

A peculiar fusuline assemblage from the Tanes locality, Campo de Caso section (Pennsylvanian, upper Moscovian; Cantabrian Zone, Spain)

Elisa VILLA^{1}, Katsumi UENO², Oscar MERINO-TOMÉ¹ & Jaime MARTÍN-LLANEZA¹*

¹ Departamento de Geología, Universidad de Oviedo, c/ Jesús Arias de Velasco, s/n, 33005 Oviedo, Spain; evilla@uniovi.es, omerino@geol.uniovi.es, jmartin@geol.uniovi.es

² Department of Earth System Science, Fukuoka University, Fukuoka 814-0180, Japan; katsumi@fukuoka-u.ac.jp

*Corresponding author

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ABSTRACT

The Campo de Caso section (eastern part of the Cantabrian Zone, NW Spain) exposes a middle to upper Moscovian (Middle Pennsylvanian) succession, up to 3500-m thick, consisting of marine shelfal and deltaic siliciclastic and shale deposits with numerous intercalated fossiliferous limestones. A limestone outcropping in the upper part of this section, close to the village of Tanes, has yielded a fusuline assemblage composed of species of the genera *Eostaffella*, *Pseudonovella*, *Ozawainella*, *Pseudostaffella*, *Neostaffella*, *Schubertella*, *Fusiella*, *Taitzeoella*, *Fusulinella*, *Beedeina* and *Putrella*. The specific composition of these genera, considered as a whole, indicates an early to mid-Myachkovian age; however, some of the taxa exhibit rare aspects, among which are the occurrence of pseudostaffellids having a “primitive” appearance recalling that of the Bashkirian *Pseudostaffella*, and a *Putrella* species exhibiting a wall that, at first glance, resembles the schwagerinid wall. Data gathered during this study question the validity of the genus *Quasistaffella* Solovieva 1986 and point to consider it as a junior synonym of *Pseudostaffella* Thompson 1942.

Keywords: Fusulines, Cantabrian Zone, upper Moscovian, Pennsylvanian.

RESUMEN

En la sección de Campo de Caso (parte oriental de la Zona Cantábrica, NW de España) aflora una sucesión del Moscoviense superior (Pensilvánico) de hasta 3500 m de espesor, formada por depósitos de plataforma marina y depósitos deltaicos con numerosas intercalaciones de calizas. En un afloramiento de la parte alta de esta sucesión, cercano a la localidad de Tanes, se han recogido fusulinas pertenecientes a los géneros *Eostaffella*, *Pseudonovella*, *Ozawainella*, *Pseudostaffella*, *Neostaffella*, *Schubertella*, *Fusiella*, *Taitzeoella*, *Fusulinella*, *Beedeina* y *Putrella*. En conjunto, las especies identificadas señalan que estas capas pertenecen al Myachkoviense inferior o medio. Sin embargo, parte de los taxones presentan algunos rasgos que podrían parecer discrepantes, como ocurre con numerosos especímenes de *Pseudostaffella* con un aspecto “primitivo” que los asemeja a las formas del Bashkiriense, y con una especie de *Putrella* cuya pared recuerda la de los schwagerínidos. Los datos recogidos ponen en cuestión la validez del género *Quasistaffella* Solovieva, 1986 y lo señalan como un probable sinónimo de *Pseudostaffella* Thompson, 1942.

Palabras clave: Fusulinas, Zona Cantábrica, Moscoviense superior, Pensilvánico.

1. INTRODUCTION

The Cantabrian Zone, part of the Variscan Orogen in the NW Iberian Peninsula (Lotze, 1945), exposes the thickest and most extensive Carboniferous deposits, mainly of marine and paralic nature, in Western Europe (Fig. 1 a-b). These deposits, ranging from the base of the Mississippian to the upper part of the Pennsylvanian (Gzhelian), were accumulated in a highly subsiding marine foreland basin (Julivert, 1978; Marcos & Pulgar, 1982; Águeda *et al.*, 1991; Bahamonde *et al.*, 2015; Merino-Tomé *et al.*, 2019) developed during the assemblage of the Pangea supercontinent (Fig. 1a). From a biostratigraphic point of view, the Pennsylvanian successions of this Zone are of great interest since they consist of fossiliferous marine and terrestrial strata that provide clues for comparing and correlating the Western and Eastern Europe stratigraphic scales (van Ginkel 1965; Wagner & Higgins, 1979; Wagner & Winkler Prins, 1994; Wagner & Álvarez-Vázquez, 2010; Villa & Merino-Tomé, 2016, among many other publications). Moreover, their interest for global correlation has increased since the study of a series of ash-fall layers (Merino-Tomé *et al.* 2017) that yielded radiometric data that have permitted comparison with the absolute ages of the Carboniferous Time Scale (Davydov *et al.*, 2012; Schmitz & Davydov, 2012; Ogg *et al.*, 2016). Within the marine deposits, most attention has been focused on fusuline foraminifera, as these are the most commonly used fossils in the shallow water carbonates of the Urals and the Moscow Basin, the areas where the chronostratigraphic units subdividing the marine Pennsylvanian of Eastern Europe have been defined (Nikitin, 1890; Ivanov, 1926; Dan'shin, 1947; Teodorovich, 1949).

The present paper is devoted to the study of the fusulines collected from a single limestone bed outcropping near the village of Tanes (Fig. 1c), a locality situated in the western part of the Ponga Nappe, which is, in turn, part of the major Bodón-Ponga structural unit (Alonso *et al.*, 2009). The Tanes strata belong to the upper part of the Fito Formation (Figs. 1c and 2), a thick upper Moscovian lithostratigraphic unit consisting of alternating carbonate and terrigenous strata that represents the top of the Carboniferous succession in this area.

