

## Fusulinids of the Khan formation (Kalmard region, eastern Iran) and some problems of their paleobiogeography

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Received 21 April 2007; accepted 22 July 2007; published 2 October 2007.

[1] Fusulinids of the Khan Formation of Eastern Iran are described. The assemblage includes 10 species of *Pseudofusulina* (two new species *P. gachalensis* and *P. kalmardensis*), 4 species of *Eoparafusulina* and single forms of *Pseudoendothyra*, *Palaeostaffella* (?) and *Schubertella* unidentifiable at species level. The assemblage is endemic. Similarity to the Kalaktash fusulinid association of Central Pamirs allows the assemblage to be referred to the Sakmarian. Similarity with assemblages of Central Pamirs, Karakorum, Eastern Hindukush, South Afghanistan, and Oman may evidence that the Posht Badam tectonic block where the section studied is located was a part of the South Tethyan biogeographic province in the Early Permian. **INDEX TERMS:** 0473 Biogeosciences: Paleoclimatology and paleoceanography; 0498 Biogeosciences: General or miscellaneous; 4999 Paleoceanography: General or miscellaneous; 9616 Information Related to Geologic Time: Carboniferous; 9320 Geographic Location: Asia; **KEYWORDS:** Permian, fusulinids, stratigraphy, biogeography, Iran.

**Citation:** Leven, E. Ja., and M. N. Gorgij (2007), Fusulinids of the Khan formation (Kalmard region, eastern Iran) and some problems of their paleobiogeography, *Russ. J. Earth. Sci.*, 9, ES1004, doi:10.2205/2007ES000219.

### Introduction

[2] The Khan Formation established by Afghanabati (1977) to the west of the town of Tabas stretches along the large Kalmard fault dividing the Posht Badam and Tabas tectonic blocks (Figure 1). The formation lies with a hiatus on the Lower Carboniferous Gachal Formation and under the Lower Triassic Sorkh Shale Formation. Fusulinids of the formation were first described by Kahler [1977], who identified them as subspecies "*Pseudofusulina alpina antiqua*" and "*Triticites primarius isfarensis*", known previously from the Upper Carboniferous deposits of the Alps and Fergana. Finds of fusulinids ("*Schwagerina*", "*Pseudofusulina*", "*Staffella*", "*Brevaxina*") were reported by Afghanabati [1977] and used as an evidence for Early Permian age of the formation. Arefifard and Davydov [2004] studied several exposures of the formation. Based on preliminary fusulinid identifications they concluded on Asselian

(possibly Sakmarian) age of its middle and upper parts. V. I. Davydov also indicated similarity of these fusulinids to those of Central Pamirs (pers. comm.).

[3] We studied only one incomplete section of the formation but peculiar endemic fusulinid assemblage found in its upper part is of great interest in terms of age refinement and paleobiogeographic reconstruction. 115 oriented thin sections are stored in the Laboratory of Micropaleontology of the Geological Institute of Russian Academy of Sciences (collection number 4782).

### Brief characteristics of the section

[4] The section is located 90 km to the southwest of the Tabas (33°15'25" and 56°10'14") in the eastern limb of anticline; a core being exposed at the watershed of the Godar-e-Gachal Range stretching northeastward along the Kalmard fault (Figures 1, 2). The core is composed of gypsum and limestone beds of the Gachal Formation. The upper part of the limestones (Bed D) contains scarce brachiopods, conodonts, and foraminifers of Early Carboniferous age

