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SMALLER FORAMINIFERS FROM THE LOWER PERMIAN EMARAT FORMATION, EAST OF FIRUZKUH (CENTRAL ALBORZ, IRAN)

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Abstract. The uppermost Carboniferous-Lower Permian Dorud Group of the Gaduk section in Central Alborz (Iran) is more than 44 m-thick; it includes thick succession of conglomerates, quartzarenites, calcareous sandstones, oncolitic fusulinid limestones, sandy limestones, sandstones and shales. The Toyeh, Emarat and Shah Zeid formations of this Group were dated from the Gzhelian to the Sakmarian. A review of the uppermost Gzhelian, Asselian and lower Sakmarian smaller foraminifers of the Emarat Formation of the Gaduk section is here presented. Three foraminiferal biozones are defined: the *Nodosinelloides shikhanica-Geinitzina primitiva* Zone is latest Gzhelian in age; the *Nodosinelloides* spp.-*Geinitzina* spp.-*Pseudoacutella partoazari* Zone is Asselian; the *Rectogordius iranicus gadukensis-Endothyra* cf. *bamberi* Zone is early Sakmarian in age. A new subspecies *Rectogordius iranicus gadukensis* n. subsp. is described, and the genera *Pseudovidalina* and *Grovesella* are discussed. The studied assemblages are correlated with those from the Carnic Alps (Austria-Italy), East European Platform of Russia, the Urals (Russia), Darvaz (Uzbekistan), the northern and central Pamirs (Tajikistan), Central Iran, northern Afghanistan and other classical regions of the Tethyan realm.

INTRODUCTION

The upper Paleozoic faunas and microfaunas of the Alborz Range (northern Iran) have been extensively described since more or less half a century (see Stepanov et al. 1969; Bozorgnia 1973; Stampfli 1978; Jenny & Stampfli 1978; Lys et al. 1978; Jenny-Deshusses 1983; Partoazar 1995; Taghavi-Anaraki 1996; Vachard 1996; Mazaheri 2003; Taleblu 2007; Vaziri 2008; Angiolini et al. 2008, 2010; Gaetani et al. 2009; Leven & Gorgij 2011a; Alipour et al. 2013; Yarahmadzahi & Vachard 2014 and Zandkarimi et al. 2016). However, the Carboniferous and Permian fusulinids and smaller foraminifers remained relatively poorly studied in the Alborz in comparison with adjacent areas of Russia, Armenia, Azerbaijan and Turkey. Brief descriptions of these fossils and illustrations have been published in the monographies of Bozorgnia (1973), Jenny-Deshusses (1983), Partoazar (1995) and Leven & Gorgij (2011a), and in the papers of Kahler (1977), Lys et al. (1978), Jenny & Stampfli (1978), Vachard (1996), and Gaetani et al. (2009). For instance, the list of fusulinids published by Lys et al. (1978) includes over 100 species from central Alborz, many of which are quite doubtful.

In central Alborz, the Dorud Formation was defined as unconformably overlying the Geirud Formation (Upper Devonian) and being conformably overlain by the Ruteh Formation (middle Permian) (Assereto 1963). Considered as a group by Jenny & Stampfli (1978), the Dorud Group was divided by Gaetani et al. (2009) into four formations: Toyeh, Emarat, Ghosnavi, and Shah Zeid. Lithologically, the Dorud Group includes thick succession of red sandstones, shales, conglomerates, fossiliferous oncolitic limestones and quartzites. The Toyeh Formation is composed of conglomerate, quartzarenite and calcareous sandstone; the Emarat Formation is composed of oncolitic fusulinid limestones and sandy limestones, and the Shah Zeid Formation of sandstones and shales. The Emarat Formation principally contains the

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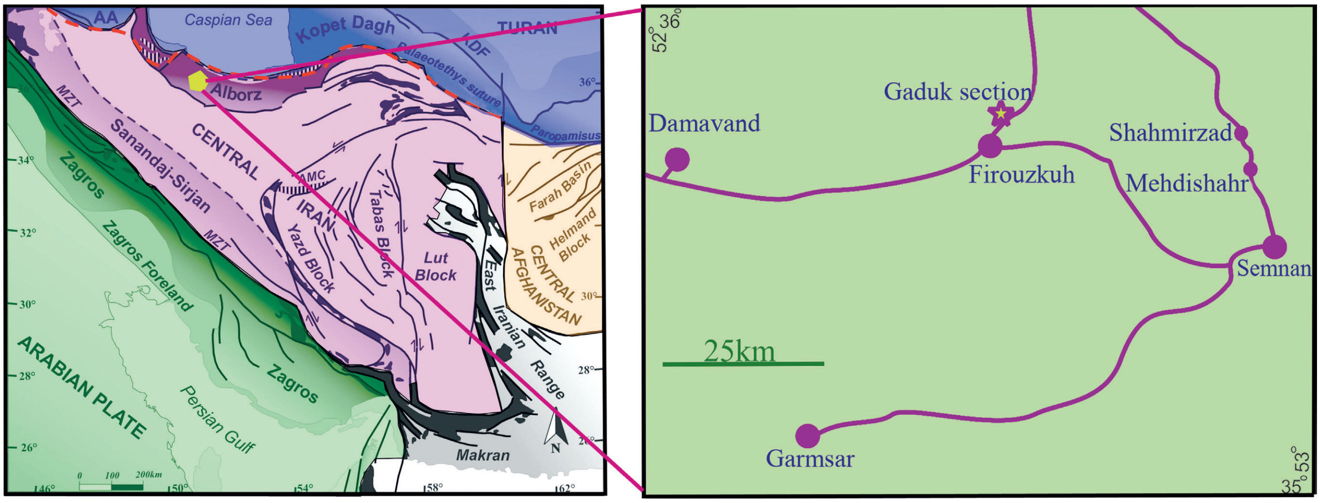


Fig. 1 - Position of the studied area, East of Firuzkuh (Central Alborz, Iran) on the schematic tectonic map of Iran (modified from Zanchi et al. 2009).

fusulinids *Ruzhencevites*, *Praepseudofusulina*, *Sphaeroschwagerina* and *Pseudoschwagerina*, which indicate that it is essentially Asselian with a lowermost part which is latest Gzhelian in age.

Geological setting and lithostratigraphy

The studied area is located 10 km east of Firuzkuh city at 35° 49' 25" N- 52° 53' 05" E (Fig. 1).

The studied section is the Gaduk section, which is part of the Middle Alborz in the sense of Alavi (1991) or of the Iran Central Domain (Alborz subzone) in the sense of Aghanabati (2004). There, the Lower Carboniferous Mobarak Formation was accurately studied (e.g., Bozorgnia 1973; Vachard 1996; Devuyst 2006), but the Upper Carboniferous and Lower Permian rocks are less known. Lithostratigraphically, this part of the Gaduk section corresponds to the Toyeh, Emarat and Shah Zeid formations. The Toyeh Formation unconformably overlays the Lower Carboniferous Mobarak Formation; it is approximately 10 m-thick and consists of sandstones, siltstones and shales. The Emarat Formation, 24.5 m-thick, is composed of different limestones (mainly fusulinid oncolitic grainstones, wackestones and carbonate mudstones). The Shah Zeid Formation, 9.5 m-thick, is composed of alternating shales, siltstones and sandstones (Figs 2-3).

