.
Fig. 10-12 - *Rauserites tabasensis* Leven n. sp. Axial sections, GIN 4773/24 (holotype, fig. 10), GIN 4773/25 and GIN 4773/26; Zaladu Member, samples Z99, Z100.
Fig. 13 - *Rauserites infrequentis* Leven n. sp. Axial section, GIN 4773/27; Zaladu Member, sample Z102.
Fig. 14-16 - *Rauserites* aff. *samaricus* (Rauzer-Chernousova). Subaxial sections, GIN 4773/28, GIN 4773/18 and GIN 4773/28; Zaladu Member, sample Z103.
Fig.17, 18 - *Rauserites inobservabilis* Leven n. sp. 17) Axial section of the holotype, GIN 4773/29; 18) subaxial section, GIN 4773/30; Zaladu Member, sample Z100.
Fig. 19, 20 - *Rauserites fusoideus* Leven n. sp. 19)Axial section of the holotype, GIN 4773/4; 20) subaxial section, GIN 4773/31; Zaladu Member, samples Z101 and Z103.
Fig. 21, 23 - *Rauserites elongatissimus* (Rozovskaya). Subaxial sections, GIN 4773/32 and GIN 4773/34; Zaladu Member, samples Z99 and Z100.
Fig. 22 - *Rauserites* (?) *persicus* Leven n. sp. Axial section, GIN 4773/33; Zaladu Member, sample Z108.

PLATE 3
All x 15, except fig. 19

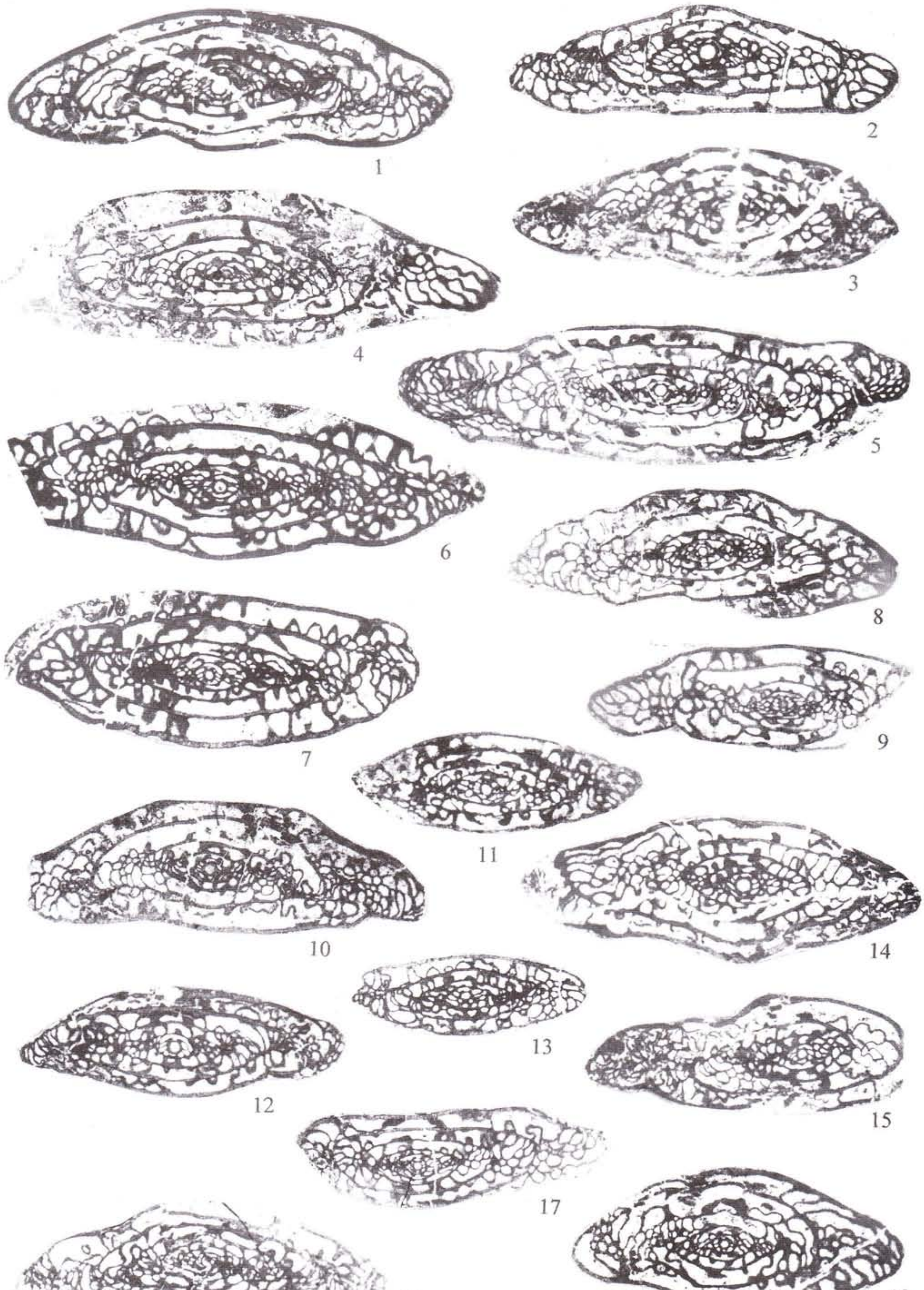