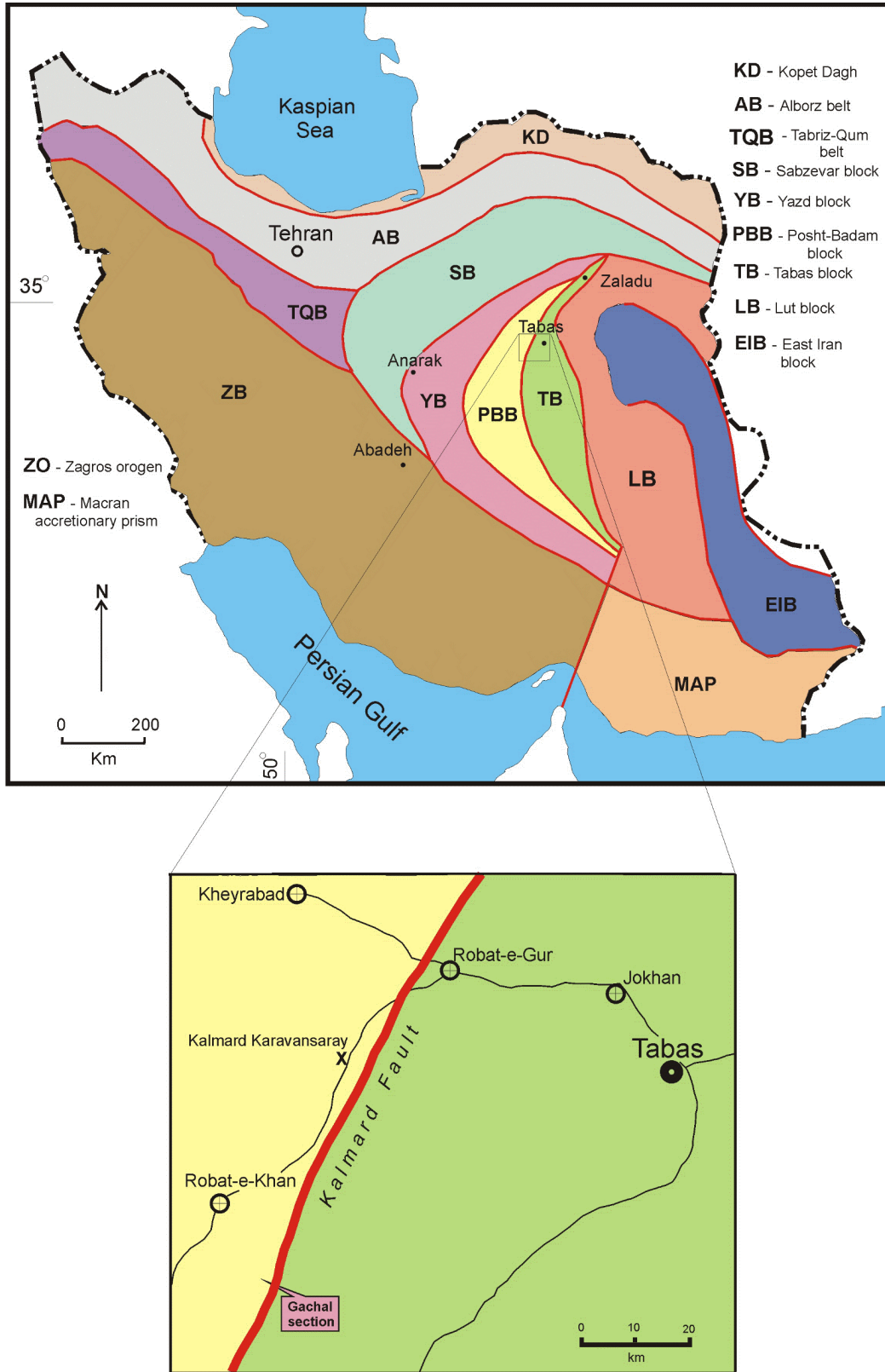
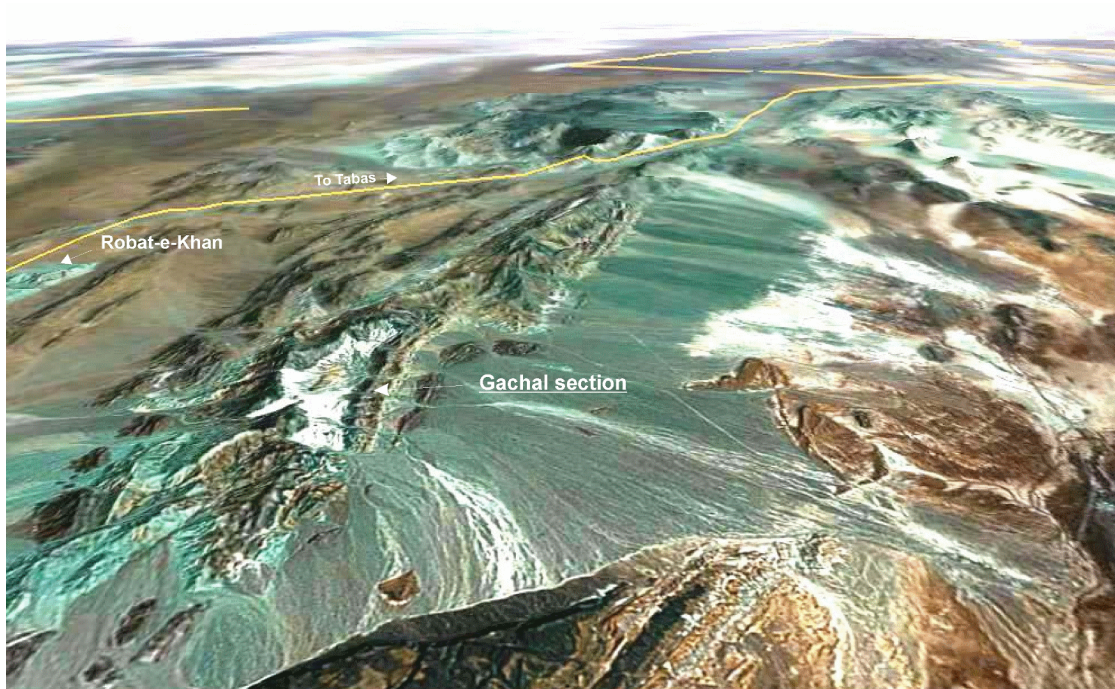


Figure 1. The region under study on the tectonic map of Iran [Alavi, 1991].



**Figure 2.** The region under study. A view from the space. A white spot in the southern part of the ridge is gypsums of the Carboniferous Gachal Formation, which are exposed in the anticlinal core.

[Afghanabati, 1977]. With parallel but distinct stratigraphic disconformity the Gachal Formation is overlain by the Khan Formation. The section lacks the entire Pennsylvanian Series of the Carboniferous and a part of or entire Asselian Stage of the Lower Permian (Figures 3, 4). The following bed succession is observed (from the base upward):

[5] Unit 1. Brown ferruginate, thick-bedded to massive sandstones and sandy dolomites with thin interbeds of lighter color grey biosparitic limestones; basal limestone conglobreccia lie with a sharp contact on Bed D of the Gachal Formation. Thickness 34.5 m.

[6] Unit 2. Grey, locally brown, ferruginate thin- and



**Figure 3.** Photo of the section studied. Below are gypsums (Bed C) and overlying limestones (Bed D) of the Carboniferous Gachal Formation, above is the Permian Khan Formation.



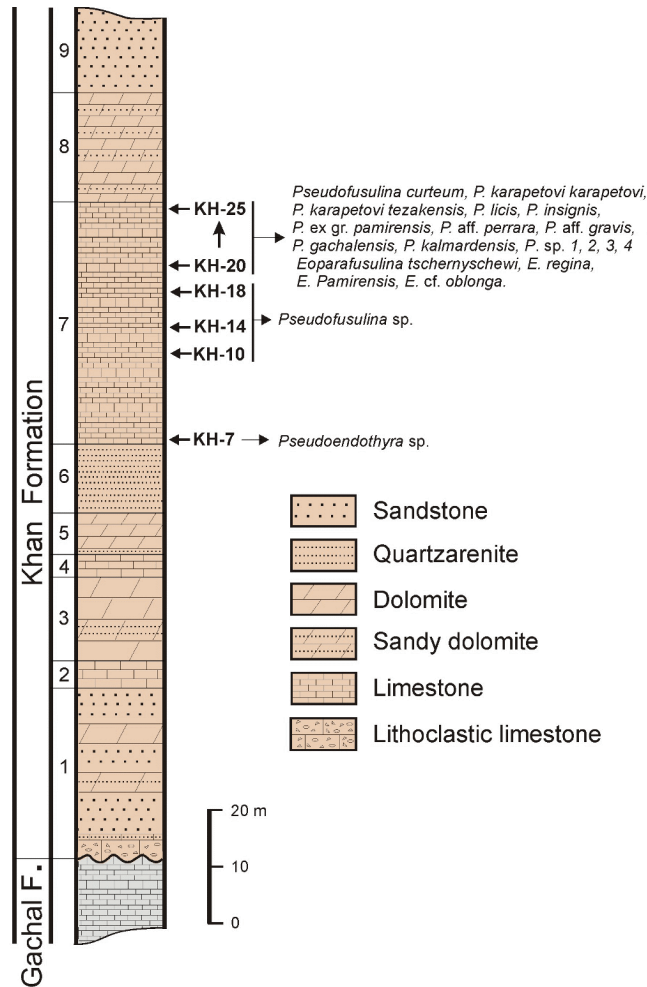


Figure 4. Stratigraphic column and fusulinid locations.

medium-bedded limestones. Thickness 4 m.