Material and methods

The studied material includes 120 standard thin sections, referring to sample numbers DH1-13, and housed at the Faculty of Science, Islamic Azad University of Zahedan (Iran), Collection ESRC 1/1395.

The thin sections were prepared from rock samples collected at an average sampling interval of 50 cm throughout the succession. For each sample, the microfacies, biofacies and foraminiferal data were recorded.

Our foraminiferal taxonomy follows Pinard & Mamet (1998), Nestell & Nestell (2006), Gaillot & Vachard (2007), Filimonova (2010), Alipour et al. (2013), and Vachard (2016). For the taxonomic part, we have followed the International Code of Zoological Nomenclature (ICZN; Ride et al. 1999) and the paper of Matthews (1973). The microfacies and paleoenvironments were analyzed according to the methods and nomenclature compiled by Flügel (2004). Our stratigraphic terminology follows the recommendations of Owen (2009).

Biostratigraphy

In this study, our principal goal was to establish the biostratigraphy of the Emarat Fm. in the Gaduk section (Figs 2-3).

We used as biostratigraphic references the pioneer works of Rauzer-Chernousova (1949), Lipina (1949) and Morozova (1949) about the Asselian and Sakmarian stratotypes, as well as the recent works of Filimonova (2010) about their regional equivalents in Uzbekistan and Tajikistan. We referred also to the papers of Sosipatrova (1972) and Blazejowski (2009). In the Carnic Alps, the smaller foraminifers of the Auernig and Rattendorf groups were investigated by Vachard & Krainer (2001a, b). In North

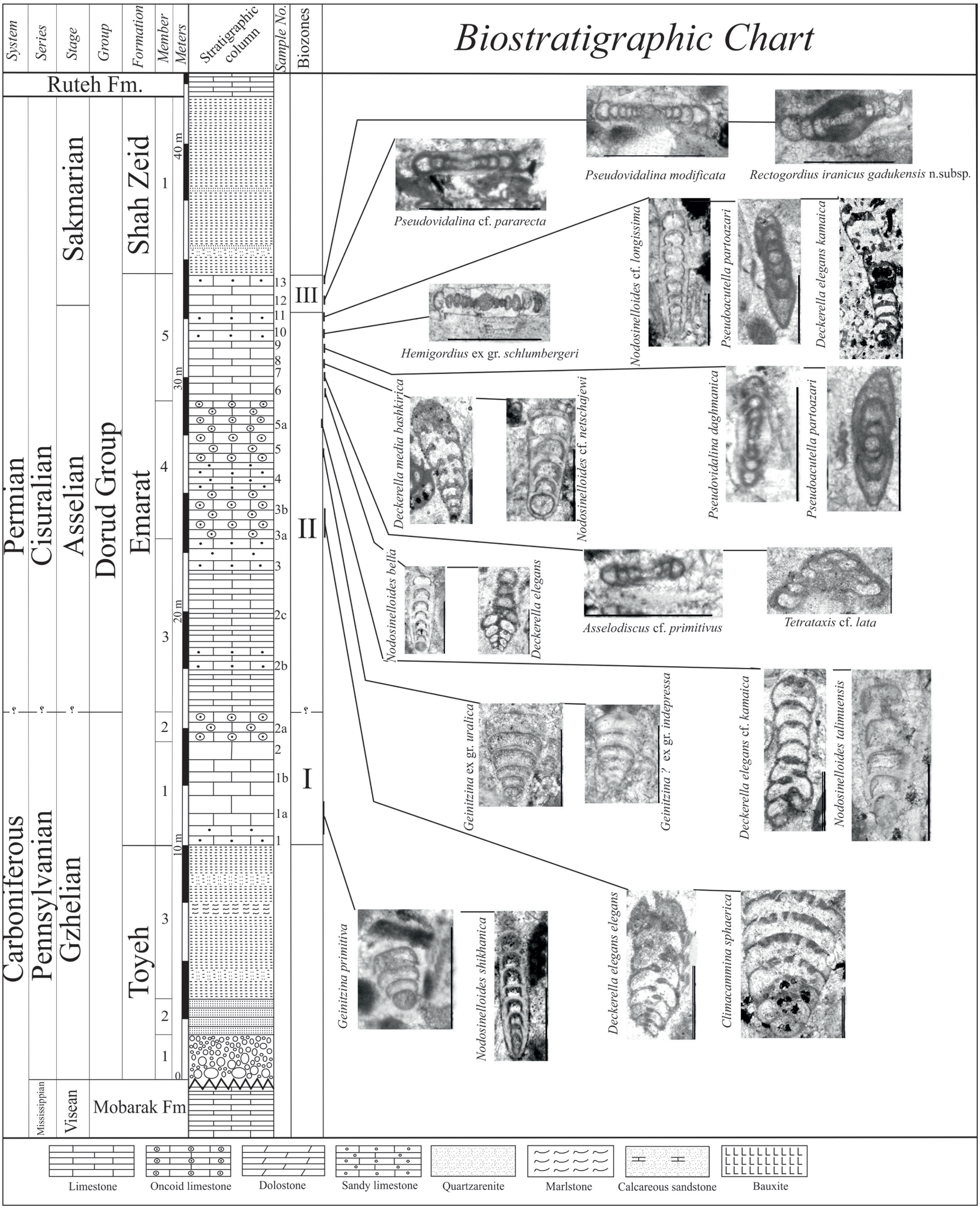


Fig. 2 - Biostratigraphic chart with the main species of smaller foraminifers in the Emarat Formation, East of Firuzkuh (Central Alborz, Iran). (Abbreviations: I, II and III correspond to the three biozones of smaller foraminifers described in this paper).

America, the Wolfcampian smaller foraminifers were studied by Groves (2000), Groves & Wahlman (1997), Pinard & Mamet (1998), Groves & Boardman (1999), Krainer et al. (2009) and Lucas et al. (2015). In Afghanistan, no biozone has been established because it was lying at high paleolatitudes in

