Journal of Paleontology, Volume 95, Memoir 81, 2021, p. 1–30

0022-3360/21/1937-2337
doi: 10.1017/jpa.2020.46

JOURNAL OF PALEONTOLOGY
A PUBLICATION OF THE Paleontological SOCIETY

Biostratigraphy, taxonomy and paleobiogeography of the upper Cisuralian (upper Yakhtashian–Bolorian) foraminifers from east-central Iran, with clarification of the taxonomy of the fusulinid genera *Cuniculinella* and *Cuniculina* pre-occupied

Safoora Yasbolaghi Sharahi,[1] Bizhan Yousefi Yeganeh,[1] Sakineh Arefifard,[1]* Daniel Vachard,[2] and Mohammad Mehdi Farahpour[1]

[1]Geology Department, Faculty of Sciences, Lorestan University, Khorramabad, Iran *<arefi.s@lu.ac.ir>, <sharahi.sa@fs.lu.ac.ir>, <yousefi.b@lu.ac.ir>, <farahpour.m@lu.ac.ir>
[2]Department of Palaeontology, Faculty of Sciences, University of Lille, Villeneuve d'Ascq, France <daniel.vachard@univ-lille.fr>

Abstract.—Detailed studies of upper Cisuralian (i.e., upper lower Permian) fusulinids make it possible to decipher the paleobiogeographic relations of central Iran, as part of the Cimmerian terranes, with other Paleotethyan regions. Two sections, Bagh-e Vang and Shesh Angosht, located in east-central Iran, are revised. Four local fusulinid biozones are distinguished: upper Yakhtashian *Pamirina darvasica* and *Sakmarella* spp. Zone, lower Bolorian *Misellina* (*Brevaxina*) *dyrhenfurthi* Zone, mid-Bolorian *Cuniculinella* Zone, and upper Bolorian *Misellina* (*Misellina*) cf. *M.* (*M.*) *termieri* Zone (probably equivalent to the traditional *Misellina* (*Brevaxina*) *parvicostata* Zone). Taxonomically, the main results are as follows: (1) a clarification is provided of the fusulinid genus or subgenus "*Cuniculina*," the name of which is pre-occupied, and its synonymy with *Cuniculinella*; and (2) a lectotype is designated for *Darvasites* (*Alpites*) *sinensis* (Chen, 1934). The mid-Bolorian *Cuniculinella* Zone is recognized for the first time in Iran. Among the Bolorian fusulinids, *Cuniculinella* is reported in SE Pamir, Karakoram, central Afghanistan, SW Japan, central Japan, and California, confirming the faunal affinity of the study area in east-central Iran with both Paleotethyan and Panthalassan bioprovinces. Such a distribution is considered to have resulted from combined effects of global warming during the upper Cisuralian, warm oceanic currents along the Paleotethys Ocean, and the northward drift of the Iran block toward lower paleolatitudes.

Introduction

In east-central Iran, the Jamal Formation is underlain by the Carboniferous–lower Permian shales and sandstones of the Sardar Formation (e.g., Leven and Taheri, 2003) and is composed, from base to top, of gray medium-bedded, sandy bioclastic grainstone, gray thick-bedded calcareous conglomerate, red marl and alternating calcareous shale, and gray to dark gray, medium- to thin-bedded bioclastic wackestone to packstone. Outcrops of the Jamal Formation in the Shirgesht area, north of the town of Tabas, were first studied by Ruttner et al. (1968), who assigned a late Permian age. They are composed mainly of limestone and dolomitic limestone, with chert nodules, containing small foraminifers, fusulinids, calcareous algae, bryozoans, brachiopods, crinoids, and corals. The basal part of the Jamal Formation has well-exposed outcrops on the western side of Bagh-e Vang Mountain and on the northwestern side of Shesh Angosht Mountain (Fig. 1) and is named the Bagh-e Vang Formation (Partoazar, 1995). The basal part of the Jamal Formation was named the Bagh-e Vang Member by Leven and Vaziri Moghaddam (2004) in the Shirgesht area (eastern Iran), but later was considered as a formation at the base of the Shirgest Group (Leven et al., 2006). It includes calcareous algae, smaller foraminifers, fusulinids, corals, bryozoans, brachiopods, crinoids, ostracodes, and ammonoids (Fig. 2). The boundary between the Bagh-e Vang and Sardar formations is a disconformity, and there are some additional discontunities as a result of minor faulting.

Kahler (1974) examined the fusulinid contents of a few samples collected from the Shesh Angosht section and assigned them to the *Misellina* Zone of Kungurian age. Partoazar (1995) considered the Bagh-e Vang Formation in the type section as Asselian–Sakmarian in age based on its fusulinid content. Later, Leven and Vaziri Moghaddam (2004) re-examined the biostratigraphy of the Bagh-e Vang Formation using fusulinids and identified several fusulinid biozones, in ascending order, including *Pamirina-Mesoschubertella*, *Misellina-Chalaroschwagerina-Paraleeina*, and *Misellina-Armenina*, ranging in age from upper Cisuralian to possibly lower Guadalupian (i.e., lower–middle Permian boundary interval). Although most fusulinid assemblages of the Bagh-e Vang Formation in the type section are indicative of the upper Cisuralian, the age of the upper part of this formation remains uncertain. Therefore, it is necessary to check the precise age of the Bagh-e Vang Formation in the Shesh Angosht section, which has not been examined using high-resolution biostratigraphy.

*Corresponding author

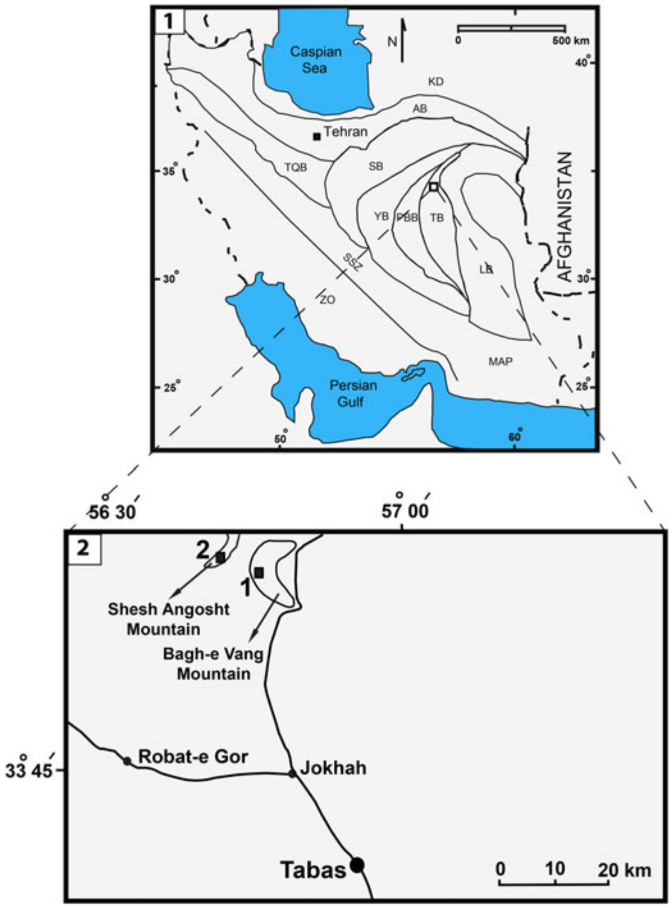

Figure 1. (1) Location map showing the position of studied sections in the east-central Iran, Tabas area. Abbreviations: AB = Alborz Belt; KD = Kopeh Dagh, LB = Lut Block, MAP = Makran accretionary Prism, PBB = Posht-e-Badam Block, SB = Sabzevar Block, SSZ = Sanandaj-Sirjan Zone, TB = Tabas Block, TQB = Tabriz-Qom Block, YB = Yazad Block, ZO = Zagros Orogen. (2) Enlarged map showing the studied sections in the Tabas area, east-central Iran: 1 = Bagh-e Vang section; 2 = Shesh Angosht section.

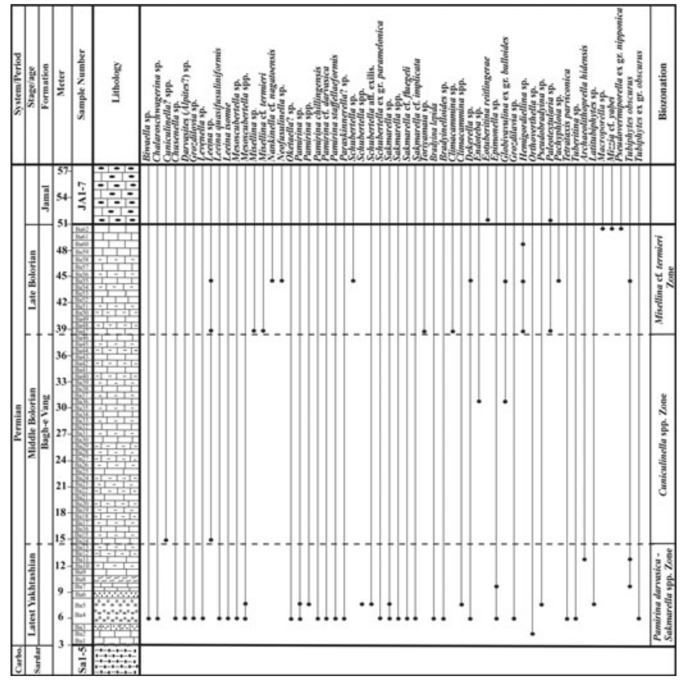

Figure 2. Fusulinid biozonation and faunal distribution of the Bagh-e Vang Formation, Bagh-e Vang section, east-central Iran. Abbreviation: Carbo. = Carboniferous.

Here, we examine lithological and faunal changes within the Bagh-e Vang Formation at two stratigraphic sections in the Bagh-e Vang and Shesh Angosht mountains. The Bagh-e Vang section is located 54 km north of Tabas and the Shesh Angosht section is 4 km northwest of the Bagh-e Vang section. Unlike at the Bagh-e Vang section, the basal part of the Bagh-e Vang Formation at Shesh Angosht does not contain sandy bioclastic grainstone, calcareous conglomerate, and red marls. It is instead composed of alternating bioclastic wackestone and/or packstone with calcareous shales and lies conformably on greenish shales and sandstones of the Sardar Formation (Fig. 2). The purpose of this research is to: (1) identify the foraminiferal fauna and calcareous algae flora of the Bagh-e Vang Formation in both sections, (2) describe their biozones and stratigraphic distribution, and (3) discuss the paleobiogeographic affinity of their fusulinid faunas.

Geological setting

The area under study is situated in the Tabas Block (Fig. 1). The Tabas Block is bounded to the west by the Kalmard fault and to the east by the Nayband fault, which are both strike-slip faults (Alavi, 1991). The Tabas Block, together with the Posht-e Badam, Yazd, and Lut blocks, forms the Central Iranian Midcontinent. Ruttner et al. (1968) reported more than 8 km of Paleozoic deposits in this block; these outcrops represent the most complete Paleozoic section of the Central Iran Midcontinent and include Upper Devonian and upper Carboniferous deposits that are missing in most parts of Iran. The Permian stratigraphic sections in the Shirgesht area include deposits that span the early Permian, with early part of the early Permian in the Zaladu section and the later part of the early Permian in the Bagh-e Vang and Shesh Angosht sections. There are also some outcrops of mid- and late Permian carbonates in the Tabas Block, both in the type section of the Jamal Formation and elsewhere. Therefore, the study of this block is particularly significant in terms of paleobiogeographic and tectonic reconstructions of Iran during the late Paleozoic.

Biostratigraphy

In this study, the series are subdivided into four biozones, which are: (1) *Pamirina darvasica* and *Sakmarella* spp. Zone, upper Yakhtashian; (2) *Misellina* (*Brevaxina*) *dyrhenfurthi* Zone, lower Bolorian; (3) *Cuniculinella* spp. Zone, mid-Bolorian); and (4) *Misellina* (*Misellina*) cf. *M.* (*M.*) *termieri* Zone, upper Bolorian (Fig. 2). The photomicrographs of the identified fusulinids, smaller foraminifer, microproblematica, and algae of this study are provided in Figures 3–7 for the Bagh-e Vang section and Figures 9–14 for the Shesh Angosht section.

Biozone 1.—Pamirina darvasica and *Sakmarella* spp. Zone

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

Figure 3. Lower Permian small foraminiferans and calcareous algae from the Bagh-e Vang Formation, Bagh-e Vang section, in east-central Iran. (**1, 2**) *Tetrataxis parviconica* Lee and Chen in Lee, Chen, and Chu, 1930, (**1**) axial section, BA-4-5-2, ALU-902, (**2**) subaxial section, BA-4-30-3, ALU-903; (**3–6**) *Bradyina* ex gr. *B. lepida* Reitlinger, 1950, (**3**) subaxial section, BA-4-16-2, ALU-909, (**4**) axial section, BA-4-26-1, ALU-910, (**5**) subaxial section, BA-4-31-1, ALU-911, (**6**) oblique subaxial section, BA-4-49-2, ALU-912; (**7, 8**) *Deckerella* sp., (**7**) subaxial section, BA-4-24-4-1, ALU-913, (**8**) oblique section, BA-4-54-2, ALU-914; (**9**) *Bradyina* sp. 2, axial section, BA-4-49-1, ALU-916; (**10**) *Bradyina* sp. 3, transverse section, BA-5-2-3, ALU-917; (**11**) *Endoteba* sp., axial section, BA-36-4, ALU-944; (**12, 13**) *Climacammina* spp., four subaxial sections, (**12**) BA-5-14-1, ALU-919, (**13**) BA-5-19-4, ALU-920; (**14, 15**) *Globivalvulina* ex gr. *G. bulloides* (Brady, 1876), (**14**) transverse section, BA-36-2, ALU-942, (**15**) transverse section, BA-55-14-2, ALU-943; (**16–18**) *Hemigordiellina* sp., three random sections, (**16**) BA-47-10-2, ALU-945, (**17**) BA-47-12-1, ALU-946, (**18**) BA-47-12-3, ALU-947; (**19**) *Palaeotextularia* sp., subaxial section, BA-47-11-1, ALU-954; (**20**) *Pachyphloia* sp., axial section, BA-55-13-2, ALU-956; (**21, 22**). *Orthovertella* sp., (**21**) subaxial section, BA-3-1, ALU-958, (**22**) subaxial section, BA-3-3, ALU-959; (**23**) *Agathammina* sp., subaxial section, BA-47-15-1, ALU-960; (**24, 25**) *Epimonella* sp., two longitudinal sections, (**24**) BA-4-9-3, ALU-969, (**25**) BA-7-6, ALU-970; (**26**) *Archaeolithoporella hidensis* Endo, 1961, transverse section of an oncoidal grain of tebagite type, BA-11-6, ALU-996; (**27**) *Tubiphytes obscurus* Maslov, 1956, transverse section, BA-55-4-1, ALU-993; (**28**) *Mizzia* cf. *M. yabei* (Karpinsky, 1909) emend. Pia, 1920, transverse section, BA-62-2, ALU-1003; (**29**) *Macroporella* sp., subaxial section, BA-62-3, ALU-1004.

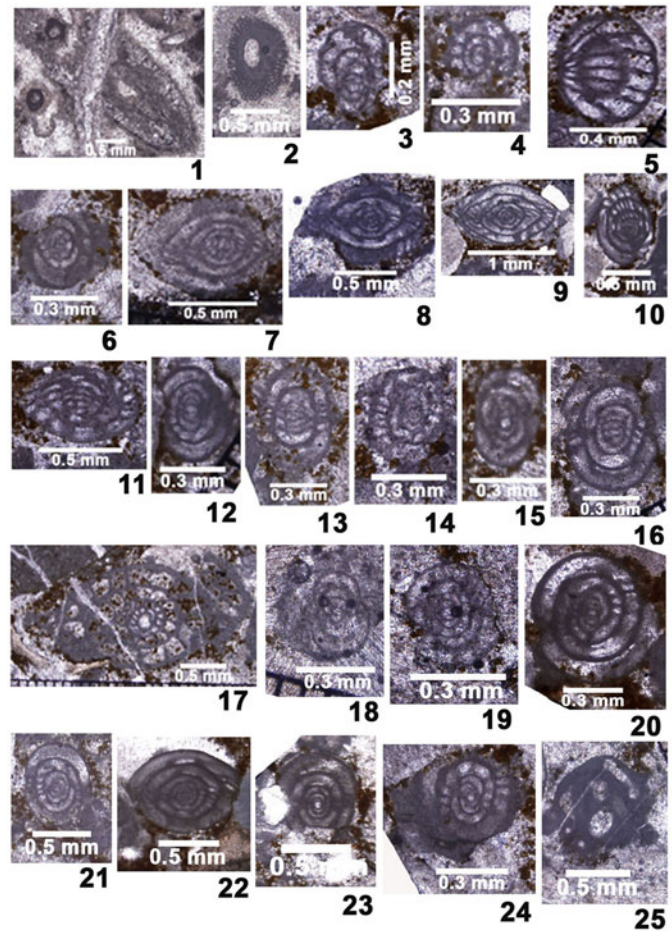

Figure 4. Lower Permian fusulinids and calcareous algae from the Bagh-e Vang Formation, Bagh-e Vang section, in east-central Iran. (**1**) *Permocalculus* sp., longitudinal section, BA-62-8, ALU-1010; (**2**) *Pseudovermiporella* ex gr. *P. nipponica* (Endo in Endo and Kanuma, 1954), transverse section, BA-62-10, ALU-1012; (**3, 4**) *Levenella* sp. transitional to *Pamirina* sp., (**3**) oblique section, BA-4-1-3, ALU-1015, (**4**) transverse section, BA-4-1-4, ALU-1016; (**5, 6**) *Pamirina* spp., (**5**) subtransverse section, BA-4-8-1, ALU-1026, (**6**) oblique section, BA-4-15-1, ALU-1027; (**7–11**) *Mesoschubertella* spp., five different sections, (**7**) BA-4-4-3, ALU-1017, (**8**) BA-2-5-1, ALU-1019, (**9**) BA-4-6-2, ALU-1020, (**10**) BA-4-15-2, ALU-1022, (**11**) BA-4-8-4, ALU-1021; (**12–15**) *Pamirina chilingensis* (Wang and Sun, 1973), (**12**) axial section, BA-4-8-2, ALU-1028, (**13**) subaxial section, BA-4-10-2, ALU-1029, (**14**) oblique section, BA-4-16, ALU-1030, (**15**) axial section, BA-4-15-3, ALU-1031; (**17**) *Chusenella*? sp., oblique section, BA-4-14-2, ALU-1034; (**16, 18–20**) *Pamirina* cf. *P. darvasica* Leven, 1970, (**16**) subaxial section, BA-4-30-1, ALU-1048, (**18**) axial section, BA-4-30-8, ALU-1049, (**19**) oblique section, BA-4-32-1, ALU-1050, (**20**) oblique section, BA-4-22-1, ALU-1051; (**21**) *Pamirina staffellaeformis* Zhou, Sheng, and Wang, 1987, axial section, BA-4-42-2, ALU-1057; (**22**) *Schubertella* ex gr. *S. paramelonica* Suleimanov, 1949, axial section, BA-4-53-2, ALU-1062; (**23, 24**) *Pamirina darvasica* Leven, 1970, (**23**) axial section, BA-4-56-2, ALU-1063, (**24**) oblique section, BA-42-57-2, ALU-1064; (**25**) *Latitubiphytes*, oblique section, BA-5-5-2, ALU-1067.

Definition.—This zone, with a thickness of ∼8 m in the Bagh-e Vang section, is an assemblage zone characterized by the first occurences of two fusulinid markers, *Pamirina* and *Sakmarella*. The base of this biozone rests on the Sardar Formation. The top of this biozone is characterized by the first occurrence/first appearance datum (FO/FAD) of the markers of the overlying zone (i.e., several species of the fusulinid *Cuniculinella*; see later discussion, with "*Cuniculina*" pre-occupied). It is noteworthy that the FO of *Pamirina* is probably coeval with its probable FAD in the Pamirs in the upper Yakhtashian (see Leven, 1970; Davydov et al., 2013).

Distribution.—This first biozone is recorded in the Bagh-e Vang section, from samples BA-4 to BA-13, but not in the Shesh Angosht section.

Composition.—The microproblematica, smaller foraminifers, and fusulinids in biozone 1 (Figs. 3–6) include *Archaeolithoporella hidensis* Endo, 1961; *Tubiphytes obscurus*

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

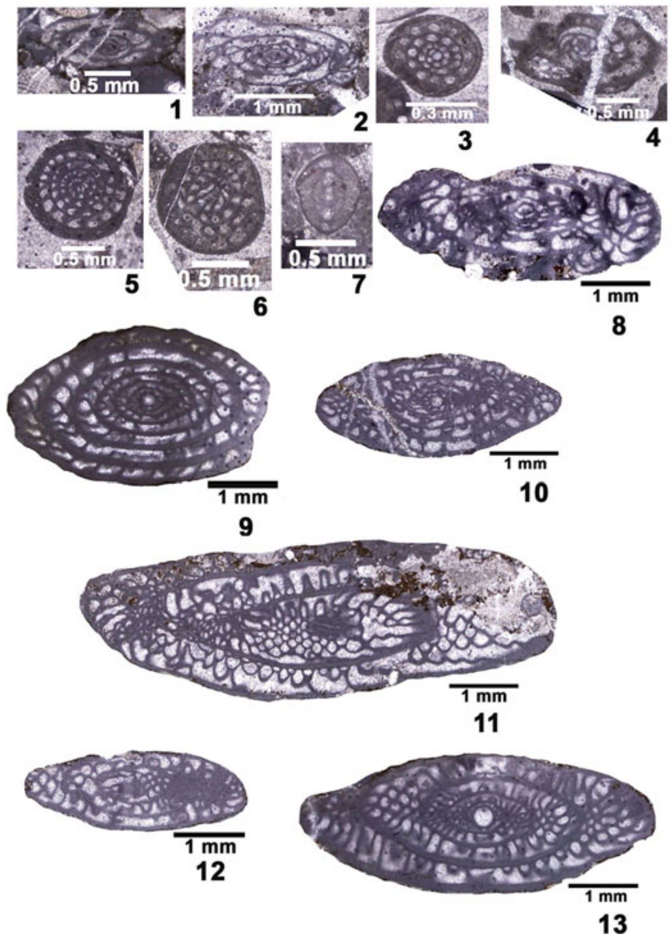

Figure 5. Lower Permian fusulinids from the Bagh-e Vang Formation, Bagh-e Vang section, in east-central Iran. (**1, 2**) *Schubertella* aff. *S. exilis* Suleimanov, 1949, (**1**) subaxial section, BA-5-9-3, ALU-1078, (**2**) axial section, BA-5-12-2, ALU-1079; (**3**) *Misellina* (*Misellina*) sp., BA-47-1-1, ALU-1102; (**4**) *Toriyamaia* sp., axial section, BA-47-11-2, ALU-1104; (**5, 6**) *Misellina* (*Misellina*) cf. *M.* (*M.*) *termieri* (Deprat, 1915), (**5**) transverse section, BA-47-12-4, ALU-1105, (**6**) oblique subaxial section, BA-47-13-1, ALU-1106; (**7**) *Nankinella* cf. *N. nagatoensis* Toriyama, 1958, axial section, BA-57-15-1, ALU-1109; (**8**) *Grozdilovia* sp., subaxial section, BA-4-2-2, ALU-1110; (**9**) *Darvasites* (*Alpites*?) sp., oblique section, BA-4-17-12-2, ALU-1111; (**11**) *Sakmarella* cf. *S. fluegeli* Davydov in Davydov, Krainer, and Chernykh, 2013, subaxial section, BA-4-11-2, ALU-1112; (**10, 12**) *Sakmarella* spp., (**10**) axial section, BA-4-19-3, ALU-1113, (**12**) oblique subaxial section, BA-4-27-1-1, ALU-1115; (**13**) *Sakmarella* cf. *S. implicata* (Schellwien, 1908), axial section, BA-4-37-1, ALU-1116.

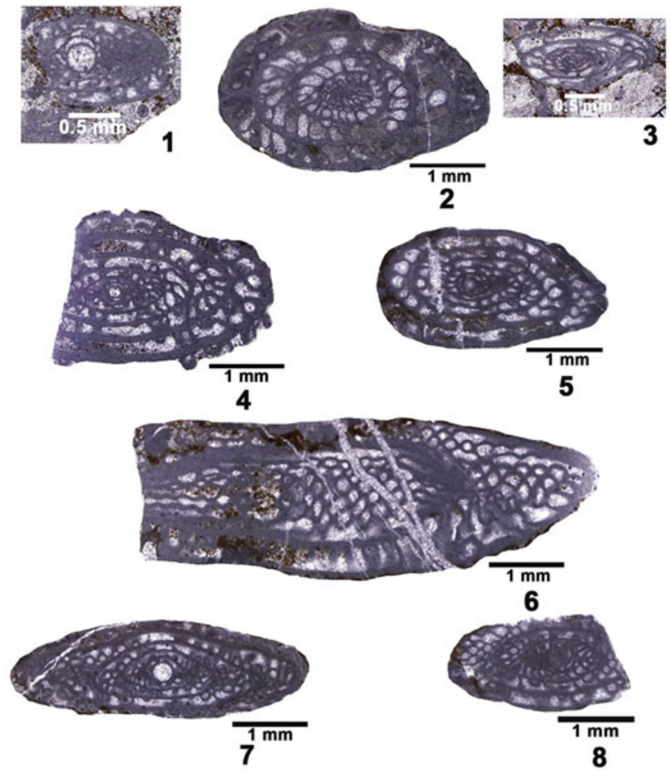

Figure 6. Lower Permian fusulinids from the Bagh-e Vang Formation, Bagh-e Vang section, in east-central Iran. (**1**) *Leeina* cf. *L. quasifusuliniformis* (Leven, 1967), axial section, BA-4-38-1, ALU-1117; (**2**) *Chalaroschwagerina* sp., oblique section, BA-4-41-1-1, ALU-1118; (**3**) *Biwaella* sp., axial section, BA-4-57-5, ALU-1119; (**4, 5**) *Sakmarella* spp., (**4**) axial section, BA-4-47-1, ALU-1120, (**5**) oblique section, BA-5-4-3, ALU-1121; (**6**) *Paraskinnerella*? sp., subaxial section, BA-4-53-1, ALU-1122; (**7, 8**) *Sakmarella* spp., (**7**) axial section, BA-5-20-1-1, ALU-1124, (**8**) subaxial section, BA-5-8-2, ALU-1126.

Maslov, 1956; *T.* ex gr. *obscurus*; *Epimonella* sp.; *Latitubiphytes* sp.; *Eotuberitina reitlingerae* Miklukho-Maklay, 1958; *Bradyina* ex gr. *lepida* Reitlinger, 1950; *B.* sp. 2; *B.* sp. 3; *Climacammina* spp.; *Deckerella* sp.; *Tetrataxis parviconica* Lee and Chen in Lee, Chen, and Chu, 1930; *Orthovertella* sp.; *Hemigordiellina* sp.; *Schubertella* ex gr. *S. paramelonica* Suleimanov, 1949; *S.* aff. *S. exilis* Suleimanov, 1949; *S.* spp.; *Toriyamaia* sp.; *Mesoschubertella* sp.; *Biwaella* sp.; *Levenella* sp.; *Pamirina darvasica* Leven, 1970; *P. chinlingensis* (Wang and Sun, 1973); *P. staffellaeformis* Zhou, Sheng, and Wang, 1987; *P.* sp.; *Darvasites* (*Alpites*?) sp.; *Sakmarella* cf. *S. fluegeli* Davydov in Davydov, Krainer, and Chernykh, 2013; *S.* cf. *S. implicata* (Schellwien, 1908); *Leeina* cf. *L. quasifusuliniformis* (Leven, 1967); *Grozdilovia* sp.; *Chalaroschwagerina*? sp.; *Chusenella* sp.; *Paraskinnerella*? sp.