2. THE PENNSYLVANIAN SUCCESSION OF THE CAMPO DE CASO SECTION

The stratigraphy of the Carboniferous successions of the Ponga Nappe area was described by Sjerp (1967), van Ginkel (1965), Bahamonde & Colmenero (1993), and is synthetised in Bahamonde *et al.* (2015, 2017). In the Campo de Caso thrust unit, three lithostratigraphic

units are recognized in the ca. 3500 m-thick succession of Moscovian age that overlie the mostly Bashkirian Ricacabiello Formation (Sjerp, 1967) (Figs. 1c and 2):

a) The Beleño Formation (van Ginkel, 1965), a nearly 900 m thick terrigenous unit, is composed of sandstone strata near the base and poorly-bedded shales and siltstones in the upper part. The basal sandstone strata have been interpreted as basin floor turbidite lobes, and the upper strata have been interpreted to represent a thick prograding prodeltaic wedge overlain by distal shelf siliciclastics and minor deltaic deposits (Bahamonde & Colmenero, 1993).

b) The Escalada Formation (van Ginkel, 1965), a thick limestone unit of late Kashirian to Podolskian age, ca-340 m thick, which was built on the previous deltaic and shelfal deposits of the Beleño Formation (Bahamonde *et al.*, 2015, 2017).

c) The Fito Formation (van Ginkel, 1965), a paralic succession, more than 2200 m thick, consisting of terrigenous marine deposits (shales, siltstones, and sandstones containing some coal seams) with limestone intercalations. This last formation represents the proximal equivalent of a late Podolskian to Myachkovian carbonate platform developed in more distal sectors of the basin (Escalada II platform of Bahamonde *et al.*, 2015, 2017).

An essentially complete succession of the Escalada and Fito formations can be seen in the Campo de Caso section, which outcrops along the AS-117 road between the villages of Tanes and Campo de Caso (Fig. 1c). This succession was first studied by Martín-Llaneza (1979) and some of his results were later published in Vera de la Puente *et al.* (1984). The stratigraphy and biostratigraphy of the Escalada and Fito formations along this section were also investigated by Leyva *et al.* (1983, 1985), who made a comprehensive collection of fossils, including 66 fusuline samples, as well as abundant conodont, brachiopod and megafloora materials. This sampling allowed them to provide a general description of the Kashirian, Podolskian and Myachkovian fusuline assemblages, and on the basis of these data, to establish the position of the Kashirian/Podolskian and Podolskian/Myachkovian boundaries in this section. Further research of the same section by Bahamonde *et al.* (2015, 2017), focused mainly on the stratigraphy and sedimentology of the Escalada and Fito (lower part) formations, provided a remarkable new intrabasinal correlation of the middle/upper Moscovian successions of the Ponga Nappe area.

3. FUSULINES FROM THE LOCALITY OF TANES AND DISCUSSION OF AGE

As mentioned above, the present paper analyzes a fusuline assemblage yielded by a single limestone bed (sample CTA-24; Fig. 2) from the upper part of the Fito Formation. Within

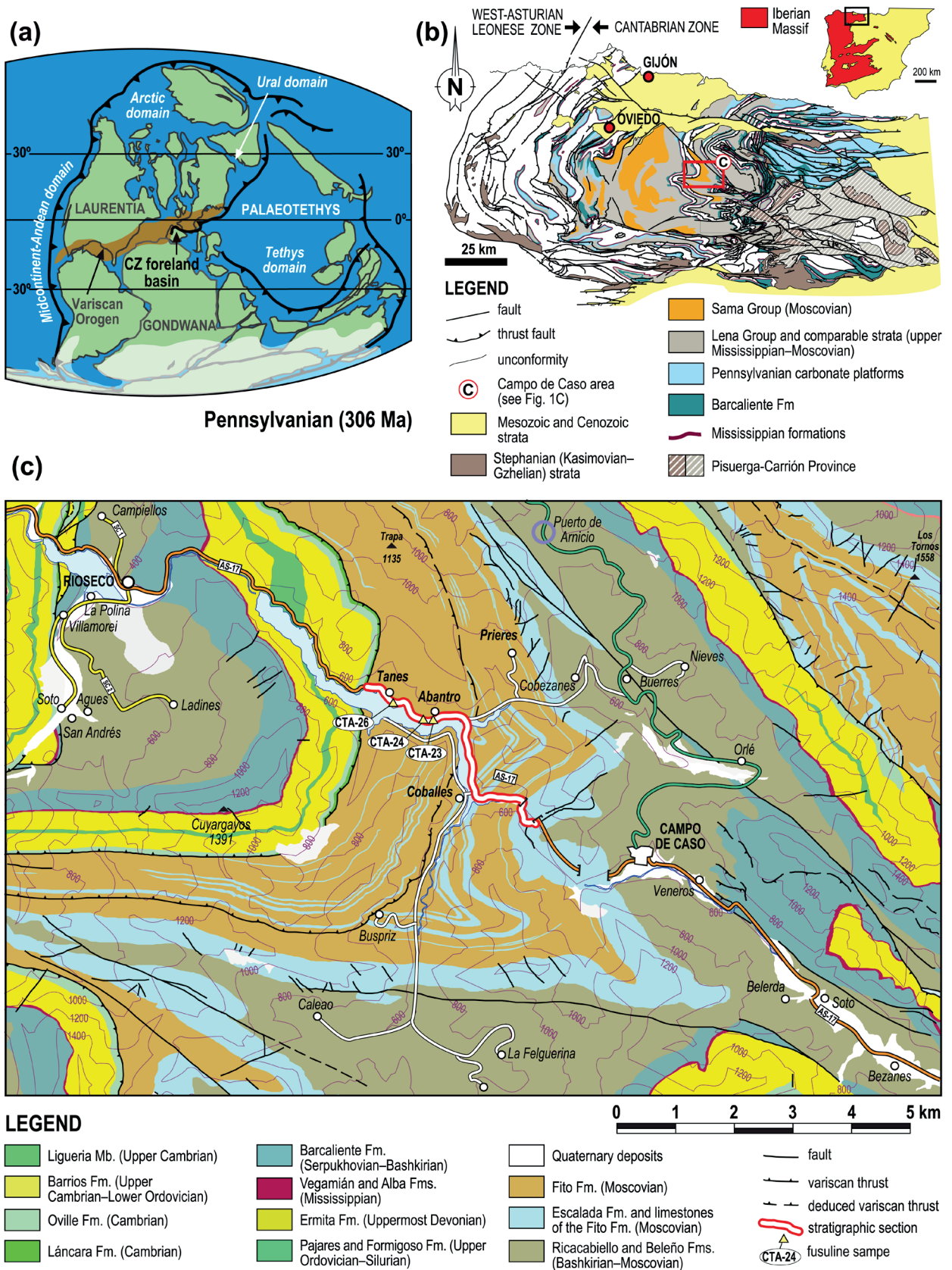


Figure 1. a) Paleogeography of Pangea during Pennsylvanian time with the location of the Variscan orogen and the foreland basin of the CZ (Scotese, 2001, modified; Golonka, 2002). Paleobiogeographic domains after Lin *et al.* (1991). b) Schematic geological map of the CZ showing the location of the studied section (modified from Villa *et al.*, 2018). c) Synthetic geological map of the Campo de Caso/Tanes area showing the location of the stratigraphic sections and samples referred to in the text (modified from Merino-Tomé *et al.*, 2011).