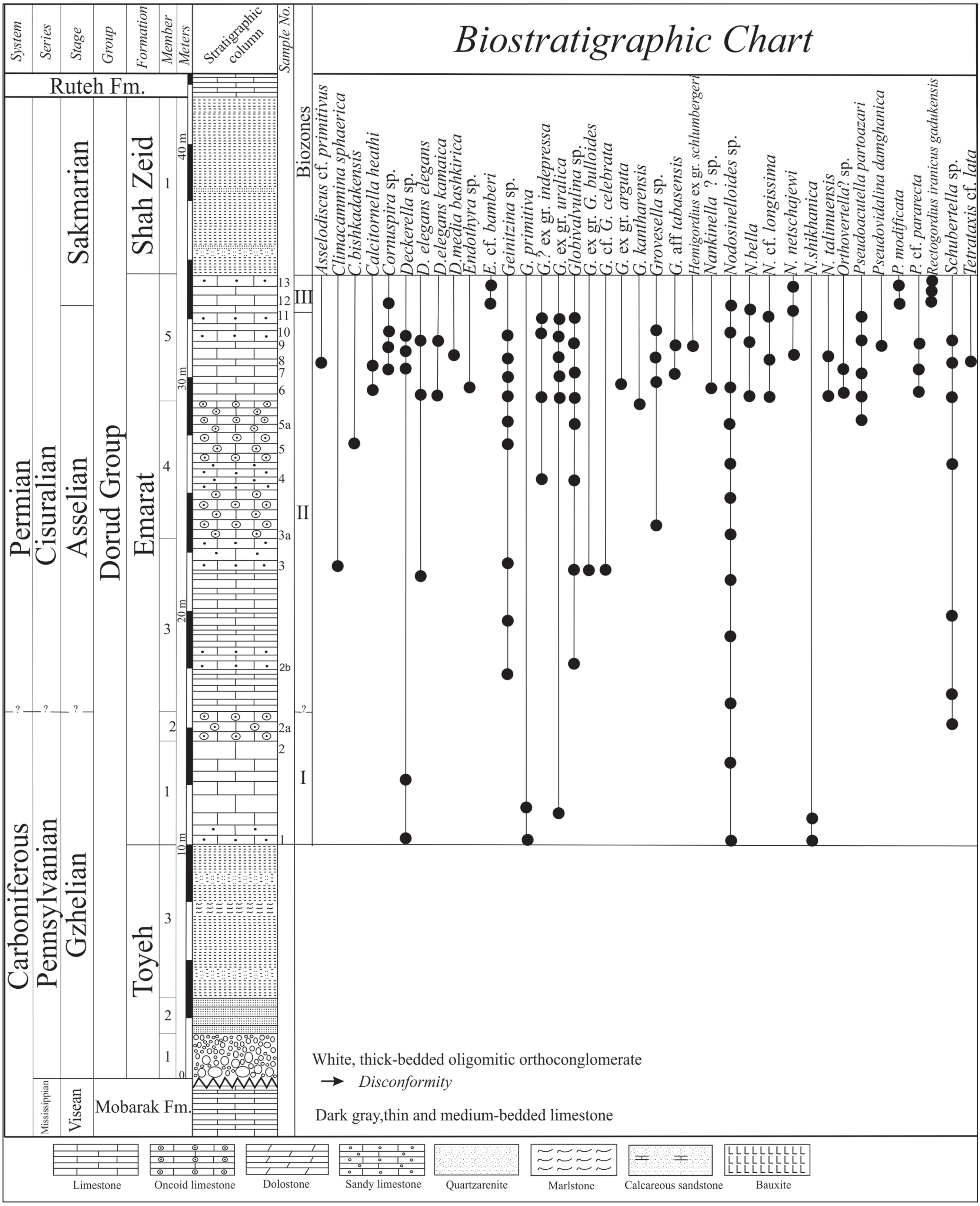


Fig. 3 - Biostratigraphic chart with the distribution of the smaller foraminifers in the Emarat Formation, East of Firuzkuh (Central Alborz, Iran). (Abbreviations: I, II and III correspond to the three biozones of smaller foraminifers described in this paper).

cold climate conditions during the Asselian-early Sakmarian (Vachard 1980; Vachard & Montenat 1981, 1996). However, *Tezaquina* Vachard in Vachard & Montenat 1981 non Vachard, 1980 was described from this country; it is an important genus that records the first pseudoseptation among the ancestral nodosariates.

In Iran, the foraminiferal zonations were especially based on large fusulinids (Leven & Gorgij 2011a with references therein); however, two papers have used the smaller foraminifers for dating, especially in the Emarat Formation: Filimonova (2013) and Alipour et al. (2013).

Based on smaller foraminifers, three biozones labelled zones I-III are here defined as follows (Figs 2-3, Pl. 1-2).

Biozone I: *Nodosinelloides shikhanica-Geinitzina primitiva* Zone

Both markers, *Nodosinelloides shikhanica* (Lipina, 1949) (Fig. 2, Pl. 1, fig. 18) and *Geinitzina primitiva* Potievskaya, 1962 (Fig. 2, Pl. 1, fig. 20) are associated with rare species of *Nodosinelloides* (Fig. 3). We attribute this zone to the latest Gzhelian because of (a) the general dating of the Emarat Formation by fusulinids, and (b) because it is similar to the *Nodosinelloides potievskayae-Vervilleina bradyi* Zone of Alipour et al. (2013), which was also assigned to the latest Gzhelian.

The lowermost limit of this zone coincides with the base of the Emarat Formation in Gaduk, whereas its top is not precisely defined. Because of the similarities with the coeval zone in the eastern Alborz (Alipour et al. 2013), it is tentatively emplaced herein at the top of the first unit with oncoids (Figs 2-3). This level, which coincides with the Carboniferous/Permian boundary, needs further investigations. The biozone I has a thickness of 6 m in the Gaduk section (Figs 2-3).

Biozone II: *Nodosinelloides* spp.-*Geinitzina* spp.-*Pseudoacutella partoazari* Zone

At Gaduk, this biozone has a thickness of 19 m (Figs 2-3), which varies from 10 to 32 m in coeval sections. The lower part of this zone is characterized by LOs (lowest occurrences) of various species of *Geinitzina* and *Nodosinelloides*, whereas the top is defined with the HO (highest occurrence) of *Pseudoacutella partoazari* Yarahmadzahi & Vachard, 2014. The smaller foraminifers of this biozone are (in alphabetical order): *Asselodiscus* cf. *primitivus* Mamet & Pinard, 1992 (Pl. 2, fig. 23), *Calcitornella heathi* Cushman & Waters, 1928 (Pl. 2, figs 24-25), *Climacammina sphaerica* (Potievskaya, 1962) (Pl. 1, fig. 9), *C. bishkadakensis* Morozova, 1949, *Cornuspira* sp. (Pl. 1, figs 48?, 49, Pl. 2, fig. 27), *Deckerella elegans elegans* Morozova, 1949 (Pl. 1, fig. 2), *D. elegans kamaica* Baryshnikov in Baryshnikov et al. 1982 (Pl. 1, figs 5?, 10-12), *D. media bashkirica* (Morozova, 1949) (Pl. 1, figs 1, 7, 8?, 9?), *Deckerella* sp. (Pl. 1, fig. 3), *Endothyra* sp. 1 (Pl. 1, fig. 40), *E.* sp. 2 (perhaps transitional to *Neoendothyra*) (Pl. 1, fig. 41), *Eotuberitina* sp. (Pl. 1, fig. 38), *Geinitzina postcarbonica* Spandel, 1901 (Pl. 2, fig. 12), *G. primitiva* Potievskaya, 1962 (Pl. 2, figs 18, 21), *G.* ex gr. *uralica* Suleimanov, 1949 (Pl. 1, fig. 22, Pl. 2, figs 2, 4?, 7, 8?, 10?, 11, 13), *G.*? ex gr. *indepressa* Cherdyntsev, 1914 (Pl. 1, fig. 21, Pl. 2, fig. 3), *G.*? cf. sp. 2 (Pl. 2, fig. 15), *Globivalvulina* ex gr. *bulloides* (Brady, 1876) (Pl. 1, figs 30, 34), *G.* cf. *celebrata* Zamilatskaya, 1969 (Pl. 1, figs 29, 31-33), *G. kantharensis* Reichel, 1946 (Pl. 1, fig. 35), *G.* ex gr. *arguta* Konovalova, 1962 (Pl. 1, figs 36-37), *Grovesella* aff. *tabasensis* Davydov & Arefifard, 2007 (Pl. 1, figs 24-28), *Hemigordius* ex gr. *schlumbergeri* (Howchin, 1985) (Pl. 2, fig. 25), *H.*? sp. (Pl. 2, fig. 36), *Hemigordiellina* sp. (Pl. 2, fig. 29), *Nankinella*? sp. (Pl. 1, fig. 42), *Nodosinelloides bella* (Lipina, 1949) (Pl. 1, fig. 19, Pl. 2, figs 6, 17, 22), *N.* cf. *longissima* (Suleimanov, 1949) (Pl. 2, figs 14, 19), *N. talimuensis* (Han in Zhao et al., 1984) (Pl. 1, fig. 17), *Orthovertella*? sp. (Pl. 1, figs 43-45, *Palaeotextularia* sp. (Pl. 1, figs 4-6), *Pseudoacutella partoazari* Yarahmadzahi & Vachard, 2014 (Pl. 1, figs 13, 16, 50?, 51?, 52-57), *Pseudoagathammina*? sp. (Pl. 2, fig. 28), *Pseudovidalina* (involute stage) *damghanica* Alipour & Vachard in Alipour et al. 2013 (Pl. 1, fig. 47), *P. modificata* (Potievskaya, 1962) (Pl. 2, fig. 32), *P.* cf. *pararecta* Pinard & Mamet, 1998 (Pl. 2, figs 33-35), *P.* sp. (Pl. 1, figs 38, 46), *Schubertella* sp. (Pl. 1, fig. 23), *Tetrataxis* cf. *lata* Spandel, 1901 (Pl. 1, fig. 39), *Tezaquina* ex gr. *clivuli* Vachard in Vachard & Montenat 1981 non Vachard, 1980.