[7] Unit 3. Pale grey, brownish medium- and thick-bedded dolomitized limestones and massive sandy dolomites. Thickness 16.5 m.

[8] Unit 4. Grey thin-bedded biotrital limestones with abundant brachiopods. Thickness 4 m.

[9] Unit 5. Brown medium- and thick-bedded dolomites; quartzitic sandstones at the base. Thickness 7.8 m.

[10] Unit 6. White thick-bedded to massive quartzarenite with thin interbeds of biotrital limestones (biomicrites, pelmicrites); fragments of crinoids and bryozoans in debris. Thickness 12.6 m.

[11] Unit 7. Interbedding of grey and light-grey thin- and medium-bedded biotrital limestones with abundant bryozoans, brachiopods, crinoids, and fusulinids. The latter occur throughout the unit but most frequently in the upper part. At the base a thin interbed is overcrowded by badly preserved tests of *Pseudoendothyra* sp. (sample KH7). Single forms of *Pseudofusulina* unidentifiable at species level (samples KH10, KH14, KH18) occur above. Farther up-section species of this genus increase in abundance, locally they overcrowd the rock. These are *Pseudofusulina curteum*

Leven, *P. karapetovi karapetovi* Leven, *P. karapetovi tezakensis* Leven, *P. licis* Leven, *P. insignis* Leven, *P. ex gr. pamirensis* Leven, *P. aff. perrara* Leven, *P. aff. gravis* Leven, *P. gachalensis* n. sp., *P. kalmardensis* n. sp., *Pseudofusulina* sp. 1, 2, 3 and 4. In addition to *Pseudofusulina*, there are frequent *Eoparafusulina tschernyschewi* (Schellwien), *E. regina* Nie et Song, *E. pamirensis* Leven, *E. cf. oblonga* (Grozdilova et Lebedeva), and single *Eoschubertella* ex gr. *obscura* (Lee et Chen) and *Palaeostaffella*(?) sp. (samples KH20, KH22, KH23, KH24, KH24A, KH24D, KH25, and R). Thickness 48.5 m.

[12] Beside fusulinids, R. V. Gorjunova found two bryozoan assemblages. The lower assemblage (samples KH2 and KH13) contains *Goniocladia perillustris* Gorjunova, *Rhombotrypella darvasica* Gorjunova, *Mackinneyella ornamentata* (Schulga-Nesterenko), *Alternifenestella* aff. *absoluta* (Gorjunova), *Streblascopora marmionensis* (Etheridge). The upper assemblage (samples KH16, KH18, KH22) is composed by *Alternifenestella* aff. *megacapillaris* (Sakagami); *Thamniscus* sp. nov.; *Filites* sp. nov., *Hexagonella* aff. *recta* Gorjunova, *Fistulipora enodata* Gorjunova, *Ulrichotrypa* aff. *ramulosa* Bassler, *Streblascopora marmionensis* (Etheridge), *Filites* aff. *quasites* (Trizna), *Diploporaria* sp. nov., *Thamniscus* sp., *Tabulipora* aff. *frugalis* Trizna et Klaučen.

[13] Unit 8. Light-brown massive dolomites and sandy dolomites. Thickness 20 m.

[14] Unit 9. Red, red-brown medium- and coarse-bedded sandstones. Thickness 20 m.

[15] Younger beds of the Khan Formation are missing in the section.

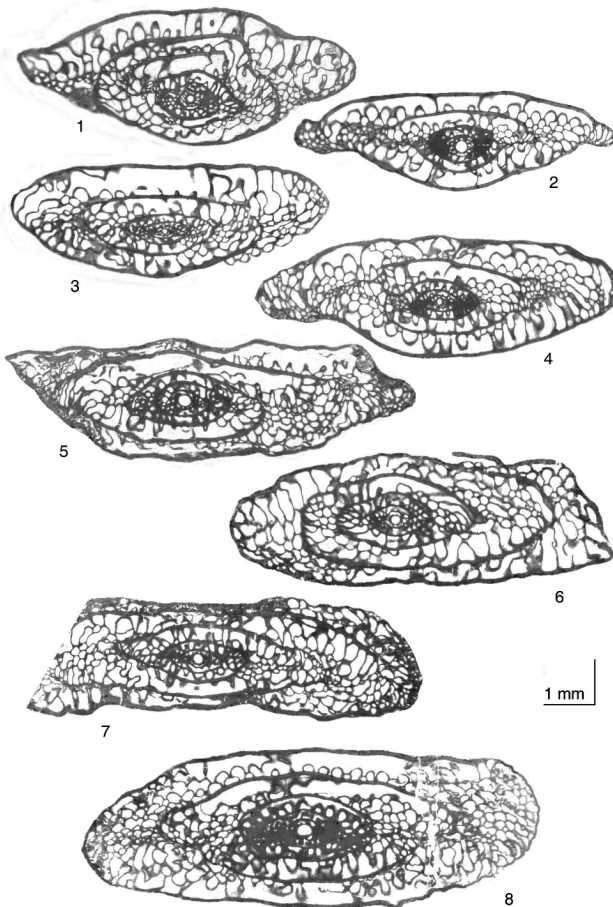
## Analysis of the Fusulinid Assemblage

[16] The lower part of the section (up to Bed KH-20) does not contain fusulinids. The interbeds of biotrital limestones enclose mainly fragments of bryozoans, less frequent brachiopods, crinoids, gastropods, and rare small foraminifers, such as *Tuberitina*, *Globivalvulina*, *Palaeotextularia*, *Climacammina*, *Cribrogenerina* and some others. Fusulinids represented by abundant badly preserved tests of unidentifiable species of *Pseudoendothyra* were first discovered in Bed KH-7. Single *Pseudofusulina* were found in beds KH-10, KH-14, and KH-18 but occur in abundance in beds KH-20–KH-26. They are frequently associated with subordinate *Eoparafusulina*. Primitive *Eoschubertella* and representatives of *Pseudoendothyridae* (*Pseudoendothyra* sp. and *Palaeostaffella*? sp.) are very rare. No trends of distribution of *Pseudofusulina* and *Eoparafusulina* throughout the section have been recorded, and the assemblage is perceived as a single whole.