Remarks.—The regional *Pamirina darvasica* and *Sakmarella* spp. Zone is assigned to the upper Yakhtashian based on the recent dating of the *Pamirina darvasica* Zone of Darvaz by Davydov et al. (2013) and Krainer et al. (2019) in the Carnic Alps. However, the same interval was previously included in the lower Bolorian by Leven and Vaziri Moghaddam (2004), who had another interpretation of the stratigraphic range of *Pamirina* (see discussion in Davydov et al., 2013).

Biozone 2.—Misellina (*Brevaxina*) *dyrhenfurthi* Zone

Definition.—This zone is the range zone of *Misellina* (*Brevaxina*) *dyrhrenfurthi* (Dutkevich in Likharev, 1939), with a thickness of 3 m in the Shesh Angosht section. The lower boundary of this zone is characterized by the FO/FAD of *Misellina* (*Brevaxina*) *dyhrenfurthi* and its upper boundary is marked by the last occurrence/last appearance datum (LO/LAD) of *Misellina* (*Brevaxina*) *dyhrenfurthi* and/or the FO/FAD of *Cuniculinella*.

Distribution.—*Misellina* (*Brevaxina*) *dyrhenfurthi* was not recovered in our samples from the Bagh-e Vang section, but it was found in this locality by Leven and Vaziri Moghaddam (2004). We have found *Misellina* (*Brevaxina*) *dyrhenfurthi* in the Shesh Angosht section (Fig. 8), where it is present in the SHB-1 to SHB-3 samples.

Composition.—The second biozone contains the microproblematica, smaller foraminifers, and fusulinids: *Tubiphytes*

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

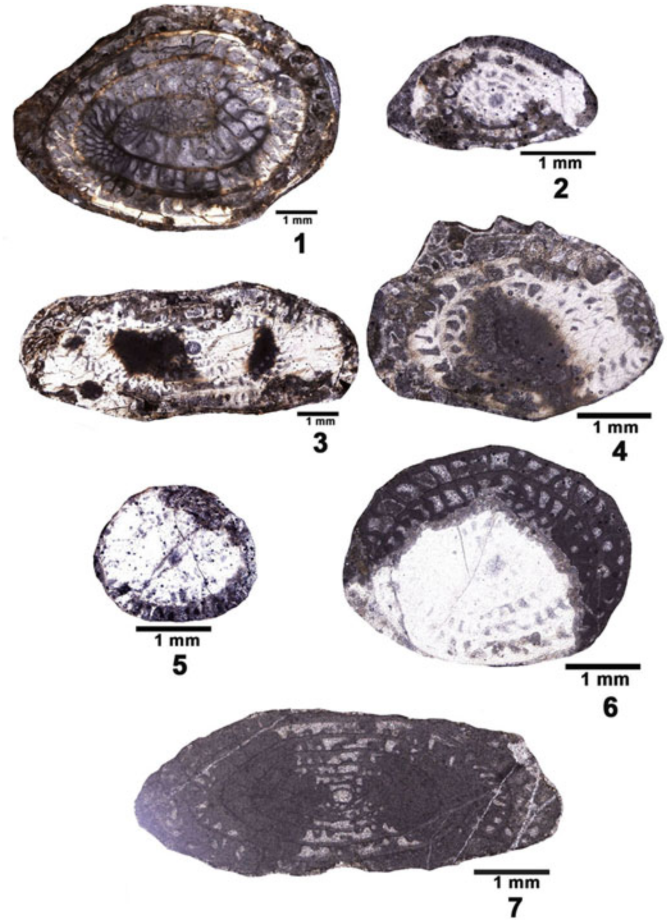

Figure 7. Lower Permian fusulinids from the Bagh-e Vang Formation, Bagh-e Vang section, in east-central Iran. (**1**) *Cuniculinella*? spp., subaxial section, BA-14-3, ALU-1128; (**2**) *Sakmarella*? sp., axial section, BA-47-18-3, ALU-1129; (**3–6**) Silicified *Leeina* sp., (**3**) axial section, BA-14-5-1, ALU-1130, (**4**) oblique section, BA-47-18-4, ALU-1131, (**5**) oblique axial section, BA-55-5-1, ALU-1132, (**6**) oblique axial section, BA-55-11-1, ALU-1133. (**7**) *Leeina isomie* (Igo, 1965), axial section, BA-61-1, ALU-1134.

obscurus; *Endothyra* sp.; *Deckerella* sp.; *Hemigordiellina regularis* (Lipina, 1949); *Schubertella* sp.; *Neofusulinella*? *pseudogiraudi* (Sheng, 1963); *Darvasites* (*Alpites*) *sinensis*; *Sakmarella* sp.; and *Misellina* (*Brevaxina*) *dyrhenfurthi* (Figs. 9, 10).

Remarks.—This lower Bolorian zone has been traditionally mentioned in the Cisuralian fusulinid-based biozonation since the work of Deprat (1915) and Leven (1967, 1997, 1998). It was recently re-studied in its type locality by Angiolini et al. (2016).

Biozone 3.—Cuniculinella spp. Zone

Definition.—This zone is the probable range zone of *Cuniculinella*, the taxonomy of which is discussed hereafter. Its thickness is 24 m in the Bagh-e Vang section and 41 m in the Shesh Angosht section. The base of this biozone is characterized by the FO/FAD of *Cuniculinella*. The top of this biozone is marked by the LO/LAD of this genus and/or the FO/FAD of typical *Misellina* (*Misellina*).

Distribution.—In Bagh-e Vang section, this biozone extends from BA-14 to BA-46; in the Shesh Angosht section, it is located between SHB-10 and SHB-52.

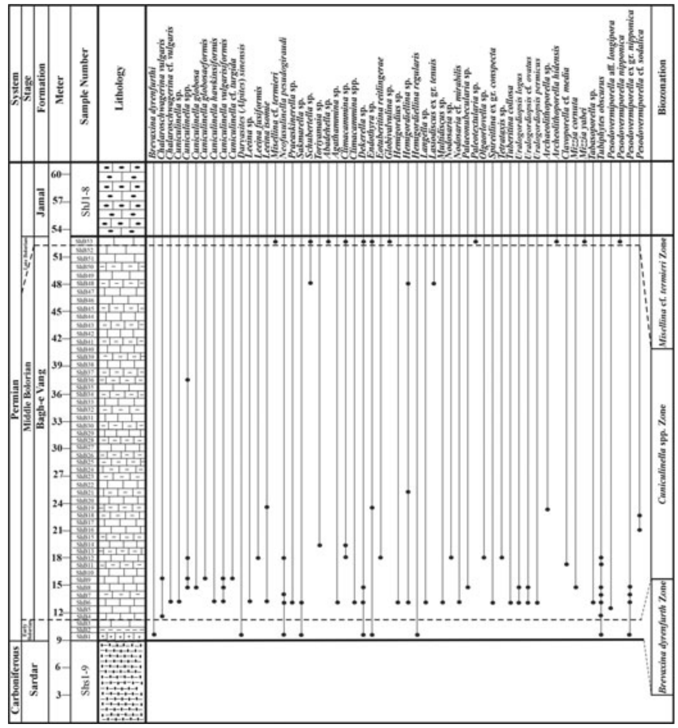

Figure 8. Fusulinid biozonation and faunal distribution of the Bagh-e Vang Formation, Shesh Angosht section, east-central Iran.

Composition.—In our material from the Bagh-e Vang section, we found the following microproblematica, smaller foraminifers, and fusulinids (Fig. 7): *Tubiphytes* sp.; *Endoteba* sp.; *Globivalvulina* ex gr. *G. bulloides* (Brady, 1876); *Schubertella* spp.; *Cuniculinella*? sp.; and *Leeina* spp. The sample BA14 collected near the base of this zone was silicified. The material of Leven and Vaziri Moghaddam (2004) was richer in larger fusulinids with *Cuniculinella hawkinsiformis* (Igo, 1965), *C. vulgarisiformis* (Morikawa, 1952), *C. globosaeformis* (Leven, 1967), *Skinnerella* spp., "*Iranella*" spp. (this name is also pre-occupied according to F. Le Coze, personal communication, June 2019), *Leeina fusiformis* (Schellwien in Schellwien and Dyhrenfurth, 1909), and *Paraleeina postkraffti* (Leven, 1967). In the Shesh Angosht section, we identified the microproblematica, cyanobacteria, dasycladale algae, smaller foraminifers, and fusulinids: *Tubiphytes obscurus*; *Archaeolithoporella hidensis*; *Mizzia cornuta* Kochansky and Herak, 1960; *Tabasoporella* sp.; *Tuberitina collosa* Reitlinger, 1950; *Climacammina* spp.; *Spireitlina* ex gr. *S. conspecta* (Reitlinger, 1950); *Palaeonubecularia* sp.; *Pseudovermiporella* aff. *P. longipora* (Praturlon, 1963); *P.* ex gr. *P. nipponica* (Endo in Endo and Kanuma, 1954); *Hemigordiellina* sp.; *Agathammina* spp.; *Uralogordiopsis longus* (Grozdilova, 1956); *U. permicus* (Grozdilova, 1956); *U.* cf. *U. ovatus* (Grozdilova, 1956); "*Multidiscus*" sp.; *Nodosaria* cf. *N. mirabilis* Lipina, 1949; *Langella* sp.; *Neofusulinella*? *pseudogiraudi*; *Sakmarella* sp.; *Leeina isomie* (Igo, 1965); *L.* sp.; *Chalaroschwagerina*? *vulgaris* (Schellwien in Schellwien and Dyhrenfurth, 1909); *C.*? cf. *C. vulgaris*; *Cuniculinella hawkinsiformis*; *C. vulgarisiformis*; *C. tumida* Skinner and Wilde, 1965a; *C. globosa* (Schellwien in Schellwien and Dyhrenfurth, 1909); *C.* spp.; and *Praeskinnnerella* sp. (Figs. 9–14).

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

Remarks.—A mid-Bolorian age is suggested here for this biozone because of its occurrence between a well-characterized lower Bolorian biozone and an upper Bolorian biozone, but this suggestion can be debated because, so far, *Cuniculinella* has not been mentioned, either in Leven's work in Darvaz (e.g., Leven et al., 1992) or in the Bolorian stratotype by Angiolini et al. (2016). In this case, this local zone corresponds either to the top of the *Misellina* (*Brevaxina*) *dyhrenfurthi* Zone (i.e., upper lower Bolorian); or to the lower part of the *Misellina* (*Brevaxina*) *parvicostata* Zone (i.e., lower upper Bolorian).

Biozone 4.—Misellina (*Misellina*) cf. *M*. (*M*.) *termieri* Zone

Definition.—This appearance zone is characterized by the FO/FAD of *Misellina* (*Misellina*) cf. *M*. (*M*.) *termieri* (Deprat, 1915). It is 12 m thick in the Bagh-e Vang section and 1 m thick in the Shesh Angosht section.

Distribution.—This biozone extends from BA-47 to BA-62 in the Bagh-e Vang section and occurs in the Shesh Angosht section in SHB-53.

Composition.—The microproblematica, smaller foraminifers, fusulinids, and cyanobacteria occurring in this zone in Bagh-e Vang section are: *Tubiphytes obscurus*; *Palaeotextularia* sp.; *Deckerella* sp.; *Climacammina* sp.; *Globivalvulina* ex gr. *G. bulloides*; *Hemigordiellina* sp.; *Agathammina* sp.; *Pachyphloia* sp.; *Nankinella* cf. *N. nagatoensis* Toriyama, 1958; *Schubertella* spp.; *Toriyamaia* sp.; *Leeina isomie*; *Misellina* (*Misellina*) cf. *M*. (*M*.) *termieri*; and *M*. (*M*.) sp. (Figs. 5, 7). The microproblematica, smaller foraminifers, and fusulinids occurring in this zone in Shesh Angosht section are: *Archaeolithoporella hidensis*; *A*. sp.; *Mizzia yabei* (Karpinsky, 1909) emend. Pia, 1920; *Eotuberitina reitlingerae*; *Lasiodiscus* ex gr. *L. tenuis* Reichel, 1946; *Endothyra* sp.; *Palaeotextularia* sp.; *Deckerella* sp.; *Climacammina* sp.; *Tetrataxis* sp.; *Globivalvulina* sp.; *Pseudovermiporella nipponica*; *P*. cf. *P. sodalica* Elliott, 1958; *Schubertella* sp.; *Neofusulinella*? *pseudogiraudi*; *Toriyamaia* sp.; *Leeina fusiformis*; *L. isomie*; and *Misellina* (*Misellina*) cf. *M*. (*M*.) *termieri* (Figs. 9, 10).

Remarks.—Our *Misellina* (*Misellina*) cf. *M*. (*M*.) *termieri* is not necessarily the *M*. (*M*.) aff. *M*. (*M*.) *termieri* in the sense of Leven and Vaziri Moghaddam (2004, pl. 6, fig. 7), but most probably something similar to *Misellina* (*Misellina*) *claudiae* (Deprat, 1915) in the sense of Leven and Vaziri Moghaddam (2004, pl. 6, fig. 3), which was found by these authors in the same sample as *Misellina* (*Brevaxina*) *parvicostata* (pl. 6, figs. 4, 8–10) and is the zonal marker of the upper Bolorian. Inversely, if our *Misellina* (*Misellina*) cf. *M*. (*M*.) *termieri* is the *M*. (*M*.) aff. *M*. (*M*.) *termieri* in the sense of Leven and Vaziri Moghaddam (2004), this last local biozone 4 could be lower Kubergandian in age. However, that is unlikely, due to the absence of associated *Armenina* found by Leven and Vaziri Moghaddam (2004).

Materials and methods

For the biostratigraphic study, 62 and 49 samples were collected from the Bagh-e Vang Formation in the Bagh-e Vang and Shesh

Figure 9. Lower Permian small foraminiferans and calcareous algae from the Bagh-e Vang Formation, Shesh Angosht section, in east-central Iran. (**1**) *Endothyra* sp., axial section, SHB-1-3-1, ALU-1135; (**2**) *Deckerella* sp., oblique longitudinal section, SHB-1-7-2, ALU-1136; (**3**) *Hemigordiellina regularis* (Lipina, 1949), transverse section, SHB-1-8-1, ALU-1137; (**4**) *Uralogordiopsis* cf. *U. ovatus* (Grozdilova, 1956), subaxial section, SHB-6-4-3, ALU-1140; (**5–7**). *Uralogordiopsis longus* (Grozdilova, 1956), (**5**) subtransverse section, SHB-6-4-2, ALU-1142, (**6**) axial section, SHB-6-5-4, ALU-1143, (**7**) axial section, SHB-6-9-3, ALU-1145; (**8**) *Hemigordiellina* sp., axial section, SHB-6-7-1-2, ALU-1153; (**9**) *Agathammina* sp., transverse section, SHB-6-16-2, ALU-1155; (**10**) *Tuberitina collosa* Reitlinger, 1950, axial section, SHB-6-9-4, ALU-1160; (**11**) *Langella* sp., axial section, SHB-6-26-1, ALU-1164; (**12**) *Spireitlina* ex gr. *S. conspecta* (Reitlinger, 1950), subaxial section, SHB-6-26-2, ALU-1165; (**13**) *Nodosaria* cf. *N. mirabilis* Lipina, 1949, axial section, SHB-6-33-1, ALU-1172; (**14, 15**) *Uralogordiopsis permicus* (Grozdilova, 1956), (**14**) axial section, SHB-6-37-1, ALU-1178, (**15**) subaxial section, SHB-8-2-3, ALU-1179; (**16**) *Olgaorlovella* sp., random section, SHB-12-7-1, ALU-1192; (**17**) *Tetrataxis* sp., subaxial section, SHB-12-8-2, ALU-1195; (**18**) *Lasiodiscus* ex gr. *L. tenuis* Reichel, 1946, axial section, SHB-48-1, ALU-1204; (**19**) *Tubiphytes obscurus* Maslov, 1956, oblique section, SHB-1-1-2, ALU-1216; (**20**) *Tabasoporella* sp. (see Rashidi and Senowbari-Daryan, 2010), transverse section, SHB-6-10-4, ALU-1221; (**21**) *Pseudovermiporella* ex gr. *P. nipponica* (Endo in Endo and Kanuma, 1954), transverse sections, SHB-6-21-2, ALU-1228; (**22**) *Mizzia cornuta* Kochansky and Herak, 1960, subtangential section, SHB-8-4, ALU-1239; (**23**) *Palaeonubecularia* sp., oblique section, SHB-8-4-3-3, ALU-1240; (**24**) *Clavaporella* cf. *C. media* (Vachard in Vachard and Montenat, 1981), sublongitudinal section, SHB-11-1, ALU-1249; (**25, 26**) *Pseudovermiporella* cf. *P. sodalica* Elliott, 1958, two oblique sections, (**25**) SHB-16-2, ALU-1251, (**26**) SHB-18-1, ALU-1252; (**27**) oncoid of *Archaeolithoporella* sp., longitudinal section, SHB-19-3, ALU-1253; (**28**) *Archaeolithoporella hidensis* Endo, 1961, longitudinal section, SHB-53-6, ALU-1254.

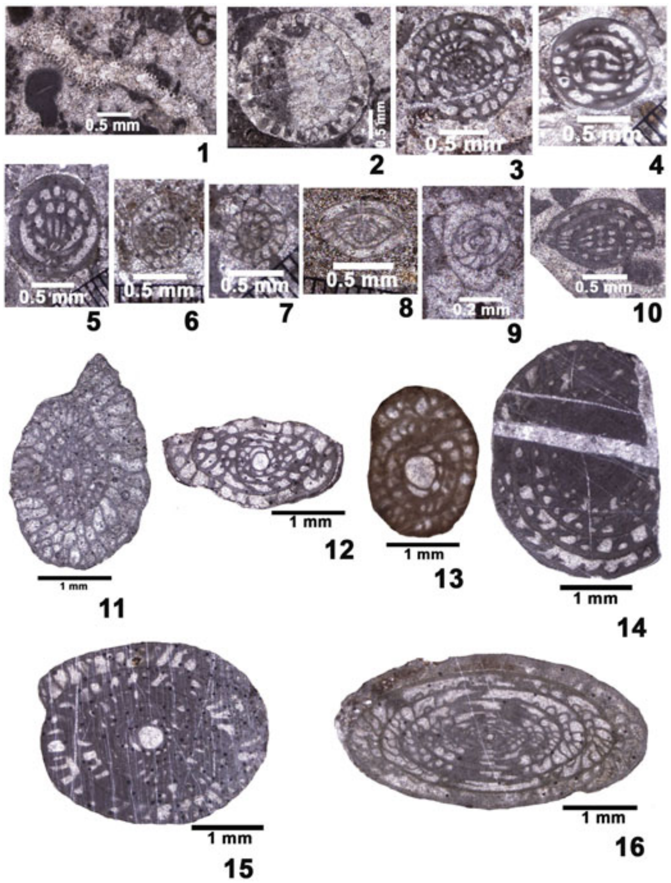

Figure 10. Lower Permian fusulinids and calcareous algae from the Bagh-e Vang Formation, Shesh Angosht section, in east-central Iran. (**1**) *Pseudovermiporella nipponica* (Endo in Endo and Kanuma, 1954), subtangential section, SHB-53-10, ALU-1255; (**2**) *Mizzia yabei* (Karpinsky, 1909) emend. Pia, 1920, transverse section, SHB-53-11, ALU-1256; (**3–5**) *Misellina* (*Brevaxina*) *dyrenfurthi* (Dutkevich, 1939), (**3**) subtransverse section, SHB-1-2-3, ALU-1261, (**4**) subaxial section, SHB-1-12-5, ALU-1263, (**5**) oblique section, SHB-1-8-3, ALU-1262; (**6–8**) *Neofusulinella*? *pseudogiraudi* (Sheng, 1963), (**6**) transverse section, SHB-1-5-2, ALU-1264, (**7**) subtransverse section, SHB-1-8-2, ALU-1265, (**8**) subaxial section, SHB-7-1, ALU-1270; (**9**) *Toriyamaia* sp., oblique section, SHB-14-1, ALU-1274; (**10**) *Misellina* (*Misellina*) cf. *M.* (*M.*) *termieri* (Deprat, 1915), subaxial section, SHB-53-4, ALU-1277; (**11**) *Chalaroschwagerina*? *vulgaris* (Schellwien in Schellwien and Dyhrenfurth, 1909), oblique section, SHB-4-1-2, ALU-1278; (**12, 13**). *Sakmarella* sp., (**12**) oblique section, SHB-1-4-2, ALU-1279; (**13**) subtransverse section, SHB-6-12-1, ALU-1280; (**14**) *Leeina isomie* (Igo, 1965), subtransverse section, SHB-6-6-5, ALU-1288; (**15**) *Leeina* sp., transverse section, SHB-6-1-1, ALU-1281; (**16**) *Darvasites* (*Alpites*) *sinensis* (Chen, 1934), axial section, SHB-1-7-4, ALU-1282.

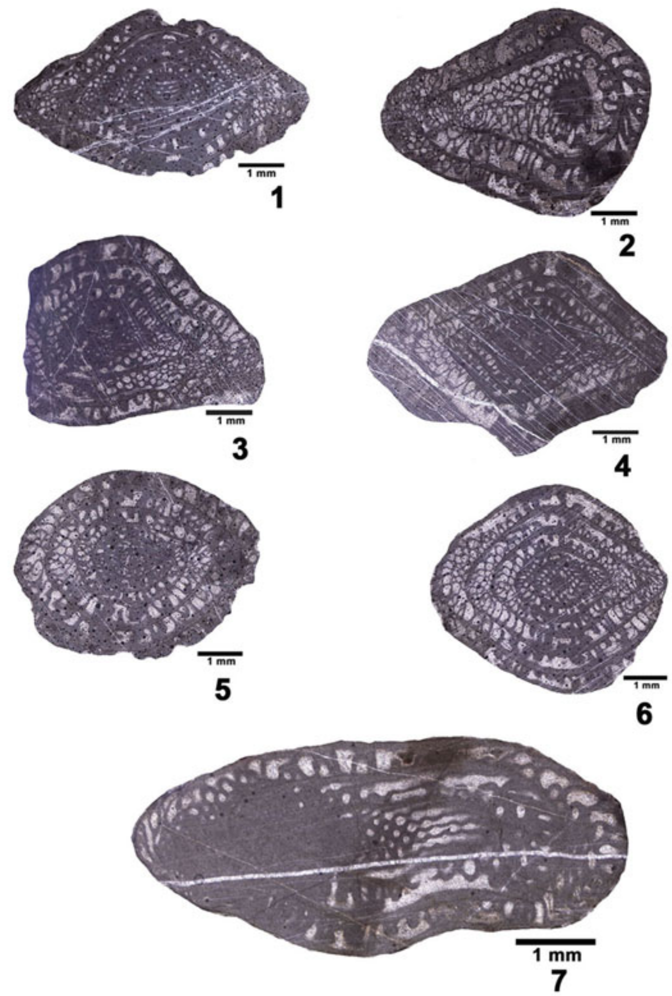

Figure 11. Lower Permian fusulinids from the Bagh-e Vang Formation, Shesh Angosht section, in east-central Iran. (**1–6**) *Culiculinella vulgarisiformis* (Morikawa, 1952), (**1**) oblique subaxial section, SHB-6-16-1, ALU-1292, (**2**) oblique section, SHB-6-17-1, ALU-1293, (**3**) subaxial section, SHB-6-18-1, ALU-1295, (**4**) axial section, SHB-6-19-1, ALU-1296, (**5**) subaxial section, SHB-6-20-1, ALU-1297, (**6**) subaxial section, SHB-6-24-2, ALU-1298; (**7**) *Leeina isomie* (Igo, 1965), subaxial section, SHB-6-9-1, ALU-1289.

Angosht sections, respectively. In order to study smaller foraminifers and algae, 128 thin sections were prepared as well as 250 oriented thin sections for fusulinid identification. The biostratigraphical analyses and biozones described in this study have been established following Salvador (1994), Armstrong and Brasier (2008), and Owen (2009), with references therein. Taxonomically, we have followed the classification of Vachard (2016, 2018) for the Paleozoic foraminifers and that of Vachard et al. (2001a) and Vachard (2018) for the Paleozoic cyanobacteria, calcareous algae, and microproblematica. In the regional biozones established here, the lower boundary of each zone is defined by the presence of a characteristic assemblage or a characteristic taxon. The upper boundary is generally conventional and placed under the base of next zone. The ranges of markers of biozones were mainly compiled from Leven (1970, 1993a, b, 1997, 1998), Leven et al. (1992), Leven and Vaziri Moghaddam (2004), Davydov et al. (2013), and Krainer et al. (2019). In this research, specimens larger than 1 mm are considered large in size, those between 500 μm and 1000 μm are medium in size, and those less than 500 μm are small in size.

Repository and institutional abbreviation.—The prepared thin sections are housed in the Paleontology Repository of Lorestan University, Iran (Collection ALU-900–ALU-1353).

Systematic micropaleontology

This section describes foraminiferal taxa that are biostratigraphically interesting. The main nomenclatural problem is a taxon called *Cuniculina* or *Cuniculinella* (in part) in the literature, the most advanced forms of chalaroschwagerinids exhibiting cuniculi.

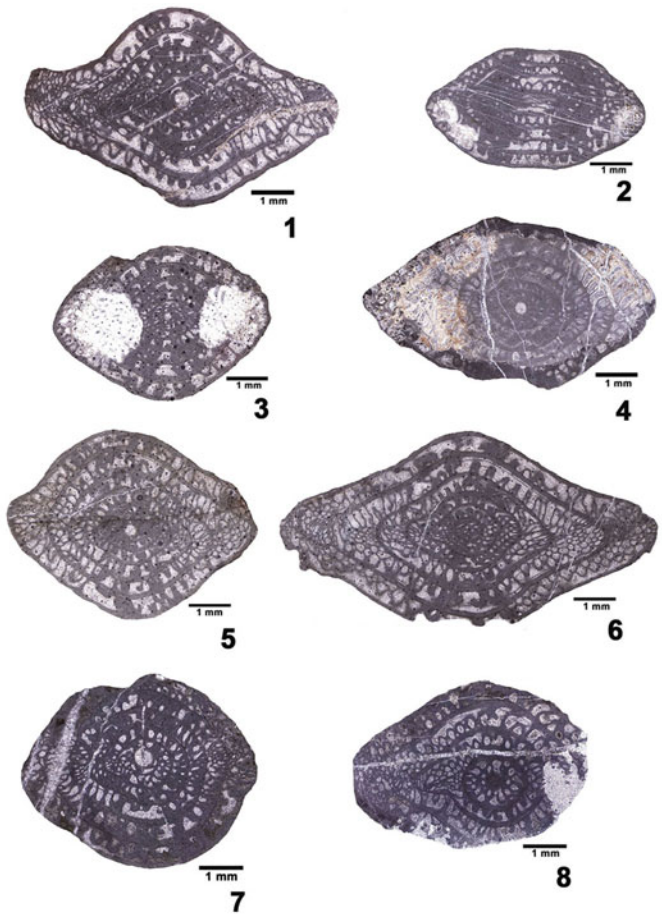

Figure 12. Lower Permian fusulinids from the Bagh-e Vang Formation, Shesh Angosht section, in east-central Iran. (**1**) *Cuniculinella hawkinsiformis* (Igo, 1965), axial section, SHB-6-2-2, ALU-1283; (**2**) *Praeskinnnerella* sp., subaxial section, SHB-6-32-3, ALU-1302; (**3–5**) *Cuniculinella* sp., (**3**) axial section, partly silicified, SHB-6-31-2, ALU-1305, (**4**) axial section, SHB-6-38-1, ALU-1307, (**5**) axial section, SHB-6-31-3, ALU-1306; (**6**) *Cuniculinella vulgarisiformis* (Morikawa, 1952), axial section, SHB-6-34-2, ALU-1309; (**7, 8**) *Cuniculinella tumida* Skinner and Wilde, 1965a, (**7**) oblique axial section, SHB-8-3-2, ALU-1312, (**8**) oblique subaxial section, SHB-8-4-2, ALU-1314.