Fig. 1-5 - *Rauserites* (?) *persicus* Leven n. sp. Axial sections: 1) GIN 4773/35 (holotype), 2) GIN 4773/35, 3) GIN 4773/36, 4) GIN 4773/37, 5) GIN 4773/38; Zaladu Member, sample Z108.
Fig. 6 - *Rauserites* sp. 2. Axial section, GIN 4773/39; Zaladu Member, sample Z100.
Fig. 7-9 - *Rauserites samaricus* (Rauzer-Chernousova). Axial and subaxial sections, GIN 4773/30, GIN 4773/40 and GIN 4773/41; Zaladu Member, samples Z100 and Z102.
Fig. 10 - *Rauserites* aff. *pseudolaxus* (Igo). Subaxial section, GIN 4773/22; Zaladu Member, sample Z99.
Fig. 11-13 - *Schellwienia orenburgensis* (Dobrokhotova). Subaxial sections, GIN 4773/42, GIN 4773/43 and GIN 4773/18; Zaladu Member, sample Z103.
Fig. 14 - *Kushanella* (?) sp. Oblique section, GIN 4773/6; Zaladu Member, sample Z89.
Fig. 15 - *Schellwienia* aff. *dissimilis* (Scherbovich). Axial section, GIN 4773/44; Zaladu Member, sample Z103.
Fig. 16, 17 - *Anderssonites* (?) aff. *anderssoni simplex* (Konovalova). Axial sections, GIN 4773/45 and GIN 4773/46; Zaladu Member, samples Z102 and Z103.
Fig. 18 - *Schellwienia* sp. Subaxial section, GIN 4773/47; Zaladu Member, sample Z101.
Fig. 19 - *Schellwienia* aff. *modesta* (Scherbovich). Axial section, x10. GIN 4773/48; Zaladu Member, sample Z89.