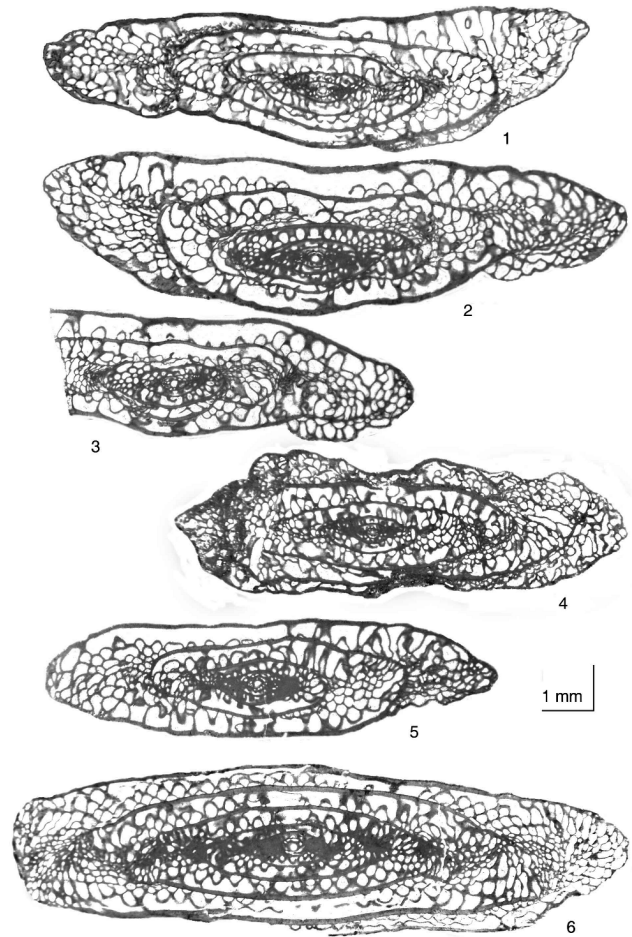
[17] As a whole, the assemblage has a peculiar character due to endemic species of *Pseudofusulina*, which do not occur in most of the known Permian sections of the Tethyan region. It shows a close similarity only to so called “Kalaktash” assemblage from a Lower Permian section of Central Pamirs [Leven, 1993], which is also dominated by *Pseudofusulina* and shares some species of *Pseudofusulina* and *Eoparafusulina*. The only distinc-

tion of the "Kalaktash" assemblage is the presence of *Sphaeroschwagerina*, *Robustoschwagerina* and *Zellia*, which are however rare and were discovered by examining a great number of thin sections (several thousands). The Iranian material is only 115 thin sections, so chances to detect these forms, even if they initially occurred together with *Pseudofusulina*, are few. In spite of great morphological varieties of the *Pseudofusulina* forms, most of them show differently pronounced distinctions of early whorls from later ones. This feature is characteristic of many species of the Kalaktash assemblage.

[18] Endemic fusulinid assemblages composed mostly by *Pseudofusulina* (Plates 1–6) including the Kalaktash species were also found in Karakorum and Eastern Hindukush [Gaetani and Leven, 1993; Gaetani et al., 1995], South Afghanistan [Leven, 1997], and Oman [Angiolini et al., 2006]. The following species of *Pseudofusulina* can be identified in the assemblage studied more or less confidently.



**Plate 1.** 1–4. *Pseudofusulina curteum* Leven. GIN 4782/1, GIN 4782/2, GIN 4782/3, GIN 4782/4, Samples 25, 24D, 24 accordingly; 5, 6. *Pseudofusulina kalaktashensis* Leven. GIN 4782/5, GIN 4782/6, Samples 24 and 22 accordingly; 7. *Pseudofusulina* aff. *gachalensis* n. sp. GIN 4782/7, Sample 22; 8. *Pseudofusulina* sp. 1. GIN 4782/8, Sample 20.

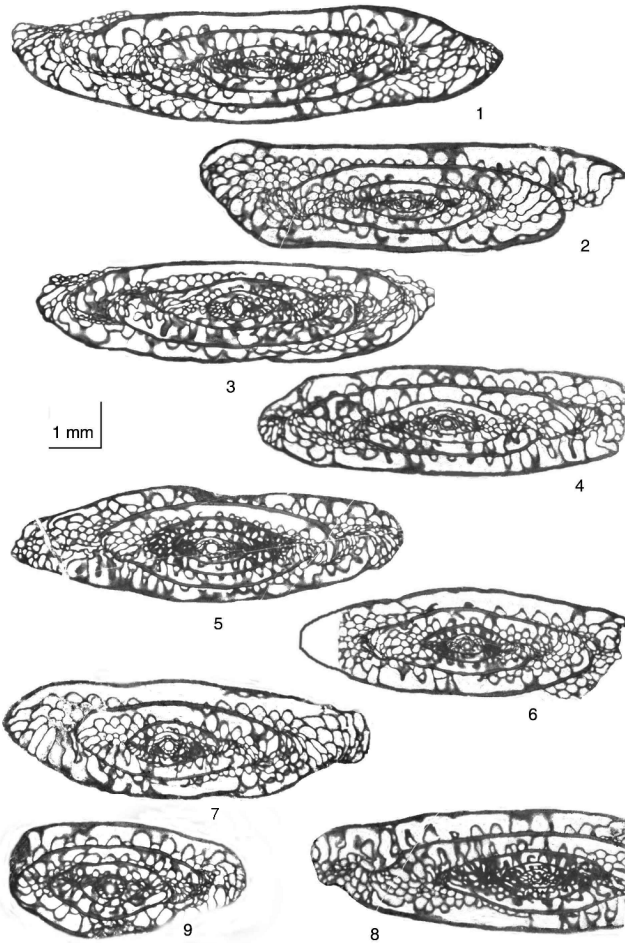


**Plate 2.** 1–5. *Pseudofusulina gachalensis* n. sp. (1, 4, 5) GIN 4782/9 (holotype), GIN 4782/12, GIN 4782/13, Sample 22, (2, 3) GIN 4782/10, GIN 4782/11, Sample 24; 6. *Pseudofusulina* sp. 2. GIN 4782/14, Sample 20.