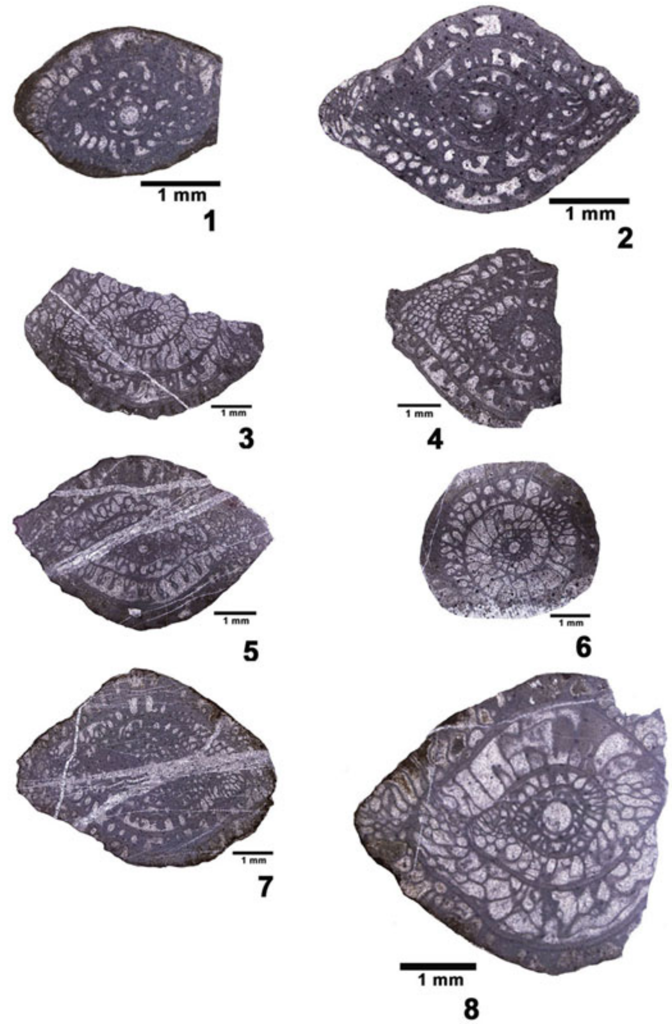

Figure 13. Lower Permian fusulinids from the Bagh-e Vang Formation, Shesh Angosht section, in east-central Iran. (**1, 2**) *Cuniculinella tumida* Skinner and Wilde, 1965a, (**1**) axial section, SHB-8-11-1, ALU-1317, (**2**) axial section, SHB-8-12-2, ALU-1319; (**3**) *Chalaroschwagerina globosa* (Schellwien in Schellwien and Dyhrenfurth, 1909), axial section, SHB-8-6-2, ALU-1320; (**4**) *Cuniculinella vulgarisiformis* (Morikawa, 1952), axial section, SHB-8-9-1-1, ALU-1322; (**5, 6**) *Chalaroschwagerina*? *vulgaris* (Schellwien in Schellwien and Dyhrenfurth, 1909), (**5**) axial section, SHB-9-3-1, ALU-1334, (**6**) subaxial section, SHB-9-10-2, ALU-1335; (**7**) *Cuniculinella vulgarisiformis* (Morikawa, 1952), axial section, SHB-9-5-1, ALU-1336; (**8**) *Cuniculinella globosaeformis* (Leven, 1967), oblique axial section, SHB-9-17-1, ALU-1343.

The abbreviations used are as follows: w = width; D = diameter; h = height of last whorl; s = wall thickness.

Subkingdom Rhizaria Cavalier-Smith, 2002
Phylum Foraminifera d'Orbigny, 1826 emend. Cavalier-Smith, 2003
Class Fusulinata Maslakova, 1990 nom. translat. Gaillot and Vachard, 2007 emend. Vachard, Krainer, and Lucas, 2013
Subclass Fusulinana Maslakova, 1990 nom. correct. Vachard, Pille, and Gaillot, 2010 emend. Vachard, 2016
Order Endothyrida Fursenko, 1958
Suborder Endothyrina Bogush, 1985
Superfamily Bradyinoidea Rauzer-Chernousova et al., 1996
Family Bradyinidae Reitlinger, 1950 nom. translat. Reitlinger, 1958
Genus *Bradyina* Möller, 1878

Type species.—*Bradyina nautiliformis* Möller, 1878; subsequently designated by Cushman (1928).

Other species.—See Morozova (1949); Reitlinger (1950); and Pinard and Mamet (1998).

Diagnosis.—Tests free, nautiloid, involute, and planispirally coiled, with a few whorls and chambers. Septa short with additional, longer and thinner, pre- and post-septal lamellae. Alveolar wall overlain by a continuous tectum. Simple aperture becomes cribrate in the last chamber. Additional sutural pores present.

Occurrence.—Upper Visean (Poty et al., 2006; Somerville, 2008; Hance et al., 2011) to upper Cisuralian (Baryshnikov et al., 1982; Filimonova, 2010; Vachard, 2018). Our study makes it possible to establish that the LAD of *Bradyina* is

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

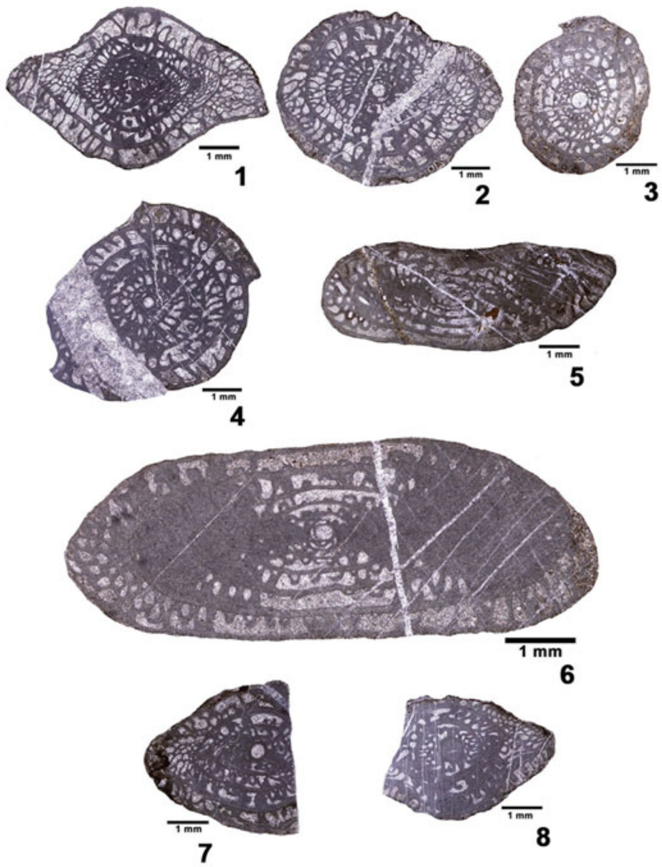

Figure 14. Lower Permian fusulinids from the Bagh-e Vang Formation, Shesh Angosht section, in east-central Iran. (**1**) *Chalaroschwagerina*? *vulgaris* (Schellwien in Schellwien and Dyhrenfurth, 1909), subaxial section, SHB-9-22-1, ALU-1350; (**2**) *Cuniculinella vulgarisifomis* (Morikawa, 1952), oblique axial section, SHB-9-22-2, ALU-1351; (**3, 4**) *Cuniculinella* spp.; (**3**) transverse section, SHB-12-8-1, ALU-1348, (**4**) transverse section, SHB-9-23-1, ALU-1347; (**5**) *Leeina fusiformis* (Schellwien in Schellwien and Dyhrenfurth, 1909), subaxial section, SHB-12-2-1, ALU-1352; (**6**) *Leeina isomie* (Igo, 1965), axial section, SHB-19-1, ALU-1353; (**7, 8**) *Cuniculinella* cf. *turgida* Skinner and Wilde, 1965a, (**7**) axial section, SHB-9-19-1, ALU-1344. (**8**) subaxial section, SHB-9-20-1, ALU-1345.

definitively upper Yakhtashian. The Guadalupian and Lopingian species assigned to *Bradyina* belong in reality to *Postendothyra* (see Hance et al., 2011; Vachard, 2018). The genus *Bradyina* was Paleotethyan and Panthalassan in the Upper Mississippian, and cosmopolitan since the Lower Pennsylvanian (e.g., Mamet, 1970; Hance et al., 2011; Vachard, 2018).

Bradyina spp.
Figure 3.3–3.6, 3.9, 3.10

Remarks.—The exact LAD of *Bradyina* was discussed in Vachard (2018) and Krainer et al. (2019). Our material makes it possible to establish that this LAD is upper Yakhtashian in age because representatives of this genus are still numerous in samples BA-4 and BA-5, but are absent from younger samples, despite the paleoenvironments remaining identical (i.e., a shallow carbonate platform).

Suborder Palaeotextulariina Hohenegger and Piller, 1975
emend. Vachard, 2016

Superfamily Endoteboidea Vachard, Krainer, and Lucas, 2013
Family Endotebidae Vachard et al., 1994
Genus *Endoteba* Vachard and Razgallah, 1988

Type species.—Endoteba controversa Vachard and Razgallah, 1988, by original designation.

Other species.—See Vachard and Razgallah (1988) and Vachard et al. (1994).

Diagnosis.—Endothyroidally coiled Palaeotextulariina with faint deviations of the axis. Wall brownish, microgranular with a calcareous, or rarely siliceous, agglutinate. Aperture terminal, basal simple.

Occurrence.—The genus *Endoteba* first occured in the upper Cisuralian (Vachard et al., 2001b; Vachard, 2018; Krainer et al., 2019; and this paper). It was recently mentioned in the Kubergandian (lower Guadalupian) of Japan (Kobayashi, 2019). It becomes abundant in the Capitanian (upper Guadalupian), is rare in the Lopingian and Lower Triassic, and diversifies again in the Middle Triassic (Vachard et al., 1994).

Endoteba sp.
Figure 3.11

Remarks.—There was a question about the exact FAD of *Endoteba* (see Vachard et al., 2001b and Vachard, 2018). Our samples indicate a FO (first local occurrence), and probable FAD (oldest occurrence), of this genus in the upper Yakhtashian of central Iran.

Class Miliolata Saidova, 1981
Order Cornuspirida Mikhalevich, 1980
Superfamily Cornuspiroidea Bogdanovich in Subbotina et al., 1981
Family Hemigordiidae Reitlinger in Vdovenko et al., 1993
Genus *Agathammina* Neumayr, 1887

Type species.—Serpula pusilla Geinitz in Geinitz and Gutbier, 1848, by original designation.

Other species.—See Zolotova and Baryshnikov (1980) and Gaillot and Vachard (2007).

Diagnosis.—Test formed by the coiling of an undivided tubular chamber similar to that of the eosigmoilinid archaediscoids and not, as classically indicated, to miliolid chambers with a quinqueloculine coiling. Wall porcelaneous. Aperture terminal and simple.

Occurrence.—The Permian FAD and LAD of this genus, relatively common from Capitanian to Changhsingian, are poorly known; its so-called Triassic survivors are now assigned to other genera.

Agathammina sp.
Figures 3.23, 9.9

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

Remarks.—As indicated by Gaillot and Vachard (2007), the transitional form between *Hemigordiellina* and *Agathammina* seems to be *Glomospira parapusilliformis* Baryshnikov in Zolotova and Baryshnikov, 1980, which is Kungurian in age. Our samples indicate a FO (and probable FAD) of this genus in the upper Bolorian; this datum is relevant to a problem mentioned by Gaillot and Vachard (2007, p. 87) and Vachard (2018, p. 221) concerning the exact age of the FAD of the genus *Agathammina*.

Family Neodiscidae Lin, 1984 nom. translat. and emend. Gaillot and Vachard, 2007

Genus *Uralogordiopsis* Vachard in Krainer, Vachard, and Schaffhauser, 2019

Type species.—*Uralogordiopsis grozdilovae* Vachard in Krainer, Vachard, and Schaffhauser, 2019, by original designation.

Other species.—See Krainer et al. (2019).

Diagnosis.—Planispiral, lenticular, and often biumbilicate. Proloculus is followed by an undivided tubular chamber with a high lumen and poorly developed buttresses. Porcelaneous wall generally well preserved and amber-colored. Aperture terminal and simple.

Occurrence.—Cisuralian of the Urals, Carnic Alps, and Mexico; Kubergandian of Japan and northern Afghanistan; Upper Murgabian of Japan; Guadalupian of Transcaucasia; ? Guadalupian of Yunnan (according to Krainer et al., 2019).

Remarks.—*Uralogordiopsis* differs from *Hemigordius* by the bilayered wall and the much larger size, and from *Uralogordius* Gaillot and Vachard, 2007 (= *Arenovidalina* sensu Baryshnikov et al., 1982) (Vachard et al., 2000a, p. 9; Vachard and Bouyx, 2001; not Ho, 1959) by the planispiral coiling entirely evolute and the discoid profile.

Uralogordiopsis spp.
Figure 9.4–9.7, 9.14, 9.15

Remarks.—We have found *Uralogordiopsis* cf. *U. ovatus* (Grozdilova, 1956) and *U. longus* (Grozdilova, 1956) in sample SHB-6, and *U. permicus* (Grozdilova, 1956) in samples SHB-6 and SHB-8. Such biodiversity in a few beds of the studied section indicates an acme and diversification of this genus in the mid-Bolorian *Cuniculinella* sp. Zone. This local datum is possibly a general datum for the genus *Uralogordiopsis*, recently described by Vachard in Krainer et al. (2019), and still poorly known.

Order Fusulinida Fursenko, 1958

Suborder Staffellina Zhang et al., 1981 emend. Vachard, 2016

Superfamily Staffelloidea Miklukho-Maklay, 1949 nomen translat. Solovieva, 1978

Family Nankinellidae Miklukho-Maklay, 1963

Genus *Nankinella* Lee, 1934

Type species.—*Staffella discoides* Lee, 1931, by original designation.

Other species.—See Sheng (1963); Rozovskaya (1975); Wang et al. (1981); and Zhang (1982).

Diagnosis.—Tests lenticular to rhombic, carinate, and moderate- to large-sized. Planispiral and involute, with planar septa, and faint pseudochomata. The wall, originally aragonitic, becomes secondarily completely microsparitized. Aperture terminal and simple.

Occurrence.—Guadalupian–Lopingian; on the Palaeotethyan, Neotethyan, and Panthalassan shelves.

Nankinella cf. *N. nagatoensis* Toriyama, 1958
Figure 5.7

1958 *Nankinella nagatoensis* Toriyama, p. 65, pl. 6, figs. 5–13.
1958 *Nankinella* spp.; Toriyama, p. 68, pl. 6, figs 14, 15 (fide Kobayashi, 2019).
1962 *Nankinella nagatoensis*; Ishizaki, p. 137, pl. 7, figs. 2, 3.
1966 *Nankinella nagatoensis*; Kahler and Kahler, p. 57.
1998 *Nankinella nagatoensis*; Leven, pl. 1, fig. 19.
1998 *Nankinella nagatoensis*; Zhang and Hong, p. 209, pl. 2, figs. 15–17.
2012 *Nankinella nagatoensis*; Kobayashi, fig. 6.40, 6.41, 6.52.
2017 *Nankinella nagatoensis*; Kobayashi, p. 33, pl. 1, figs. 51–54.
2019 *Nankinella nagatoensis*; Kobayashi, p. 58, pl. 3, figs. 21–30, 34–36.

Holotype.—Axial section (No. GK.D1623, Loc. 497, Department of Geology, Kyushu University) from the Cisuralian of Akiyoshi (Loc. 4E97), Japan (Toriyama, 1958, pl. 6, figs. 8, 13, which is the same specimen in two magnifications).

Occurrence.—Guadalupian of Japan (Akiyoshi Group; Toriyama, 1958), Transcaucasia (Asni Fm; Leven, 1998), and South China (Zhang and Hong, 1998). It is found in the upper Bolorian *Misellina* (*Misellina*) cf. *M.* (*M.*) *termieri* Zone of the Bagh-e Vang section (sample BA-55).

Description.—Species are relatively small for the genus, subrhomboidal or rarely inflated lenticular, with a few whorls and an exceptionally narrow whorl section in axial section. Measurements: D = 770–1250 µm; w = 500–540 µm; w/D = 0.40–0.77; proloculus diameter = 55 µm; number of whorls = 3–5; h = 250 µm; s = 20 µm.

Remarks.—Our specimens are smaller than the type material of Toriyama (1958) and that of Kobayashi (2019) from Japanese localities, but, characteristically, they show the highest whorl profile immediately above the tunnel and decreasing in height poleward.

Suborder Fusulinina Wedekind, 1937 nom. correct. Loeblich and Tappan, 1961 emend. Vachard, 2016

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

Superfamily Schubertelloidea Vachard in Vachard, Clift, and Decrouez, 1993

Diagnosis.—According to Vachard (2016), tests are small- to medium-sized, short fusifom, and inflated fusiform to elongate fusiform. Spherical proloculi testify to generations A and B. Juvenaria generally lenticular and perpendicular to the adult whorls. Primitive forms of schubertelloids, such as *Schubertina* Marshall, 1969 emend. Davydov, 2011 (= *Eoschubertella* of the authors, non Thompson, 1937; see discussion in Ghazzay-Souli et al., 2015, p. 257), have a unilayered, dark, microgranular wall, but, typically, the wall is bilayered with an outer, dark, microgranular tectum and an inner, thicker, yellowish, microgranular layer, called the protheca. Septa planar in the central parts of the chambers and faintly to moderately folded at the poles. Chomata small to moderate. Cuniculi very rarely conspicuous.

Occurrence.—Mid-Bashkirian to upper Lopingian; with endemic or cosmopolitan genera.

Family Schubertellidae Miklukho-Maklay, Rauzer-Chernousova, and Rozovskaya, 1958 emend. Leven, 1987

Subfamily Schubertellinae Skinner, 1931

Genus *Schubertella* Staff and Wedekind, 1910 emend. Sheng, 1963

Type species.—*Schubertella transitoria* Staff and Wedekind, 1910, by subsequent designation by Thompson (1937) due to the initial monotypy (see Dunbar and Henbest, 1942; Kahler in Ebner and Kahler, 1989).

Other species.—See Kahler and Kahler (1966); Rozovskaya (1975); Leven et al. (1992); and Davydov (2011).

Diagnosis.—Test shortly fusiform, often asymmetrical. Early stage discoidal and forms a juvenarium perpendicular to the later stage, which is more or less fusiform, with acute poles. Septa numerous, unfluted in the center of the chambers and slightly fluted at the poles, especially in the outer whorls. Chomata low, asymmetrical, bordering a broad and low tunnel. Wall bilayered with an outer tectum and a protheca. Primitive forms (*Schubertina* or *Eoschubertella* of the authors) exhibit only the dark tectum. Advanced forms (*Dutkevitchites*, *Oketaella*, and *Biwaella*) show tectum and an inner porous layer. Aperture terminal and simple.

Occurrence.—Bashkirian–lower Moscovian forms belong more probably to the genus *Schubertina* (or *Eoschubertella* of the authors), whereas typical representatives are distributed from the upper Moscovian (only lower Virgilian in North America; according to Sanderson et al., 2001) to Lopingian. *Schubertella* is cosmopolitan from the Moscovian to the Wordian (see Rauzer-Chernousova et al., 1951; Skinner and Wilde, 1966a, b; Leven, 1998; Davydov, 2011); then, it is only Paleotethyan.

Schubertella ex gr. *S. paramelonica* Suleimanov, 1949
Figure 4.22

1949 *Schubertella paramelonica* Suleimanov, p. 31, pl.1, fig.5.
2019 *Schubertella paramelonica*; Vachard in Krainer et al., p. 66, pl. 16, figs. 2?, 7, 8, 10? (with 22 references in synonymy).

Holotype.—Axial section (No. 3494, Institute of Geological Sciences, Academy of Sciences of the SSSR), from the Sakmarian (lower Tastubian) of Shak-Tau Hill, Russia (Suleimanov, 1949, pl. 1, fig. 5).

Occurrence.—Cisuralian of southern Urals, Darvaz, Slovenia (as mentioned by Forke, 2002), Artinskian of Japan (Ueno, 1996). Yakhtashian–Bolorian of the Carnic Alps (Krainer et al., 2019) and found in the upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Description.—Shell is large for the genus, fusiform to ovoid with variable shapes of the lateral slopes, and broadly rounded to more or less truncated axial regions. The small and spherical proloculus is followed by a small juvenarium, nautiloid, and deviated at ~60° compared to the adult whorls. The septa are almost planar. The chomata are relatively well developed, especially in the penultimate and last whorls. Measurements: D = 500–700 μm; w = 675–1000 μm; w/D = 1.35–1.43; proloculus diameter = 30 μm; number of whorls = 4; h = 150 μm; s = 10 μm.

Remarks.—Compared to the type material of Suleimanov (1949), our specimens are smaller and have fewer whorls and a thinner wall.

Schubertella aff. *S. exilis* Suleimanov, 1949
Figure 5.1, 5.2

1949 *Schubertella kingi* var. *exilis* Suleimanov, p. 33, pl. 1, figs. 11–13.
1981 *Schubertella kingi* var. *exilis*; Wang et al., p. 19, pl. 12, figs. 4, 5, 12.
1982 *Schubertella kingi exilis*; Zhang, p. 145, pl. 2, fig. 22.
2019 *Schubertella exilis*; Vachard in Krainer et al., p. 65, pl. 15, figs. 11–17, pl.16, fig. 1, pl. 17, figs. 1, 2 (with 21 references in synonymy).

Holotype.—Axial section (No. 7637; Institute of Geologic Sciences, Academy of Sciences of the SSSR), from Sakmarian of Preurals, Russia (Suleimanov, 1949, pl. 1, fig. 11).

Occurrence.—Cisuralian of the Paleotethys and Urals Ocean shelves (Krainer et al., 2019), lower Yakhtashian (Zweikofel Fm and Zottachkopf Fm) of the Carnic Alps (Davydov et al., 2013; Krainer et al., 2019), and found in the upper Yakhtashian of the Bagh-e Vang section (sample BA-5).

Description.—The elongate species of *Schubertella* correspond to the group of *S. kingi* Dunbar and Skinner, 1937. In this group, *S. exilis* is a relatively small and biconvex species. Measurements: D = 610–800 μm; w = 1200–2000 μm; w/D = 2.00–2.50; proloculus diameter = 20–25 μm; number of whorls = 4–5; h = 100–200 μm; s = 10 μm.

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

Remarks.—Compared to the type material of Suleimanov (1949), our specimens have a thinner wall and a smaller proloculus diameter.

Genus *Neofusulinella* Deprat, 1912b

Type species.—*Neofusulinella lantenoisi* Deprat, 1913, by subsequent designation (Thompson, 1934, not Galloway and Ryniker, 1930).

Other species.—See Kahler and Kahler (1966); Rozovskaya (1975); and Leven et al. (1992).

Diagnosis.—Test fusiform, medium-sized, with planar septa only folded in the polar extremities. Chomata moderately developed. Wall typically schubertelloid with dark tectum and yellowish primatheca. Aperture terminal and simple.

Occurrence.—Bolorian–Murgabian (= Kungurian–Wordian) of the Paleotethyan shelves (Leven et al., 1992).

Genus *Neofusulinella*?

Remarks.—Apparently, several representatives of the group *Schubetella paramelonica* were called *Mesoschubertella* by Ueno (1996) (see below). On the other hand, Leven (1987) considered *Mesoschubertella* Kanuma and Sakagami, 1957 as transitional between *Schubertella* and *Yangchienia* Lee, 1934 (see Leven, 1987, pl. 2, fig. 5), whereas the *Mesoschubertella* of Ueno (1996) are obviously transitional between *Schubertella* and *Neofusulinella* Deprat, 1912b. Such forms, which are transitional between *S. paramelonica* and *Neofusulinella giraudi* (Deprat, 1915), are known from the upper Yakhtashian–Bolorian of Japan, Iran, and Darvaz (Uzbekistan), Pamir (Tajikistan), Thailand, and North and South China (Leven, 1987; Ueno, 1996; Leven and Vazari Moghaddam, 2004). We infer also that this transitional stage is present in Guatemala with *Neofusulinella*? *muelleriedi* (Thompson and Miller, 1944), as redescribed by Vachard et al. (1997), Davydov (2011), and Granier et al. (2017).

Neofusulinella? *pseudogiraudi* (Sheng, 1963 non 1962)
Figure 10.6–10.8

1962 *Schubertella pseudogiraudi* Sheng, p. 427, pl. 1, figs. 8, 9 (holotype not designated).
1963 *Schubertella pseudogiraudi* Sheng, p. 159, pl. 4, figs. 14–19.
1965 *Schubertella pseudogiraudi*; Sheng, p. 566, pl. 5, figs. 15–17.
1966 *Schubertella pseudogiraudi*; Kahler and Kahler, p. 211.
1975 *Schubertella* (*Schubertella*) *pseudogiraudi*; Rozovskaya, p. 13.
1977 *Schubertella pseudogiraudi*; Lin et al., p. 34, pl. 6, fig. 20.
1978 *Schubertella pseudogiraudi*; Chen and Wang, p. 26, pl. 3, figs. 36, 37.
1978 *Schubertella pseudogiraudi*; Liu, Xiao, and Dong, p. 20, pl. 2, fig. 4.
1979 *Schubertella pseudogiraudi*; Igo et al., pl. 17, figs. 9, 10, pl. 18, figs. 11–14.
1982 *Schubertella pseudogiraudi*; Zhou, p. 230, pl. 1, fig. 10.
1982 *Schubertella pseudogiraudi*; Xie, p. 15, pl. 6, fig. 7.
1982 *Schubertella pseudogiraudi*; Zhang, p. 144, pl. 2, figs. 18, 20, 21, 24, 25, 34, 35.
1982 *Schubertella pseudogiraudi*; Zhou, p. 230, pl. 1, fig. 10.
1984 *Schubertella pseudogiraudi*; Zhou and Zhang, pl. 2, figs. 12, 13.
1987 *Schubertella pseudogiraudi*; Zhou, Sheng, and Wang, pl. 3, fig. 10.
1987 *Schubertella pseudogiraudi*; Leven, pl. 2, fig. 7.
? 1988 *Schubertella pseudogiraudi*; Sun and Zhang, pl. 1, fig. 7, pl. 2, figs. 15, 18, pl. 3, figs. 3, 13.
1992 *Schubertella pseudogiraudi*; Zhang, pl. 1, figs. 3, 7.
1993 *Neofusulinella*? *pseudogiraudi*; Ueno and Sakagami, p. 282, fig. 5.11–5.13.
1995 *Neofusulinella*? *pseudogiraudi*; Partoazar, pl. 5, figs. 11–13 (from Ueno and Sakagami, 1993).
1996 *Schubertella pseudogiraudi*; Leven and Okay, pl. 9, fig. 13.
2016 *Neofusulinella pseudogiraudi*; Angiolini et al., p. 567, figs. 9E–G, 13A–D, 14H, 15D–F.

Holotype.—Axial section (No. 12009, Institute of Geology and Palaeontology, Academia Sinica, Beijing, People's Republic of China) from the Maokou Limestone, near Zisongzheng of Wangmo, Kueichow Province, China (Sheng, 1963, pl. 4, fig. 15).

Occurrence.—Bolorian–Murgabian (= Kungurian–Wordian) of eastern Paleotethys (as indicated by the synonymy list, above), Darvaz (Leven, 1987), and Turkey (Leven and Okay, 1996). Identified from the lower and mid-Bolorian *Misellina* (*Brevaxina*) *dyhrenfurthi* and *Cuniculinella* spp. zones of the Shesh Angosht section (samples SHB-1 and SHB-7).

Description.—The test is fusiform, moderately sized, and primitive for the genus; it is harmoniously vaulted in the central regions and bluntly pointed in the polar regions. The septa are planar, and only folded in the polar extremities, but more than in *Schubertella*. The proloculus is spherical. The first whorl is deviated, like many schubertellids. Moderate chomata are present in all of the whorls. The tunnel is low, but relatively wide. The wall is typically schubertelloid, with a dark tectum and yellowish primatheca. Septal pores are conspicuous. The aperture is terminal and simple. Measurements: D = 500–700 µm; w = 1000 µm; w/D = 2.00; number of whorls = 4–5; proloculus diameter = 20 µm; h = 100–170 µm; s = 50 µm.