The presence of *Globivalvulina celebrata*, *G. kantharensis*, *G. arguta*, *Tezaquina clivuli, Nodosinelloides bella*, *N. talimuensis,* and *N. shikhanica* has been documented by Filimonova (2010) in the Tethyan shelves of the Pamirs, northern Afghanistan and central and eastern Iran. Filimonova (2010) has assigned an Asselian age to this latter assemblage based on the presence of *Bradyinelloides* (until now unknown in Iran) and *Nodosinelloides talimuensis* (also found in this study), "*Geinitzina multicamerata*" (for us, a misinterpreted *Nodosinelloides*), *Cribrogenerina major* (Morozova, 1949) (for us, *Climacammina* ex gr. *sphaerica*), and *Mesolasiodiscus grandis* (Lipina, 1949) [never found in Iran; and only Kungurian in the

Carnic Alps, (Krainer, Vachard & Schaffhauser, unpublished data)]. Based on these data, the biozone II is assigned herein to the Asselian.

Other field-sections of Emarat Formation have provided the fusulinids *Pseudoschwagerina* spp., *Triticites* sp. and *Praepseudofusulina kaljasmica* (Semina, 1961) (see Leven & Gorgij 2011a), which confirm the Asselian age of the smaller foraminifer biozone described herein. Moreover, as this fusulinid assemblage has been reported from the Anarak region in central Iran (Leven & Gorgij 2006a, b), the Asad-Abad section in Shahreza area (Leven & Gorgij 2011a, b; Yarahmadzahi 2011) and the uppermost Gzhelian-lowermost Permian of Darvas (Davydov in Chuvashov et al. 1986), the biozone II, as defined herein, is probably also present in northern and central Iran.

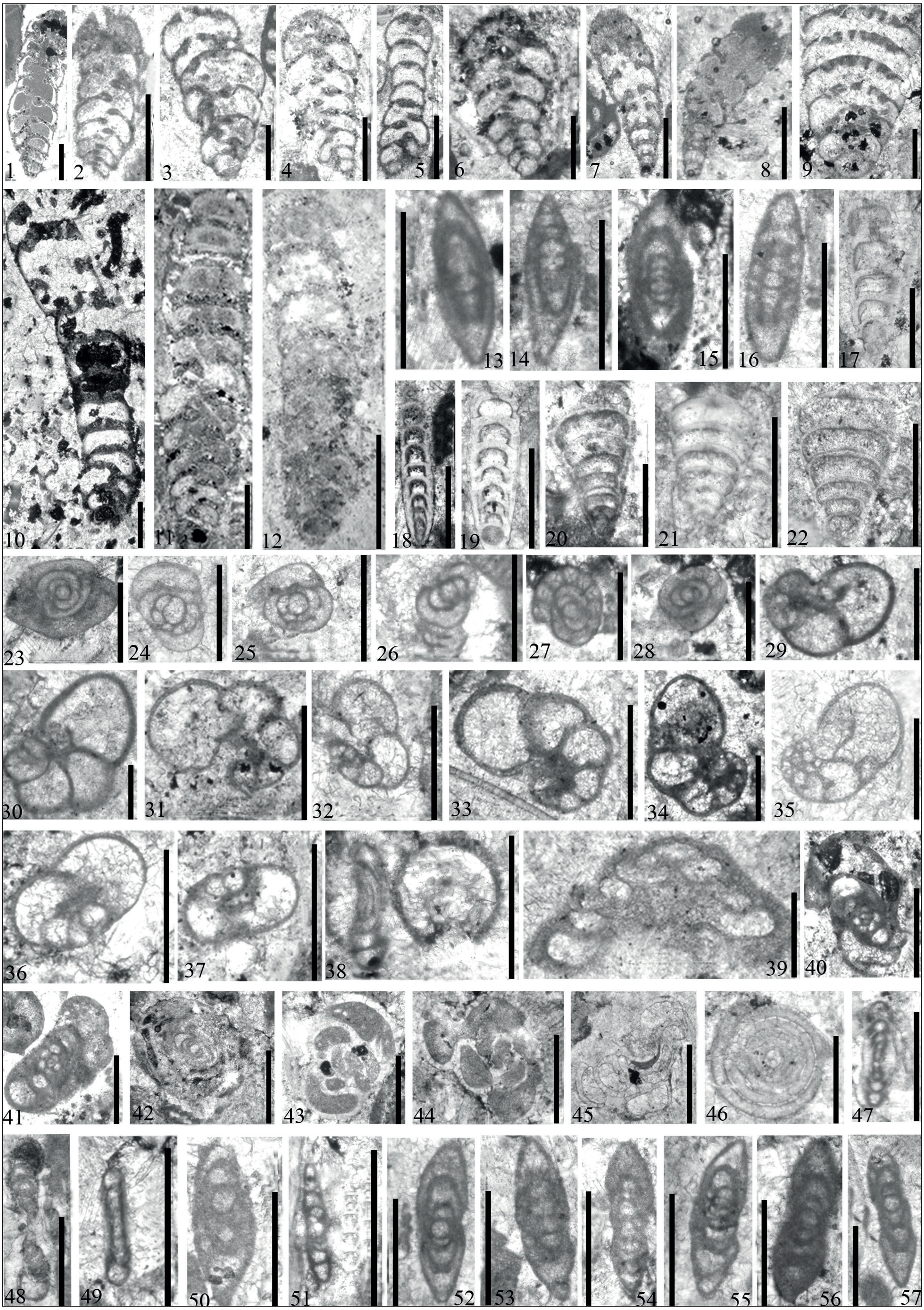
Biozone III: *Rectogordius iranicus gadukensis* n. subsp.-*Endothyra* cf. *bamberi* Zone