[19] *Pseudofusulina curteum* Leven (Plate 1, Images 1–4) having a short fusiform shell with flattened central part, sharply increased spiral coiling after the third whorl, small axial fillings in juvenarium. Iranian representatives of the species are not actually different from typical forms described first from the Kalaktash section of Central Pamirs (see [Leven, 1993, Plate 4, Images 5, 7; Plate 5, Images 1, 3]).

[20] *Pseudofusulina karapetovi* Leven reported from both the Central Pamirs section and sections of Hindukush, Afghanistan, and Oman. In the Iranian materials it is represented by two subspecies:

[21] *Pseudofusulina karapetovi karapetovi* Leven (Plate 3, Images 1–4) having true fusiform shell with pointed poles, relatively uniform spiral coiling, and indistinct secondary deposits in initial whorls. The subspecies was first described from South Afghanistan (see [Leven, 1997, Plate 11, Figures 1–5]) and occurs in abundance in the Kalaktash assemblage of Central Pamirs (see [Leven, 1993, Plate 1, Images 4, 9]).



**Plate 3.** 1-4. *Pseudofusulina karapetovi karapetovi* Leven. (1-3) GIN 4782/15, GIN 4782/16, GIN 4782/17, Sample 24D, (4) GIN 4782/18, Sample 24A; 5-8. *Pseudofusulina karapetovi tezakensis* Leven, GIN 4782/19, GIN 4782/20, GIN 4782/21, GIN 4782/22, Samples 24D, 24A, 24A and 24 accordingly; 9. *Pseudofusulina licis* Leven, GIN 4782/44, Sample 24D.

[22] *Pseudofusulina karapetovi tezakensis* Leven (Plate 3, Images 5-8) distinguished from the preceding subspecies by shorter shell and better pronounced secondary deposits in two or three initial whorls. It was also first found from South Afghanistan (see [Leven, 1997, Plate 11, Images 9-11]) and recorded in the Pamirs (see [Leven, 1993, Plate 1, Images 5, 7]) and Oman (see [Angiolini et al., 2006, Plate 1, Images 7-10]).

[23] *Pseudofusulina kalaktashensis* Leven (Plate 1, Images 5, 6) represented by forms close to typical representatives of the species from Central Pamirs (see [Leven, 1993, Plate 2, Images 4-6]) but distinguished by shorter shell and relatively irregular septal fluting.

[24] *Pseudofusulina licis* Leven (Plate 3, Image 9) represented by forms whose parameters are identical of those of type specimens from the Kalaktash section (see [Leven, 1993, Plate 6, Images 3, 4]).

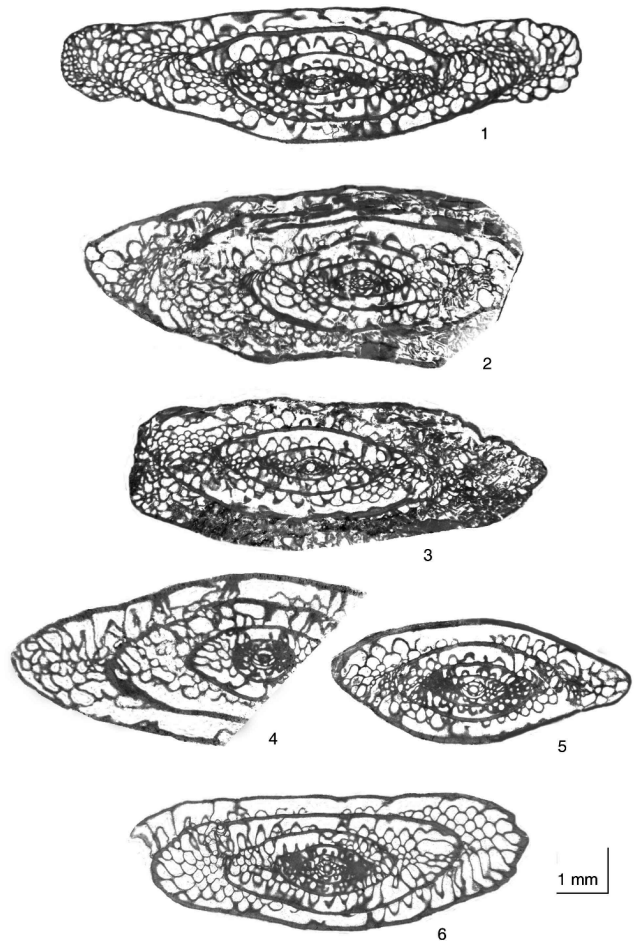
[25] *Pseudofusulina insignis* Leven (Plate 4, Images 4, 6) similar to typical representatives from the Kalaktash section of Central Pamirs (see [Leven, 1993, Plate 4, Images 6, 8]). Similar forms were found in the Rosh Gol section of Eastern Hindukush [Gaetani and Leven, 1993].

[26] *Pseudofusulina* aff. *perrara* Leven (Plate 5, Image 5) distinguished from typical representatives of the species from the Kalaktash section by less elongated shell.

[27] *Pseudofusulina* ex gr. *pamirensis* Leven (Plate 5, Images 1-4) having big elongated shell and thus similar to the Kalaktash typical representatives of the species but distinguished by less regular septal fluring.

[28] *Pseudofusulina* aff. *gravis* Leven (Plate 5, Image 6) resembling forms of this species from Central Pamirs (see [Leven, 1993, Plate 6, Images 6-8, 10]), but differing in looser spiral coiling.

[29] Beside the listed species of *Pseudofusulina*, which were identified to the species of the Kalaktash assemblage, the as-



**Plate 4.** 1-3. *Pseudofusulina kalmardensis* n. sp. GIN 4782/23 (holotype), GIN 4782/24, GIN 4782/25, Samples 24D, 23A and 24 accordingly; 4, 6. *Pseudofusulina insignis* Leven. GIN 4782/26, GIN 4782/28, Samples 23A and 25 accordingly; 5. *Pseudofusulina* ex gr. *karapetovi tezakensis* Leven, GIN 4782/27, Sample 24D.

semblage studied includes unidentifiable forms that may represent new species. Two species were named (*Pseudofusulina kalmardensis* and *P. gachalensis*) and described below. The rest forms were only numbered from 1 to 4.