Remarks.—As indicated by Ueno and Sakagami (1993), this species is transitional between *Schubertella* and *Neofusulinella*. However, due to the symmetrical, fusiform shape, the species closely resembles *Neofusulinella*. Comparisons with *Neofusulinella giraudi* were indicated by Sheng (1963) and Igo et al. (1979) (e.g., smaller w/D ratio, thicker wall, and stronger chomata).

Genus *Mesoschubertella* Kanuma and Sakagami, 1957 emend. Rozovskaya, 1975

Type species.—*Mesoschubertella thompsoni* Kanuma and Sakagami, 1957, by original designation.

Other species.—See Rozovskaya (1975); Leven et al. (1992); Ueno (1996); and Davydov (2011).

Diagnosis.—Test small, subrhombic to fusiform, with strong chomata and polar folding relatively developed. Aperture terminal and simple with tunnel. Wall schubertelloid with primatheca.

Occurrence.—Yakhtashian–Bolorian (= Artinskian–Kungurian) of the Paleotethyan and Panthalassan shelves (see Leven et al., 1992; Leven and Vaziri Moghaddam, 2004; Kobayashi, 2019).

Remarks.—The type of wall of *Mesoschubertella* has been discussed by many authors. We follow the authors Rozovskaya, 1975; Leven et al., 1992; Ueno, 1996; Davydov, 2011; and Kobayashi, 2019, who consider *Mesoschubertella* as a taxon possessing a typical schubertellid wall with a primatheca, and not a keriothecal wall, as indicated by Kanuma and Sakagami (1957) and Loeblich and Tappan (1987). *Mesoschubertella* and *Schubertella* have such a wall, therefore, the same microstructure; nevertheless, *Mesoschubertella* morphologically differs by its symmetrical shape, often rhombic, with strong chomata, and slightly more-developed septal folding. *Mesoschubertella* is relatively characteristic of the Kungurian/Bolorian.

Mesoschubertella spp.
Figure 4.7–4.11

Remarks.—Representatives of this genus, although relatively abundant in our material, are left in open nomenclature due to the discussed definition of the genus. This genus is distinguished in the upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Genus *Toriyamaia* Kanmera, 1956

Type species.—*Toriyamaia laxiseptata* Kanmera, 1956, by original designation.

Other species.—See Kahler and Kahler (1966); Rozovskaya (1975); Leven et al. (1992); Krainer et al. (2019).

Diagnosis.—Test involute, elongate fusiform, and asymmetrical with weakly deviated juvenarium. Adult stages loosely coiled. Planar septa only gently curved in the polar areas. Wall typical of schubertellid with primatheca. Chomata more distinct than in *Schubertella*.

Occurrence.—?Sakmarian–Artinskian–Kungurian–Guadalupian of the Paleotethys and Panthalassa; very rare in the USA (Texas; Stewart, 1966).

Toriyamaia sp.
Figures 5.4, 10.9

Remarks.—Rare sections in our material correspond to an undetermined species of *Toriyamaia*. Measurements: Diameter = 1400–2000 µm; w = 1300–3000 µm; w/D = 1.50. This taxon, in open nomenclature, was found in the upper Bolorian *Misellina* (*Misellina*) cf. *M.* (*M.*) *termieri* Zone of the Bagh-e Vang and Shesh Anghost sections (samples BA-47 and SHB-14).

Family Biwaellidae Davydov, 1984 nom. translat. Leven in Leven et al., 1992

Occurrence.—Late Pennsylvanian–upper Cisuralian; rare, but probably cosmopolitan.

Remarks.—Test schubertelliform, inflated fusiform to elongate fusiform, or subcylindrical, with an inconspicuous juvenarium. Septa weakly folded. Chomata diversely developed. Wall initially dark microgranular becoming porous, perforated and falsely keriothecal in adult whorls. Aperture terminal, simple.

Genus *Biwaella* Morikawa and Isomi, 1960

Type species.—*Biwaella omiensis* Morikawa and Isomi, 1960, by original designation.

Other species.—See Kahler and Kahler (1966); Rozovskaya (1975); Leven et al. (1992); Davydov (2011); and Krainer et al. (2019).

Diagnosis.—Test moderately large and elongate fusiform. Proloculus relatively small, juvenarium absent. Septa planar to slightly folded in the poles. Wall pseudokeriothecal with tectum. Central aperture with tunnel and asymmetrical chomata.

Occurrence.—Gzhelian–Cisuralian (Davydov, 2011) or mid-Asselian–lower Bolorian (Leven et al., 1992), cosmopolitan. The Gzhelian–Asselian forms assigned to *Biwaella* often belong to *Oketaella* because the acme of true *Biwaella* is generally Sakmarian and Yakhtashian. Moreover, Pasini (1965, p. 85) indicated that *Oketaella* and *Biwaella* may be two generations, megalo- and microspheric, of the same genus. In our opinion, the relationship of both genera is justified, and several species of *Biwaella* in the literature more probably belong to *Oketaella* (see Krainer et al., 2019, p. 70). Rare Bolorian *Biwaella* were mentioned by Leven et al. (1992) and Leven (1993b).

Biwaella sp.
Figure 6.3

Remarks.—Test elliptical with sparsely located chomata and relatively developed septal folding. D = 1300 µm; w = 2000 µm; w/D = 1.53; proloculus diameter = 40 µm; number of whorls = 5. A few specimens were found in the upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Superfamily Schwagerinoidea Solovieva, 1978 (as Schwagerinacea)

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

Family Triticitidae Davydov, 1986 nomen translat. Rauzer-Chernousova et al., 1996
Subfamily Darvasitinae Leven in Leven, Leonova, and Dmitriev, 1992 nom. translat. Herein
Genus *Darvasites* Miklukho-Maklay, 1959
Subgenus *Alpites* Davydov, Krainer, and Chernykh, 2013

Type species.—*Fusulina contracta* Schellwien in Schellwien and Dyhrenfurth, 1909, by original designation.

Diagnosis.—Test medium sized and subcylindrical fusiform with slightly convex lateral slopes and bluntly rounded poles. Small to medium spherical proloculus. No individualized juvenarium, but the first whorls are more tightly coiled. Septal folding developed in lateral zones, absent in central zones. Chomata small and asymmetrical. Tunnel has more or less regular path. Axial filling faint or absent. Wall shows fine keriotheca.

Occurrence.—Upper Asselian of Turkey (Kobayashi and Altıner, 2008); Lower Sakmarian of the Urals (Grozdilova and Lebedeva, 1961); Hermagorian–Bolorian (= Sakmarian–Kungurian in the Paleotethys; Davydov et al., 2013) of South China (Chen, 1934; Zhou, 1998), Japan (Nogami, 1961; Choi, 1973), Vietnam (Saurin, 1954), Malaysia (Vachard, 1990), NE Thailand (Igo et al., 1993), Sumatra (Vachard, 1989), North China (Han, 1975), Tarim (Zhao et al., 1984), Pamirs (Leven, 1967), Darvaz (Miklukho-Maklay, 1949; Leven and Shcherbovich, 1980; Leven, 1998), Afghanistan (Leven, 1997), Iran (Kahler, 1976; Lys et al., 1978; Leven and Vaziri Moghaddam, 2004), Turkey (Leven, 1995; Leven and Okay, 1996; Okuyucu, 1999), Hungary (Bérczi-Makk and Kochansky-Devidé, 1981), Croatia (Kochansky-Devidé, 1955, 1964, 1970; Ramovš and Kochansky-Devidé, 1965; Kochansky-Devidé and Ramovš, 1966), Sicily (Carcione et al., 2004), and Carnic Alps (Kahler and Kahler, 1980; Kahler, 1989; Davydov et al., 2013; Krainer et al., 2019). *Alpites* is currently unknown in the Americas; however, some forms are relatively similar to *Alpites*, such as *Pseudofusulinoides pusillus* and *P.* aff. *P. changi* (Schellwien, 1898) sensu Vachard et al., 2000c in Guatemala and “*Schwagerina*” *tintensis* Roberts in Newell, Chronic, and Roberts, 1953, in Peru.

Darvasites (*Alpites*) *sinensis* (Chen, 1934)
Figure 10.16

1934 *Triticites sinensis* Chen, p. 36, pl. 7, figs. 8, 12.
1954 *Triticites* cf. *sinensis*; Saurin, p. 10, pl. 1, figs. 28, 29.
1958 *Triticites* (*Rauserites*) *sinensis*; Rozovskaya, p. 100, pl. 8, figs. 8, 9.
1966 *Triticites sinensis*; Kahler and Kahler, p. 524.
1975 *Nagatoella* (*Darvasites*) *sinensis*; Rozovskaya, p. 163.
1982 *Darvasites sinensis*; Zhou, p. 244, pl. 4, figs. 5–8.
1982 *Darvasites sinensis*; Xie, p. 23, pl. 9, figs. 4–7.
1986 *Darvasites sinensis*; Xiao et al., p. 144, pl. 2, fig. 23.
1992 *Darvasites sinensis*; Leven in Leven et al., p. 86, pl. 11, figs. 10, 11.
1995 *Darvasites sinensis*; Leven, p. 238, pl. 1, fig. 9.
1998 *Darvasites sinensis*; Zhou, pl. 1, fig. 11.

Lectotype.—We herein designate as lectotype the axial section (No. 3262, Research Institute of Geology, Academia Sinica, Nanking) from the Permian Swine Limestone, Chuanshan, southern Kiangsu, China (Chen, 1934, pl. 7, fig. 8).

Occurrence.—Yakhtashian–Bolorian (= Artinskian–Kungurian) of the Paleotethyan and Panthalassan shelves. It is found in the lower Bolorian *Misellina* (*Brevaxina*) *dyhrenfurthi* Zone of the Shesh Anghost section (sample SHB-1).

Description.—This species is ellipsoidal and relatively large for the genus. The chomata begin to show the regular arrangment of those of *Darvasites*, which is the descendent of *Alpites*. Measurements: w = 4000–6220 µm; D = 2100–3090 µm; w/D = 1.90–2.0; number of whorls = 9; proloculus diameter = 60 µm; h = 300 µm; s = 80 µm.

Remarks.—In their morphology and dimensions, our specimens are similar to the lectotype of Chen (1934), designated herein.

Darvasites (*Alpites*?) sp.
Figure 5.9

Remarks.—An oblique section with a diameter of 2500 µm in our material could be a representative of this subgenus. Rare specimens were found in the upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Family Schwagerinidae Dunbar and Henbest, 1930
Subfamily Schwagerininae Miklukho-Maklay, 1953.
Genus *Sakmarella* Bensh and Kireeva in Bensh, 1987

Type species.—*Fusulina moelleri* Schellwien, 1908, by original designation.

Other species.—See Bensh (1987).

Diagnosis.—Test large and moderately to strongly elongate fusiform with tighter internal volution. Polar extremities smooth and rounded. Septal folding strong and developed in the entire chamber. Tunnel absent. Axial filling absent or weakly developed. Phrenothecae present.

Occurrence.—Sakmarian of Central Pamir (Leven, 1993a); upper Sakmarian of Central Afghanistan (Vachard, 1980; Vachard and Montenat, 1981; Leven, 1997); upper Asselian–lower Sakmarian of Pre-Urals, South Urals, and Precaspian Basin (Schellwien, 1908; Korzhenevskiy, 1940; Leven, 1993a); Sakmarian–Kungurian of NW Pakistan (Leven, 2010); Cisuralian of South China (Chen and Wang, 1978) and the Carnic Alps (Davydov et al., 2013); Wolfcampian of the USA (Nevada, New Mexico, Texas, California; Thompson, 1954; Skinner and Wilde, 1965a; Kahler and Kahler, 1966).

Remarks.—This genus has been discussed for a long time, and there are several partial synonyms of *Sakmarella* (see Davydov et al., 2013; Krainer et al., 2019), the species of

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

which were previously assigned to the following taxa: *Nonpseudofusulina*; *Pseudofusulina* (part., especially in Leven, 1993a); *Schwagerina* (part.); *Fusulina* (part.); *Daixina* (part.); and *Paraschwagerina* (part.).

Sakmarella spp.
Figures 5.10–5.13, 6.4, 6.5, 6.7, 6.8, 7.2?, 10.12, 10.13

Remarks.—Our sections are too oblique to provide precise species names; hence, they are only compared with known species (such as *S.* cf. *S. fluegeli* and *S.* cf. *S. implicata*) or remain in open nomenclature. Specimens occur in the upper Yakhtashian *Pamirina darvasica* and *Sakmarella* spp. Zone of the Bagh-e Vang section and in the lower Bolorian *Misellina* (*Brevaxina*) *dyhrenfurthi* Zone and the mid-Bolorian *Cuniculinella* Zone of the Shesh Anghost section (samples BA-4, BA-5, BA-47, SHB-1, and SHB-6).

Genus *Chalaroschwagerina* Skinner and Wilde, 1965a

Type species.—*Chalaroschwagerina inflata* Skinner and Wilde, 1965a, by original designation.

Other species.—See Choi (1973), Bensh (1987), Zhou (1989), Leven et al. (1992); Leven (1997), Vachard et al. (2001b), and Krainer et al. (2019).

Diagnosis.—Test inflated fusiform to globular and constantly bilaterally symmetrical, often strongly vaulted in median part, with poles rounded to bluntly pointed. Proloculus moderate to large, spherical to reniform. No true juvenarium, but 0.5–2 initial whorls are often more tightly coiled and followed by later, loosely coiled whorls. Septa strongly fluted and form rounded to triangular loops that reach three-quarters of the chamber height. Cuniculi absent. Axial filling absent or very weak. Weak chomata on the proloculus and absent in the later whorls. Low and narrow tunnel and diversely developed phrenothecae and septal pores. Wall composed of a tectum and an alveolar keriotheca.

Occurrence.—Cosmopolitan (see e.g., Leven, 1995, 1998, and Vachard et al., 2001b) and known from Sakmarian–Kungurian of Uzbekistan (Darvaz; Leven et al., 1992, 2007), Pakistan (Leven, 2010), Malaysia (Fontaine et al., 1999), Sumatra (Nguyen Duc Tien, 1986), South China (Zhou et al., 1987; Zhou, 1989) and western Yunnan (Ueno et al., 2003), East Siberia (Davydov et al., 1996), Mexico (Chiapas) (Thompson and Miller, 1944; Vachard et al., 2000b), southern Chile (Douglass and Nestell, 1976), and the Carnic Alps (Davydov et al., 2013; Krainer et al., 2019).

Remarks.—Before being formally described, this genus was assigned to the following taxa: *Pseudofusulina* (part), *Schwagerina* (part.), and *Taiyuanella* (part.); see discussion in Krainer et al. (2019).

Chalaroschwagerina sp.
Figure 6.2

Remarks.—Rare *Chalaroschwagerina* have been observed in our material, but not determined because they are oblique sections. They were found in the upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Genus *Chalaroschwagerina*?

Remarks.—This form is transitional between true *Chalaroschwagerina* and *Cuniculinella* emend. Kobayashi, 2019 (= *Cuniculina* Leven and Vaziri Moghaddam, 2004) because it has the rhombic form septal folding of the former, but does not exhibit cuniculi. It is recognized in the upper Yakhtashian of eastern Paleotethys (see the synonymy lists of the two species described below).

Chalaroschwagerina? *vulgaris* (Schellwien in Schellwien and Dyhrenfurth, 1909)
Figures 10.11, 13.5, 13.6, 14.1

1909 *Fusulina vulgaris* Schellwien in Schellwien and Dyrhenfurth, p. 163, pl. 14, figs. 1, 2.
1925 *Schellwienia vulgaris*; Ozawa, p. 23, pl. 7, fig. 3.
1939 *Schwagerina vulgaris*; Likharev, p. 39, pl. 2, figs. 7–9.
1949 *Pseudofusulina vulgaris*; Miklukho-Malay, p. 87, pl. 8, figs. 2, 3, pl. 9, figs. 1–3.
1967 *Pseudofusulina vulgaris*; Kalmykova, p. 179, pl. 8, figs. 1–6.
1977 *Pseudofusulina vulgaris*; Ota, pl. 2, figs. 7, 8.
1978 *Pseudofusulina vulgaris*; Liu, Xiao, and Dong, p. 58, pl. 12, fig. 2.
1982 *Pseudofusulina vulgaris*; Zhang, p. 177, pl. 15, figs. 2, 5, 6, 8.
1992 *Chalaroschwagerina vulgaris*; Leven in Leven et al., p. 91, pl. 14, figs. 5–7.
1992 *Chalaroschwagerina vulgaris*; Ueno, fig. 3.1–3.4.
1997 *Chalaroschwagerina vulgaris*; Leven, p. 67, pl. 10, figs. 1, 2.
1998 *Chalaroschwagerina vulgaris*; Leven, pl. 4, figs. 2, 4.
1998 *Chalaroschwagerina vulgaris*; Zhou, pl. 3, fig. 11.
2004 *Chalaroschwagerina vulgaris*; Leven and Özkan, pl. 2, figs. 12, 13.

Lectotype.—Axial section (Geologisches Institut, Königsberg, Germany, currently Kaliningrad, Russia; catalogue number not given) from Permian of Obi-Niou river, Darvaz, Uzbekistan (Schellwien in Schellwien and Dyhrenfurth, 1909, pl. 14, fig. 1; subsequently designated by Toriyama, 1958, p. 167).

Occurrence.—Upper Yakhtashian of Darvaz, Afghanistan, South China, Japan (see references in Leven et al., 1992; Ueno, 1992). It is found in the mid-Bolorian *Cuniculinella* Zone of the Shesh Anghost section (samples SHB-4 and SHB-9).

Description.—Test relatively large and subglobular with highly vaulted median portion and blunt poles. Proloculus spherical. Initial two whorls tightly coiled, adult whorls loosely coiled. Septa intensively fluted. Thin phrenothecae. Chomata absent.

Table 1. Elements of comparison between the fusulinid genera *Leeina*, *Chalaroschwagerina*, *Chalaroschwagerina*?, *Cuniculina*, and *Cuniculinella*.

Genera	Type species	Main characters	Remarks	Ages
Leeina Galloway, 1933	*Fusulina vulgaris* var. *fusiformis* Schellwien, 1902	Tests elongate fusiform with strong septal folding and strong axial filling	The genus is admitted here in the sense of Davydov et al., 2013	Hermagorian–Bolorian (= Sakmarian–Kungurian)
Chalaroschwagerina Skinner and Wilde, 1965a	*Chalaroschwagerina inflata* Skinner and Wilde, 1965a	Tests elongate fusiform to inflated fusiform terminal whorls higher than the initial ones. Septal folding moderate to strong. Phrenothecae common.	—	Yakhtashian (= Artinskian)
Chalaroschwagerina?	Species groups of *C. vulgaris* and *C. globosa*	Tests subglobular. Coiling regular. Strong septal folding. A few phrenothecae.	—	Late Yakhtashian (= late Artinskian)
"*Cuniculina*" Leven in Leven and Vaziri, 2004 pre-occupied by an insect Phasmida	*Parafusulina*? *vulgarisiformis* Morikawa, 1952	Tests similar to *C. vulgaris* and *C. globosa* but with additional cuniculi.	*vulgarisiformis* is homeomorphous of *vulgari*, but posseses cuniculi; *globosaeformis* is homeomorphous of *globosa*, but with cuniculi.	Bolorian (= late Kungurian) Bolorian-Kubergandian
Cuniculinella Skinner and Wilde, 1965a emend. Kobayashi, 2019	*Cuniculinella tumida* Skinner and Wilde, 1965a	1. Type species similar to "*Cuniculina*" 2. Other species relatively similar to *Leeina*, but with cuniculi.	*Cuniculinella* has a double priority upon *Cuniculina* (its anteriority and because *Cuniculina* is pre-occupied).	(= late Kungurian–early Roadian)

Tunnel indistinct. Measurements: w = 6000–7855 µm; D = 2000–6000 µm; w/D = 1.52–1.67; proloculus diameter = 200–310 µm; number of whorls = 5; s = 100 µm.

Remarks.—*Cuniculinella* emend. Kobayashi, 2019 (= *Cuniculina* Leven and Vaziri Moghaddam, 2004) probably derives from *Chalaroschwagerina vulgaris* (Table 1). Its difference in shape, in comparison with true other *Chalaroschwagerina*, justifies a posteriori the name "*Chalaroschwagerina*? *vulgaris*" with a question mark, proposed by Vachard et al. (2001b).

Chalaroschwagerina? *globosa* (Schellwien in Schellwien and Dyhrenfurth, 1909)
Figure 13.3

1909 *Fusulina vulgaris* var. *globosa* Schellwien in Schellwien and Dyrhenfurth, p. 164, pl. 14, figs. 3–7.
1912a *Fusulina globosa*; Deprat, p. 22, pl. 6, figs. 5–7.
1925 *Schellwienia vulgaris var. globosa*; Ozawa, p. 24, pl. 7, figs. 1, 2.
1958 *Pseudofusulina vulgaris* var. *globosa*; Toriyama, p. 168, pl. 21, figs. 16–18, pl. 22, figs. 1–7.
1959 *Pseudofusulina vulgaris* var. *globosa*; Igo, p. 240, pl. 1, figs. 4–6, pl. 3, fig. 4.
1961 *Pseudofusulina globosa*; Morikawa and Isomi, p. 17, pl. 13, fig. 8.
1967 *Pseudofusulina globosa*; Kalmykova, p. 178, pl. 7, figs. 1–4.
1982 *Pseudofusulina vulgaris globosa*; Zhang, p. 178, pl. 15, fig. 3, 11, 12.
1987 *Pseudofusulina vulgaris globosa*; Rui and Hou, p. 231, pl. 26, figs. 5–7.
1992 *Chalaroschwagerina globosa*; Leven in Leven et al., p. 91, pl. 15, fig. 3.
1998 *Chalaroschwagerina globosa*; Leven, pl. 4, fig. 8.
2001b *Chalaroschwagerina* (?) *globosa*; Vachard et al., p. 47, pl. 2, figs 1–8.

Lectotype.—Axial section (Geologisches Institut, Königsberg, Germany, currently Kaliningrad, Russia; catalogue number not given) from Permian of Obi-Niou river, Darvaz, Uzbekistan (Schellwien in Schellwien and Dyhrenfurth, 1909, pl. 14, fig. 3; subsequently designated by Toriyama, 1958, p. 168).

Occurrence.—Upper Yakhtashian–Bolorian of Transcaucasia, Urals, Darvaz, Afghanistan, North China, South China, Indochina, Japan (compiled in Leven et al., 1992; Vachard et al., 2001b), and Sicily (Vachard et al., 2001b). It is found in the mid-Bolorian *Cuniculinella* Zone of the Shesh Anghost section (sample SHB-8).

Description.—Measurements: w = 6500 µm; D = 4900 µm; w/D = 1.33; proloculus diameter = 400 µm; number of whorls = 7.

Remarks.—Test is more globose than that of *C.*? *C. vulgaris*, but similar in size and septal folding (Toriyama, 1958). It also has more phrenothecae.

Genus *Cuniculinella* Skinner and Wilde, 1965a emend. herein

Type species.—*Cuniculinella tumida* Skinner and Wilde, 1965a by original designation.

Diagnosis.—Test moderately large, inflated fusiform to subglobular with prominent, bluntly pointed poles. Intense septal folding. Phrenothecae and cuniculi present. See also Kobayashi, 2019, p. 65.

Occurrence.—Bolorian/Kungurian and other stratigraphic equivalents; probably cosmopolitan.

Remarks.—The genus *Cuniculina* Leven in Leven and Vaziri Moghaddam, 2004 has a name pre-occupied by an insect name (F. Le Coze, personal communication, June 2018). On the other hand, as recently indicated by Kobayashi (2019), the type species of *Cuniculinella*, *C. tumida* Skinner and Wilde 1965a (pl. 35, figs. 13–18) and sensu Kahler, 1987 (pl. 5, fig. 4), has an inflated to subrhombic form, with faint axial filling, characteristic of "*Cuniculina.*" It differs, therefore, basically from all the other species of "*Cuniculinella*" described by Skinner and Wilde (1965a), which are fusiform and with thick axial fillings: *Cuniculinella ventricosa*, *C. fusiformis*, *C. acuta*, *C. munda*, *C. extensa*, *C. solita*, *C. mira*, *C. rotunda*, *C. ampla*, and *C. inflata*. These latter species are most probably related to *Paraleeina* Leven in Leven and Vaziri Moghaddam, 2004 and/or some *Parafusulina* Dunbar and Skinner, 1931, such as *P.* of the group *kaerimizensis* (Ozawa, 1925), or *Praeparafusulina* Tumanskaya, 1962, such as *P.* of the group *lutugini* (Schellwien, 1908), in the upper Cisuralian of northern California (Skinner and Wilde, 1965a), Pamirs (Leven, 1967; as *Parafusulina* [part.]), and Chios and Kos islands (Kahler, 1987). On the other hand, some "*Cuniculinella*" sensu Bensh, 1972 belong to another genus, which could be *Pseudochusenella* Bensh, 1987; *Rugochusenella* Skinner and Wilde, 1965b; or *Leeina* in the sense of Davydov et al., 2013 (for discussion with *Leeina* Galloway, 1933 sensu stricto; see Krainer et al., 2019).

Cuniculinella tumida Skinner and Wilde, 1965a
Figures 12.7, 12.8?, 13.1, 13.2

1965a *Cuniculinella tumida* Skinner and Wilde, p. 84, pl. 35, figs. 13–18.
1966 *Cuniculinella tumida*; Kahler and Kahler, p. 624.
1975 *Praeparafusulina tumida*; Rozovskaya, p. 176, pl. 22, figs. 3–5.
1987 *Cuniculinella tumida*; Kahler, p. 308, pl. 5, fig. 5.
1987 *Cuniculinella tumida*; Loeblich and Tappan, p. 281, pl. 288, figs. 7, 8.
1992 *Pseudofusulina tumida*; Zhang, pl. 4, fig. 7.
1996 *Cuniculinella tumida*; Rauzer-Chernousova et al., p. 141, pl. 39, fig. 7.

Holotype.—Axial section (Skinner and Wilde, 1965a, pl. 35, fig. 13) from Leonardian McCloud Limestone, Klamath Mountains, Shasta County, California.

Occurrence.—Zone E of the Klamath Mountains (Skinner and Wilde, 1965a), Chios Island (Kahler, 1987), South China (Zhang, 1992). It is found in the mid-Bolorian *Cuniculinella* Zone of the Shesh Angosht section (sample SHB-8).

Description.—Test is subrhombic to subglobular with highly vaulted median portion and blunt poles. The proloculus is spherical, large, and relatively thick-walled. The two initial whorls are tightly coiled and the adult whorls are loosely coiled. The septa are intensively and rather irregularly fluted with high and narrow septal loops. The tunnel is low and narrow. Other characteristics are: poorly developed axial filling, thin phrenothecae, absence of chomata, relatively thick wall, and presence of cuniculi in outer whorls. Measurements: w = 4200–6500 µm; D = 2600–4300 µm; w/D = 1.51–1.62; proloculus diameter = 250–350 µm; number of whorls = 4.

Remarks.—Our specimens are smaller than the type material of Skinner and Wilde (1965a), but are morphologically similar.

Cuniculinella cf. *turgida* (Thompson and Wheeler in Thompson, Wheeler, and Hazzard, 1946)
Figure 14.7, 14.8

1946 *Parafusulina*? *turgida* Thompson and Wheeler in Thompson et al., 1946, p. 30, pl. 4, figs. 1–3, pl. 5, figs. 1–6.
1965a *Cuniculinella turgida*; Skinner and Wilde, p. 85, pl. 46, figs. 7–12, pl. 40, figs. 8–11, pl. l 41, fig. 1.
1966 *Parafusulina*? *turgida*; Kahler and Kahler, p. 654.
1989 *Chalaroschwagerina turgida*; Zhou, p. 260, pl. 1, fig. 6.