this assemblage, the following fusuline species have been identified:

- Eostaffella (Pseudoacutella) sp. A*
Eostaffella (Pseudoacutella) sp. B
Eostaffella (Pseudoacutella) sp. C
Eostaffella (Pseudoacutella) grozdilovae Maslo & Vachard, 1997
Pseudonovella cf. P. irregularis Kireeva, 1949
Ozawainella cf. O. magna Sheng, 1958
Ozawainella sp. A
Ozawainella aff. O. aurora Grozdilova & Lebedeva, 1954
Ozawainella aff. O. turgida Sheng, 1958
Pseudostaffella aff. P. varsanofievae Rauzer-Chernousova, 1951, in Rauzer-Chernousova *et al.*, 1951
Pseudostaffella sp. A
Neostaffella cf. N. rostovzevi Rauzer-Chernousova, in Rauzer-Chernousova *et al.*, 1951
Schubertella ex gr. S. obscura Lee & Chen, in Lee *et al.*, 1930
Fusiella cf. F. pulchella Safonova, in Rauzer-Chernousova *et al.*, 1951
Taitzhoella cf. T. pseudolibrovitchi (Safonova, in Rauzer-Chernousova *et al.*, 1951)
Fusulinella aff. F. bockiformis Bogush, 1963
Beedeina cf. B. samarica (Rauzer-Chernousova & Belyaev, in Rauzer-Chernousova *et al.*, 1940)
Putrella sp. A

These species allowed us to estimate an upper Moscovian position (probably lower Myachkovian) for the CTA-24 sample (Fig. 2). Although most of the species described elsewhere that resemble these Cantabrian forms range through the Podolskian and Myachkovian, we exclude the former and assign this bed to the Myachkovian. This conclusion is mainly based on some features of *Beedeina cf. B. samarica* and *Fusulinella aff. F. bockiformis*. Regarding *Beedeina cf. B. samarica*, the age estimation is supported by the existence of some larger and more inflated specimens that deviate from the average and exhibit a L/D shorter than in *B. samarica* types. We think that they could be representatives of an advanced stage within the species and, in this sense, it is significant that they are reminiscent of the type specimens of *B. paradistenta*, which is a species that is common in the Myachkovian (Rauzer-Chernousova *et al.*, 1951). With respect to *Fusulinella aff. F. bockiformis*, it is probably a new species that, along with thick supplementary deposits, are common in the *Fusulinella bocki* species group, showing a very rapid spiral growth. This feature

is typical of several Myachkovian *Fusulinella*, such as *F. alvaradoi*, *F. altispiralis*, *F. curtissima* or (Bogush, 1963; van Ginkel, 1965; among others). In addition to these observations on *Beedeina* and *Fusulinella*, it is relevant to highlight the presence in *Putrella sp. A* of a wall pierced by very distinct, thick pores, that is thicker than in the rest of *Putrella* species so far known; this feature, coupled with the large test size of this species, points to a highly evolved evolutionary stage, previously unknown within the Podolskian forms of this genus.

The CTA-24 sample also yielded a *Taitzhoella* species very similar to *Taitzhoella pseudolibrovitchi*, species originally described by Safonova (in Rauzer-Chernousova *et al.*, 1951) from the Kashirian and Podolskian strata of the Russian Platform. The possible joint occurrence of *Taitzhoella pseudolibrovitchi* with Myachkovian species suggests that this bed is not younger than early Myachkovian.

At first glance, the occurrence in this sample of *Pseudostaffella sp. A*, a species reminiscent of Bashkirian forms, could seem surprising. However, as will be discussed later, primitive-looking pseudostaffellids may appear rarely throughout the Moscovian, even in the lowermost Kasimovian.

Finally, the Myachkovian age is confirmed by fusulines yielded by other closely situated samples of the Campo de Caso section (this study). In this respect, the most relevant data were provided by samples CTA-23 (containing *Taitzhoella librovitchi*), and CTA-26 (*Neostaffella ex gr. N. sphaeroidea*) (Fig. 2). These two forms have been reported from the Podolskian and Myachkovian, but they are usually more characteristic of the latter (e.g. Rauzer-Chernousova *et al.*, 1951).

The Podolskian/Myachkovian transition in this section has been estimated to lie at around CF-11 (Fig. 2), a sample collected by Bahamonde *et al.* (2015) that yielded *Fusiella praelancetiformis* and *Fusiella typica extensa*, which clearly point to a Myachkovian age. Abundant fusuline materials were identified by Bahamonde *et al.* (2015) and used to date and correlate the sections studied. However, descriptions and illustrations of these microfaunas have not been published. CF-11 lies only slightly lower than bed C-40 (Fig. 2), collected by Leyva *et al.* (1985) in the same section and from which these authors recovered an unequivocal Myachkovian assemblage.

Although the peculiarities exhibited by the CTA-24 fusuline assemblage preclude a detailed species-by-species comparison with other coeval localities of the Cantabrian Zone, the inferred age of the bed strongly suggests an approximate correlation of this part of the Fito Formation with: a) the Entrerregueras stratal package in the upper part of the well-known classic Central Asturian Coalfield succession (Villa *et al.*, 2018); b) an indeterminate level within the middle or upper part of the Fito Formation of the Ponga Nappe (Espinaledo thrust-unit of Bahamonde