[30] As noted above, important components of this assemblage, as in the Kalaktash assemblage of Central Pamirs, are species of *Eoparafusulina*. All of them belong to the group of *Eoparafusulina tchernyschewi* (Schellwien) characteristic of the Tastuba Horizon of the Sakmarian Stage of Timan [Grozdilova and Lebedeva, 1961]. The Iranian collection contains four species of the group, i.e., *E. tchernyschewi* (Schellwien), *E. regina* Nie et Song, *E. pamirensis* Leven, and *E. cf. oblonga* (Grozdilova et Lebedeva). The former three species were described from the Kalaktash assemblage [Leven, 1993]. *E. pamirensis* was also found in the Luggar section of Northern Karakorum [Gaetani et al., 1995]. Forms similar to *E. regina* were recorded in the Gudri-Mazar section of South Afghanistan, where they are associated with

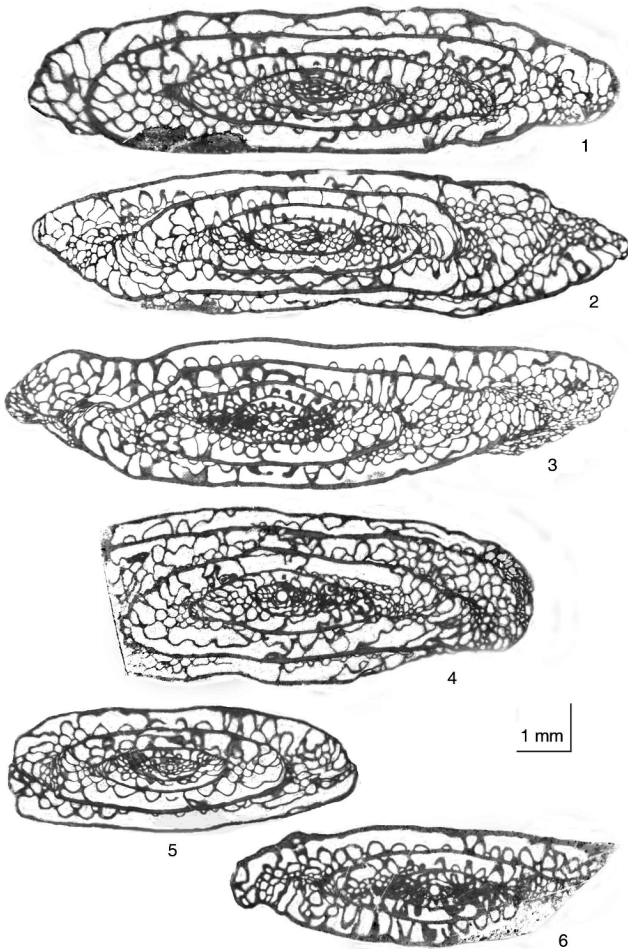
*Pseudofusulina karapetovi* typical of the Kalaktash assemblage and described as a new species *E. afghanensis* (Leven). The four of the listed species *E. oblonga* is characteristic of the lower Sakmarian (Tastuba) deposits of Timan.

[31] The listed species of *Pseudofusulina* and *Eoparafusulina* are main components of the assemblage studied. There are also single *Eoschubertella* cf. *obscura* (Lee et Chen), *Pseudoendothyra* sp., and *Palaeostaffella?* sp. having a wide stratigraphic range but occurring in most abundance in the Middle Carboniferous.

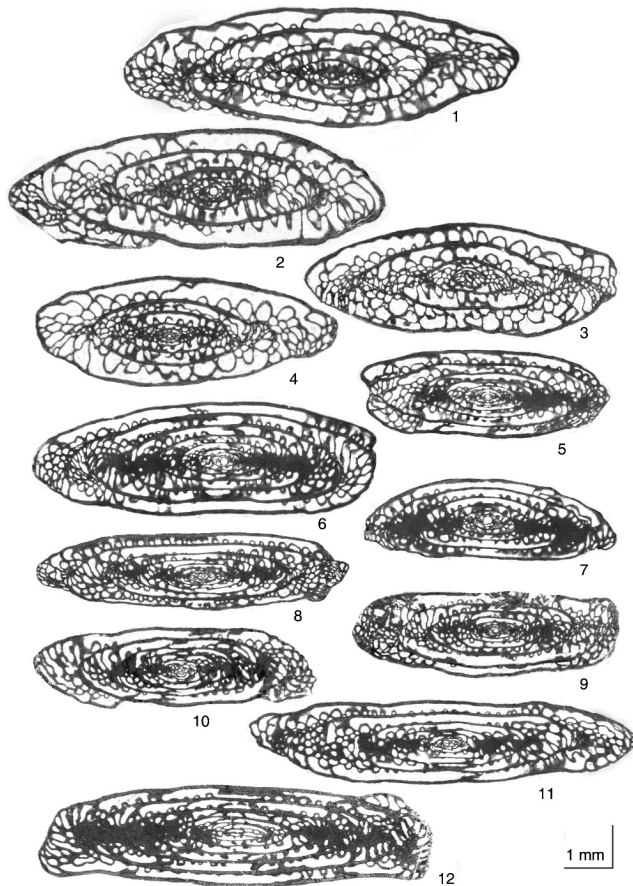
### Age of the Fusulinids and Their Biogeography

[32] The endemism of the fusulinid assemblage under consideration, which prevents correlation to those of well studied Permian sections of the Urals, East European platform, and Tethys, makes dating it difficult. In addition, the Khan Formation containing beds with fusulinids in its middle part is bounded by unconformities between Lower Carboniferous(?) and Triassic deposits. The position in the section does not allow assigning the formation more precisely than to the interval from Middle Carboniferous to Permian.

[33] The only indication of age of the assemblage is provided by its similarity with the Kalaktash assemblage of Central Pamirs. Sakmarian age of the latter assemblage was substantiated in [Leven, 1993] and there is no need to repeat the arguments herein. After the article came out new records that confirmed or contradicted its conclusions were published. The confirming data was derived from sections at the upper part of the Yarkhun River, northern Karakorum (Pakistan). There a fusulinid assemblage similar to the Kalaktash one occurs in deposits between beds with brachiopods (the *Hunzina electa* Zone), which according to Angiolini have Sakmarian age, and beds with fusulinids (*Pamirina*, *Pseudoreichelina*, *Chalaroschwagerina*, *Darvasites*) typical of the Yakhtashian Stage [Gaetani et al., 1995]. The Yakhtashian Stage of the Tethyan scale is commonly considered to be equivalent of the Artinskian of the standard chronostratigraphic scale. If it is correct, the beds with the fusulinid assemblage studied have pre-Yakhtashian (pre-Artinskian), i.e., Sakmarian age. Because isochroneity of the lower boundaries of the Yakhtashian and Artinskian stages has not been proved yet, these beds may belong entirely or partly to the basal portion of the Artinskian Stage. This is indirectly supported by finds of *Streptogathodus* aff. *whitei* in the Upper Pseudoschwagerina limestones of the Southern Alps [Forke, 2002]. The first occurrence of this conodont species is marked the Artinskian lower boundary. Previously the limestones were assigned to upper Asselian-Sarmarian. Presence characteristic for this limestone *Zellia* and *Robustoschwagerina* in the beds with the Kalaktash fusulinid assemblage was a serious argument for Sakmarian age of the beds. The cooccurrence of these fusulinids and Artinskian conodonts makes the argument less important because it appeared that *Zellia* passed from