Rectogordius iranicus gadukensis n. subsp. has its lowest occurrence and acme in this biozone III, and characterizes it. This biozone III, 2 m-thick (from meter 32 to meter 34 in the studied section, Figs 2-3), includes several foraminifers of the previous biozone II. The main taxa of smaller foraminifers are: *Cornuspira* sp., *Endothyra* cf. *bamberi* Pinard and Mamet, 1998 (Pl. 2, figs 30-31), *Nodosinelloides* cf. *netschajewi* (Cherdyntsev, 1914) sensu Groves & Wahlman 1997, *N. bella* (Lipina, 1949), *Pseudovidalina modificata* (Potievskaya, 1962), *P.* cf. *pararecta* Pinard & Mamet, 1998, and *Rectogordius iranicus gadukensis* Yarahmadzahi & Vachard n. subsp. (Pl. 2, figs 37-47). The biozone III cannot be dated by fusulinids, because the coastal clastic sedimentation of the Shah Zeid Formation prevented their development. Nevertheless, the appearance of *Rectogordius iranicus gadukensis* n. subsp. (sample 12), rapidly followed by its abundance (sample 13) (Figs 2-3), permits to assign this biozone to the upper Asselian-lower Sakmarian on the basis of the range of the genus *Rectogordius* (see Alipour et al. 2013), or only to the lower Sakmarian, based on the four following criteria (1) the range-zone of *Rectogordius iranicus iranicus* Alipour & Vachard in Alipour et al., 2013 (according to the data of Alipour et al. 2013 and Yarahmadzahi & Vachard 2014); (2) a comparison with the distribution of the group of species *Rectogordius sverdrupensis* (Pinard & Mamet, 1998)–*R. beauchampi* (Pinard & Mamet, 1998)–*R. carnicus* (Filimonova, 2010); (3) the association with *Pseudovidalina iranica* Alipour & Vachard in Alipour et al. 2013, an evolved species of this genus; (4) by a comparison and correlation with the upper Asselian-lower Sakmarian smaller foraminiferal biozonation established in the Alborz and other Cimmerian and Perigondwanan regions of the Paleotethys (Filimonova 2010).

PLATE 1

Smaller foraminifers from the Gaduk section, central Alborz.
The ordinary scale bar is 0.2 mm and the double scale bar is 0.5 mm.

Figs 1, 7, 8 - *Deckerella media bashkirica* Morozova, 1949; samples DH 3, 9.
Fig. 2 - *Deckerella elegans elegans* Morozova, 1949; sample DH 3.
Fig. 3 - *Deckerella* sp.; sample DH 5.
Figs 4, 6 - *Palaeotextularia* sp.; sample DH 5.
Fig. 5 - *Deckerella elegans* cf. *kamaica* Baryshnikov in Baryshnikov et al., 1982; sample DH 6.
Fig. 9 - *Climacammina* (transitional to *Cribrogenerina*) *sphaerica* Potievskaya, 1962; sample DH 3.
Figs 10-12 - *Deckerella elegans kamaica* Baryshnikov in Baryshnikov et al., 1982; sample DH 9.
Figs 13-16, 50?, 51?, 52-57 - *Pseudoacutella partoazari* Yarahmadzahi & Vachard, 2014; samples DH 6, 9, 10.
Fig. 17 - *Nodosinelloides talimuensis* (Han in Zhao et al. 1984); sample DH 6.
Fig. 18 - *Nodosinelloides shikhanica* (Lipina, 1949); sample DH 1.
Fig. 19 - *Nodosinelloides bella* (Lipina, 1949); sample DH 11.
Fig. 20 - *Geinitzina primitiva* Potievskaya, 1962; sample DH 1.
Fig. 21 - *Geinitzina*? ex gr. *indepressa* (Cherdyntsev, 1914); sample DH 6.
Fig. 22 - *Geinitzina* ex gr. *uralica* Suleimanov, 1949; sample DH 6.
Fig. 23 - *Schubertella* sp. (including a juvenarium of *Grovesella*-type), sample DH 10.
Figs 24-28 - *Grovesella* aff. *tabasensis* Davydov & Arefifard, 2007; samples DH 7, 9, 10.
Figs 29, 31-33- *Globivalvulina* cf. *celebrata* Zamilatskaya, 1969; samples DH 3, 6, 9, 11.
Figs 30, 34 - *Globivalvulina* ex gr. *bulloides* (Brady, 1876); samples DH 6, 11.
Figs 36-37 - *Globivalvulina* ex gr. *arguta* Konovalova, 1962; sample DH 6.
Fig. 38 - *Eotuberitina* sp. (left) and *Pseudovidalina* sp. (right); sample DH 7.
Fig. 39 - *Tetrataxis* cf. *lata* Spandel, 1901; sample DH 7.
Fig. 40 - *Endothyra* sp. 1; sample DH 6.
Fig. 41 - *Endothyra* (perhaps transitional to *Neoendothyra*) sp. 2; sample DH 8.
Fig. 42 - *Nankinella*? sp.; sample DH 8.
Figs 43-45 - *Orthovertella*? sp.; samples DH 6, 7.
Fig. 46 - *Pseudovidalina* sp.; sample DH 7.
Fig. 47 - *Pseudovidalina* (involutus stage) *damghanica* Alipour & Vachard in Alipour et al., 2013; sample DH 9.
Fig. 48 - *Cornuspira*? sp.; sample DH 9.
Fig. 49 - *Cornuspira* sp.; sample DH 7.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SYSTEMATIC DESCRIPTIONS

This chapter is devoted to the discussion, description and emendation of some foraminiferal taxa.

Subphylum **FORAMINIFERA** d'Orbigny, 1826 emend. Cavalier-Smith, 2003
Class **FUSULINATA** Gaillot & Vachard, 2007
Subclass **AFUSULININA** Vachard et al., 2010
Order **Archaediscida** Poyarkov & Skvortsov, 1979
Superfamily Lasiodiscoidea Reitlinger in Vdovenko et al., 1993
Family Pseudovidalinidae Altiner, 1988

Remarks. We have two recurrent problems with the Pseudovidalinidae: (1) the exact definition of *Pseudovidalina*; (2) the number of lineages and their composition in North America and in Tethys. The definition and illustrations of *Pseudovidalina* in Sosnina (1978) and Loeblich & Tappan (1987) differ from those of Altiner (1988), Vachard & Beckary (1991), Lin et al. (1990) and Alipour et al. (2013). The redefinition of these latter authors includes as synonyms of *Pseudovidalina, Raphconilia* Brenckle & Wahlman, 1996, some *Eolasiodiscus* Reitlinger, 1956, and a part of *Falsodiscus* Davydov, 1991. However, to be valid, this redefinition needs currently an accurate revision of the type material of Sosnina (1978). Similarly, among the archaediscids, *Nudarchaediscus* Conil & Pirlet in Pirlet & Conil 1974 is for us an immature stage of *Glomodiscus* Malakhova, 1973 and currently only the genus name *Glomodiscus* is used in the literature. In the three cases, i.e., *Pseudovidalina* sensu Sosnina/*Pseudovidalina* sensu auctorum and *Nudarchaediscus*/*Glomodiscus*, the dark-microgranular layer first appears and then the hyaline-pseudofibrous umbilical plug successively covers all the previous whorls (e.g., Hance et al. 2011; Zandkarimi et al. 2016).