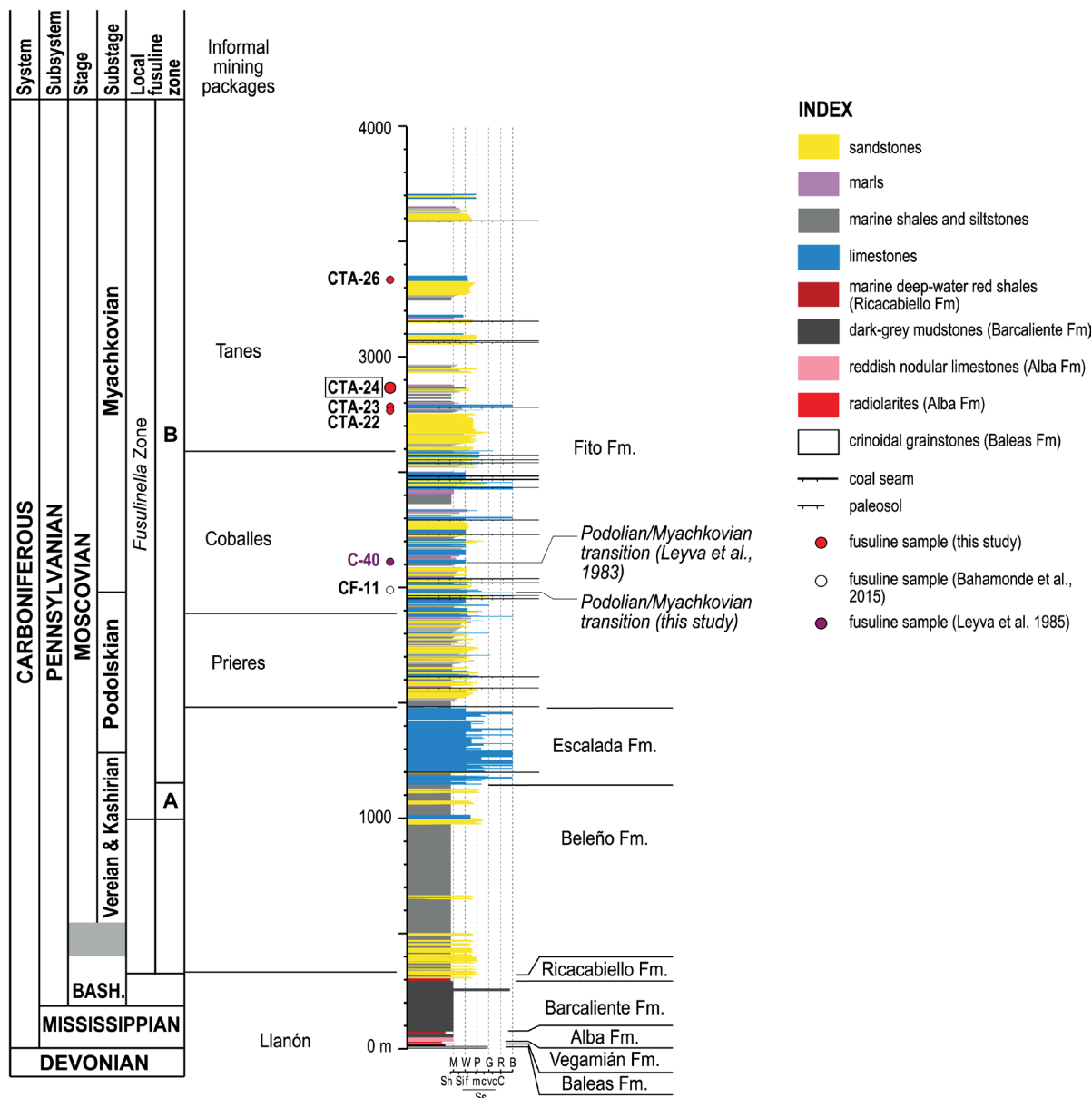


Figure 2. Stratigraphic log of the Campo de Caso-Tanes section after data from Martín-Llaneza (1979), Leyva *et al.* (1983, 1985), Bahamonde *et al.* (2015, 2017) and new data gathered in this research.

et al., 2015); and c) the Myachkovian part of the Picos de Europa Formation studied by Villa & van Ginkel (2000) in the Picos de Europa area.

4. SYSTEMATIC PALAEOONTOLOGY

Descriptions of taxa provide measurements of the following parameters: L, length of the outer shell; D, diameter of the outer shell; L/D, length/diameter ratio; n, number of volutions; D_{IV} , diameter of the fourth whorl; d, diameter of the proloculus; wth_{pen} and wth_{ult} , wall thickness referred to the penultimate and ultimate volutions, respectively. All

measurements are given in mm, except for the diameter of the proloculus and wall thickness, which are in microns.

Family **Ozawainellidae** Thompson & Foster, 1937

Genus *Eostaffella* Rauzer-Chernousova, 1948

Type-species *Staffella (Eostaffella) parastruvei* Rauzer-Chernousova, 1948

Subgenus *Pseudoacutella* Vachard, Krainer & Lucas, 2013

Note on *Eostaffella (Pseudoacutella)*. Forms having a mostly evolute shell and an acute median region in the

last volution are here assigned to *Eostaffella* Rauzer-Chernousova, 1948, subgenus *Pseudoacutella* Vachard, Krainer & Lucas, 2013 (*Pseudoacutella* replaced *Acutella* Orlova, 1996, a junior homonym of a brachiopod genus). According to van Ginkel (2010), the subgenus introduced by Orlova should be included in *Paramillerella* Thompson, 1951, rather than in *Eostaffella*. The basis for his assertion was that *Paramillerella*, a genus restricted to the Pennsylvanian, has better developed secondary deposits, forming true chomata in advanced species, and a more stable axis of coiling than *Eostaffella* (Mississippian-Pennsylvanian). As these characteristics are somewhat variable among the individuals described below, we adopt a conservative stance and tentatively assign them to *Eostaffella*, the genus to which most of the species resembling our material were originally assigned.

Eostaffella (*Pseudoacutella*) sp. A
(Fig. 4a)

Measurements. L = 0.20 mm; D = 0.50 mm; L/D = 0.40; n = 3.5; d = 50 μm ; wth_{ult} = 20 μm .

Remarks. Specimen showing a large size for the genus, asymmetric shape, somewhat variable position of the axis of coiling, acute last volution and undifferentiated wall. Secondary deposits appear as pseudo-chomata or as thickenings extending to the umbilical regions. Its size, shape of whorls, somewhat variable position of the axis of coiling, and slightly protruding umbilical regions, are reminiscent of *Eostaffella parastruvei miranda* described by Kireeva (1949) from the C₂¹(F) Suite (Limestone F) of the Donets Basin (a stratigraphic level much older than the one studied here).