Holotype.—Axial section (Type Collection 7638, Stanford University Paleontology) from upper McCloud Limestone, Shasta County, California (Thompson and Wheeler in Thompson et al., 1946, pl. 5, fig. 2).

Occurrence.—Bolorian? (zone G) of Klamath Mountains (California, USA). It is found in the mid-Bolorian *Cuniculinella* Zone of the Shesh Anghost section (sample SHB-9).

Description.—Globose species characterized by a thick wall, moderately developed axial filling and well-developed phrenothecae. Measurements: w = 5000–5500 µm; D = 3000–4000 µm; w/D = 1.38; proloculus diameter = 400 µm; number of whorls = 4.5 (to compare with the measurements of type material: w = 5600–10400 µm; D = 4500–6650 µm; w/D = 1.25–1.56; number of whorls = 7–8)

Remarks.—Our specimens are smaller than the type material of Thompson, Wheeler, and Hazzard (1946), and have fewer whorls.

Cuniculinella hawkinsiformis (Igo, 1965)
Figure 12.1

1965 *Schwagerina hawkinsiformis* Igo, p. 216, pl. 30, figs. 7, 8.
2004 *Chalaroschwagerina* (*Cuniculina*?) *hawkinsi* (Dunbar and Skinner); Leven and Vaziri Moghaddam, p. 452, pl. 2, fig. 8.
2011 *Chalaroschwagerina* (*Cuniculina*) *hawkinsi*; Leven and Gorgij, pl. 25, fig. 10.

Holotype.—Axial section (No. 23999, Institute of Geology and Mineralogy, Tokyo University of Education) from Permian of the Sote Formation, Nyukawa, Central Japan (Igo, 1965, pl. 30, fig. 7).

Occurrence.—Permian of central Japan (Igo, 1965). Bolorian of Iran: Bagh-e Vang (Leven and Gorgij, 2011) and Shesh Angosht sections (sample SHB-6).

Description.—Our material differs from the representatives of *C. hawkinsi* by the presence of cuniculi and the less-coarse keriotheca. It measures: w = 8500 µm; D = 5200 µm; w/D = 1.63; proloculus diameter = 400 µm; number of whorls = 6; h = 600 µm; s = 150 µm.

Remarks.—Our specimens are smaller than those of Igo (1965), but exhibit the same form ratio (w/D) and almost the same number of whorls.

Cuniculinella vulgarisiformis (Morikawa, 1952) emend. Bensh, 1987
Figures 11.1–11.6, 12.6, 13.4, 13.7, 14.2

1952 *Parafusulina*? *vulgarisiformis* Morikawa, p. 31, pl. 1, figs. 1–4.
1966 *Parafusulina*? *vulgarisiformis*; Kahler and Kahler, p. 70.
1967 *Parafusulina vulgarisiformis*; Leven, p. 176, pl. 27, figs. 2, 3, 5 (with six references in synonymy).
1974 *Parafusulina vulgarisiformis*; Kahler, p. 102, pl. 1, fig. 6, pl. 2, fig. 9.
1975 *Parafusulina vulgarisiformis*; Rozovskaya, p. 17.
1987 *Cuniculinella vulgarisiformis*; Bensh, p. 49.
1992 *Chalaroschwagerina vulgarisiformis*; Leven in Leven et al., p. 92, pl. 14, fig. 4.
1997 *Chalaroschwagerina vulgarisiformis*; Leven, p. 67, pl. 10, fig. 3.
2001 *Parafusulina vulgarisiformis*; Ueno, p. 197.
2003 *Chalaroschwagerina vulgarisiformis*; Leven, text-fig. 5.
2004 *Chalaroschwagerina* (*Cuniculina*) *vulgarisiformis*; Leven and Vaziri Moghaddam, p. 452, pl. 2, figs. 2–6.
2011 *Chalaroschwagerina* (*Cuniculina*) *vulgarisiformis*; Leven and Gorgij, pl. 25, figs. 7, 8.
2019 *Cuniculinella vulgarisiformis*; Kobayashi, p. 66, pl. 6, fig. 1

Holotype.—Axial section (No. 10800, Laboratory of Earth Sciences, Saitama University) from Permian of Urawa, Honshu, Japan (Morikawa, 1952, pl. 1, fig. 1).

Occurrence.—Bolorian of the SE Pamirs (Leven, 1967); upper Yakhtashian–Bolorian of Darvaz (Leven et al., 1992); Afghanistan (Khoja Murod area; Leven, 1997); Shesh Angosht section (Kahler, 1974; this study: samples SHB-6, SHB-8, SHB-9); Bagh-e Vang section (Leven and Vaziri Moghaddam, 2004; Leven and Gorgij, 2011); and Japan (Koika, Kanto Mountains: Morikawa, 1952; Akiyoshi Limestone: Kobayashi, 2019).

Description.—This species is characterized by particularly intensive septal folding at the poles and well-developed phrenothecae. Measurements: w = 6000–8000 µm; D = 4000–5200 µm; w/D = 1.19–1.80; proloculus diameter = 250 µm; number of whorls = 5–7; h = 500–600 µm; s = 100 µm.

Remarks.—Our specimens are similar to the material described in the Pamirs and Darvaz by Leven (1967) and Leven et al. (1992), and in the Bagh-e Vang section by Leven and Vaziri Moghaddam (2004) and Leven and Gorgij (2011).

Cuniculinella globosaeformis (Leven, 1967)
Figure 13.8

1967 *Parafusulina globosaeformis* Leven, p. 176, pl. 27, figs. 2, 3, 5.
1974 *Parafusulina* cf. *globosaeformis*; Kahler, p. 98, pl. 2, fig. 2.
1992 *Chalaroschwagerina globosaeformis*; Leven in Leven et al., p. 92, pl. 14, figs. 1–3.
2011 *Chalaroschwagerina* (*Cuniculina*) *globosaeformis*; Leven and Gorgij, pl. 25, fig. 4.

Holotype.—Axial section (No. 3475/164, Geological Science Institute, Academy of Sciences SSSR) from Artinskian of the southeastern Pamirs, Tajikistan (Leven, 1967, pl. 27, fig. 5).

Occurrence.—Bolorian of southeastern Pamirs (Leven, 1967), upper Yakhtashian–Bolorian of Darvaz (Leven et al., 1992), Bagh-e Vang section (Leven and Gorgij, 2011), and Shesh Angosht section (Kahler, 1974; this study: sample SHB-9).

Description.—Test globose with relatively few whorls. The median portion is highly vaulted and has blunt poles. The proloculus is spherical and large. The initial two whorls are tightly coiled and more rhomboidal, and adult whorls are loosely coiled. Septa are intensively and irregularly fluted. Tunnel is indistinct. Phrenothecae and cuniculi are relatively well developed. Measurements: w = 5500 µm; D = 3000 µm; w/D = 1.83; proloculus diameter = 400 µm; number of whorls = 4–5; h = 500 µm; s = 75 µm.

Remarks.—Our specimens are identical to the material of this species previously described in the Bagh-e Vang section by Leven and Gorgij (2011).

Cuniculinella spp.
Figures 7.1, 12.3–12.5, 14.3, 14.4

Remarks.—Several sections, in open nomenclature, belong to *Cuniculinella*. They were found from the mid-Bolorian *Cuniculinella* spp. Zone of the Shesh Angosht section (samples SHB-9 and SHB-12) and the Bagh-e Vang section (sample BA-12).

Genus *Leeina* Galloway, 1933

Type species.—*Fusulina vulgaris* var *fusiformis* Schellwien in Schellwien and Dyhrenfurth, 1909, by original designation.

Diagnosis.—Test fusiform to stumpy fusiform with heavy to very heavy axial filling. Proloculus large, spherical to reniform. Septa intensively folded, except in central part of chambers. Chamber height increases moderately and gradually. Chomata and phrenothecae absent.

Occurrence.—Cisuralian–Guadalupian of Darvaz, Pamirs (Bensh, 1987), South China (Sheng, 1963; Zhou, 1998), Japan (Ueno, 1992; Kobayashi, 2019), Malaysia (Fontaine et al., 1999), Oman (Vachard et al., 2001a), North Pakistan (Leven et al., 2007; Leven, 2010), and Austria (Davydov et al., 2013).

Remarks.—As suggested by Krainer et al. (2019, p. 85), there are probably several groups of species in the genus *Leeina*

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

sensu lato: (1) the group *L. fusiformis* more or less phylogenetically related to the genus *Kutkanella* Bensh, 1987; (2) the group of species accurately described in the Carnic Alps by Davydov et al. (2013), which is the possible ancestor of *Cuniculinella* Skinner and Wilde, 1965a of the authors (presented and discussed later in this paper as the taxon *Leeina*?, with question mark); and (3) the group *L. kraffti* Schellwien, 1908, which gives rise to *Paraleeina* Leven in Leven and Vaziri Moghaddam, 2004.

Leeina isomie (Igo, 1965)
Figures 7.7, 10.14, 11.7, 14.6

1965 *Pseudofusulina isomie* Igo, p. 219, pl. 29, fig. 6, pl. 30, figs. 5, 6, pl. 31, figs. 6, 7.
1992 *Pseudofusulina isomie*; Leven in Leven et al., p. 100, pl. 23, fig. 6.

Holotype.—Axial section (No. 23999, Institute of Geology and Mineralogy, Tokyo University of Education) from the Permian of the Sote Formation, Nyukawa, Central Japan (Igo, 1965, pl. 30, fig. 5).

Occurrence.—Permian of central Japan (Igo, 1965), upper Yakhtashian–Bolorian of eastern Paleotethys (see Leven et al., 1992), and the Bagh-e Vang (sample BA-61) and Shesh Angosht sections (samples SHB-6 and SHB-19).

Description.—Test is elongate fusiform with rectilinear central parts of chambers. Axial filling is heavy. Measurements: w = 7500–8000 μm; D = 2500–3000 μm; w/D = 2.50–3.90; proloculus diameter = 250 μm; number of whorls = 6–7; h = 450 μm; s = 75 μm.

Remarks.—Our specimens are similar to the type material described in Japan by Igo (1965), in morphology as well as in measurements.

Leeina cf. *L. quasifusuliniformis* (Leven, 1967)
Figure 6.1

1967 *Pseudofusulina quasifusuliniformis* Leven, p. 151, pl. 12, figs. 7–9.
2003 *Pseudofusulina quasifusuliniformis*; Kobayashi and Ishii, p. 316, pl. 3, figs. 12, 13.

Holotype.—Axial section (No. 3475/81, Institute of Geological Science, Academy of Sciences of the SSSR) from Kubergandian of the southeastern Pamirs (Tajikistan) (Leven, 1967, pl. 12, fig. 8).

Occurrence.—Kubergandian of the Pamirs (Leven, 1967). It is found in the upper Yakhtashian *Pamirina darvasica* and *Sakmarella* spp. Zone of the Bagh-e Vang section (sample BA-4).

Description.—Test is relatively short fusiform. Axial filling is heavy. Measurements: w = 3300 μm; D = 1800 μm; w/D = 1.61; proloculus diameter = 300 μm; number of whorls = 3; h = 100 μm; s = 20 μm.

Remarks.—Our specimens have the shape and the heavy axial filling of *L. quasifusuliniformis*, but differ in their smaller measurements; nevertheless, they are supposed to be immature specimens of *L. quasifusuliniformis*.

Leeina fusiformis (Schellwien in Schellwien and Dyhrenfurth, 1909)
Figure 14.5

1909 *Fusulina vulgaris* var. *fusiformis* Schellwien in Schellwien and Dyhrenfurth, p. 165, pl. 15, figs. 1–4.
1934 *Pseudofusulina tschernyshewi*; Chen, p. 52, pl. 10, fig. 11.
1959 *Pseudofusulina vulgaris* var. *fusiformis*; Kanuma, p. 75, pl. 7, figs. 7–11.
1959 *Pseudofusulina valida*; Igo, p. 242, pl. 2, figs. 5, 6.
1967 *Pseudofusulina fusiformis*; Kalmykova, p. 181, pl. 9, figs. 1–5.
1978 *Pseudofusulina fusiformis*; Chen and Wang, p. 86, pl. 19, figs. 12, 13.
1978 *Pseudofusulina fusiformis*; Liu, Xiao, and Dong, p. 59, pl. 13, fig. 1.
1984 *Pseudofusulina fusiformis*; Huang and Zeng, pl. 3, fig. 13.
1992 *Pseudofusulina fusiformis*; Leven in Leven et al., p. 100, pl. 20, figs. 2, 3.
1992 *Pseudofusulina fusiformis*; Ueno, p. 1283, fig. 3.7–3.11.
1997 *Pseudofusulina fusiformis*; Leven, p. 69, pl. 12, fig. 14.
1998 *Pseudofusulina fusiformis*; Zhou, pl. 3, fig. 2.
2004 *Leeina fusiformis*; Leven and Vaziri Moghaddam, p. 454, pl. 6, figs. 1, 2.
2016 *Leeina fusiformis*; Angiolini et al., figs. 9B, 14I.
2019 *Pseudofusulina fusiformis*; Kobayashi, p. 71, pl. 6, figs. 2–4.

Lectotype.—Axial section (Geologisches Institut, Königsberg, Germany, currently Kaliningrad, Russia; catalogue number not given) from Safed-Koh Mountain, Darvaz, Uzbekistan (Schellwien in Schellwien and Dyhrenfurth, 1909, pl. 15, fig. 2; subsequently designated by Thompson, 1948).

Occurrence.—Yakhtashian and Bolorian of eastern Paleotethys and western Panthalassa (see Leven et al., 1992; Ueno, 1992; Kobayashi, 2019). It is found in the upper Bolorian part of the Shesh Anghost section (sample SHB-12).

Description.—Test is subcylindrical with rounded poles. It has loosely, but uniformly coiled volutions. Septa are weakly fluted in the central parts and strongly folded at the poles. Small chomata are present in earlier whorls. Axial filling is weak or relatively developed.

Remarks.—This well-known species is easy to identify. Our specimens are particularly similar to the specimens from the Darvaz and the Pamirs described in the literature (Schellwien in Schellwien and Dyhrenfurth, 1909; Kalmykova, 1967; Angiolini et al., 2016).

Leeina spp.
Figures 7.3–7.6, 10.15

Remarks.—There are additional, indeterminate, often silicified, oblique sections of *Leeina* in our material. They were found in the mid-Bolorian *Cuniculinella* Zone and upper Bolorian *Misellina* (*Misellina*) cf. *M.* (*M.*) *termieri* Zone of the Bagh-e Vang (samples BA-14-5-1, BA-47, and BA-55) and Shesh Anghost sections (sample SHB-6).

Chusenellinae Kahler and Kahler, 1966
Genus *Chusenella* Hsu, 1942

Type species.—*Chusenella ishanensis* Hsu, 1942, by original designation.

Other species.—See Sheng (1963); Stewart (1963); Rozovskaya (1975); Lin et al. (1977); Wang, Sheng, and Zhang (1981); Bensh (1987); and Vachard and Ferrière (1991).

Diagnosis.—Test fusiform. Proloculus small. Early whorls tighly coiled, adult whorls more loosely coiled. Septa strongly folded. Rudimentary chomata on the proloculus. Axial filling heavy.

Occurrence.—The FAD was supposed to be Kubergandian (Bensh, 1987; Leven, 1997); its FO/FAD is possibly upper Yakhtashian in our material. The LAD is recorded in the upper Capitanian/Midian (Ghazzay-Souli et al., 2015).

Chusenella? sp.
Figure 4.17

Remarks.—Our sections are too oblique to be assigned precisely to the genus *Chusenella*. They were found in the upper Yakhtashian *Pamirina darvasica* and *Sakmarella* spp. Zone of the Bagh-e Vang section (sample BA-4).

Genus *Grozdilovia* Bensh, 1987

Type species.—*Schwagerina ellipsoides* Grozdilova, 1938, by original designation.

Other species.—See Bensh (1987).

Diagnosis.—Test ellipsoidal, fusiform to elongate fusiform. Juvenarium, axial filling, chomata, cuniculi absent. Phrenothecae rare. Septal folding strong, generalized to the entire chamber, except in its center. Tunnel irregular, but often present.

Occurrence.—Upper Asselian–Sakmarian of the Paleotethyan, Uralian, and western Panthalassan shelves (see Bensh, 1987; Krainer et al., 2019; and this study).

Grozdilovia sp.
Figure 5.8

Remarks.—Test is elongate fusiform with moderately to strongly septal folding. Measurements: w = 4500 µm; D = 1750 µm; w/D = 2.60; number of whorls = 5. It is found in the upper Yakhtashian *Pamirina darvasica* and *Sakmarella* spp. Zone of the Bagh-e Vang section (sample BA-4).

Family Polydiexodinidae Miklukho-Maklay, 1953
Genus *Praeskinnerella* Bensh, 1991

Type species.—*Schwagerina guembeli* Dunbar and Skinner, 1937, by original designation.

Other species.—*Schwagerina guembeli pseudoregularis* Dunbar and Skinner, 1937; *S. crassitectoria* Dunbar and Skinner, 1937; *Pseudofusulina cushmani* Chen, 1934; *Schwagerina cushmani longa* Zhou, 1982; *S. cushmani robusta* Zhou, 1982; *Pseudofusulina ellipsoidalis* Sheng, 1963; *Schwagerina formosa* Kochansky-Devidé, 1959 (= *Schwagerina postcallosa huanghuigouensis* Zhang and Xia in Rui and Hou, 1987 = *Praeskinnerella pseudofragilis* Leven in Leven, Leonova, and Dmitriev, 1992 = ?*Schwagerina moorei* Skinner and Wilde, 1965a); *Schwagerina meloformata* Roberts in Newell, Chronic, and Roberts, 1953; *Pseudofusulina parviflucta* Zhou, 1982; *P. pavlovi* Leven, 1967; *Praeskinnerella pseudogruperaensis* Leven in Leven, Leonova, and Dmitriev, 1992.

Diagnosis.—Test short ellipsoidal to subhexagonal with convex to flattened lateral slopes and bluntly pointed poles. Individualized juvenarium absent. Early whorls more fusiform and more closely coiled. Proloculus small to moderate in size. Septa folded. Tunnel poorly defined or absent. Chomata absent. Axial filling heavy and developed in all whorls. Cuniculi present in the last whorls.

Occurrence.—Sakmarian–Bolorian of Darvaz (Leven et al., 1992; Davydov et al., 2013), Cisuralian of Croatia (Kochansky-Devidé, 1959), Leonardian of the North American craton (Dunbar and Skinner, 1937), Peru (Roberts in Newell et al., 1953), and Zone F of California (Skinner and Wilde, 1965a), Cisuralian of South China (Rui and Hou, 1987), Yakhtashian–Bolorian of the Carnic Alps (Davydov et al., 2013; Krainer et al., 2019), and Yakhtashian of eastern Iran (Leven and Vaziri Moghaddam, 2004; Leven and Gorgij, 2011; this study).

Remarks.—The genus was initially called *Guembelites* Bensh, 1987, but this pre-occupied name was subsequently changed to *Praeskinnerella*.

Praeskinnerella sp.
Figure 12.2

Remarks.—Test is subhexagonal with heavy axial filling. Measurements: w = 5300 µm; D = 2830 µm; w/D = 1.52; number of whorls = 6; h = 415 µm; s = 25 µm. Our unique specimen is in subaxial section and therefore difficult to identify to the species level; however, it differs from *Praeskinnerella pavlovi* as well as *P. pseudogruperaensis*, which were both found by Leven and Vaziri Moghaddam (2004) in the Bagh-e Vang section. It is identified in the

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

mid-Bolorian *Cuniculinella* spp. Zone of the Shesh Anghost section (sample SHB-6).

Genus *Paraskinnerella* Bensh in Rauzer-Chernousova et al., 1996

Type species.—*Parafusulina leonardensis* Ross, 1962, by original designation.

Other species.—*Parafusulina apiculata* Knight, 1956; *P. allisonensis* Ross, 1960; *P. australis* Thompson and Miller, 1944; *P. brooksensis* Ross, 1960; *P. deltoides* Ross, 1960; *P. durhami* Thompson and Miller, 1944; *Schwagerina graciliseptata* (sic: *gracilseptata*) Xie, 1982; *Eoparafusulina juvaensis* Chuvashov in Chuvashov et al., 1990; *Parafusulina*? *khossedaensis* Konovalova, 1991; *P*.? *kolvensis* Grozdilova and Lebedeva in Grozdilova, Izotova, and Lebedeva in Azbel, Bagdasaryan, and Belyakova, 1980; *P*.? *lajaensis* Konovalova in Konovalova and Baryshnikov, 1980; *Fusulina Lutugini* Schellwien, 1908; *Parafusulina skinneri* Dunbar, 1939; *P. vidriensis* Ross, 1960.

Diagnosis.—Test elongate fusiform to subcylindrical with bluntly pointed poles and convex to flattened lateral slopes. Individualized juvenarium absent, even if early whorls more fusiform and more closely coiled. Proloculus small to moderate in size. Septa strongly folded with numerous loops, irregular in size and shape. Tunnel poorly defined or absent. Chomata absent. Axial filling present in initial whorls, but poorly represented or absent in last whorls. Cuniculi present in the last whorls.

Occurrence.—Upper Artinskian–Kungurian (Sarginian–Irginskian) of southern Urals (Schellwien, 1908; Rauzer-Chernousova, 1949), northern Timan (Grozdilova and Lebedeva, 1961), Spitsbergen (Forbes, 1960), Croatia (Ramovš and Kochansky-Devidé, 1965), Japan (Toriyama, 1958), eastern Iran (Kahler, 1974), Italy, Darvaz, and China (Kahler, 1989), Carnic Alps: Treßdorfer Kalk, Forni Avoltri (Kahler and Kahler, 1980), and Trogkofel Formation (Krainer et al., 2019), and Leonardian of the USA (Bensh, 1987).

Remarks.—*Paraskinnerella*, initially described as a subgenus of *Skinnerella* Coogan, 1960, is considered here as a genus transitional between *Skinnerella* and *Parafusulina* Dunbar and Skinner, 1931 (see discussion in Bensh in Rauzer-Chernousova et al., 1996; Vachard et al., 2000a, b; and Vachard in Krainer et al., 2019).

Paraskinnerella? sp.
Figure 6.6

Remarks.—Only one section in our material is close to *Paraskinnerella* by the shape of its test, but it does not show the cuniculi that distinguish this genus, due to its type of oblique section. Measurements: w = 9000 µm, D = 2500 µm. It was found in the upper Yakhtashian of Bagh-e Vang section (sample BA-4).

Superfamily Neoschwagerinoidea Solovieva, 1978
Family Misellinidae Leven, 1982
Subfamily Misellininae Miklukho-Maklay, 1958
Genus *Levenella* Ueno, 1994 (= *Levenia* Ueno, 1991 pre-occupied)

Type species.—*Pamirina leveni* Kobayashi, 1977, by original designation.

Other species.—See Kobayashi (1977) and Ueno (1991).

Diagnosis.—Test small, discoid, almost planispiral, biumbilicate, with rounded periphery. Septa planar. Rare neoschwagerinoid parachomata present, instead of schubertelloid chomata. Wall composed of a tectum and a thin, finely keriothecal, inner layer. Aperture terminal and simple.

Occurrence.—Upper Yakhtashian–lower Bolorian of central and eastern Paleotethys (see Ueno, 1991; Leven et al., 1992).

Levenella sp.
Figure 4.3, 4.4

Remarks.—The species observed in our material is advanced for the genus because its shape is nautiloid instead of discoid, and already transitional to *Pamirina*. It is possibly a new species, but more specimens are necessary to describe it. It was identified in the upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Genus *Pamirina* Leven, 1970

Type species.—*Pamirina darvasica* Leven, 1970.

Other species.—See Wang and Sun (1973) and Leven et al. (1992).

Diagnosis.—Test moderate in size, nautiloid to subglobose, planispirally coiled, involute. Juvenarium absent. Septa planar. Wall schubertelloid to finely keriothecal. Parachomata relatively numerous. Aperture simple and terminal.

Occurrence.—Darvaz (Leven, 1970; Leven et al., 1992), South China (Wang and Sun, 1973; Ueno, 1991), Carnic Alps (Kahler and Kahler, 1980; Kahler in Ebner and Kahler, 1989; Davydov et al., 2013), Afghanistan (Vachard, 1980; Leven, 1997), Karakorum (Gaetani and Leven, 2014), northern Thailand (Igo et al., 1993), and Japan (Ueno, 1991; Kobayashi, 2019).

Remarks.—The phylogeny of this genus is well known (Leven, 1970; Ueno, 1991; Vachard et al., 2013; Angiolini et al., 2016; Krainer et al., 2019). Some individuals that are transitional between *Levenella* Ueno, 1994 and *Pamirina* are present in our material (see earlier).

Pamirina darvasica Leven, 1970
Figure 4.23, 4.24

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

1970 *Pamirina darvasica*; Leven, p. 23, pl. 1, figs. 1–12.
1974 *Pamirina darvasica*; Kahler, p. 85.
1975 *Pamirina darvasica*; Rozovskaya, pl. 35, figs. 4, 5.
1978 *Pamirina darvasica*; Liu, Xiao, and Dong, p. 80, pl. 18, figs. 8, 12.
1980 *Pamirina darvasica*; Kahler and Kahler, p. 187, pl. 3, figs. 7, 8.
1984 *Pamirina* (*Pamirina*) *darvasica*; Huang and Zeng, pl. 4, fig. 14.
1986 *Pamirina darvasica*; Xiao et al., p. 144, pl. 12, figs. 8, 9, 13 (fide Leven et al., 1992).
1987 *Pamirina darvasica*; Loeblich and Tappan, p. 286, pl. 295, figs. 11, 12.
1989 *Pamirina darvasica*; Kahler in Ebner and Kahler, p. 137, pl. 1, figs. 2–4.
1991 *Pamirina* (*Pamirina*) *darvasica*; Ueno, p. 744, fig. 3.1–3.7.
1992 *Pamirina darvasica*; Leven in Leven et al., p. 72, pl. 3, fig. 12.
1993 *Pamirina* (*Pamirina*) *darvasica*; Igo et al., p. 20, figs. 3.1–3.9, 4.1–4.33.
2004 *Pamirina* (*Pamirina*) *darvasica*; Leven and Vaziri Moghaddam, p. 450, pl. 1, fig. 9.
2011 *Pamirina darvasica*; Leven and Gorgij, pl. 24, fig. 8.
2019 *Pamirina darvasica*; Kobayashi, p. 56, pl. 3, figs. 32, 38, 45–50.

Holotype.—Axial section (No. MGRI, VI-160/1, Moscow Geological Prospecting Institute) from Artinskian of Safet-Daron suite, Obi-Niou river, southwestern Darvaz, Uzbekistan (Leven, 1970, pl. 1, fig. 1).

Occurrence.—Upper Yakhtashian–lower Bolorian of Darvaz (Leven, 1970; Leven et al., 1992), Iran: Koh-e Shesh-Angosht (Kahler, 1974) and Kaviz sections (Leven and Gorgij, 2011), Carnic Alps (Kahler and Kahler, 1980; Kahler in Ebner and Kahler, 1989; Davydov et al., 2013), South China and Japan (Ueno, 1991; Kobayashi, 2019), and North Thailand (Igo et al., 1993). It is found in the upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Description.—This species is characterized by its globose and slightly biumbilicated test. It measures: w = 600–700 µm; D = 600–870 µm; w/D = 0.63–0.80; proloculus diameter = 20 µm; number of whorls = 4–4.5; h = 100–200 µm; s = 20–30 µm.

Remarks.—This well-known species is easy to identify. The morphologies and measurements of our specimens correspond exactly to those of Leven (1970).