**Plate 5.** 1–4. *Pseudofusulina* ex gr. *pamirensis* Leven. (1, 2) GIN 4782/29; GIN 4782/30, Sample 24, (3, 4) GIN 4782/31, GIN 4782/32, Samples 25 and 23A accordingly; 5. *Pseudofusulina* aff. *perrara* Leven. GIN 4782/33, Sample 24D; 6. *Pseudofusulina* aff. *gravis* Leven. GIN 4782/34, Sample 22A.



**Plate 6.** 1, 2, 4. *Pseudofusulina* sp. 3. GIN 4782/35, GIN 4782/36, GIN 4782/37, Samples 24D, R and 24A accordingly; 3. *Pseudofusulina* sp. 4, GIN 4782/17, Sample 24D; 5, 9, 10. *Eoparafusulina regina* Nie et Song, GIN 4782/38, GIN 4782/42, GIN 4782/41, Samples 24D, 24 and 24 accordingly; 6. *Eoparafusulina tschernyschewi* (Schellwien). GIN 4782/11, Sample 24; 7. *Eoparafusulina* ex gr. *tschernyschewi* (Schellwien). GIN 4782/39, Sample 24; 8, 11. *Eoparafusulina pamirensis* Leven. GIN 4782/40, GIN 4782/20, Sample 24A; 12. *Eoparafusulina* cf. *oblonga* (Grozdilova et Lebedeva). GIN 4782/43, Sample 25.

the Sakmarian deposits into Artinskian ones. The fact that *Robustoschwagerina* survived till the terminal Early Permian is well known. However in the Kalaktash section *Zellia* and *Robustoschwagerina* are accompanied by *Sphaeroschwagerina*, which has been recorded nowhere above the Sakmarian beds. In addition, the Sakmarian age of the Kalaktash assemblage is evidenced by the same type *Eoparafusulina* as in the lower Sakmarian deposits of Timan and by relatively primitive morphology of *Pseudofusulina* forms as compared with those of the Artinskian beds of the Urals.

[34] Bryozoan records cannot clarify this problem either. According to R. V. Gorjunova, the lower of two bryozoan assemblages of Unit 7 is Asselian-Sakmarian in age and the upper one is Artinskian. In view of their close proximity in

the section, this large age interval seems doubtful. By the way, Artinskian age was also indicated by Gorjunova [1975] for Kalaktash bryozoans of Central Pamirs.

[35] With all reservations from the said above, we take the Sakmarian age for the Kalaktash assemblage and similar fusulinid assemblage of the Khan Formation.

[36] This conclusion somewhat contradicts the datings of F. Kahler mentioned above. However, one of two fusulinid species reproduced in his publication [Kahler, 1977] is identical of *Eoparafusulina pamirensis* of our material and the other may belong to new species *Pseudofusulina gachalensis* described below. So, the identifications of F. Kahler are most likely incorrect. As for the datings of A. Afghanabati, our conclusions make them more precise. It should be noted, however, that fusulinids listed by this author include *Brevaxina*, a genus of higher fusulinids, which is characteristic of the Bolorian Stage of the Lower Permian and found nowhere in older deposits. The presence of this genus in the Khan Formation does not agree with the suggested Sakmarian age. However our age assignment is related to the middle part of the formation only. As noted, the section lacks its upper part, which may contain *Brevaxina*. There is high probability that its identification may appear incorrect but now we are unable to check it.

[37] When describing Asselian fusulinids of Darvaz, Leven and Shcherbovich [1978] noticed differences in Asselian facies and faunas between the northern and southern regions of the Tethys. Correspondingly, the North Tethyan and South Tethyan biogeographic provinces have been established. The differences can be explained by location of the provinces in different climatic belts. The former province occurred within the tropical belt. The latter province stretched along the northern margin of Gondwana, crossing several climatic zones from subtropical in the northwest up to temperate-cold and cold in the southeast. This position brought about succession of biotas peculiar to certain climatic belts. Asselian fusulinids occupied the northwestern part of the province (the Mediterranean region, Turkey, Iran) but were not found in its southeastern part (Afghanistan, Karakorum and farther), where supposed Asselian deposits are represented by terrigenous facies with cool-water fauna of Gondwana-type (bivalves, Conularia, brachiopods, bryozoans).

[38] This paleobiogeographic pattern derived from analysis of the Asselian materials is in accordance with later data on the Sakmarian Stage [Leven, 1993] and distribution of Late Permian foraminifers [Ueno, 2003]. The Sakmarian Kalaktash-type fusulinids are absolutely different from coeval forms of the North Tethyan province. In the South Tethyan province they are known from sections of Oman [Angiolini et al., 2006], South Afghanistan [Leven, 1997], Central Pamirs [Leven, 1993], Eastern Hindukush (the Rosh-Gol section in the Mastuj River basin) [Gaetani and Leven, 1993], northern Karakorum (upper part of the Yarkhun River) [Gaetani et al., 1995]. In the extreme southeast of the province the Kalaktash fusulinids are supposed to occur in the Tengchong and Baoshan tectonic blocks of southwestern China and in the Sibumasu block of western Indo-China. *Monodioxodina*, *Eoparafusulina*, and *Pseudofusulina* were found there. Their host beds are correlated to the Kalaktash deposits [Ueno, 2003] but well devel-



oped *Monodioxodina* indicate their younger age. Most likely these beds are related to the Artinskian (Yakhtashian) Stage because beds bearing similar *Monodioxodina* lie directly on beds with Kalaktash fusulinids in the Rosh-Gol section of East Hindukush [Gaetani et al., 1995]. In Karakorum and southeastern Pamirs the *Monodioxodina* beds are of Bolorian age.