Eostaffella (*Pseudoacutella*) sp. B
(Fig. 3b)

Measurements. L = 0.19 mm; D = 0.55 mm; L/D = 0.35; n = 4; d = 45 μm ; wth_{ult} = 10 μm .

Remarks. This single specimen also exhibits a rather large size, somewhat asymmetric shape, acute last two volutions, and stretched keel in the last volution, sharing all these features with the above described sp. A. Therefore, it would be conceivable that both belonged to the same species, but, as its wall is thinner and the secondary deposits are weaker (appearing either in the form of pseudo-chomata or as weak thickenings extending to the umbilical regions), we tentatively consider it a separate taxon. The acute volutions and the presence of a stretched keel point to a possible affinity with *Ozawainella* species, but its size, very small for *Ozawainella*, irregular shape, and absence of typical chomata indicate a closer relationship

with *Eostaffella*. Among the eostaffellid species showing a remarkable diameter elongation, stretched last volution and incipient keel, it somewhat recalls *Eostaffella rjasanensis* Rauzer-Chernousova, in Rauzer-Chernousova *et al.*, 1951, and, to lesser degree, *Millerella japonica* Kanmera, 1952. However, this specimen differs clearly from both in exhibiting a fully involute coiling, and, in the case of the *M. japonica*, also in having a more acute periphery and a much smaller size.

Eostaffella (*Pseudoacutella*) sp. C
(Figs. 3c-3d)

Measurements. L = 0.10-0.11 mm; D = 0.30-0.33 mm; L/D = 0.30-0.33 mm; n = 3.5-4.5; d = 5-10 μm ; wth_{ult} = 5-8 μm .

Remarks. These two specimens share several features (slight shifts of the axis of coiling in each volution, acute and stretched last two volutions, presence of a keel in the last one, secondary deposits developed as thickenings of the wall, absence of a clearly marked tunnel) with *E. (Pseudoacutella)* sp. B described above but differ in having a smaller size and an irregular spirotheca (crushed or natural?).

Eostaffella (*Pseudoacutella*) *grozdilovae* Maslo & Vachard, 1997
(Figs. 4e-4o)

Measurements. L = 0.08mm-0.27 mm; D = 0.18-0.54 mm; L/D = 0.26-0.50; n = 2.5-3.5; d = 30-50 μm ; wth_{ult} = 10-15 μm .

Remarks. As their most remarkable features, these *Pseudoacutella* specimens exhibit an involute coiling (except for a few specimens, as Fig. 4h, that show whorls that are barely in contact in the umbilical region), an acute median region of the last volution, large proloculus, poorly-differentiated wall (sometimes, a discontinuous tectum may be observed in places), and irregular supplementary deposits in the form of chomata, pseudo-chomata, or mere thickenings of the wall that do not form a tunnel. The polar ends vary from umbilicated (Fig. 4h) to convex (Fig. 4i). Differences in shape and supplementary deposits make one wonder if several species are represented in this collection. However, although this possibility cannot be completely ruled out, we consider the differences are more likely to be due to intraspecific variability. The specimens can be compared to forms included by Rauzer-Chernousova *et al.* (1951), in their composite species group *Eostaffella acuta* and *Eostaffella mutabilis*, especially *Eostaffella grozdilovae* Maslo & Vachard 1997 (= *E. acuta* Grozdilova & Lebedeva 1950, pre-occupied name). Other similar

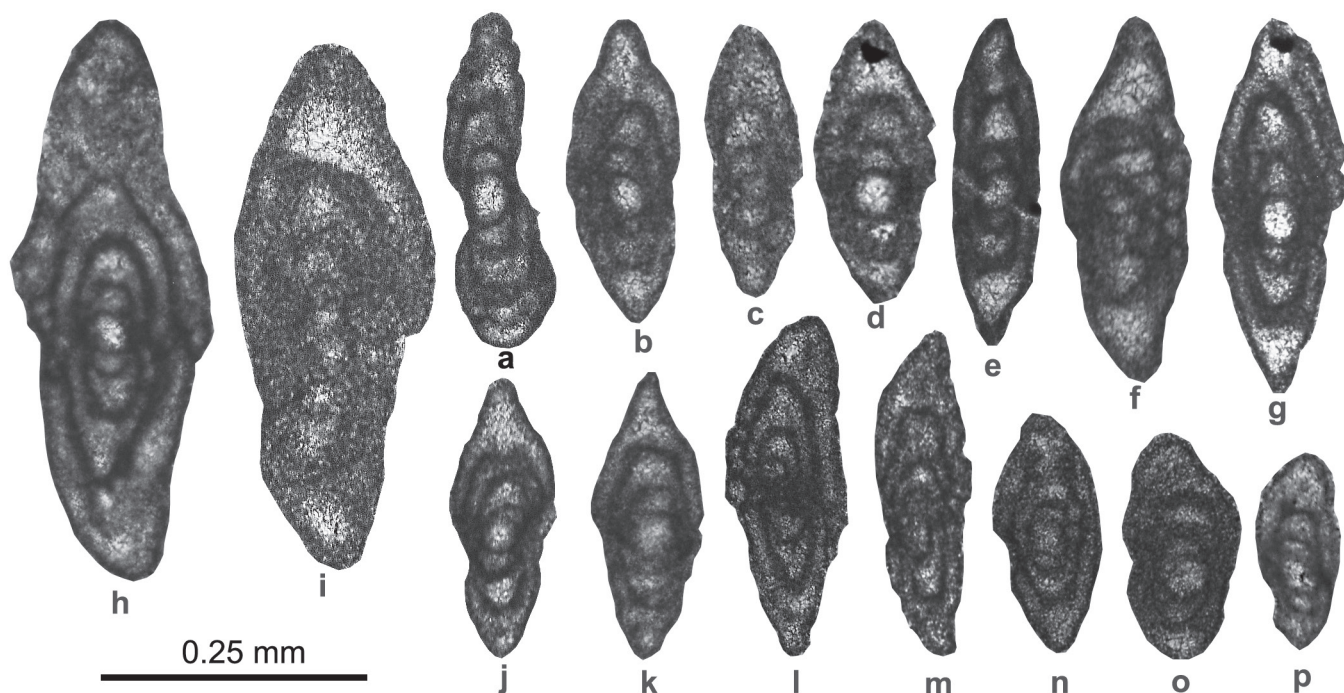


Figure 3. **a)** *Eostaffella (Pseudoacutella)* sp. A, CT24/114. **b)** *Eostaffella (Pseudoacutella)* sp. B, CT24/88d. **c-d)** *Eostaffella (Pseudoacutella)* sp. C. **(c)** CT24/98b; **(d)** CT24/35b. **e-o)** *Eostaffella (Pseudoacutella) grozdilovae* Maslo & Vachard, 1997. **(e)** CT24/11a; **(f)** CT24/67b; **(g)** CT24/48d; **(h)** CT24/20d; **(i)** CT24/32c; **(j)** CT24/31b; **(k)** CT24/35c; **(l)** CT24/60d; **(m)** CT24/113d; **(n)** CT24/88a; **(o)** CT24/125e. **p)** *Pseudonovella* cf. *P. irregularis* (Kireeva 1949), CT24/26d.