Pamirina chinlingensis (Wang and Sun, 1973)
Figure 4.12–4.15

1973 *Chinlingella chinlingensis* Wang and Sun, p. 152, pl. 1, figs. 12, 17–32, pl. 3, figs. 1, 5, 10.
1984 *Pamirina* (*Pamirina*) *chinlingensis*; Huang and Zeng, pl. 4, fig. 7.
1986 *Pamirina chinlingensis*; Xiao et al., p. 144, pl. 12, figs. 3, 4 (fide Leven et al., 1992).
1987 *Pamirina chinlingensis*; Loeblich and Tappan, p. 286, pl. 295, figs. 8–10.
1992 *Pamirina chinlingensis*; Leven in Leven et al., p. 73, pl. 3, figs. 8, 9.

Holotype.—Axial section (No. CFO15, Depository not given. Probably deposited in the collections of the Department of Invertebrate Fauna, Academy of Geological Sciences, Ministry of Geology, Beijing, China) from Cisuralian, Yazi Formation, Chinling Range, China (Wang and Sun, 1973, pl. 1, fig. 10).

Occurrence.—Yakhtashian of South China, lower Bolorian of Darvaz, and upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Description.—This species differs from *P. darvasica* in its smaller parameters for an identical w/D ratio. Our material measures: w = 140–430 µm; D = 320–600 µm; w/D = 0.70–0.73; proloculus diameter = 30–40 µm; number of whorls = 3.5–4.5; h = 70–100 µm; s = 25–100 µm.

Remarks.—We consider our specimens as immature *P. chinlingensis* because they are smaller and have fewer whorls than this latter species; nevertheless, their form ratio (w/D) is typical of *P. chinlingensis.*

Pamirina staffellaeformis Zhou, Sheng, and Wang, 1987
Figure 4.21

1987 *Pamirina staffellaeformis* Zhou, Sheng and Wang, p. 141, pl. 3, figs. 1, 2.
1992 *Pamirina staffellaeformis*; Leven in Leven et al., p. 72, pl. 3, figs. 10, 11.

Holotype.—Axial section (No. 101978, Nanjing Institution of Geology and Paleontology, Academica Sinica, Nanjing) from Permian of Eastern Yunnan, China (Zhou, Sheng, and Wang, 1987, pl. 3, fig. 2).

Occurrence.—Cisuralian of South China (Zhou et al., 1987) and upper Yakhtashian of the Bagh-e Vang section (sample BA-4).

Description.—This species differs from *P. darvasica* in its thinner wall. Our material measures: w = 580 µm; D = 710 µm; w/D = 0.80; proloculus diameter = 20 µm; number of whorls = 4.5; h = 100 µm; s = 10 µm.

Remarks.—Same remark as for *P. chinlingensis*: we consider that our specimens of *P. staffellaeformis* are immature, with smaller dimensions and fewer whorls.

Pamirina spp.
Figure 4.5, 4.6

Remarks.—Several specimens of our material are poorly oriented and remain in open nomenclature. They were found in the upper Yakhtashian *Pamirina darvasica* and *Sakmarella* spp. Zone of the Bagh-e Vang section (sample BA-4).

https://doi.org/10.1017/jpa.2020.46 Published online by Cambridge University Press

Genus *Misellina* (*Brevaxina*) Schenck and Thompson, 1940

Type species.—Doliolina compressa Deprat, 1915, by original designation.

Other species.—See Lin et al. (1977).

Diagnosis.—Test subspherical with flattened poles. Proloculus small. Early whorls deviated ("endothyroid" juvenarium). Septa planar. Parachomata numerous, high, wide. Wall with a tectum and an inner, fine keriotheca. Aperture simple and terminal.

Occurrence.—Bolorian–Kubergandian; rare in western Paleotethys and relatively common in eastern Paleotethys and western Panthalassa (see Deprat, 1915; Kobayashi, 1977; Lin et al., 1977; Loeblich and Tappan, 1987; Leven et al., 1992; and Ueno, 1992).

Misellina (*Brevaxina*) *dyrhenfurthi* (Dutkevich in Likharev, 1939)
Figure 10.3–10.5

1939 *Doliolina dyrhenfurthi* Dutkevich in Likharev, p. 42, pl. 4, figs. 3–5.
1967 *Brevaxina dyrhenfurthi*; Kalmykova, p. 216, pl. 30, figs. 1–8.
1970 *Misellina* (*Brevaxina*) *dyrhenfurthi*; Leven, pl. 1, figs. 14, 20, 25.
1977 *Brevaxina dyrhenfurthi*; Lin et al., p. 86, pl. 26, figs. 12, 13.
1977 *Misellina dyrhenfurthi*; Kobayashi, pl. 2, figs. 4–7, 12, 13.
1986 *Brevaxina dyrhenfurthi*; Xiao et al., p. 152, pl. 19, figs. 22, 23.
1992 *Misellina* (*Brevaxina*) *dyrhenfurthi*; Leven in Leven et al., p. 73, pl. 3, figs. 19–21.
1997 *Misellina* (*Brevaxina*) *dyrhenfurthi*; Leven, p. 74, pl. 20, figs. 8, 9.
1998 *Brevaxina dyrhenfurthi*; Zhou, pl. 3, fig. 11.
2004 *Misellina* (*Brevaxina*) *dyrhenfurthi*; Leven and Vaziri Moghaddam, p. 455, pl. 5, figs. 10, 11.
2016 *Brevaxina dyrhenfurthi*; Angiolini et al., p. 547, figs. 9B–E, 10 B–D, 11B, 12D, 13G, 15D–F.
2019 *Misellina dyrhenfurthi*; Kobayashi, p. 73, pl. 16, figs. 1–22.

Holotype.—Axial section (The Central Geological and Prospecting Institute, Leningrad/Saint Petersburg, depository number not given), from Cisuralian of Charyndar River, Darvaz, Uzbekistan (Dutkevich in Likharev, 1939, pl. 4, fig. 3).

Occurrence.—Lower Bolorian of the Palaeotethys (as for the subgenus). It is found, in this study, in the lower Bolorian *Misellina* (*Brevaxina*) *dyrenfurthi* Zone of the Shesh Anghost section (sample SHB-1).

Description.—This species is relatively large for the subgenus and was recently redescribed in detail by Kobayashi (2019). Measurements: D = 800–1000 µm; number of whorls = 4–5; h = 130–150 µm; s = 20 µm.

Remarks.—Our specimens are typical representatives of *Misellina* (*Brevaxina*) *dyrhenfurthi* and similar to material from Darvaz and the Pamirs (Dutkevich in Likharev, 1939; Kalmykova, 1967; Leven in Leven et al., 1992; Angiolini et al., 2016).

Genus *Misellina* (*Misellina*) Schenck and Thompson, 1940

Type species.—Doliolina ovalis Deprat, 1915, by original designation.

Other species.—See Deprat, 1915; Kahler and Kahler, 1966; Leven, 1967, 1998; Rozovskaya, 1975; Lin et al., 1977; and Leven et al., 1992.

Diagnosis.—Test relatively small, subspherical or ellipsoidal. Septa planar. Numerous parachomata generally low and wide. Wall with tectum and fine keriotheca.

Occurrence.—Bolorian–lower Kubergandian (see discussion in Angiolini et al., 2016), Paleotethys (see Deprat, 1915; Loeblich and Tappan, 1987; Leven et al., 1992).

Misellina (*Misellina*) cf. *M*. (*M*.) *termieri* (Deprat, 1915)
Figures 5.5, 5.6, 10.10

1915 *Doliolina Termieri* Deprat, p. 17, pl. 3, figs. 15–20.
1949 *Misellina termieri*; Miklukho-Maklay, p. 106.
1967 *Misellina termieri*; Leven, p. 183, pl. 29, figs. 10, 11.
? 1975 *Misellina* (*Misellina*) cf. *termieri*; Toriyama, p. 49, pl. 2, figs. 5–10.
1986 *Misellina termieri*; Xiao et al. p. 147, pl. 19, figs. 26, 27.
1992 *Misellina* (*Misellina*) *termieri*; Leven in Leven et al., p. 74, pl. 3, figs. 28, 29.
1997 *Misellina* (*Misellina*) *termieri*; Leven, p. 75, pl. 20, figs. 14, 15.
2004 *Misellina* (*Misellina*) *termieri*; Leven and Vaziri Moghaddam, p. 455, pl. 6, fig. 7.
2016 *Brevaxina* sp. 1 transitional to the first true *Misellina*, i.e., *M. termieri* (Deprat, 1915); Angiolini et al., p. 549, fig. 15 K.

Lectotype.—Axial section (No. F61569, Collection de Micropaléontologie, Muséum National d'Histoire Naturelle, Paris) from Permian of Cam-mon (Laos) (Deprat, 1915, pl. 3, fig. 15; subsequently designated by Toriyama, 1975, p. 49).

Occurrence.—Upper Bolorian–lower Kubergandian; rare in western Paleotethys, relatively common in eastern Paleotethys and western Panthalassa (see Miklukho-Maklay, 1949; Kahler and Kahler, 1966; Leven et al., 1992). Upper Bolorian of the Shesh Anghost section (sample SHB-53).

Description.—Test is elliptical with numerous parachomata that are relatively high in outer whorls. Measurements: D = 1300–2000 µm; number of whorls = 4; h = 130–180 µm; s = 30 µm.

Remarks.—We found only immature specimens of *M. termieri* in our material; they are relatively similar to the *M.* cf. *M. termieri* of Toriyama (1975) in Thailand.

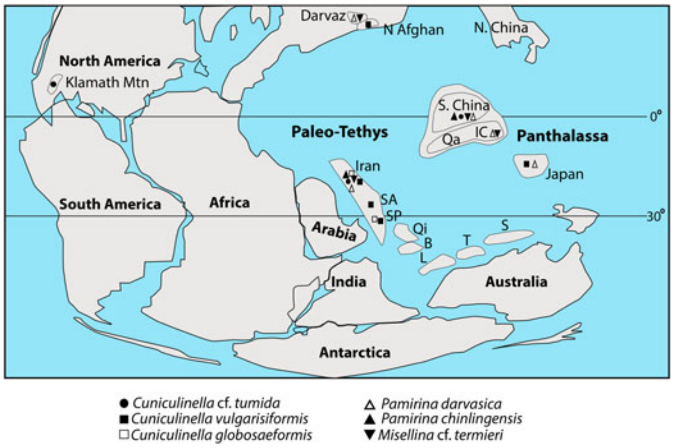

Figure 15. Paleogeography of Iran and surrounding areas during the late ealy Permian showing several paleobiogeographically important taxa (map modified from Rees et al., 2002; Zhang et al., 2013, Liu et al., 2017). Abbreviations: B = Baoshan Block, IC = Indochina Block, L = Lhasa Block, Klamath Mtn = Klamath Mountains, N Afghan = North Afghanistan, N. China = North China, Qa = Qamdo Block, Qi = Qiangtang Block, S = Sibumasu Block, S. China = South China, SA = South Afghanistan, SP = South Pamir, T = Tengchong Block.

Misellina (*Misellina*) sp.
Figure 5.3

Remarks.—A unique transverse section, identified in sample BA-47 of the Bagh-e Vang section, cannot be assigned to *Misellina* (*Misellina*) cf. *M.* (*M.*) *termieri*. Because it is difficult to assign it to another particular species of *Misellina*, it remains in open nomenclature.

Paleobiogeographic implications

Iran is considered to be a Gondwanan-derived block that broke off from the eastern margin of the Gondwana supercontinent in the late Paleozoic, moved northward across the Paleotethys, and eventually collided with the southern margin of Eurasia in the Late Triassic, creating the Eo-Cimmerian orogeny (Sengör, 1979; Besse et al., 1998; Ruban et al., 2007; Muttoni et al., 2009a, b; Zanchi et al., 2009, 2015; Berra and Angiolini, 2014). Paleomagnetic data obtained in northern Iran and Alborz (Besse et al., 1998; Muttoni et al., 2009a; Berra and Angiolini, 2014) suggest a location in the mid-latitude belt of the southern hemisphere, on the northern margin of Gondwana and the southern margin of the Paleotethys (Angiolini et al., 2007, 2013; Brenckle et al., 2009; Qiao et al., 2017; Vachard and Arefifard, 2015).

The presence of early Carboniferous warm-water smaller foraminifers (Zandkarimi et al., 2014; Vachard and Arefifard, 2015) and brachiopods (Brenckle et al., 2009; Bahrammanesh et al., 2011; Qiao et al., 2017) in Iran has been explained by counterclockwise oceanic currents and warm surface current gyres that brought warm taxa from the tropics toward intermediate latitudes (Kiessling et al., 1999; Angiolini et al., 2007; Brenckle et al., 2009). Other workers suggested that the Paleotethys was narrow during the early Carboniferous, facilitating faunal exchanges between its northern and southern margins, as well as the occurrence of warm water fauna along its southern margin (Zandkarimi et al., 2014; Falahatgar et al., 2015; Vachard and Arefifard, 2015).

The first evidence of continental breakup and onset of Neotethyan rifting (Al-Belushi et al., 1996; Garzanti and Sciunnach, 1997) is constrained to mid-Sakmarian time by brachiopod assemblages from central Oman (Angiolini et al., 2003, 2007). Indications of Iran separating from the northern margin of Gondwana and moving toward lower latitudes include: (1) upper Carboniferous fusulinid assemblages (Leven and Gorgij, 2011); (2) geochemical features of the upper Carboniferous coal-bearing Sardar Formation (Khanehbad et al., 2012); (3) paleogeographic reconstruction based on paleomagnetic data (Muttoni et al., 2009b), which suggests a 30°S paleolatitude for Iran during the late Carboniferous; and (4) radiometric ages of the magmatic complex of NW Iran (Saccani et al., 2013; Dilek et al., 2014; Moghaddam et al., 2014). These data are contradict a previously reported middle Cisuralian (Muttoni et al., 2009b) or Guadalupian (Besse et al., 1998; Chauvet et al., 2009) opening time of Neotethys in Iran. We infer that the Iran block started to move from intermediate paleolatitudes toward lower latitudes as early as the late Carboniferous, but the rate of this movement during the Permian is unclear.

To examine the paleogeographic distribution of the Bolorian fusulinid taxa from the Bagh-e Vang Formation, we plotted the occurrence of some of the significant identified fusulinid species in the studied sections with their coeval occurrences in other regions of western and eastern Paleotethys as well as Panthalassa on a schematic upper Cisuralian paleogeographic map (Fig. 15). It is obvious that different species of the genus *Cuniculinella* were common in western, central, and eastern Paleotethys, as well as Panthalassa (Morikawa, 1952; Skinner and Wilde, 1965a; Leven, 1967, 1997; Kahler, 1974; Zhang, 1992; Leven and Gorgij, 2011) (Fig. 15). On the other hand, *Pamirina* species and *Misellina termieri* were mostly reported from the western, central, and eastern Paleotethys. However, faunal similarity between Iran and central (like Darvaz) and eastern (such as South China and Thailand) Paleotethys and Panthalassa (North America and Japan) does not mean that Iran was geographically close to these sites. We instead propose three potential explanations for the observed fusulinid faunal similarity. First, warm water paleocurrents existed that helped faunal exchange. Second, climate warming from the lower to mid-Kungurian, evidenced by low conodont apatite $\delta^{18}O$ values (Chen et al., 2013), facilitated the dispersal of warm-water fusulinids toward high latitudes and caused the world-wide occurrence of tropical species (Davydov and Arefifard, 2013). The third possible explanation is that continued northward movement of Iran toward tropical and subtropical latitudes started in the late Carboniferous, based on newly obtained evidence of volcanic activity (Moghadam et al., 2014).

Conclusions

Based on fusulinid contents of the studied materials, three biozones are identified in each of the selected sections. The Bagh-e Vang section includes the upper Yakhtashian *Pamirina darvasica* and *Sakmarella* spp. Zone, the lower Bolorian

Misellina (*Brevaxina*) *dyrhenfurthi* Zone, the mid-Bolorian *Cuniculinella* Zone and the upper Bolorian *Misellina* (*Misellina*) cf. *M*. (*M*.) *termieri* Zone. In the fusulinid literature, two genera presented nomenclatural problems: *Cuniculina* was pre-occupied; *Cuniculinella* had a type species differing from the other species of the genus and similar to *Cuniculina*. Therefore, *Cuniculinella* is proposed as a subjective synonym of *Cuniculina* pre-occupied. Furthermore, a lectotype is designated for *Darvasites* (*Alpites*) *sinensis* (Chen, 1934). The contemporaneous occurrence of *Cuniculinella* and other fusulinid species in Iran and eastern Paleotethyan and Panthalassan areas (including central Afghanistan, Karakoram, SE Pamir, South China, central Japan) and exotic terranes of North America implies paleobiogeographic connections among all these regions. Either a paleocurrent flow facilitated faunal exchange between these areas and Iran or global warming during the lower and mid-Kungurian allowed world-wide distribution of these fusulinids. The continued northward movement of Iran toward the tropical/subtropical paleolatitudes is another possible factor.

Acknowledgments

The authors wish to thank the reviewers F. Kobayashi, P. Isaacson, and C. Colpaert for their constructive comments on this paper. We particularly thank editor E. Currano for the very careful editing of the final draft and associate editor L. Soriano for his incisive and insightful critiques of the paper. We are indebted to S. Lucas for improving the English in our manuscript. We appreciate the help of F. Le Coze (Saint-Etienne), S. Clausen (Villeneuve d'Ascq). and R. Leroy (Tourcoing).

References

Alavi, M., 1991, Tectonic map of the Middle East: Geological Survey of Iran, Tehran, scale 1:5000000, 1 sheet.

Al-Belushi, J.D., Glennie, K.W., and Williams, B.P.J., 1996, Permo-Carboniferous glaciogenic Al Khlata Formation, Oman: a new hypothesis for origin of its glaciation: GeoArabia, v. 1, p. 389–404.

Angiolini, L., Balini, M., Garzanti, E., Nicora, A., and Tintori, A., 2003, Gondwanan deglaciation and opening of Neo-Tethys: the Al-Khlata and Saiwan formations of Interior Oman: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 196, p. 99–123.

Angiolini, L., Gaetani, M., Muttoni, G., Stephenson, M.H., and Zanchi, A., 2007, Tethyan oceanic currents and climate gradients 300 my ago: Geology, v. 35, p. 1071–1074.

Angiolini, L., Crippa, A., Muttoni, G., and Pignatti, J., 2013, Guadalupian (Middle Permian) paleobiogeography of the Neotethys Ocean: Gondwana Research, v. 24, p. 171–184.

Angiolini, L., Campagna, M., Borlenghi, L., Grunt, T., Vachard, D., Vezzoli, G., and Zanchi, A., 2016, Brachiopods from the Cisuralian–Guadalupian of Darvaz, Tajikistan and implications for Permian stratigraphic correlations: Paleoworld, v. 25, p. 539–568.

Armstrong, H.A., and Brasier, M.D., 2008, Microfossils, Second Edtion: Malden, MA, Oxford, Carlton, Blackwell Publishing, 296 p.

Bahrammanesh, M., Angiolini, L., Antonelli, A.A., Aghababalou, B., and Gaetani, M., 2011, Tournaisian (Mississippian) brachiopods from the Mobarak Formation, North Iran: GeoArabia, v. 16, no. 3, p. 129–192.

Baryshnikov, V.V., Zolotova, V.P., and Kosheleva, V.F., 1982, Novye vidy foraminifer artinskogo yarusa permskogo Priuralya: Akademiya Nauk SSSR, Uralskii Nauchnyi Tsentr, Institut Geologii i Geokhimii, Preprint, p. 1–54. [in Russian]

Bensh, F.R., 1972, Stratigrafiya i fuzulinidy verkhnego paleozoya Yuzhnoy Fergany: Akademiya Nauk Uzbekskoi SSR, Institut Geologii i Geofiziki im. Kh.M. Abdullaeva, Izdateltsvo Fan, Tashkent, p. 1–146. [in Russian]

Bensh, F.R., 1987, Revizya sistematiki psevdofusulinid roda *Pseudofusulina* Dunbar et Skinner i blizkikh rodov: Voprosy Mikropaleontologii, v. 29, p. 20–53. [in Russian]

Bensh, F.R., 1991, *Praeskinerella*—novye nazvanie dlya roda *Guembelites* Bensh, 1987 (Fusulinida): Paleontologicheskii Zhurnal, v. 4, p. 1–107. [in Russian]

Bérczi-Makk, A., and Kochansky-Devidé, V., 1981, Marine Lower and Middle Permian in the oil exploratory well Ujfalu-I (SW-Hungary): Acta Geologica Academiae Scientarum Hungaricae, v. 24, p. 117–128.

Berra, F., and Angiolini, L., 2014, The evolution of the Tethys region throughout the Phanerozoic: a brief tectonic reconstruction, *in* Marlow, L., Kendall, C., and Yose, L., eds., Petroleum Systems of the Tethyan Region: American Association of Petroleum Geologists Memoir, v. 106, p. 1–27.

Besse, J., Torcq, F., Gallet, Y., Ricou, L. E., Krystyn, L., and Saidi, A., 1998, Late Permian to Late Triassic palaeomagnetic data from Iran: constraints on the migration of the Iranian block through the Tethyan Ocean and initial destruction of Pangaea: Geophysical Journal International, v. 135, p. 77–92.

Bogush, O.I., 1985, Foraminifery i stratigrafiya nizhnego karbona zapadno-Sibirskoy Plity, *in* Biostratigrafiya Paleozoya Zapadnoy Sibiri: Akademiya Nauk SSSR, Sibirskoe Otdelenie, v. 619, p. 49–68. [in Russian]

Brady, H.B., 1876, A monograph of Carboniferous and Permian foraminifera (the genus *Fusulina* excepted): Palaeontographical Society of London, v. 30, p. 1–166.

Brenckle, P.L., Gaetani, M., Angiolini, L., and Bahrammanesh, M., 2009, Refinements in biostratigraphy, chronostratigraphy, and paleogeography of the Mississippian (lower Carboniferous) Mobarak Formation, Alborz Mountains, Iran: GeoArabia, v. 14, p. 43–78.

Carcione, L., Vachard, D., Martini, R., Zaninetti, L., Abate, B., Lo Cicero, G., and Montanari, L. 2004, Reworking of fusulinids and calcisphaerids in the Lercara Formation (Sicily, Italy); geological implications: Comptes Rendus Palevol, v. 3, p. 361–368.

Cavalier-Smith, T., 2002, The phagotrophic origin of eukaryotes and phylogenetic classification of Protozoa: International Journal of Systematic and Evolutionary Microbiology, v. 52, p. 297–354.

Cavalier-Smith, T., 2003, Protists phylogeny and the high-level classification of Protozoa: European Journal of Protistology, v. 39, p. 338–348.

Chauvet, F., Dumont, T., and Basile, C., 2009, Structures and timing of Permian rifting in the central Oman Mountains (Saih Hatat): Tectonophysics, v. 475, p. 563–574.

Chen, B., Joachimski, M.M., Shen, S.Z., Lambert, L.L., Lai, X.L., Wang, X.D., Chen, J., and Yuan, D.X., 2013, Permianice volume and palaeoclimate history: oxygen isotope proxies revisited: Gondwana Research, v. 24, p. 77–89.

Chen, S. 1934, Fusulinidae of South China, Part 1: Palaeontologica Sinica: series B, v. 4, p. 1–185.

Chen, X., and Wang, J.H., 1978, The fusulinids of the Maping Limestone of the Upper Carboniferous from Yishan, Guangxi: Palaeontologica Sinica, whole number 164, new series B, v. 19, p. 1–133. [in Chinese, with English abstract]

Choi, D.R., 1973, Permian Fusulinids from the Setamai-Yahagi district, southern Kitakami Mountains, N.E. Japan: Journal of the Faculty of Science, Hokkaido University, series 4, Geology and Mineralogy, v. 16, p. 1–132.

Chuvashov, B.I., Dyupina G.V., Mizens, G.A., and Chernykh, V.V., 1990, Opornye razrezy verkhnego karbona i nizhnei permi zapadnogo sklona Urala i Predural'ya: Akademiya Nauk SSSR, Uralskoie Otdelenie, p. 1–369, Sverdlovsk. [in Russian]

Coogan, A.H., 1960, Stratigraphy and paleontology of the Permian Nosoni and Dekkas formations (Bollibokka Group): University of California Publications in Geological Sciences, v. 36, p. 243–316.

Cushman, J.A., 1928, Foraminifera, Their Classification and Economic Use: Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts, Special Publications, v. 1, p. 1–401.

Davydov, V.I., 1984, K voprosy o proiskhozhdenii Shvagerin: Paleontologicheskii Zhurnal, v. 4, p. 3–16. [in Russian]

Davydov, V.I., 1986, On phylogenetic criteria of evaluation of features in systematics of foraminifera (exemplified on fusulinids): Third International Symposium on Benthic Foraminifera, Geneva, Abstracts, p. 35.

Davydov, V.I., 2011, Taxonomy, nomenclature, and evolution of the early schubertellid fusulinids: Acta Palaeontologica Polonica, v. 56, p. 181–194.

Davydov, V. I., and Arefifard, S., 2013, Middle Permian (Guadalupian) fusulinid taxonomy and biostratigraphy of the mid-latitude Dalan Basin, Zagros, Iran and their applications in paleoclimate dynamics and paleogeography: GeoArabia, v. 18, no. 2, p. 17–62.

Davydov, V.I., Belasky, P., and Karavayeva, N.I., 1996, Permian fusulinids from the Koryak terrane, northeastern Russia, and their paleobiogeographic affinity: Journal of Foraminiferal Research, v. 26, p. 213–243.

Davydov, V.I., Krainer, K., and Chernykh, V., 2013, Fusulinid biostratigraphy of the lower Permian Zweikofel Formation (Rattendorf Group; Carnic Alps, Austria) and lower Permian Tethyan chronostratigraphy: Geological Journal, v. 48, p. 57–100.