[39] The initial Permian was characterized by temperature minimum and maximal Gondwana glaciation. This explains the fact that terrigenous sequences with glacial interbeds but not carbonates were accumulated over the area from Oman to SE Asia in the South Tethyan province. This also explains occurrence of cool-water fauna in the upper part of the terrigenous sequences. Appearance of carbonates in the sections coincides with the first occurrence of Kalaktash fusulinids. Both are evidently related to a climatic warming.

[40] The fusulinids appeared suddenly. They are not taxonomically diverse but very abundant. It is still unclear from where they migrated. Logically, as climate became warmer, they gradually moved to the southeast from the low-latitude northwestern areas of the South Tethyan province. The Asselian inhabitants may give rise to Sakmarian Kalaktash-type assemblage of fusulinids. This scenario supposes some transitional assemblages, which may occur in eastern Iran or southwestern Afghanistan. No such assemblages have been found. Asselian fusulinids are absent from southern Afghanistan but described from the Anarak (Central Iran) and Ozbak-Kuh (eastern Iran) sections [Leven and Gorgij, 2006; Leven and Taheri, 2003]. They cannot be considered endemic in relation to coeval warm-water fusulinids of the Urals, Alps, Fergana, and Darvaz. Their assemblage is composed of the same genera (*Pseudoschwagerina*, *Sphaeroschwagerina*, *Likharevites*, *Anderssonites*, *Ruzhenzevites*, *Rugosofusulina*, *Pseudofusulina*) and species characteristic of the Asselian of the mentioned areas. Beside *Pseudofusulina*, none of the listed genera is a component of the Kalaktash assemblage. Single *Sphaeroschwagerina* were detected in the Kalaktash section of Central Pamirs. This is especially strange because the Khan section containing the fusulinid assemblage under consideration is located between the Anarak and Ozbak-Kuh sections relatively near (about 100 km) the latter section. The alien character of this assemblage probably stems from the position of the Khan section in the Posht-Badam tectonic block separated from the neighboring Yazd (the Anarak section) and Tabas (the Ozbak-Kuh section) blocks by the large fault (Figure 1). It should not be excluded that the recent position of the blocks in Central and Eastern Iran is a consequence of complex tectonic evolution of the region. Initially they may be very far from each other. Special investigations are needed to judge more definitely.

## Conclusions

[41] The fusulinid assemblage from the Khan Formation shows close similarity with the Kalaktash one of Central Pamirs and thus can be dated as Sakmarian.

[42] Previously Sakmarian deposits have not been recorded in the Iranian territory. Supposed Sakmarian age of the Dorud (Alborz) and Vazhnan (northern Zagros) formations has not been confirmed by recent fusulinid finds. They are most likely Asselian.

[43] The fusulinid assemblage of the Khan Formation is characteristic of the Peri-Gondwana South Tethyan province of relatively high paleolatitudes and essentially different from fusulinid associations of the near-equatorial North Tethyan province. The Asselian fusulinids of Iran are similar to the warm-water North Tethyan assemblages. The recent neighboring location of Asselian warm-water and Sakmarian relatively cool-water assemblages is surprising, the more so as they demonstrate no inheritance.

## Description of New Species

### *Pseudofusulina gachalensis* Leven, n. sp.

[44] Plate 2, Images 1–5

[45] **Etymology.** The species is named for the Gachal section where it was found.

[46] **Holotype.** GIN 4782/9. Subaxial section; Iran, Gachal section, Khan Formation; Lower Permian, Sakmarian (?).

[47] **Material.** 8 axial and subaxial sections.

[48] **Description.** Shell moderately large, irregular fusiform to subcylindrical, with bluntly pointed poles. Adult specimens have 5 to 5.5 volutions and measure 8.5 to 11 mm in length and 2.3 to 2.8 mm in diameter. First 2 to 3.5 whorls rather tightly coiled but later ones loose; form ratio 3.3 to 4.2. Spirotheca composed of tectum and rather fine-textured keriotheca 0.1 to 0.12 mm thick in outer volution. Septa thin strongly fluted from pole to pole rather regularly in inner volutions and very irregularly in later ones. Proloculus small, its outside diameter 0.175 to 0.185 mm. Tunnel low and not very wide. Chomata weak, present in first one-two volutions. Small axial fillings sometimes present in first two or three volutions.

[49] **Discussion.** The species is characterized by sharp differences in shell form, spiral coiling and fluting at early and later stages of evolution: as spiral becomes wider, shell wall is curved and fluting is irregular. In this respect the species somewhat resembles *Pseudofusulina curteum* Leven but differs in very elongated shell.

[50] **Stratigraphic range and occurrence.** The same as holotype.

### *Pseudofusulina kalmardensis* Leven, n. sp.

[51] Plate 4, Images 1–3

[52] **Etymology.** The species is named for the Kalmard area where Gachal section is locate.

[53] **Holotype.** GIN 4782/23. Axial section; Iran, Gachal section, Khan Formation; Lower Permian, Sakmarian (?).

[54] **Material.** 3 axial and 2 sagittal sections.

[55] **Description.** Shell moderately large, elongate fusiform with bluntly rounded to bluntly pointed poles. Adult specimens have 4.5 to 5.5 loosely coiled volutions and measure 9 to 10 mm in length and 2.7 to 3 mm in diameter; early 1.5 to 2 whorls rather tightly coiled but later ones loose; form ratio 3.3 to 3.8. Spirotheca composed of tectum and rather fine-textured keriotheca 0.07 to 0.10 mm thick in outer volution. Septa thin strongly fluted from pole to pole. Septal folds rather high and rounded. Proloculus middle of size, its outside diameter 0.12 to 0.18 mm. Tunnel low and not very wide. Chomata weak, present in first one-two volutions.

[56] **Discussion.** *Pseudofusulina kalmardensis* n. sp. is distinguished from *P. gachalensis* n. sp. by regular shell form, more uniform spiral coiling, and more regular septal fluting. The species resembles *P. moelleri* (Schellwien), especially a form from the Tastuba Horizon of Northern Timan which was arbitrarily referred to this species [Grozdilova and Lebedeva, 1961, Plate 12, Image 4]. From true *P. moelleri* it differs in looser coiling and looser and less regular septal fluting.

[57] **Stratigraphic range and occurrence.** The same as holotype.

[58] **Acknowledgments.** The authors thank R. V. Gorjunova for identifications of bryozoan specimens. This work was supported by the Russian Foundation for Basic Research, projects Nos. 06-05-65201 and 06-05-39015-GFEN-a.

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