forms are *Eostaffella mutabilis* Rauzer-Chernousova in Rauzer-Chenousova *et al.*, 1951, *Eostaffella postera* Kireeva, 1949 (originally described as *E. mutabilis postera*), and *Eostaffella korobchevi* Rauzer-Chernousova in Rauzer-Chenousova *et al.*, 1951. It should be noted that most of these species have been reported from the upper Moscovian.

Genus *Pseudonovella* Kireeva, 1949

Type species *Pseudonovella irregularis* Kireeva, 1949

Pseudonovella cf. *P. irregularis* Kireeva, 1949
(Fig. 3p)

Measurements. L = 0.10 mm; D = 0.31 mm; L/D = 0.32; n = 3; d = 50 μ m; wth_{ult} = 10 μ m.

Remarks. Test asymmetric, showing evolute coiling in the last one and a half volutions, the last whorl growing abruptly in the median region. Supplementary deposits appear as wall thickenings in the inner volutions and as pseudo-chomata in the penultimate volution, where a tunnel is formed. The proloculus is remarkably large for the size of the shell. All these characteristics are similar to those of *Pseudonovella irregularis*, described by Kireeva (1949) from the Moscovian (C₂⁵-C₂⁶) of the Donets Basin.

Genus *Ozawainella* Thompson, 1935

Type species *Fusulinella angulata* Colani, 1924

Ozawainella cf. *O. magna* Sheng, 1958
(Figs. 4a-4d)

Measurements. L = 0.41-0.47 mm; D = 1.29-1.39 mm; L/D = 0.32-0.34; n = 4.5-6; d = 35-50 μ m; D_{IV} = 0.70-1.02; wth_{ult} = 10-18 μ m.

Remarks. Test showing a carinate median region, shallow umbilical depressions and high chomata extending to the poles, except in the penultimate volution, in which they are lower, although increasing abruptly in height on the tunnel side. This species recalls forms usually included in the *O. mosquensis* species group, such as *O. magna* Sheng, 1958, *O. mosquensis* Rauzer-Chernousova in Rauzer-Chenousova *et al.*, 1951, *O. vozghalica* Safonova in Rauzer-Chernousova *et al.*, 1951, and *O. recta* Pogrebnjak, 1975, among others. *O. mosquensis*, and *O. vozghalica*, species widely distributed in the upper Moscovian strata of the Eurasian Carboniferous basins, differ in having lesser lateral compression and smaller size of the test, whereas *O. recta*, collected from the C₂⁷ (M) Suite (Limestone M) of the Donets Basin, has shorter length and smaller L/D ratio, and, according to the single specimen illustrated by

Pogrebyak, flattened umbilici. Our specimens seem to be closest to *O. magna*, described from the Moscovian of the lowermost Penchi series of China, in having shallow umbilici, and similar lateral compression, test size and number of whorls.

Ozawainella sp. A
(Figs. 4e-4g, 4n-4o)

Measurements. L = 0.40-0.56 mm; D = 0.88-1.30 mm; L/D = 0.34-0.48; n = 4.5-6.5; d = 30-50 μ m; D_{IV} = 0.40-0.61; wth_{ult} = 12-18 μ m.

Remarks. Test moderate to large in size, exhibiting a somewhat irregular shape that tends to give a subrhomboidal profile in section. Umbilical depressions absent. Lateral

sides irregular, somewhat undulating. Chomata ribbon-like, typical for the genus. The species somewhat resembles *Ozawainella kumpani* as well as some specimens of *Ozawainella mosquensis* (the less umbilicated ones), both species described by Rauzer Chernousova in Rauzer Chernousova *et al.* (1951). However, *Ozawainella* sp. 1 from the Tanes section clearly differs from them in its more irregular shape, and possibly a more stretched keel. The specimen illustrated in Fig. 4g is tentatively included in *Ozawainella* sp. A; it could have undergone shell compression, which hampers comparison with the rest of the specimens.

Ozawainella aff. *O. aurora* Grozdilova & Lebedeva, 1954
(Figs. 4h-4l)