PLATE 4
All x10, except fig.11 and 14

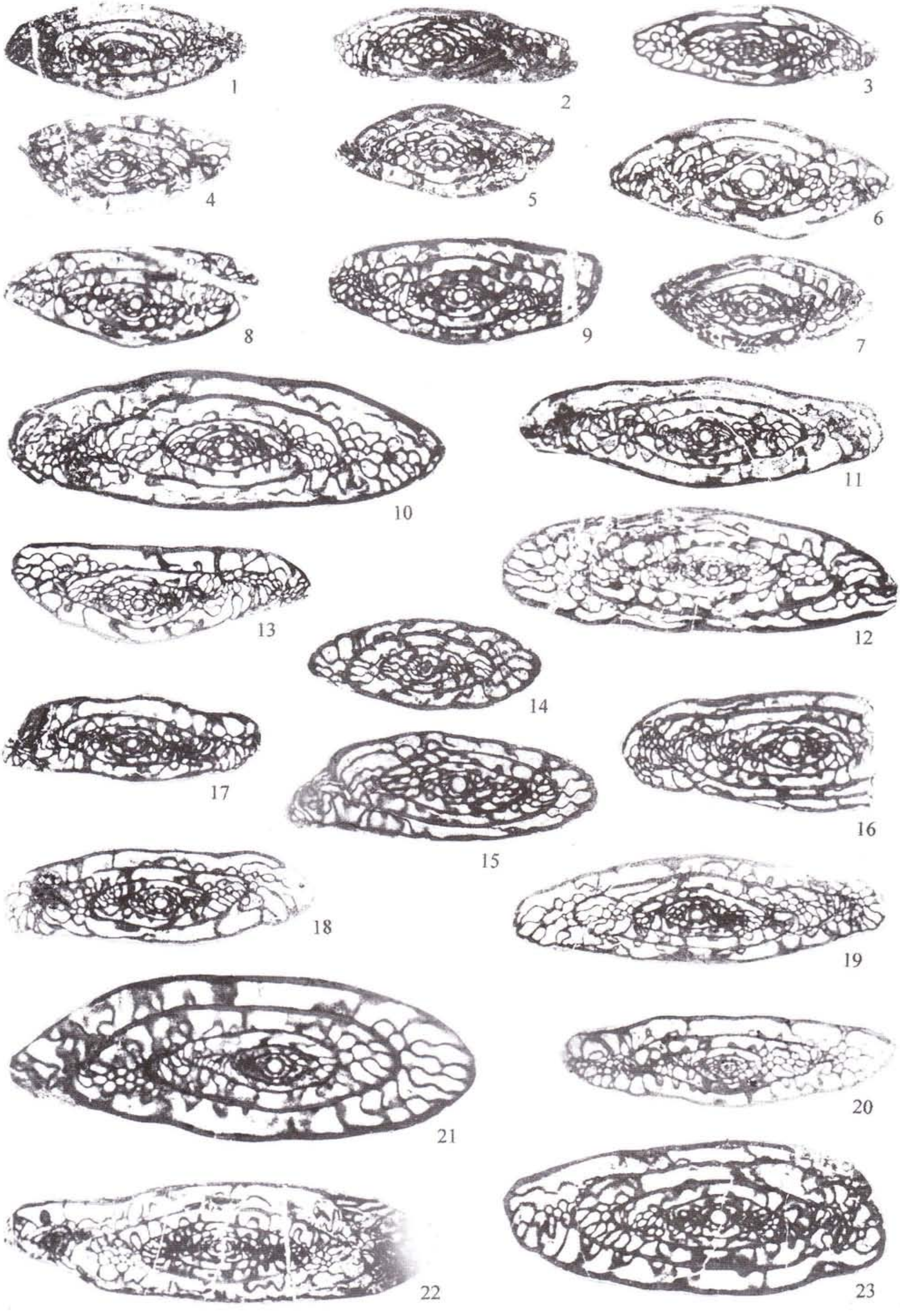
Fig. 1 - *Pseudofusulina* (?) *macilenta* Leven. Axial section, GIN 4773/49; Zaladu Member, sample Z126.
Fig. 2, 3 - *Pseudofusulina* (?) ex gr. *macilenta* Leven. Axial and subaxial sections, GIN 4773/50 and GIN 4773/51; Zaladu Member, sample Z126.
Fig. 4-7 - *Ruzhenzevites ferganensis ferganensis* (Dutkevitch). 4-6) Axial sections, GIN 4773/52, GIN 4773/53 and GIN 4773/25; 7) tangential section, GIN 4773/54; Zaladu Member, samples Z100 and Z102.
Fig. 8 - *Ruzhenzevites ferganensis curtus* Leven n. subsp. Axial section of the holotype, GIN 4773/55; Zaladu Member, sample Z102.
Fig. 9 - *Paraschwagerina* cf. *tianshanensis* (Chang). Subaxial section, GIN 4773/56; Zaladu Member, sample Z127.
Fig. 10, 11, 14 - *Praepseudofusulina ikensis* (Dobrokhotova). Axial sections, GIN 4773/57, GIN 4773/58 and GIN 4773/61; Zaladu Member, sample Z125. Fig. 11 and 14 x15.
Fig. 12, 13 - *Ruzhenzevites zaladuensis zaladuensis* Leven n. sp. and subsp. Axial sections: 12) GIN 4773/59 (holotype), 13) GIN 4773/60; Zaladu Member, sample Z125.
Fig. 15 - *Ruzhenzevites subcylindricus* (Bensh). Axial section, GIN 4773/62; Zaladu Member, sample Z131.
Fig. 16-18 - *Quasitriticites iranicus* Leven n. sp. 16) Subaxial sections, GIN 4773/63, axial section, GIN 4773/64 (holotype), 18) subaxial section 4773/65; Zaladu Member, sample Z125.