In our opinion, there is only one phylogenetic lineage among the pseudovidalinids; nevertheless, some vicariant lineages can also exist in North America (for example with *Raphconilia*) and in different regions of the Tethys (with not yet described taxa). For us, the evolutionary lineages begin with *Asselodiscus* (the ancestor of which can be an unknown lasiodiscoid, more or less related with *Eolasiodiscus*). *Asselodiscus* (Pl. 2, fig. 23) gives rise to *Pseudovidalina* at the involutus stage (such as *P. damghanica*; Pl. 1, fig. 47), then to *Pseudovidalina* (concavus stage, which is, in our hypothesis, the typical *Pseudovidalina*), then to *Pseudovidalina* (angulatus stage) which has no generic name, then to different species of South China which have a slit-shaped lumen. Moreover, *Pseudovidalina* at the concavus stage gives rise to two evolute forms: one with a double wall (*Xingshandiscus*) in the Kungurian, and the other one with only a pseudofibrous wall (*Altineria*) in the late Guadalupian-early Wuchiapingian.

In the Gaduk section, we recognized the traditional Paleotethyan lineage under the form of *Asselodiscus* cf. *primitivus*-*Pseudovidalina* (involutus stage) *damghanica* and *Pseudovidalina* (concavus stage) *modificata* (Pl. 2, fig. 23, Pl. 1, fig. 47, Pl. 2, fig. 32). The taxon *P.* cf. *pararecta* (Pl. 2, figs 33-35) is more difficult to include in this lineage, but it can be considered as homeomorph of the genus *Pirletidiscus* Vachard, 1988 among the archaediscids.

On the other hand, we consider "*Permodiscus sumsariensis*" sensu Filimonova (2010) as similar to *Pseudovidalina* (involutus stage) *damghanica*, and *Eolasiodiscus facetus* sensu Filimonova (2010) as similar to *Pseudovidalina* (concavus stage) *modificata*.

Subclass **AFUSULININA** Vachard et al., 2010
Order **Endothyrida** Fursenko, 1958
Superfamily Palaeotextularioidea Habeeb, 1979

Remarks. There are abundant and diversified representatives of *Deckerella* (Pl. 1, figs 1-3, 5, 7-8), and rarer *Palaeotextularia* sp. (Pl. 1, figs 4, 6), *Climacammina* sensu stricto and atypical *Climacammina* with lower chambers and more pores in the cribrate aperture (Pl. 1, fig. 9), i.e., transitional to *Cribrogenerina* according to Vachard & Krainer 2001a, text-fig. 7, or even belonging to *Cribrogenerina* according to Filimonova (2010). On the other hand, *Cribrogenerina major*, marker of the middle/upper Asselian according to Filimonova (2010), is probably synonymous of our *Climacammina sphaerica* (Pl. 1, fig. 9).

Superfamily Globivalvulinoidea Hance et al., 2011

Remarks. Only one lineage of small forms of *Globivalvulina* with thin, unilayered, dark-microgranular wall, with the last chamber rapidly increasing in height and a strong valvula (see Pl. 1, figs 29-31, 33, 35-37). Rare larger forms have a more triangular last chamber (Pl. 1, figs 30, 33).

Order **Fusulinida** Fursenko, 1958

Remarks. Larger fusulinids are absent in the beds studied here; only small fusulinids are represented by *Pseudoacutella partoazari*, the staffellids *Nankinella*? sp., and the schubertelloids: *Schubertella* sp. and *Grovesella* aff. *G. tabasensis* Davydov & Arefifard, 2007 (Pl. 1, figs 24-28). However, *Grovesella* is to be emendated (see Ebrahim-Nedjad et al. 2015 for discussion), because it includes diverse representatives of the genera *Eoschubertella* (or *Schubertina* sensu Davydov 2011), *Zarodella*?, immature *Levenella*?, immature *Schubertella* (that seems to be the case for our material: Pl. 1, fig. 23), and finally a part of the taxon defined by Davydov & Arefifard (2007). We have followed in this paper the redefinition of *Grovesella* proposed by Ebrahim-Nedjad et al. (2015): test small to medium-sized inflated, discoidal to nautiloid or nearly globular, with broadly rounded periphery and weakly to mildly umbilicate flanks. Form ratio equal to, or less than 1.0. Coiling skewed in initial one or two volutions or can be nearly straight. Length of the test is equal or less than width and consequently the means of form ratio is equal or less than one. Wall thin, poorly visible, most probably two layered with darker and thin tectum and slightly lighter, structureless primatheca. Chomata absent to very faint. Aperture terminal, basal, simple.

Class **Miliolata** Saidova, 1981
Order **Cornuspirida** Vdovenko et al., 1993
Superfamily Cornuspiroidea Mikhalevich, 1988
Family Hemigordiidae Reitlinger in Vdovenko et al., 1993
Genus *Rectogordius* Alipour & Vachard in Alipour et al., 2013

Type species. *Rectogordius iranicus* Alipour & Vachard in Alipour et al., 2013.

Occurrence. Upper Asselian-Artinskian; Iran (Alipour et al. 2013; this study); Donets Basin; Arctic Canada (Pinard & Mamet 1998); Afghanistan (Filimonova 2010); Carnic Alps (Vachard & Krainer 2001b; Forke et al. 1998); i.e., a genus possibly restricted to the northern Paleotethys margin, northern Cimmerian margin, shelf of Uralian Ocean as far as the northernmost part of North America.

Rectogordius iranicus gadukensis
Yarahmadzahi & Vachard n. subsp.

Pl. 2, figs 37-47

?1998 *Neohemigordius*? sp. - Forke et al., pl. 4, figs. 12.

v?2001b "*Arenovidalina*" sp. 1 - Vachard & Krainer, pl. 5, fig. 1.

Etymology: Geographic name, after Gaduk area (North Iran).

Holotype: Pl. 2, fig. 38; sample DH 13; Azad Islamic University Zahedan Branch.

Paratypes: Pl. 2, figs 36-37, 39-46, Collection (ESRC 1/1395).

Type locality: Gaduk area, east of Firuzkuh city in the central Alborz, North Iran.

Type level: Dorud Group; Emarat Formation, lower Cisuralian, lower Sakmarian.

Material: 7 axial, 4 subaxial sections and several dozens of oblique sections, Collection (ESRC 1/1395).

Diagnosis: A subspecies of *Rectogordius iranicus* characterized by an inflated, subrhombic profile.

Description. Test small, inflated lenticular with biconvex flanks and rounded periphery. Proloculus spherical, followed by a second tubular chamber, almost planispirally coiled, with four to seven involute whorls. Axis of coiling straight to slightly sigmoidal (as in the holotype, for example). The lumen of the tubular chamber is at a concavus stage [according to the archaediscid nomenclature of Pirlet & Conil (1974) and Vachard (1988), adapted to the hemigordiids by Alipour et al. 2013]. The increase in height and width of the tubular chamber is slow and regular, giving the characteristic profile in axial section. The wall is plurilamellar with successive lamellae laterally in contact and forming a thickened umbilical region and strongly biconvex tests, whereas the last whorl is covered by a unique lamella and appears relatively evolute (as in the holotype). This wall is porcelaneous, occasionally well preserved with the amber color characteristic of the first step of diagenesis of the extant representatives of the class Miliolata; then entirely black after intermediate diagenetic alteration. No microsparitized or silicified walls, corresponding to the late diagenetic stages of the Miliolata have been observed in our material. Aperture terminal, simple.