Deprat, J., 1912a, Etude des Fusulinidés de Chine et d'Indochine et classification des calcaires à fusulines: Mémoires du Service Géologique de l'Indochine, v. 1, no. 3, p. 1–76.
Deprat, J., 1912b, Sur deux genres nouveaux de Fusulinidés de l'Asie orientale, intéressants au point de vue phylogénique: Comptes Rendus de l'Académie des Sciences, v. 154, p. 1548–1550.
Deprat, J., 1913, Etude des Fusulinidés de Chine et d'Indochine et classification des calcaires à fusulines (2e Mémoire). Les Fusulinidés des calcaires carbonifériens et permiens du Tonkin, du Laos et du Nord-Annam: Mémoires du Service Géologique de l'Indochine, v. 2, no. 1, p. 1–75.
Deprat, J., 1915, Etude des Fusulinidés de Chine et d'Indochine et classification des calcaires à fusulines (Ive Mémoire). Les Fusulinidés des calcaires carbonifériens et permiens du Tonkin, du Laos et du Nord-Annam: Mémoires du Service Géologique de l'Indochine, v. 4, p. 1–30.
Dilek, Y., Azimzadeh, Z., Saccani, E., and Jahangiri, A., 2014, Early Carboniferous Magmatism and Rift Tectonics in the Western Sector of Paleotethys as Evidenced by the Misho Mafic Complex (NW Iran). Istanbul (Turkey): American Association of Petroleum Geologists International Conference and Exhibition, p. 14–17.
Douglass, R.C., and Nestell, M.K., 1976, Late Paleozoic Foraminifera from southern Chile: U.S. Geological Survey Professional Papers, v. 858, p. 1–4.
Dunbar, C.O., 1939, Permian fusulines from Sonora: Geological Society of America Bulletin, v. 50, p. 1745–1760.
Dunbar, C.O., and Henbest, L.G., 1930, The fusulinid genera *Fusulina*, *Fusulinella* and *Wedekindella*: American Journal of Science, v. 20, p. 357–364.
Dunbar, C.O., and Henbest, L.G., 1942, Pennsylvanian Fusulinidae of Illinois: Illinois State Geological Survey Bulletin, v. 67, p. 1–218.
Dunbar, C.O., and Skinner, J.W., 1931, New fusulinid genera from the Permian of West Texas: American Journal of Science, v. 22, p. 252–268.
Dunbar, C.O., and Skinner, J.W., 1937, Permian Fusulinidae of Texas: The University of Texas Bulletin, v. 3, no. 3701, p. 518–825.
Dutkevich, G.A., 1939, Tip Protozoa, Klass Rizopoda, *in* Likharev, B.K., ed., Atlas rukovodyashchikh form iskopaemykh faun SSSR (26–46): Tsentralnyi Nauchno-issledovatelskii Geologo-razvedochnyi Institut (TsNIGRI), tom 6 (Permskaya Sistema), Leningrad, Moskva, p. 26–46. [in Russian]
Ebner, F., and Kahler, F., 1989, Catalogus Fossilium Austriae (Ein systematisches Vereichnis aller auf österreichischem Gebiet festgestellten Fossilien), Heft II/b/1: Foraminifera Palaeozoica: Wien, Österreichische Akademie der Wissenschaften, p. 1–295.
Elliott, G.F., 1958, Fossil microproblematica from the Middle East: Micropaleontology, v. 4, p. 419–428.
Endo, R., 1961, Stratigraphical and paleontological studies of the Later Paleozoic calcareous algae in Japan, XIV. Fossil algae from the Nyugawa Valley in the Hida Massif: Science Reports Saitama University, series B, v. 3, p. 177–207.
Endo, R., and Kanuma, M., 1954, Stratigraphical and paleontological studies of the later Paleozoic Calcareous Algae in Japan. VII. Geology of the Mino mountainland and southern part of Hida plateau with description of the algal remains found in those districts: Reports of the Saitama University, series B, v. 1, p. 177–205.
Falahatgar, M., Vachard, D., and Ahmadi Sakha, L., 2015, The Tournaisian (early Carboniferous) of the Kahanag section (central Alborz; northern Iran); biostratigraphy with calcareous algae and foraminifers; palaeobiogeographic implications: Revue de Micropaléontologie, v. 58, p. 217–237.
Filimonova, T.V., 2010, Smaller foraminifers of the lower Permian from Western Tethys: Stratigraphy and Geological Correlation, v. 18, p. 687–811.
Fontaine, H., Bin Amnan, I., and Vachard, D., 1999, Important discovery of late early Permian limestone in southern Terengannu, Peninsular Malaysia: Ninth Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia—GEOSEA' 98, 17–19 August 1998, Kuala-Lumpur, GEOSEA' 98, Proceedings, Geological Society Malaysia, v. 43, p. 453–460.
Forbes, C.L., 1960, Carboniferous and Permian Fusulinidae from Spitsbergen: Palaeontology, v. 2, no. 2, p. 210–225.
Forke, H.C., 2002, Biostratigraphic subdivision and correlation of uppermost Carboniferous/lower Permian sediments in the southern Alps; fusulinoidean and conodont faunas from the Carnic Alps (Austria/Italy), Karavanke Mountains (Slovenia), and Southern Urals (Russia): Facies, v. 47, p. 201–276.
Fursenko, A.V., 1958, Osnovnye etapy razvitiya faun foraminifer v geologicheskom proshlom: Akademiya Nauk Beloruskoi SSR, Trudy Instituta Geologicheskikh Nauk, v. 1, p. 10–29. [In Russian]
Gaetani, M., and Leven, E. Ya., 2014, The Permian succession of the Shaksgam Valley, Sinkiang (China): Italian Journal of Geosciences, v. 133, p. 45–62.
Gaillot, J., and Vachard, D., 2007, The Khuff Formation (Middle East) and time-equivalents in Turkey and South China: biostratigraphy from Capitanian to Changhsingian times (Permian), new foraminiferal taxa and palaeogeographical implications: Coloquios de Paleontología, v. 57, p. 37–223.
Galloway, J.J., 1933, A Manual of Foraminifera. James Furman Kemp Memorial Series: Bloomington, Indiana, The Principia Press Inc., Publication 1, 483 p.
Galloway, J.J., and Ryniker, C., 1930, Foraminifera from the Atokan Formation of Oklahoma: Oklahoma Geological Survey Circular, v. 21, p. 1–36.
Garzanti, E., and Sciunnach, D., 1997, Early Carboniferous onset of Gondwanian glaciation and Neo-Tethyan rifting in southern Tibet: Earth and Planetary Science Letters, v. 148, p. 359–365.
Geinitz, H.B., and Gutbier, A., 1848, Die Versteinerungen des Zechsteingebirges und Rothliegenden. (Heft 1): Dresden, Arnold, 26 p.
Ghazzay-Souli, W., Vachard, D., and Razgallah, S., 2015, Carboniferous and Permian biostratigraphy by foraminifers and calcareous algae of Bir Mastoura (BMT-1) and related boreholes of southern Tunisia: Revue de Micropaléontologie, v. 58, p. 239–265.
Granier, B., Basso, D., and Vachard, D., 2017, Les algues "calcaires" fossiles (Permien–Miocène) du Guatémala (Catalogue critique de la Collection J.H. Johnson. 3[e] partie): Archives des Sciences, v. 69, p. 29–54.
Grozdilova, L.P., 1938, Fuzulinidi neftenoskykh izvestnyakov Ishimbaevskogo rayona, *in* Toltstikhinoy, M.M., ed., Materialy k poznaniyu Ishimbaevskogo Mestorozhdenya nefti, Leningrad, Moscow, p. 90–114. [In Russian]
Grozdilova, L.P., 1956, Miliolidy verkhneartinskikh otlozheniy nizhney permi zapadnogo sklona Urala: Trudy VNIGRI, 98, Mikrofauna SSSR, v. 8, p. 521–529. [In Russian]
Grozdilova, L.P., and Lebedeva, N.S., 1961, Nizhnepermskie foraminifery severnogo Timana: Trudy VNIGRI, 250, Mikrofauna SSSR, v. 13, p. 161–283. [in Russian]
Grozdilova, L.P., Izotova, M.N., and Lebedeva, N.S., 1980, Novye rannepermskie shvagerinidy zapadnogo sklona Urala, *in* Azbel, A.Ya., Bagdasaryan, L.L., and Belyakova, G.M., eds., Novye rody i vidy drevnikh rastenii i bespozvonochnikh SSSR, Leningrad "Nedra": Leningradskoe Otdelnie, p. 48–57. [in Russian]
Han, J. X., 1975, Late Carboniferous fusulinaceans from Amushan district of Inner Mongolia: Professional Papers of Stratigraphy Paleontology, v. 2, p. 132–166. [in Chinese]
Hance, L., Hou, H.F., and Vachard, D., 2011, Upper Famennian to Visean Foraminifers and Some Carbonate Microproblematica from South China, Hunan, Guangxi and Guizhou: Beijing, Geological Science Press, 359 p.
Ho, J., 1959, Triassic Foraminifera from the Chialingchiang Limestone of South Szechuan: Acta Palaeontologica Sinica, v. 7, p. 387–418.
Hohenegger, J., and Piller, W., 1975, Wandstrukturen und Grossgliederung der Foraminiferen: Sitzungberichten der österreichische Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse, Abteilung 1, v. 184, p. 67–96.
Hsu, Y.C., 1942, On the type species of *Chusenella*: Bulletin of the Geological Society of China, v. 22, p. 175–176.
Huang, Z.X., and Zeng, X.L., 1984, The early early Permian (Longlinian Stage), fusulinid fauna from Longlin, Guangxi: Earth Science Journal of Wuhan College of Geology, v. 3, p. 11–24. [in Chinese with English abstract]
Igo, H., 1959, Some Permian fusulinids from the Hirayu District, southeastern part of the Hida Massif, Central Japan: Science Report of the Tokyo Kyoiku Daigaku, section C, v. 5, no. 47, p. 153–246.
Igo, H., 1965, Permian fusulinids of Nyukawa, Central Japan. Part 2. Some fusulinids from the lower part of the Sote Formation: Journal of Paleontology, v. 39, p. 210–223.
Igo, H., Rajah, S.S., and Kobayashi, F., 1979, Permian Fusulinaceans from the Sungei Sedili Area, Johore, Malaysia: Contributions of the Geology and Palaeontology of Southeast Asia, CCIV (204), p. 95–99.
Igo, H., Ueno, K., and Sashida, K., 1993, Lower Permian fusulinaceans from Bhan Phia, Changwat Loei, northeastern Thailand: Transactions and Proceedings Paleontological Society of Japan, v. 169, p. 15–43.
Ishizaki, K., 1962, Stratigraphical and palaeontological studies of the Onogahara and its neighbouring area, Kochi and Ehime prefectures, southwest Japan: Science Reports Tohoku University, 2[nd] Series, v. 34, p. 95–185.
Kahler, F., 1974, Iranische Fusuliniden: Jahrbuch der Geologischen Bundesanstalt, v. 117, p. 75–107.
Kahler, F., 1976, Fusuliniden der Dorud Formation in Djadjerud-Tal nördlich von Teheran (Iran): Rivista Italiana di Paleontologia, v. 82, p. 439–466.
Kahler, F., 1987, Fusuliniden-Faunen auf Chios, Kalymnos and Kos in der Ägäis: Mitteilungen der Österreichischen Geologischen Gesellschaft, v. 80, p. 287–323.
Kahler, F., 1989, Die Fusuliniden, *in* Ebner, F., and Kahler, F., eds., Catalogus Fossilium Austriae, Heft II/b/1: Foraminifera Paleozoica Österreichische Akademie der Wissenschaften, Vienna, p. 87–295.
Kahler, F., and Kahler, G., 1966, Fusulinida (Foraminiferida). Fossilium Catalogus, Animalia: s'Gravenhage, W. Junk Publishers, Pars 111, Teil 1, p. 1–254; Pars 112, Teil 2, p. 255–538; Pars 113, Teil 3, p. 539–870.
Kahler, F., and Kahler, G., 1980, Fusuliniden aus den Kalken der Trogkofel-Schichten der Karnischen Alpen. *in* Flügel, E., ed., Die Trogkofel-Stufe im Unterperm Karnischen Alpen: Carinthia II, Klagenfurt, v. 36, p. 183–254.

Kalmykova, M.A., 1967, Permskie fuzulinidy Darvaza: Kratkaya istoriya izucheniya Permi i permskikh fuzulinid Darvaza: Trudy VSEGEI, v. 116, Biostratigraficheskiy Sbornik, no. 2, p. 116–287. [in Russian]
Kanmera, K., 1956, *Toriyamaia*, a new Permian fusulinid genus from the Kuma massif, Kyushu, Japan: Transactions and Proceedings of the Palaeontological Society Japan, v. 24, p. 251–257.
Kanuma, M., 1959, Stratigraphical and paleontological tudies of the southern part of the Hida plateau and north-eastern part of the Mino mountainland. Part 2, Paleontology: Bulletin Tokyo Gakugei Univrsity, v. 10, p. 59–83.
Kanuma, M., and Sakagami, S., 1957, *Mesoschubertella*, a new Permian fusulinid genus from Japan: Transactions and Proceedings of the Palaeontological Society of Japan, v. 26, p. 41–46.
Karpinsky, A., 1909, Einige problematische Fossilien aus Japan: Verhandlungen russische mineralogische Gesellschaft St. Petersburg, v. 2, no. 46, p. 257–272.
Khanehbad, M., Moussavi-Harami, R., Mahboubi, A., Nadjafi, M., and Mahmudy Gharaie, M.H., 2012, Geochemistry of Carboniferous sandstones (Sardar Formation), East-Central Iran: implication for provenance and tectonic setting: Acta Geologica Sinica, v. 86, p. 1200–1210.
Kiessling, W., Flügel, E., and Golonka, J., 1999, Paleoreef maps: evaluation of a comprehensive database on Phanerozoic reefs: Bulletin of American Association of Petroleum Geologists, v. 83, no. 10, p. 1552–1587.
Knight, R.L., 1956, Permian fusulines from Nevada: Journal of Paleontology, v. 30, p. 773–792.
Kobayashi, F., 1977, Some considerations on the ancestor of the family Verbeekinidae (Fusulinacea): Transactions and Proceedings Palaeontological Society of Japan, v. 105, p. 1–16.
Kobayashi, F., 2012, Late Paleozoic foraminifers from limestone blocks and fragments of the Permian Tsunemori Formation and their connection to the Akiyoshi Limestone Group, Southwest Japan: Paleontological Research, v. 16, p. 219–243.
Kobayashi, F., 2017, Late Carboniferous and early Permian fusulines of the Akiyoshi Limestone Group in the Wakatakeyama area, Akiyoshi (Japan) —biostratigraphy, biogeography, and biodiversity: Revue de Paléobiologie, Genève, v. 36, p. 1–155.
Kobayashi, F., 2019, Late early to middle Permian foraminifers of the Akiyoshi Limestone (Japan): Revue de Paléobiologie, Genève, v. 38, p. 39–123.
Kobayashi, F., and Altıner, D., 2008, Fusulinoidean faunas from the upper Carboniferous and lower Permian platform limestone in the Hadim area, central Taurides, Turkey: Rivista Italiana di Paleontologia e Stratigrafia, v. 114, p. 191–232.
Kobayashi, F., and Ishii, K.-I., 2003, Permian fusulinaceans of the Surmaq Formation, in the Abadeh region, Central Iran: Rivista Italiana di Paleontologia e Stratigrafia, v. 109, p. 307–337.
Kochansky-Devidé, V., 1955, Karbonske i permske Fusulinidne Foraminifere Velebita i Like. Opei dio i karbon: Jugoslavenka Akademija Znanosti i Umjetnosti, v. 305, p. 5–62.
Kochansky-Devidé, V., 1959, Karbonske i permske fuzulinidne foraminifere Velebita i Like. Donji perm: Palaeontologia Jugoslovica, Jugoslavenka Akademija Znanosti i Umjetnosti, v. 3, p. 1–62.
Kochansky-Devidé, V., 1964, Die Mikrofossilien des jugoslawischen Perms: Paläontologische Zeitschrift, v. 38, p. 180–188.
Kochansky-Devidé, V., 1970, Permski mikrofosili zahodnih Karavank: Geologija, Razprave in Porocila, v. 13, p. 175–256.
Kochansky-Devidé, V., and Herak, M., 1960, On the Carboniferous and Permian Dasycladaceae of Yugoslavia: Geološki Vjesnik, v. 13, p. 65–94.
Kochansky-Devidé, V., and Ramovš, A., 1966, Zgornjekarbonski mikrofosili in stratigrafski razvojv zahodni Sloveniji: Razprave IV, razreda SAZU, v. 9, p. 301–333.
Konovalova, M.V., 1991, Stratigrafiya i fuzulinidi verkhnego karbona i nizhnei permi Timano-Peehorskoy neftagazonosnoy provintsii: Nedra, Moscow, p. 1–243. [in Russian]
Konovalova, M.V., and Baryshnikov, V.V., 1980, Novye artinskie pseudofuzulinidyi, *in* Rauzer-Chernousova, D.M., and Chuvashov, B.I., eds., Biostratigrafiya artinskogo i kungurskogo yarusov Urala: Akademiya Nauk SSSR, Uralskii Nauchnyi Tsentr, Sverdlovsk Ekaterinburg, p. 25–38. [in Russian]
Korzhenevskiy, I.D., 1940, O nekotorykh novykh vidakh fuzulinid iz nizhnepermskikh izvestnyakov Ishimbaeva i Sterlimatamakskik gor-Odinochek: Akademiya Nauk SSSR, Trudy Instituta Geologicheskikh Nauk, 7, geologicheskya seriya, v. 2, p. 1–36. [in Russian]
Krainer, K., Vachard, D., and Schaffhauser, M., 2019, Early Permian (Yakhtashian; Artinskian–Kungurian) foraminifers and microproblematica from the Carnic Alps (Austria): Abhandlungen der Geologischen Bundesanstalt, v. 73, p. 1–247.
Lee, J.S., 1931, Distribution of the dominant types of the fusulinoid foraminifera in the Chinese seas: Bulletin of the Geological Society of China, v. 10, p. 273–290.
Lee, J.S., 1934, Taxonomic criteria of Fusulinidae with notes on seven new Permian genera: Memoirs of the National Research Institute of Geology, Nanking, v. 14, p. 1–32.
Lee, J.S., Chen, S., and Chu, S., 1930, The Huanglung Limestone and its fauna: Academia Sinica, Memoirs of the National Research Institute of Geology, v. 9, p. 85–144.
Leven, E.Ja., and Özkan, R., 2004, New Permian fusulinids from Turkey and some problems of their biogeography: Stratigraphy Geological Correlation, v. 12, p. 336–346.
Leven, E.Ya., 1967, Stratigrafiya i fuzulinidy permskikh otlozhenii Pamira: Akademiya Nauk SSSR, Trudy Geologicheskogo Instituta, v. 167, p. 1–224. [in Russian]
Leven, E.Ya., 1970, O proiskhozhdenii vysshikh fuzulinid: Paleontologicheskiy Zhurnal, v. 3, p. 18–25. [in Russian; English translation, p. 303–309]
Leven, E.Ya., 1982, Rod *Cancellina* Hayden i ego polozhenie b sisteme byszkikh fuzulinidi: Voprosy Mikropaleontologii, v. 25, p. 40–51. [in Russian]
Leven, E.Ya., 1987, Sistema i filogeniya semeistva Schubertellidae Skinner, 1931: Paleontologicheskiy Zhurnal, v. 2, p. 30–39. [in Russian]
Leven, E.Ya., 1993a, Early Permian fusulinids from the Central Pamir: Rivista Italiana di Paleontologia e Stratigrafia, v. 99, p. 151–198.
Leven, E.Ya., 1993b, Main events in Permian history of the Tethys and fusulinids: Stratigraphy and Geological Correlations, v. 1, p. 59–75. [in Russian]
Leven, E.Ya., 1995, Lower Permian Fusulinids from the vicinity of Ankara (Turkey): Rivista Italiana di Paleontologia e Stratigrafia, v. 101, p. 235–248.
Leven, E.Ya., 1997, Permian stratigraphy and Fusulinida of Afghanistan with their paleogeographic and paleotectonic implications: Geological Society of America, Special Paper, v. 316, p. 1–134.
Leven, E.Ya., 1998, Permian fusulinid assemblages and stratigraphy of the Transcaucasia: Rivista Italiana di Paleontologia e Stratigrafia, v. 104, p. 299–328.
Leven, E.Ya., 2003, The Permian stratigraphy and fusulinids of the Tethys: Rivista Italiana di Paleontologia e Stratigrafia, v. 109, p. 267–280.
Leven, E.Ya., 2010, Permian fusulinids of the East Hindu Kush and West Karakorum: Stratigraphy and Geological Correlation, v. 18, p. 105–117.
Leven, E.Ya., and Gorgij, M.N., 2011, Fusulinids and stratigraphy of the Carboniferous and Permian in Iran: Stratigraphy and Geological Correlation, v. 19, p. 687–776.
Leven, E.Ya., and Okay, A.I., 1996, Foraminifera from the exotic Permo-Carboniferous limestone blocks in the Karakaya complex, north western Turkey: Rivista Italiana di Paleontologia e Stratigrafia, v. 102, p. 139–174.
Leven, E.Ya., and Shcherbovich, S.F., 1980, Novye vidy fuzulinid iz samarskikh otlozhenii Darvaza: Paleontologicheskiy Zhurnal, v. 3, p. 19–27. [in Russian]
Leven, E.Ya., and Taheri, A., 2003, Carboniferous-Permian stratigraphyand fusulinids of East-Iran, Gzhelian and Asselian deposits of the Ozbak-Kuh region: Rivista Italiana di Paleontologia e Stratigrafia, v. 109, p. 399–415.
Leven, E.Ya., and Vaziri Moghaddam, H., 2004, Carboniferous–Permian stratigraphy and fusulinids of eastern Iran: the Permian in the Baghe-Vang section (Shirgest area): Rivista Italiana di Paleontologia e Stratigrafia, v. 110, p. 441–465.
Leven, E.Ya., Leonova, T.B., and Dmitriev, V.Yu., 1992, Perm Darvaz-Zaalayskoy Zony Pamira: fusulinidy, ammonoidei, stratigrafiya: Rossiyskaya Akademiya Nauk, Trudy Paleontologicheskogo Instituta, v. 253, p. 64–109. [in Russian]
Leven, E.Ya., Davydov, V., and Gorgij, M.N., 2006, Pennsylvanian stratigraphy and fusulinids of Central and Eastern Iran: Palaeontologia Electronica, v. 9, no. 1, 1A:36p. https://palaeo-electronica.org/2006_1/iran/issue1_06.htm.
Leven, E.Ya., Gaetani, M., and Schroeder, S., 2007, New findings of Permian fusulinids and corals from W Karakoram and E Hindu Kush (Pakistan): Rivista Italiana di Paleontologia e Stratigrafia, v. 113, p. 151–166.
Likharev, B.K., 1939, Tip Protozoa, Klass Rizopoda, *in* Likharev, B.K., ed., Atlas rukovodyashchikh form iskopaemykh faun SSSR: Tsentralnyi Nauchno-issledovatelskii Geologo-razvedochnyi Institut (TsNIGRI), tom 6:Tsentralnyi Nauchno-issledovatelskii Geologo-razvedochnyi Institut (TsNIGRI), Leningrad, p. 26–46. [in Russian]
Lin, J.X., 1984, Protozoa, *in* Yichan Institute of Geology and Mineral Resources, ed., Biostratigraphy of the Yangtze Gorge Area Chiefly, 3) Late Paleozoic Era. Museum Changzhou, Changzhou City, Jiangsu Province: Beijing, Geological Publishing House, p. 110–177. [in Chinese; p. 323–364 in English].
Lin, J.X., Li, J.X., Chen, G.X., Zhou, Z.R., and Zhang, B.F., 1977, Fusulinida, *in* Hubei Institute Geological Sciences, ed., Paleontological Handbook of the South Central South China (2): Late Paleozoic: Beijing, Geological Publishing House, p. 4–96. [in Chinese]
Lipina, O.A., 1949, Melkie foraminifery pogrebennykh massivov Bashkirii: Akademiya Nauk SSSR, Trudy Instituta Geologicheskikh Nauk, 105, seriya geologicheskaya, v. 35, p. 198–235. [in Russian]

Liu, C., Jarochowska, E., Du, Y., Munnecke, A., and Dai, X., 2017, Prevailing anoxia in the Kungurian (Permian) of South China: possible response to divergent climate trends between the tropics and Gondwana: Gondwana Research, v. 49, p. 81–93.

Liu, Z.A., Xiao, X.M. and Dong, W.L., 1978, Protozoa, *in* Working Group of Stratigraphy and Paleontology of Guizhou, ed., Paleontological Atlas of Southeast China, Guizhou Province, 2 (Carboniferous to Quaternary): Beijing, Geological Publishing House, p. 12–98. [in Chinese]

Loeblich, A.R., and Tappan, H., 1961, Suprageneric classification of the Rhizopodea: Journal of Paleontology, v. 35, p. 245–330.

Loeblich, A.R., and Tappan, H., 1987, Foraminiferal Genera and Their Classification: New York, Van Nostrand Reinhold Company Publisher, 970 p.

Lys, M., Stampfli, G., and Jenny, J., 1978, Biostratigraphie du Carbonifère et du Permien de l'Elbourz oriental (Iran du NE): Notes Laboratoire Paléontologie Université Genève, v. 2, p. 63–99.

Mamet, B., 1970, Carbonate microfacies of the Windsor Group (Carboniferous), Nova Scotia and New Brunswick: Geological Survey of Canada, Paper 70–21, p. 1–121.

Marshall, F.C., 1969, Lower and middle Pennsylvanian fusulinids from the Bird Spring Formation near Mountain Springs Pass, Clark County, Nevada: Brigham Young University Geological Studies, v. 16, p. 97–154.

Maslakova, N.I., 1990, Criteria of establishing of higher taxa in Foraminifera, *in* Menner, V.V., ed., Systematics and Phylogeny of Invertebrata: the Criteria for Establishing Higher Taxa.: Moscow, Izdatelstvo Nauka, p. 22–27. [in Russian]

Maslov, V.P., 1956, Iskopaemye izvestkovye vodorosli SSSR: Trudy Instituta Geologichesnikh Nauk, Akademiya Nauk SSSR, v. 160, p. 1–301. [In Russian; French translation, BRGM no. 3517]

Mikhalevich, V.I., 1980, Sistematika i evolyutsiya foraminifer v svete novykhh dannykh po ikh litologii i ultrastrukture: Akademiya Nauk SSSR, Trudy Zoologicheskogo Instituta, v. 94, p. 42–61. [in Russian]

Miklukho-Maklay, A.D., 1949, Verkhnepaleozoyskie fuzulinidy Sredney Azii (Darvaz, Fergana, Pamir): Uchenye Zapiski Leningradskogo Ordena Lenina, Gosudarstvennogo Universiteta imeni A.A. Zhdalova, Institut Zemoi Kory, v. 3, p. 1–111. [in Russian]

Miklukho-Maklay, A.D., 1953, K sistematike seveistva Fusulinidae: Uchenye Zapiski Leningradskogo Ordena Lenina Gosudarstvennogo Universiteta, seriya geologicheskikh nauk, v. 159, p. 12–24. [in Russian]

Miklukho-Maklay, A.D., 1958, Sistematika vysskikh fuzulinid: Vestnik Leningradskogo Universiteta, 1957, 12, seriya geologii i geografii, v. 2, p. 5–14. [in Russian]

Miklukho-Maklay, A.D., 1959, Novye fuzulinidy verkhnego paleozoya SSSR: Materialy k osnovam paleontologii, v. 3, p. 3–6. [in Russian]

Miklukho-Maklay, A.D., 1963, Verkhniy Paleozoy Sredney Azii: Izdateltsvo Leningradskiy Universiteta, Leningrad, 328 p. [in Russian]

Miklukho-Maklay, A.D., Rauzer-Chernousova, D.M., and Rozovskaya, S.E., 1958, Sistematika i filogeniya fuzulinidei: Voprosy Mikropaleontologii, v. 2, 521 p. [in Russian; French translation: Editions Technip Paris]

Moghadam, H.S., Li, X.-H., Ling, X.-X., Stern, R.J., Santos, J.F., Meinhold, G., Ghorbani, G., and Shahabi, S., 2014, Petrogenesis and tectonic implications of late Carboniferous A-type granites and gabbronorites in NW Iran: geochronological and geochemical constraints: Lithos, v. 212–215, p. 266–279.

Möller, V., von, 1878, Die spiral-gewundenen Foraminiferen des russischen Kohlenkalkes: Mémoires de l'Académie Impériale des Sciences de St Pétersbourg, 7th series, v. 25, no. 9, p. 1–147.

Morikawa, R., 1952, Some *Schwagerina*-like *Parafusulina*: Science Reports of Saitama University, series B, v. 1, p. 28–34.

Morikawa, R., and Isomi, H., 1960. A new genus *Biwaella*, *Schwagerina*-like *Schubertella*: Science Reports of the Saitama University, series B, v. 3, p. 301–305.

Morikawa, R., and Isomi, H., 1961, Studies of Permian Fusulinids in the East of Lake Biwa, Central Japan: Geological Survey of Japan, Report, v. 191, p. 1–29.

Morozova, V.G. 1949. Predstaviteli semeytsv Lituolidae i Textulariidae iz verkhnekamennougolnykh i artinski otlozhenii bashkirskogo Priuralya (Members of families Lituolidae and Textulariidae from late Carboniferous and Artinskian from the Bashkir Pre-Urals): Akademyia Nauk SSSR, Trudy Instituta Geologicheskikh Nauk, 105, geologicheskaya seriya, v. 35, p. 244–275. [in Russian; French translation: BRGM, no. 783]

Muttoni, G., Gaetani, M., Kent, D.V., Sciunnach, D., Angiolini, L., Berra, F., Garzanti, E., Mattei, M., and Zanchi, A., 2009a, Opening of the Neo-Tethys Ocean and the Pangea B to Pangea A transformation during the Permian: GeoArabia, v. 14, p. 17–48.

Muttoni, G., Mattei, M., Balini, M., Zanchi, A., Gaetani, M., and Berra, F., 2009b, The drift history of Iran from the Ordovician to the Triassic, *in* Brunet, M.-F., Wilmsen, M., and Granath, J.W., eds., South Caspian to Central Iran Basins: Geological Society, London, Special Publications, v. 312, p. 7–29.