PLATE 5
All x10

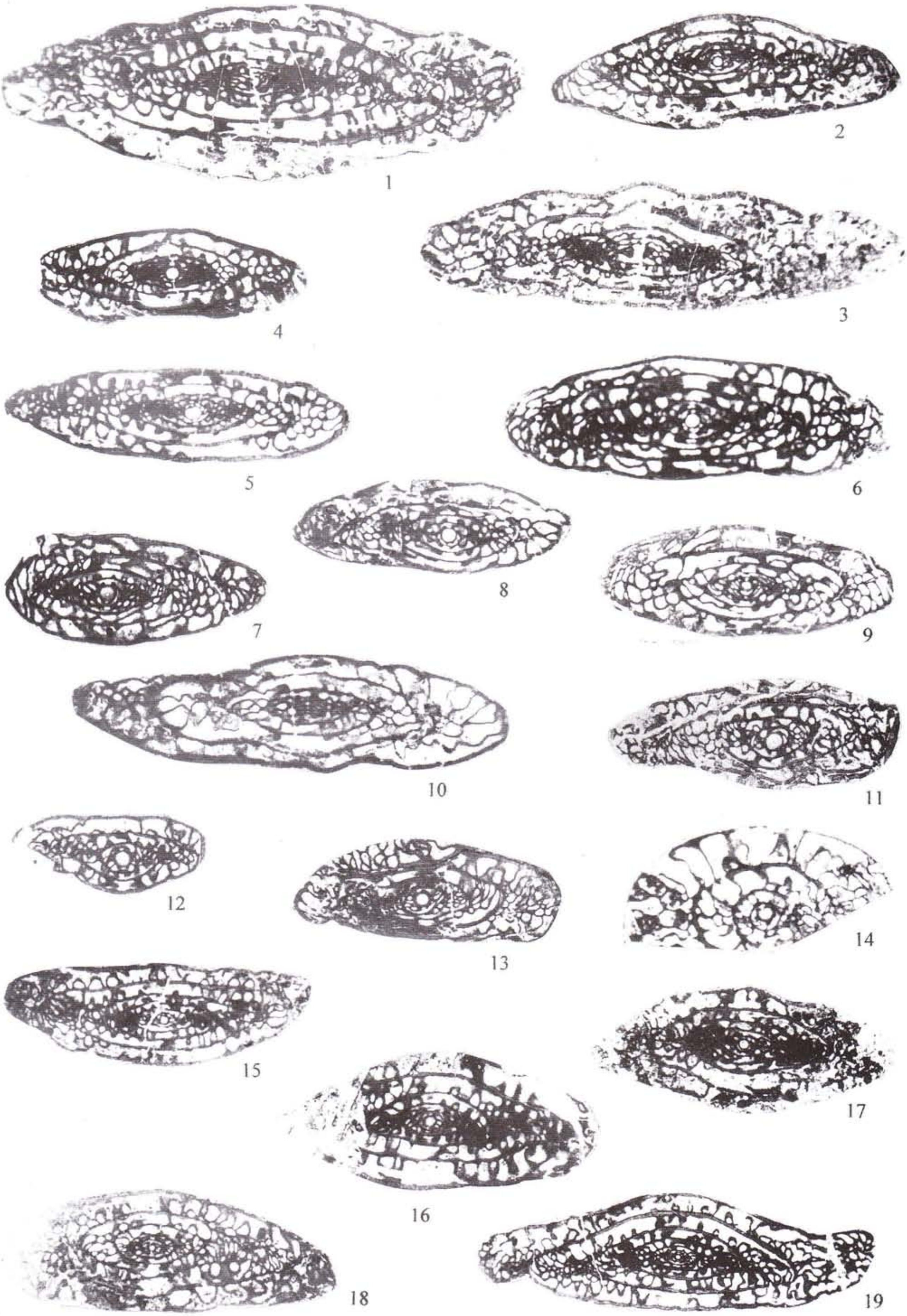
Fig. 1, 4-7 - *Ruzhenzevites zaladuensis brevis* Leven n. subsp. 1, 4, 6, 7) Axial sections, GIN 4773/66 (holotype), GIN 4773/69, GIN 4773/71 and GIN 4773/70; 5) tangential section, GIN 4773/70; Zaladu Member, Z129, Z131 and Z127.
Fig. 2 - *Ruzhenzevites parasolidus* (Bensh). Axial section, GIN 4773/67; Zaladu Member, sample Z126.
Fig. 3 - *Ruzhenzevites zaladuensis zaladuensis* Leven n. sp. and subsp. Axial section, GIN 4773/68; Zaladu Member, sample Z129.
Fig. 8, 9 - *Pseudoschwagerina velebitica* Kochansky-Devidé. Axial snd subaxial sections, GIN 4773/72 and GIN 4773/73; Zaladu Member, sample Z126.
Fig. 10, 12 - *Pseudoschwagerina parabeedei* Ross. Axial sections, GIN 4773/74 and GIN 4773/76; Zaladu Member, sample Z129.
Fig. 11, 13-15 - *Pseudoschwagerina uddeni* (Beede et Kniker). Axial sections, GIN 4773/75, GIN 4773/77, GIN 4773/78 and GIN 4773/79; Zaladu Member, samples Z133, Z129, Z133 and Z129.