Dimensions. Diameter (D) = 125-250 µm (holotype = 245 µm); width (w) = 52-145 µm (holotype = 145 µm); w/D = 0.40-0.60 (holotype = 0.59); proloculus diameter = 17-45 µm (holotype = 20 µm); number of volutions: 4-7 (holotype: 7);

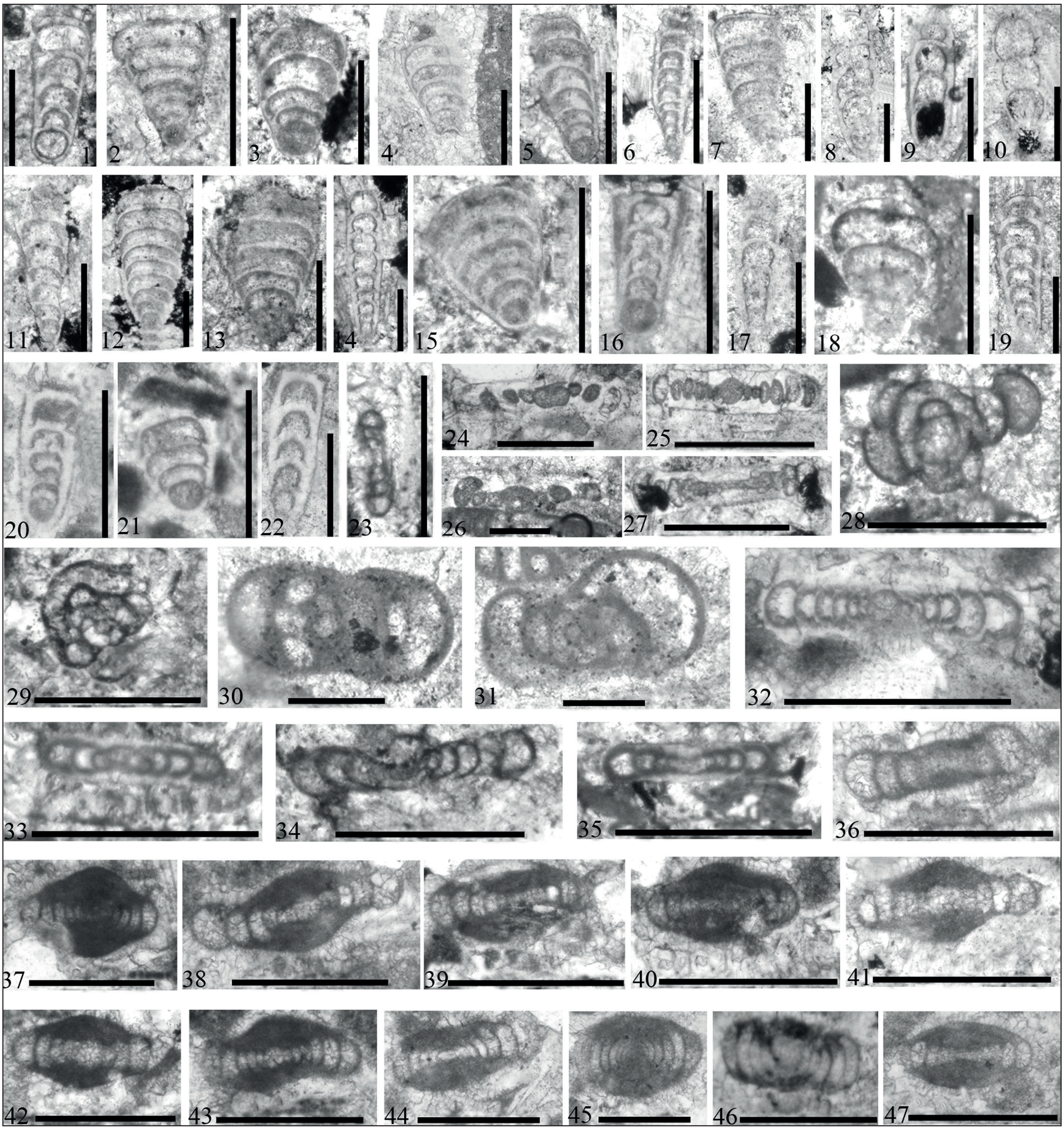

PLATE 2

Smaller foraminifers from the Gaduk section, central Alborz. The ordinary scale bar is 0.2 mm and the double scale bar is 0.5 mm.

Figs 1, 16, 20 - *Nodosinelloides* cf. *netschajewi* (Cherdyntsev, 1914) sensu Groves & Wahlman 1997, samples DH 8, 11, 13. Figs 2, 4?, 7, 8?, 9?, 10?, 11, 13 - *Geinitzina* ex gr. *uralica* Suleimanov, 1949; samples DH 6, 8, 9, 10, 11. Fig. 3 - *Geinitzina*? *indepressa* (Cherdyntsev, 1914), samples DH 10. Figs 5?, 15 - *Geinitzina*? sp. 2, samples DH 10, 11. Figs 6, 17, 22 - *Nodosinelloides bella* (Lipina, 1949); samples DH 11, 12, 13. Fig. 12 - *Geinitzina postcarbonica* Spandel, 1901; sample DH 10. Figs 14, 19? - *Nodosinelloides* cf. *longissima* (Suleimanov, 1949), samples DH 6, 11. Figs 18, 21 - *Geinitzina primitiva* Potievskaya, 1962; sample 1. Fig. 23 - *Asselodiscus* cf. *primitivus* Mamet & Pinard, 1992; sample DH 7. Figs 24, 26 - *Calcitornella heathi* Cushman & Waters, 1928; sample 6,8. Fig. 25 - *Hemigordius* ex gr. *schlumbergeri* (Howchin, 1895); sample DH 10. Fig. 27 - *Cornuspira*? sp.; sample DH 9. Fig. 28 - *Pseudoagathammina*? sp.; sample DH 12. Fig. 29 - *Hemigordiellina* sp.; sample DH 12. Figs 30-31 - *Endothyra* cf. *bamberi* Pinard & Mamet, 1998; samples DH 12, 13. Fig. 32 - *Pseudovidalina* (concavus stage) *modificata* (Potievskaya, 1962); sample DH 13. Figs 33-35 - *Pseudovidalina* cf. *pararecta* Pinard & Mamet, 1998, sample DH 12. Fig. 36 - *Hemigordius*? sp., sample DH 12. Figs 37-47 - *Rectogordius iranicus gadukensis* Yarahmadzahi & Vachard n. subsp., samples DH 12, 13. Holotype: fig. 38. Figs 37, 39-47 are paratypes in axial sections showing the variability of the subspecies. Collection (ESRC 1/1395).

height of last whorl (h) = 18-58 µm (holotype = 29 µm); wall thickness (s) = 5-10 µm (rarely 12 µm) (holotype = 8 µm).

Comparison. *Rectogordius iranicus gadukensis* n. subsp. differs from *R. iranicus iranicus* Alipour & Vachard in Alipour et al. 2013 by a more compressed test. The ratio w/D (width to Diameter) is indeed 0.40-0.60 in *R. iranicus gadukensis,* whereas it is 0.19-0.35 in *R. iranicus iranicus,* the diameters of two subspecies being similar (D = 175-300 µm in *R. iranicus iranicus* and D= 125-250 µm in *R. iranicus gadukensis*). The subspecific difference is therefore probably related with the thickness of the wall lamellae in the umbilical regions.