Neumayr, M., 1887, Die natürlichen Verwandtschaftverhältnisse der schalentragenden Foraminiferen: Sitzungsberichte der kaiserliche Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Klasse, v. 95, p. 156–186.

Newell, N.D., Chronic, J., and Roberts, T.G., 1953, Upper Paleozoic of Peru: Geological Society of America, Memoirs, v. 58, p. 1–276.

Nguyen Duc Tien, 1986, Foraminifera and algae from the Permian of Guguk Bulat and Silungkang, Sumatra, *in* Fontaine, H., ed., The Permian of Southeast Asia: CCOP Technical Bulletin, Bangkok and Tokyo, v. 18, p. 138–147.

Nogami, Y., 1961, Permische Fusuliniden aus dem Atetsu-Plateau Südwestjapans, Teil 1. Fusulininae, Schwagerininae: Memoirs College Sciences University Kyoto, series B, v. 27, p. 159–248.

Okuyucu, C., 1999, A new *Multidiscus*? species (Foraminifera) from a fusulinacean-rich succession encompassing the Carboniferous–Permian boundary in the Hadim Nappe (Central Taurus, Turkey): Rivista Italiana di Paleontologia e Stratigrafia, v. 105, p. 439–444.

Orbigny, A., d', 1826. Tableau méthodique de la classe des Céphalopodes: Annales des Sciences Naturelles, Paris, v. 7, no. 2, p. 245–314.

Ota, M., 1977, Geological studies of Akiyoshi, part I, general geology of Akiyoshi Limestone Group: Bulletin of the Akiyoshi-Dai Museum of Natural History, v. 12, p. 1–33.

Owen, D.E., 2009, How to use stratigraphic terminology in papers, illustrations, and talks: Stratigraphy, v. 6, p. 106–116.

Ozawa Y., 1925, Palaeontological and stratigraphical studies on the Permo-Carboniferous limestone of Nagato, part 2, palaeontology: Journal of the College of Science, Imperial University of Tokyo, v. 45, art. 6, p. 1–90.

Partoazar, H., 1995, Permian deposits in Iran. Treatise on the geology of Iran: Geological Survey of Iran, v. 22, p. 1–340. [in Persian with English summary]

Pasini, M., 1965, Fusulinidi, una chiave analitica per la determinazione dei generi: Palaeontographia Italica, v. 9, p. 1–107.

Pia, J., von, 1920, Die Siphoneae verticillatae vom Karbon bis zur Kreide: Abhandlungen der zoologisch-botanischen Gesellschaft in Wien, v. 11, p. 1–263.

Pinard, S., and Mamet, B., 1998, Taxonomie des petits foraminifères du Carbonifère supérieur-Permien inférieur du basin de Sverdrup, Arctique canadien: Palaeontographica Canadiana, v. 15, p. 1–253.

Poty, E., Devuyst, F.X., and Hance, L., 2006, Upper Devonian and Mississippian foraminiferal and rugose coral zonations of Belgium and Northern France, a tool for Eurasian correlations: Geological Magazine, v. 143, p. 829–857.

Praturlon, A., 1963, Dasycladaceae from the upper Permian of the Dolomites (Italy): Geologica Romana, v. 2, p. 119–150.

Qiao, L., Falahatgar, M., and Shen, S.Z., 2017, A lower Visean (Carboniferous) brachiopod fauna from the eastern Alborz Mountains, northern Iran, and its palaeobiogeographical implications: Geological Journal, v. 52, p. 317–326.

Ramovš, A., and Kochansky-Devidé, V., 1965, Die Entwicklung des Jungpaläozoikums in der Umgebung von Ortnek in Unterkrain: Académie des Sciences et des Arts de Slovénie, Class IV, Dissertation 8, p. 323–413.

Rashidi, K., and Senowbari-Daryan, B., 2010, Dasycladales from the Permian Jamal Formation of the Shotori Mountains, northern Iran: Facies, v. 56, p. 111–137.

Rauzer-Chernousova, D.M., 1949, Nekotorye psevdofuzulinidy i parafuzulinidy Bashkirkogo Priuralya: Akademiya Nauk SSSR, Trudy Instituta Geologicheskikh Nauk, 105 geologicheskaya seriya, Moscow, v. 35, p. 118–162. [in Russian]

Rauzer-Chernousova, D.M., Gryzlova, N.D., Kireeva, G.D., Leontovich, G.E., Safonova, T.P., and Chernova, E.I., 1951, Srednekamennougolnye fuzulinidy Russkoi platformyi sopredelnykh oblastey: Akademiya Nauk SSR, Institut Geologicheskikh Nauk, Ministerstvo Neftyanoy Promishlennosti SSSR, p. 1–380. [in Russian]

Rauzer-Chernousova, D.M., Bensh, F.R., Vdovenko, M.V., Gibshman, N.B., Leven, E.Ya., Lipina, O.A., and Chediya, I.O., 1996, Spravochnik po sistematike foraminifer Paleozoya; Endothyroidy, Fuzulinoidy: Rossiiskaya Akademiya Nauk, Geologicheskii Institut, Moskva "Nauka," p. 1–207. [in Russian]

Rees, P.M., Ziegler, A.M., Gibbs, M.T., Kutzbach, J.E., Behling, P.J., Rowley, D.B., 2002, Permian phytogeographic patterns and climate data/model comparisons: Journal of Geology, v. 110, p. 1–31.

Reichel, M., 1946, Sur quelques foraminifères nouveaux du Permien méditeranéen: Eclogae geologicae Helvetiae, v. 38, p. 524–560.

Reitlinger, E.A., 1950, Foraminifery srednekamennougolnykh otlozhenii tsentralnoi chasti Russkoi platformy (isklyuchaya semeistvo Fusulinidae): Akademiya Nauk SSSR, Trudy Instituta Geologicheskikh Nauk, 126, geologichevskaya seriya, v. 47, p. 1–126 [in Russian, French translation BRGM no. 1456]

Reitlinger, E.A., 1958, On the systematics and phylogeny of the superfamily Endothyridea: Voprosy Mikropaleontologii, v. 2, p. 53–73. [in Russian]

Ross, C.A., 1960, Fusulinids from the Hess Member of the Leonard Formation, Leonard series (Permian), Glass Mountains, Texas: Cushman Fundation Foraminiferal Research, Contributions, v. 11, p. 117–133.
Ross, C.A., 1962, Fusulinids from the Leonard Formation: Contributions of the Cushman Foundation for Foraminiferal Research, v. 13, p. 1–21.
Rozovskaya, S.E., 1958, Fuzulinidi i biostratigraficheskoe raschlenenie verkhnekammenougolnykh otlozhenii Samarskoi Luki: Akademiya Nauk SSSR, Trudy Geologischeskogo Instituta, v. 13, p. 57–120. [in Russian]
Rozovskaya, S.E., 1975, Sostav, sistema i filogeniya otryada fuzulinida: Akademiya Nauk SSSR, Trudy Paleontologischeskogo Instituta, v. 149, p. 1–267. [in Russian; unpublished French translation by C. Châtaigner]
Ruban, D.A., Al-Husseini, M.I., and Iwasaki, Y., 2007, Review of Middle East Paleozoic plate tectonics: GeoArabia, v. 12, no. 3, p. 35–56.
Rui, L., and Hou, J.H., 1987, Late Carboniferous fusulinaceans from southeastern Shanxi, *in* Shanxi No. 114 Institute of Coal Geological Exploration and Nanjing Institute of Geological Palaeontology, Chinese Academy of Sciences, eds., Late Palaeozoic Coal-bearing Strata and Biota from Southeastern Shanxi, China: Nanjing, Nanjing University Press, p. 139–280. [in Chinese with English abstract]
Ruttner, A., Nabavi, M., and Hajian, J., 1968, Geology of the Shirgesht area (Tabas area, East Iran): Tehran, Geological Survey of Iran, Report 4, 33 p.
Saccani, E., Azimzadeh, Z., Dilek, Y., and Jahangiri, A., 2013, Geochronology and petrology of the early Carboniferous Misho Mafic Complex (NW Iran), and implications for the melt evolution of Paleo-Tethyan rifting in Western Cimmeria: Lithos, v. 162–163, p. 264–278.
Saidova, Kh.M., 1981, O sovremennom sostoyanii sistemy nadvidovykh taksonov kaynozoyskikh bentosnykh foraminifer: Moscow, Publishing House of the P.P. Shirshov Institute of Oceanology, p. 1–73. [in Russian]
Salvador, A., 1994, International Stratigraphic Guide, 2nd Edition: Boulder, Colorado, Geological Society of America, 214 p.
Sanderson, G.A., Verville, G.J., Groves, J.R., and Wahlman, G.P., 2001, Fusulinacean biostratigraphy of the Virgilian stage (upper Pennsylvanian) in Kansas: Journal of Paleontology, v. 75, p. 883–887.
Saurin, E., 1954, Notes paléontologiques sur quelques calcaires à Fusulinidés du Nord Viet-nam: Archives Géologiques du Viet-nam, v. 1, p. 1–30.
Schellwien, E., 1898, Die Fauna des Karnischen Fusulinidenkalkes. Theil II. Palaeontographica (1897), v. 44, p. 237–282.
Schellwien, E., 1902, Trias, Perm und Carbon in China. Schriften der Physikalisch-ökonomischen Gesellschaft zu Königsberg, v. 43, p. 59–71.
Schellwien, E., 1908, Monographie der Fusuliniden. I Fusuliniden des russisch-arktischen Meergebietes: Palaeontographica, v. 55, p. 145–194.
Schellwien, E., and Dyhrenfurth, G., 1909, Monographie der Fusuliniden. Teil II. Die asiatischen Fusulinen, A. Die Fusulinen von Darwas: Palaeontographica, v. 56, p. 137–176.
Schenck, H.G., and Thompson, M.L., 1940, *Misellina* and *Brevaxina*, new Permian fusulinid Foraminifera: Journal of Paleontology, v. 14, p. 584–589.
Sengör, A.M.C., 1979, Mid-Mesozoic closure of Permo-Triassic Tethys and its implications: Nature, v. 279, p. 590–593.
Sheng, J.C., 1962, Some fusulinids of the Chihsia Stage, northern Hopei: Acta Palaeontologica Sinica, v. 10, p. 426–432.
Sheng, J.C., 1963, Permian fusulinids of Kwangsi, Kueichow and Szechuan: Palaeontologica Sinica, new series B, v. 10, p. 1–247. [in Chinese and English]
Sheng, J.C., 1965, Fusulinids from the western part of Hainan Island, Kwangtung Province: Acta Palaeontologica Sinica, v. 13, p. 563–583.
Skinner, J.W., 1931, Primitive fusulinids of the Mid-Continent region: Journal of Paleontology, v. 5, p. 253–259.
Skinner, J.W., and Wilde, G.L., 1965a, Permian biostratigraphy and fusulinid faunas of the Shasta Lake area, northern California: The University of Kansas, Paleontological Contributions Protozoa Article, v. 6, p. 1–98.
Skinner, J.W., and Wilde, G.L., 1965b, Lower Permian (Wolfcampian) fusulinids from Big Hatchet Mountains, southwestern New Mexico: Contributions from the Cushman Foundation for Foraminiferal Research, v. 16, p. 95–104.
Skinner, J.W., and Wilde, G.L., 1966a, Permian fusulinids from northeastern Washington, in Skinner, J.W., and Wilde, G.L., eds., Permian Fusulinids from Pacific Northwest and Alaska: University Kansas, Paleontological Contributions, Paper 4, part 3, p. 16–22.
Skinner, J.W., and Wilde, G.L., 1966b, Permian fusulinids from Sicily: The University of Kansas, Paleontological Contributions, Lawrence, Paper 8, p. 1–16.
Solovieva, M.N., 1978, K sisteme foraminifer (interpretatsiya biologicheskogo znacheniya osobennostey strukturnoy i prostranstvennoy organizatsii foraminifer): Byulleten Moskovskogo Obshchestva Ispytateley Prirody, Otdel Geologicheskii, v. 53, no. 5, p. 159–160. [in Russian]
Somerville, I.D., 2008, Biostratigraphic zonation and correlation of Mississippian rocks in Western Europe: some case studies in the lateViséan/Serpukhovian: Geological Journal, v. 43, p. 209–240.
Staff, H., von, and Wedekind, R., 1910, Der oberkarbonische Foraminiferensapropelit Spitzbergens: Geological Institut Bulletin, Upsala University, v. 10, p. 81–123.
Stewart, W.J., 1963, The fusulinid genus *Chusenella* and several new species: Journal of Paleontology, v. 37, p. 1150–1163.
Stewart, W.J., 1966, Schubertellinae wolfkempa (nizhnaya perm) is gor Franklina Tekhasa: Voprosy Mikropaleontologii, v. 10, p. 80–88. [in Russian; English translation and updated terminology: Stewart, W.J., 1968, Schubertellinae from the Wolfcamp, Lower Permian, Franklin Mountains, Texas: Journal of Paleontology, v. 42, p. 322–328.]
Subbotina, N.N., Voloshinova, N.A., and Azbel, A.Ya., 1981, Introduction to the study of foraminifera (classification of calcareous foraminifera of the Meso-Cenozoic): Leningrad, VNIGRI, p. 1–456. [in Russian]
Suleimanov, I.S., 1949, Novye vidi fuzulinid podsemeistva Schubertellinae Skinner iz kammenougolnikh i nizhnepermskikh otlozhenii Bashkirsgo Priuralya: Trudy Instituta Geologicheskikh Nauk, 105, geologicheskaya seriya, v. 35, p. 22–43. [in Russian]
Sun, Q.L., and Zhang, L.X., 1988, Early Permian fusulinids from the Kongkashan Pass of Xinjiang: Acta Micropaleontologica Sinica, v. 5, p. 367–368. [in Chinese]
Thompson, M.L., 1934, The fusulinids of the Des Moines series of Iowa: University of Iowa Studies natural History, v. 16, no. 284, p. 273–332.
Thompson, M.L., 1937, Fusulinids of the subfamily Schubertellinae: Journal of Paleontology, v. 11, p. 118–125.
Thompson, M.L., 1948, Studies of American fusulinids: University of Kansas, Paleontological Contributions, Protozoa, Article 1, p. 1–184.
Thompson, M.L., 1954, American Wolfcampian fusulinids: University of Kansas, Paleontological Contributions, Protozoa, Article 5, p. 1–226.
Thompson, M.L., and Miller, A.K., 1944, The Permian of southernmost Mexico and its fusulinid faunas: Journal of Paleontology, v. 18, p. 481–504.
Thompson, M.L., Wheeler, H.E., and Hazzard, J.C., 1946, Permian fusulinids of California: Geological Society of America, Memoir 17, p. 1–77.
Toriyama, R., 1958, Geology of Akiyoshi, Part III: Fusulinids of Akiyoshi: Memoirs of the Faculty of Science, Kyushu University, series D, Geology, v. 7, p. 1–264.
Toriyama, R., 1975, Fusuline fossils from Thailand. 9. Permian Fusulines from the Rat Buri Limestone in the Khao Phlong Phrab area: Memoirs Faculy of Sciences of Kyushu University, v. 23, p. 1–116.
Tumanskaya, O.G., 1962, O nekotorykh nizhnepermskikh fuzulinidakh Urala i drugikh rayonov SSSR: Doklady Akademiya Nauk SSSR, v. 146, p. 1396–1398.
Ueno, K., 1991, *Pamirina* (Permian Fusulinacea) from the Akiyoshi Limestone Group, southwest Japan: Transactions and Proceedings Paleontological Society Japan, v. 161, p. 739–750.
Ueno, K., 1992, Permian foraminifers from the Takakurayama Group of the Southern Abukuma Mountains, Northeast Japan: Transactions and Proceedings of the Paleontological Society Japan, v. 168, p. 1265–1295.
Ueno, K., 1994, *Levenella*, a new name for *Levenia* Ueno, 1991 (Foraminiferida, Fusulinacea), non Gray, 1847: Transactions and Proceedings Paleontological Society Japan, v. 173, p. 1–405.
Ueno, K., 1996, *Mesoschubertella* (Permian Fusulinacea) from the Akiyoski Limestone Group, southwest Japan: Bulletin of the Akiyoshi Museum of Natural History, v. 31, p. 21–31.
Ueno, K., 2001. Fusulinoidea, *in* Ikeya, N., Hirano, H., and Ogasawara, K., eds., The database of Japanese fossil type specimens described during the 20th Century: Palaeontological Society of Japan, Special Papers, v. 19, p. 178–220.
Ueno, K., and Sakagami, S., 1993, Middle Permian foraminifers from Ban Nam Suai Tha Sa-at Changwat Loei Northeast Thailand: Transactions and Proceedings of the Paleontological Society of Japan, v. 172, p. 277–291.
Ueno, K., Wang, Y.J., and Wang, X.D., 2003, Fusulinoidean faunal succession of a Paleo-Tethyan oceanic seamount in the Changning-Menglian Belt, West Yunnan, Southwest China: an overview: Island Arc, v. 12, p. 145–161.
Vachard, D., 1980, Téthys et Gondwana au Paléozoïque supérieur; les données afghanes: biostratigraphie, micropaléontologie, paléogéographie: Documents et Travaux IGAL, Institut Géologique Albert de Lapparent, v. 2, p. 1–463.
Vachard, D., 1989, Microfossils and microfacies of the lower Carboniferous limestones, *in* Fontaine, H., and Gafoer, S., eds., The Pre-Tertiary Fossils of Sumatra and Their Environments: Bangkok and Tokyo, CCOP Technical Publication, v. 19, p. 31–40.
Vachard, D., 1990, Fusulinoids, smaller foraminifera and pseudo-algae from southeastern Kelantan (Malaysia) and their biostratigraphic and paleogeographic value, *in* Fontaine, H., ed., Ten Years of CCOP Research on the Pre-Tertiary of East Asia: Bangkok and Tokyo, CCOP Technical Publications, v. 20, p. 43–176.
Vachard, D., 2016, Macroevolution and biostratigraphy of Paleozoic foraminifers, *in* Montenari, M., ed., Stratigraphy and Timescales, 1: Amsterdam, Elsevier, p. 257–323.

Vachard, D., 2018, Permian smaller foraminifers; taxonomy, biostratigraphy and biogeography, *in* Lucas, S.G., and Shen, S.Z., eds., 2018, The Permian Time scale: Geological Society of London, Special Publications, v. 450, p. 205–252.

Vachard, D., and Arefifard, S., 2015, Foraminifers and algae of the late Tournaisian–early Viséan boundary interval (MFZ8-9) in the Gachal Formation (Central Iran): Revue de Micropaléontologie, v. 58, p. 185–216.

Vachard, D., and Bouyx, E. 2001, Nouvelles données sur le Permien du Massif de Bulola, dans le versant méridional de l'Hindou Kouch, en Afghanistan: Annales de la Société géologique du Nord, v. 8, p. 121–135.

Vachard, D., and Ferrière, J., 1991, Une association à *Yabeina* (Foraminifère Fusulinoïde) dans le Midien (Permien supérieur) de la région de Whangaroa (Baie d'Orua, Nouvelle-Zélande): Revue de Micropaléontologie, v. 34, p. 201–230.

Vachard, D., and Montenat, C., 1981, Biostratigraphie, micropaléontologie et paléogéographie du Permien de la région de Tezak (Montagnes Centrales d'Afghanistan): Palaeontographica, B, v. 178, p. 1–88.

Vachard, D., and Razgallah, S., 1988, Importance phylogénétique d'un nouveau foraminifère endothyroïde *Endoteba controversa* n. gen. n. sp. (Permien du Jebel Tebaga, Tunisie): Geobios, v. 21, p. 805–811.

Vachard, D., Clift, P., and Decrouez, D., 1993, Une association à Pseudodunbarula (Fusulinoïde) du Permien supérieur (Djoulfien) remaniée dans le Jurassique d'Argolide (Grèce): Revue de Paléobiologie, v. 12, p. 217–242.

Vachard, D., Martini, R., Rettori, R., and Zaninetti, L., 1994, Nouvelle classification des Foraminifères endothyroïdes du Trias: Geobios, v. 27, p. 543–557.

Vachard, D., Fourcade, E., Romero, J.E., Mendez, J.E, Cosillo, A., Alonzo, M., Requeña, J., Azema, J., and Cros, P., 1997, Foraminifères et Algues du Permien du Guatemala: Geobios, v. 30, p. 745–784.

Vachard, D., Flores de Dios, A., Buitrón, B., and Grajales, M., 2000a, Biostratigraphie et Paléogéographie des Calcaires Carbonifères et Permiens de San Salvador Patlanoaya (Puebla, Mexique): Geobios, v. 33, p. 5–33.

Vachard, D., Flores de Dios, A., Pantoja, J., Buitrón, B., Arellano, J., and Grajales, M. 2000b, Les Fusulines du Mexique, une revue biostratigraphique et paléógéographique: Geobios, v. 33, p. 655–679.

Vachard, D., Vidaurre-Lemus, M., Fourcade, E., and Requeña, J., 2000c, New Early Permian fusulinid assemblage from Guatemala: Comptes Rendus de l'Académie des Sciences de Paris, v. 33, p. 789–796.

Vachard, D., Hauser, M., Martini, R., Zaninetti, L., Matter, A., and Peters, T., 2001a, New algae and problematica of algal affinity from the Permian of the Aseelah Unit of the Batain Plain (East Oman): Geobios, v. 34, p. 375–404.

Vachard, D., Martini, R., and Zaninetti, L., 2001b, Earliest Artinskian (Early Permian) fusulinid reworked in the Triassic Lercara Formation (NW Sicily): Journal of Foraminiferal Research, v. 3, p. 33–47.

Vachard, D., Pille, L., and Gaillot, J., 2010. Palaeozoic Foraminifera: systematics, palaeoecology and responses to the global changes: Revue de Micropaléontologie, v. 53, p. 209–254.

Vachard D., Krainer K., and Lucas, S., 2013, Pennsylvanian (late Carboniferous) calcareous microfossils from Cedro Peak (New Mexico, USA); part 2: smaller foraminifers and fusulinids: Annales de Paléontologie, v. 99, p. 1–42.

Vdovenko, M.V., Rauzer-Chernousova, D.M., Reitlinger, E.A., and Sabirov, A.A., 1993, Spravochnik po sistematike melkikh foraminifer paleozoya: Rossiiskaya Akademiya Nauk, Komissiya po Mikropaleontologii, "Nauka," Moscow, p. 1–128. [in Russian]

Wang, K.L., and Sun, X.F., 1973, Carboniferous and Permian foraminifera of the Chinling Range and its geologic significance: Acta Geologica Sinica, v. 2, p. 137–178. [in Chinese with English abstract]

Wang, Y.H., Sheng, J.Z., and Zhang, L.X., 1981, Fusulinids from Xizang of China, *in* Nanjing Institute Geology Paleontology, ed., Paleontology of Xizang: Beijing, Geological Publication House, v. 3, p. 1–80. [in Chinese with English abstract]

Wedekind, P.R., 1937, Einführung in die Grundlagen der historischen Geologie. Band II. Mikrobiostratigraphie die Korallen und Foraminiferenzeit: Stuttgart, Ferdinand Enke, 136 p.

Xiao, W.M., Wang, H.D., Zhang, L.X., and Dong, W.L., 1986, Early Permian stratigraphy and fauna in southern Guizhou: Guiyang, The People's Publishing House of Guizhou, p. 1–364. [in Chinese with English abstract]

Xie, S.G., 1982, Fusulinids, *in* Bureau of Geology of Hunan Province, ed., Paleontological Atlas of Hunan: Beijing, Geological Publishing House, p. 2–73. [in Chinese]

Zanchi, A., Zanchetta S., Berra, F., Mattei, M., Garzanti, E., Molyneux, S., Nawab, A., and Sabouri, J., 2009, The Eo-Cimmerian (Late? Triassic) orogeny in north Iran, *in* Brunet, M.F., Wilmsen, M., and Granath, J.W., eds., South Caspian to Central Iran Basins: Geological Society of London Special Publications, v. 312, p. 31–55.

Zanchi, A., Malaspina, N., Zanchetta, S., Berra, F., Benciolini, L., Bergomi, M., Cavallo, A., Javadi, H.R., and Kouhpeyma, M., 2015, The Cimmerian accretionary wedge of Anarak, Central Iran: Journal of Asian Earth Sciences, v. 102, p. 45–72.

Zandkarimi, K., Najafian, B., Vachard, D., Bahrammanesh, M., and Vaziri, S.H., 2014, Latest Tournaisian–late Viséan foraminiferal biozonation (MFZ8-MFZ14) of Valiabad area, northwestern Alborz (Iran); geological implications: Geological Journal, v. 51, p. 125–142.

Zhang, L.X., 1982, Fusulinids of eastern Qinghai-Tibet Plateau, *in* Bureau of Geology of Sichuan Province and Nanjing Institute of Geology and Paleontology, eds., The Stratigraphy and Paleontology of West Sichuan and East Tibet: Chengdu, Sichuan People's Publishing House, p. 119–244. [in Chinese with English abstract]

Zhang, L.X., Wang, L., and Wang, J.H., 1981, Classification of Fusulinida, *in* Micropalaeontological Society of China, ed., Selected Papers on the 1st Convention of Micropalaeontological Society of China: Beijing, Science Press, p. 30–36 [in Chinese with English abstract]

Zhang, Z.C., 1992, Permian fusulinids, *in* Yichang Institute of Geology and Mineral Resources and Bureau of Geological Mineral Resources of Hainan, eds., Geology of Hainan Island (1) Stratigraphy and Paleontology: Beijing, Geological Publishing House, p. 145–152. [in Chinese]

Zhang, Z.H., and Hong, Z.Y., 1998, Early Early Permian *Staffella* fauna from Ninghua County, Fujian Province: Acta Micropalaeontologica Sinica, v. 15, p. 199–212. [in Chinese]

Zhang, Y.-C., Shi, G., and Shen, S.-Z., 2013, A review of Permian stratigraphy, palaeobiogeography and palaeogeography of the Qinghai-Tibet Plateau: Gondwana Research, v. 24, p. 55–76.

Zhao, Z.X., Han, J.X., and Wang, Z., 1984, The Carboniferous strata and its fauna from southwestern margin of Tarim Basin in Xinjiang: Beijing, Geological Publishing House, p. 1–187. [in Chinese]

Zhou, J., 1989, *Chalaroschwagerina* (Fusulinid) from Longlin, Guangxi: Acta Micropalaeontologica Sinica, v. 6, p. 257–298. [in Chinese with English abstract]

Zhou, J.P., 1998, The Changmean–Chihsian (Permian) fusulinids from northwestern Guangxi, South China: Acta Palaeontologica Sinica, v. 37, p. 467–476. [in Chinese with English abstract]

Zhou J.P., and Zhang L.X., 1984, Fusulinids from the Chihsia Formation of Mt. Qixiashan, Nanjing: Acta Palaeontologica Sinica, v. 23, p. 716–725. [in Chinese with English abstract]

Zhou, T.M., Sheng J.Z., and Wang, Y.J., 1987, Carboniferous-Permian boundary beds and fusulinid zones of Xiaodushan, Guangnan, eastern Yunnan: Acta Micropalaeontologica Sinica, v. 4, p. 123–145 [in Chinese, p. 146–157 in English]

Zhou, Z.R., 1982, Earliest Permian *Schwagerina cushmani* fusulinid fauna from southeastern Hunan: Acta Palaeontologica Sinica, v. 21, p. 225–248. [in Chinese]

Zolotova, V.P., and Baryshnikov, V.V., 1980, Foraminifery kungurskogo yarusa stratotipicheskoi mestnosti (Foraminifers from Kungurian stage stratotype locality), *in* Rauzer-Chernousova, D.M., and Chuvashov, B.I., eds., Biostratigrafiya Artinskogo i Kungurskogo yarusov Urala (Biostratigraphy of the Artinskian and Kungurian stages from Urals): Sverdlovsk, Akademiya Nauk SSSR, Uralskii Nauchnyi Tsentr, p. 72–109. [in Russian]

Accepted: 20 June 2020