Pl. 1

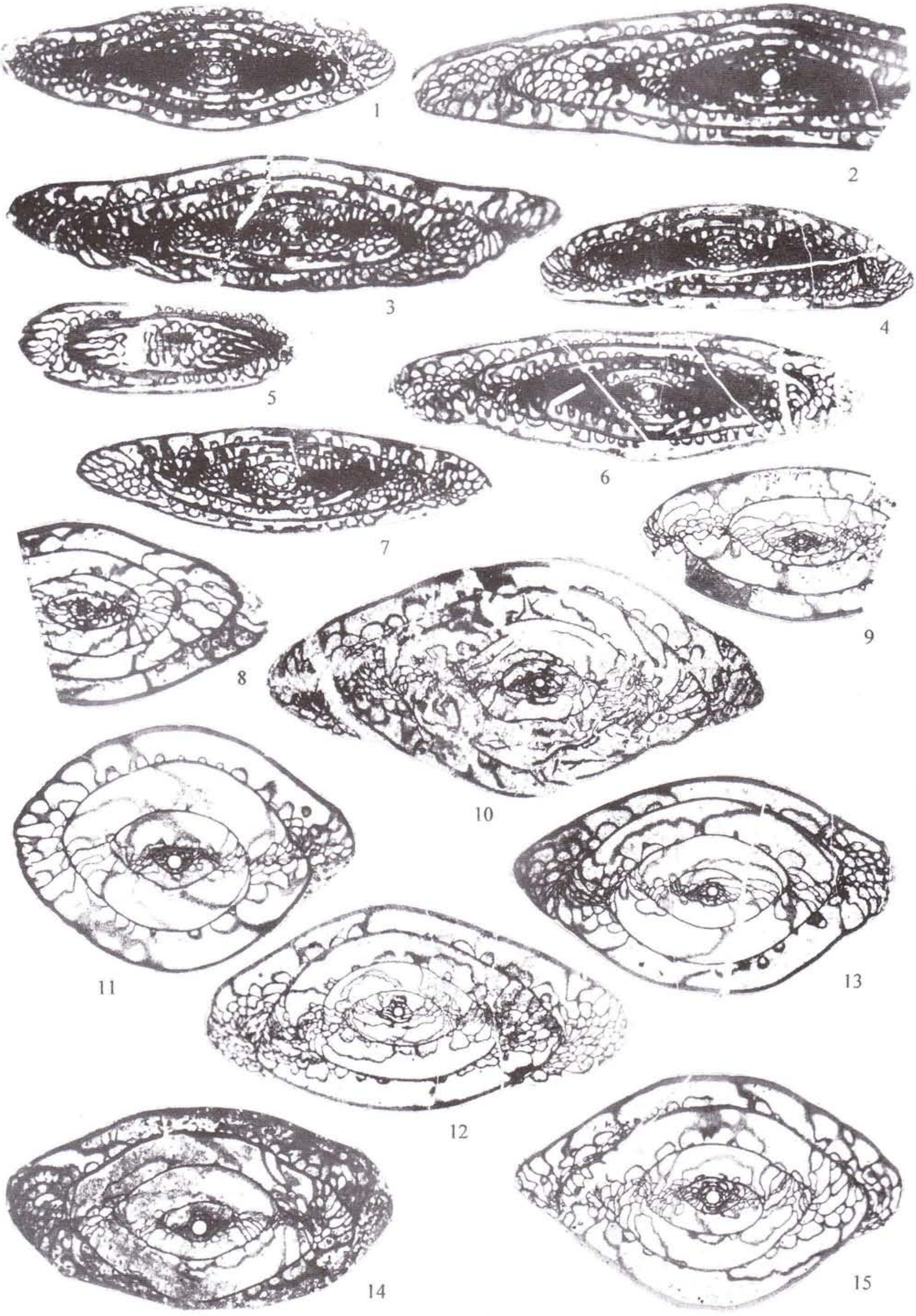


Pl. 2



Pl. 3

Pl. 4



Pl. 5

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