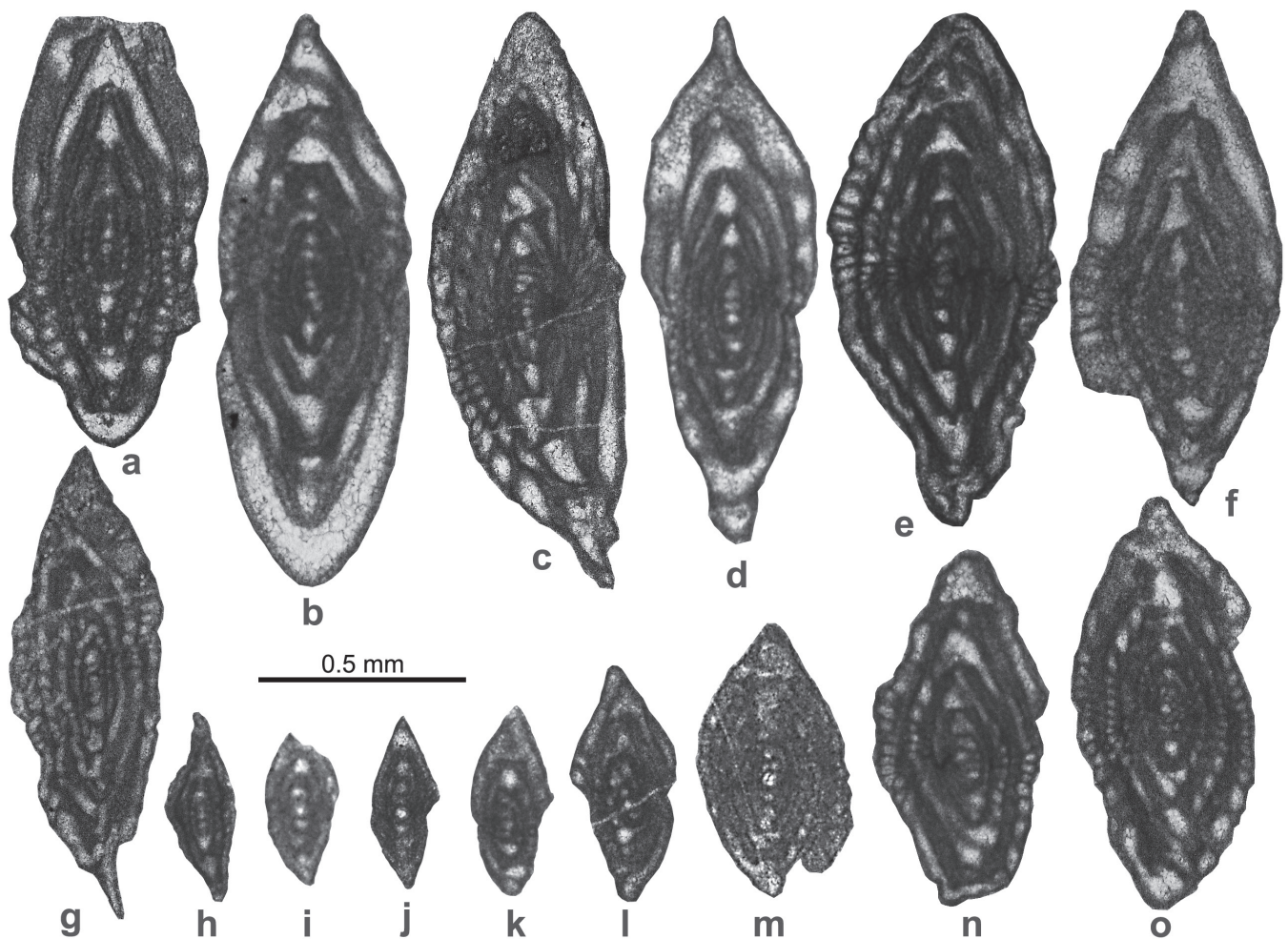


Figure 4. a-d) *Ozawainella* cf. *O. magna* Sheng, 1958. (a) CT24/15b; (b) CT24/51; (c) CT24/107d; (d) CT24/109b. e-g, n-o) *Ozawainella* sp. A. (e) CT24/71a, (f) CT24/34a; (g) CT24/93h; (n) CT24/48c; (o) CT24/75. h-l) *Ozawainella* aff. *O. aurora* Grozdilova & Lebedeva, 1954. (h) CT24/33a; (i) CT24/34b; (j) CT24/12a; (k) CT24/27a; (l) CT24/26c. m) *Ozawainella* aff. *O. turgida* Sheng, 1958, CT24/12b.

Measurements. L = 0.15-0.27 mm; D = 0.41-0.58 mm; L/D = 0.31-0.46; n = 3-4; d = 30-50 μm ; wth_{ult} = 10-15 μm .

Remarks. Characteristics of this species correspond closely to *Ozawainella aurora* described by Grozdilova & Lebedeva (1954) from the lower Bashkirian of the Kolvo-Visher region. The reason we do not fully identify our species with *O. aurora* is the much younger stratigraphic position of the Tanes specimens (upper Moscovian).

Ozawainella aff. *O. turgida* Sheng, 1958
(Fig. 4m)

Measurements. L = 0.45 mm; D = 0.68 mm; L/D = 0.66; n = 4.75; d = 40 μm ; wth_{ult} = 12 μm .

Remarks. This single specimen resembles *O. turgida* Sheng, originally described from the upper Moscovian strata of the Taitzeho valley (Lianoning, China), in its small size and prominent umbilical regions, as well as in the type of chomata and number of whorls. Our form particularly resembles Sheng's specimen 26, and also specimens 25 and 27, from which it differs slightly in having a less acute keel.

Genus *Pseudostaffella* Thompson, 1942

Type species *Pseudostaffella needhami* Thompson, 1942

1942 *Pseudostaffella*; Thompson, p. 407-411

1986 *Quasistaffella* Solovieva; p. 21 (type species *Quasistaffella postparadoxa* Solovieva, 1986)

Note on the range of *Pseudostaffella*. Solovieva (1986) introduced the new genus and species *Quasistaffella postparadoxa* for a small form that was collected from the lowermost Kasimovian strata (Krevyakinian) of the Yugorsky Peninsula, Arctic Urals. However, *Q. postparadoxa* only differs from many Bashkirian *Pseudostaffella* in characteristics of species level. Therefore, if age were not taken into account, there would be no basis for establishing a new genus. This fact, the much younger age of *Quasistaffella* compared with species of Bashkirian age, was probably the main reason for Solovieva to introduce her new genus. In this sense, it is relevant to note that *Pseudostaffella* species exhibiting a "primitive" appearance have been abundantly reported in the Moscovian up to the Podolskian (Rauzer-Chernousova *et al.*, 1951; Grozdilova & Lebedeva, 1960; Pogrebnyak, 1975; Ueno *in* Fohrer *et al.*, 2007, among others). Nevertheless, even considering these occurrences, a gap could exist between the Podolskian and the Krevyakinian forms, which would still justify the creation of a new genus

for the Krevyakinian species. The present paper, however, illustrates "primitive-looking" *Pseudostaffella* from Myachkovian strata, thus evidencing that these type of forms can be recorded throughout the Moscovian up to the Krevyakinian. Therefore, we think that, instead of a broad stratigraphic separation existing between *Pseudostaffella* and *Quasistaffella*, species of both taxa form part of the same lineage and belong to the same genus.

Pseudostaffella aff. *P. varsanofievae* Rauzer-Chernousova
in Rauzer-Chernousova *et al.*, 1951
(Fig. 5a)

Measurements. L = 0.16 mm; D = 0.21 mm; L/D = 0.76; n = 3; d = 40 μm ; wth_{ult} = 10 μm .