"*Arenovidalina*" sp. 1 sensu Vachard & Krainer 2001b and *Neohemigordius*? sp. sensu Forke et al. 1998, both from the Lower Permian of the Carnic Alps, are perhaps identical to *Rectogordius iranicus gadukensis* n. subsp. but their definitive synonymy needs further studies. It is noteworthy that these two taxa were attributed by Filimonova (2010, p. 776, pl. 4, figs 6-7) to her new species *Neohemigordius carnicus*. This species clearly belongs to *Rectogordius*, but it differs from our new subspecies by a larger size (its diameter is 230-450 µm), a more compressed test (w/D = 0.29-0.37), more whorls (7-9), and a very small proloculus. To be noted that the holotype of this species called *carnicus* comes from northern Afghanistan.

Various species of "*Arenovidalina*" sensu Sosnina in Sosnina & Nikitina (1977) and Sosnina (1978) (i.e., *Arenovidalina crassa, A. orienta, A. ovoidea, A. rotunda, A. umbilicata* and *A. vulgaris*) are larger, with diameter up to 420-650 µm and a small streptospiral juvenarium; more probably, these taxa belong to the lineage of *Multidiscus* Miklukho-Maklay, 1953, as well as "*Hemigordius*" *oliviformis* (Han) sensu Lin et al. (1990, p. 213, pl. 6, figs 6-7) or "*H.*" *paraoliviformis* Lin et al. (1990, p. 213-214, pl. 26, figs 8-9). In contrast, we suggest that: (1) *Multidiscus talimuensis* Han in Zhao et al. 1984 could be transitional between *Rectogordius* and *Multidiscus*; (2) true Early Triassic *Arenovidalina* Ho, 1959 might be ancestors of *Triadodiscus* Piller, 1978; i.e., of the Triassic involutinids.

Occurrence. The new subspecies is known in the lower Sakmarian of the Gaduk section (east of Firuzkuh city, Central Alborz; this study), and probably in the upper Asselian-Sakmarian of the Carnic Alps (Forke et al. 1998; Vachard & Krainer 2001b).

Class **NODOSARIATA** Mikhalevich, 1993
Order **Nodosariida** Calkins, 1926

Remarks. Except for the rare primitive *Tezaquina* ex gr. *clivuli*, in our material the nodosariates are only represented by diversified species of the genera *Nodosinelloides* and *Geinitzina.*

The species of *Nodosinelloides* are successively *N. shikhanica*, *N. talimuensis*, *N. bella*, *N.* cf. *netschajewi* and *N.* aff. *longissima*. The taxon *Nodosinelloides netschajewi* has numerous different interpretations in the literature. Here, we have followed Groves & Wahlman (1997) and Krainer et al. (2009), but other authors like G. Nestell (pers. comm., April 2016) do not agree with this interpretation.

Geinitzina is known to appear in the uppermost Gzhelian and diversify as early as the Asselian (Groves 2000, 2002; Groves & Wahlman 1997; Pinard & Mamet 1998; Groves & Boardman 1999; Krainer et al. 2009; Lucas et al. 2015). At Gaduk, we observed successively *G. primitiva* as early as the uppermost Gzhelian; and then, in the Asselian-lower Sakmarian, *G.* ex gr. *uralica*, *G. postcarbonica*, *G. primitiva* and two atypical taxa *G.*? *indepressa* and *Geinitzina*? sp. 2.

DISCUSSION

In agreement with fusulinid datings in the Alborz (Gaetani et al. 2009; Leven & Gorgij 2011a), the Toyeh, Emarat and Shah Zeid formations of the Dorud Group were considered as latest Gzhelian to early Sakmarian in age in the Gaduk section of the Firuzkuh area (Yarahmadzahi, unpublished data). Comparisons with the foraminiferal studies carried out in other parts of the world (Davydov 1988; Forke et al. 1998; Vachard & Krainer 2001a, b; Krainer et al. 2003; Gaillot & Vachard 2007; Filimonova 2010, 2013; Alipour et al. 2013; Yarahmadzahi & Vachard 2014; Yarahmadzahi et al. 2015) establish that the smaller foraminifers of the Dorud Group in the Central Alborz are very similar in species composition with those of the Carnic Alps, Northern Afghanistan, Northern and Central Pamirs, Central Iran (South Lut Block and Kalmard Block) and Canadian Arctic, with several assemblages of species of the genera *Pseudoacutella*, *Globivalvulina*, *Pseudovidalina*, *Calcitornella*, *Hemigordius*, *Rectogordius*, *Tezaquina*, *Nodosinelloides*, and *Geinitzina* (Figs 2-3).

The genera *Bradyina* and *Bradyinelloides*, which are quite abundant in the Asselian according to Filimonova (2010), were not found in our samples. That is probably because the sediments of Gaduk were deposited either on a relatively deep inner platform for the sediments with fusulinids, or in very shallow environments for the oligotypic deposits with miliolates, for example *Rectogordius*; instead, the environments favorable to the bradyinids require a moderate (and therefore intermediary) paleobathymetry (see e.g., Della Porta et al. 2005; Vachard et al. 2010).

In the Gaduk section, fusulinid assemblages identified by Yarahmadzahi (unpublished data) are dominated by *Triticites* and *Pseudoschwagerina*, that were originally described from the Alborz area (Gaetani et al. 2009), the Anarak region in central Iran (Leven & Gorgij 2006a, b), the Asad-Abad section in Shahreza area (Leven & Gorgij 2011a, b; Yarahmadzahi 2011), the uppermost Gzhelian-lowermost Permian of Darvaz (Davydov in Chuvashov et al. 1986) and the lower part of the Grenzland Formation (Vachard & Krainer 2001b) dated as late Asselian-Sakmarian (Davydov et al. 2013) in the Carnic Alps (Austria-Italy border). The age of this assemblage is usually considered as Asselian. Gaetani et al. (2009) and Alipour et al. (2013) already concluded that the majority of the Emarat Formation is Asselian in age, but it includes a lowermost Gzhelian part and an uppermost Sakmarian part.

CONCLUSIONS

The Dorud Group of the Gaduk section in Central Alborz (Iran) is more than 44 m thick, with thick succession of conglomerates, quartzarenites, calcareous sandstones, oncolitic fusulinid limestones, sandy limestones, sandstones and shales.

A review of the uppermost Gzhelian, Asselian and lower Sakmarian smaller foraminifers of the Emarat Formation of the Gaduk section is presented in this paper.

Three foraminiferal biozones are defined: the *Geinitzina* aff. *primitiva*-*Nodosinelloides sikhanica* Zone is latest Gzhelian in age; the *Geinitzina* spp.-*Nodosinelloides* spp.-*Pseudoacutella partoazari* Zone is Asselian; and the *Rectogordius iranicus gadukensis*-*Endothyra* cf. *bamberi* Zone is early Sakmarian in age.

The new subspecies *Rectogordius iranicus gadukensis* n. subsp. is described.

The genera *Pseudovidalina* and *Grovesella* are discussed, and some elements of emendation are presented.

The studied assemblages are correlatable with those from the Carnic Alps (Austria-Italy), East European Platform of Russia, the Urals (Russia), Darvas (Uzbekistan), the northern and central Pamirs (Tajikistan), Central Iran, northern Afghanistan and other classical regions of the Tethyan realm.

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