Remarks. Very small test, coiled tightly and with the axis of coiling of the two inner whorls inclined at an angle with respect to the last one. The shape of this last volution is nautiloid, laterally compressed, and shows flat umbilici. Tiny thickenings of the wall in the penultimate volution grow on the median region and form elevations reminiscent of chomata. This specimen recalls *Pseudostaffella varsanofievae* Rauzer-Chernousova in its small size, tight coiling, lateral compression, and nautiloid outer shape, but it differs in having fewer volutions and, especially, a smaller number of endothyroid volutions. The Rauzer-Chernousova species was assigned by Kulagina & Sinityna (2003), to their new genus *Varistaffella*.

Pseudostaffella sp. A
(Figs. 5b-5t)

Measurements. L = 0.32-0.51 mm; D = 0.33-0.57 mm; L/D = 0.80-1.00; n = 3.5-4.5; d = 35-70 μm ; wth_{ult} = 10-15 μm .

Remarks. Test usually small, except for a few specimens exhibiting a somewhat larger shell (cf. Figs. 5i and 5r) that are anyway tentatively included in a single species since individuals showing intermediate sizes seem to be present. Shape of test from spherical to laterally compressed, the latter frequently exhibiting subquadrangular outline in the last one or two volutions. In the innermost volutions, axis of coiling is usually arranged at an angle with respect to the subsequent whorls. In comparison with other *Pseudostaffella* specimens, a relatively large proloculus is observed with respect to test size. Chomata wide, irregular, present up to and including the penultimate volution and often extending to the poles. They vary in height from moderate to high; when chomata are lower, a distinct increase in height occurs near the tunnel. Wall poorly differentiated.

The stratigraphic location and accompanying fauna evidence that present specimens are late Moscovian

(Myachkovian) in age. However, their characteristics somewhat recall much older *Pseudostaffella* species, such as *Ps. needhami* Thompson (Thompson, 1942; Groves, 1984), type-species of *Pseudostaffella*, which has been described from the lower Pennsylvanian of North America, and, especially, typical Bashkirian forms belonging to the Eurasian *Pseudostaffella praegorskyi*, *Ps. antiqua* and *Ps. compressa* species groups. Along with other somewhat similar Eurasian forms described from the Moscovian strata, the present species bears resemblance in the shape of the shell, coiling, and type of chomata to the specimens assigned by Pogrebnyak (1975) to *Pseudostaffella keytei* (Roth & Skinner, 1930), which were collected from older strata (K₆ and K₈ limestones of the Donets Basin, correlatable with the lower Moscovian). Our specimens, in the event they comprise a single species, show larger variability than the individuals illustrated by Pogrebnyak, but the latter are too few in number (3) to allow proper comparisons to be made. Although to a lesser degree, some specimens also resemble *Pseudostaffella distorta*, a species introduced by Pogrebnyak, (1975) from the O₁ limestone of the Donets Basin; again, the intraspecific variability of *Pseudostaffella* sp. A seems to be larger than in the Pogrebnyak form.

Genus *Neostaffella* Miklukho-Maklay, 1959

Type species “*Pseudostaffella sphaeroidea* Ehrenberg, 1842” of Rauzer-Chernousova, in Rauzer-Chernousova *et al.*, 1951

Note on the taxonomic rank of *Neostaffella*. Miklukho-Maklay (1959) proposed splitting Bashkirian and Moscovian *Pseudostaffella* species into two genera, and introduced the genus *Neostaffella* for the Moscovian species. This author stated that the Moscovian pseudostaffellids could be distinguished from the Bashkirian ones by their much larger size, more stable position of the axis of coiling, and more massive chomata. These criteria implicitly meant assuming that *Pseudostaffella* became extinct around the Bashkirian/Moscovian transition. However, it is important to note the fact that, apart from typical *Pseudostaffella* forms occurring sporadically throughout the Moscovian, lower Moscovian strata contain abundant species whose size and other characteristics are intermediate between typical *Pseudostaffella* and typical *Neostaffella*, thus making it difficult to establish a clear morphological distinction between these two groups. It has also been argued that *Neostaffella* possesses a four-layered wall (Miklukho-Maklay, 1959; Rauzer-Chernousova *et al.*, 1996; Ueno *in* Fohrer *et al.*, 2007), but this feature is not always discernible. In many cases, large pseudostaffellid species exhibit a three-layered wall. [In some specimens, the upper tectorium is distinctly clearer than the chomata above it, creating the impression of a false “diaphanotheca”

on the tectum and thus of a four-layered wall (Villa & Merino-Tomé, 2016, p. 245)]. Nevertheless, although intermediate species make separation difficult, it is obvious that a considerable evolutive difference exists between the extreme morphotypes of the *Pseudostaffella* plexus, on the one hand, and *Neostaffella* plexus on the other. For this reason, and considering the wide acceptance of *Neostaffella* in the more recent fusulinid literature, we recognize *Neostaffella* Miklukho-Maklay (1959) as a genus.

Neostaffella cf. *N. rostovzevi* (Rauzer-Chernousova, in Rauzer-Chernousova *et al.*, 1951)
(Figs. 5u, 5v-5x)

Measurements. L = 1.08 mm; D = 0.99 mm; L/D = 1.09; n = 6.5; d = 70 µm; D_{IV} = 0.36; wth_{pen} = 20 µm; wth_{ult} = 25 µm. [Data corresponding to the specimen illustrated in Fig. 6u].

Remarks. This sample contains several *Neostaffella* specimens showing large sphaeroidal test and massive chomata extending to the poles and reaching half to two-thirds the chamber height, characteristics that point to a close affinity with forms belonging to the *N. sphaeroidea* species group. Comparing the two better orientated specimens (Figs. 6u and 6w) with the species of that group, the similarity with *Neostaffella rostovzevi* (Rauzer-Chernousova in Rauzer-Chernousova *et al.*, 1951) is noteworthy. Besides the large test and massive chomata, our species also share with *N. rostovzevi* an entirely globose shell [lacking the flattening in the median and umbilical regions that is typical in *Neostaffella sphaeroidea* (Ehrenberg, 1842)], as well as a narrow tunnel.

Genus *Schubertella* von Staff & Wedekind, 1910

Type species *Schubertella transitoria* von Staff & Wedekind, 1910

Note on *Schubertella*. The specimens described below as *Schubertella* von Staff & Wedekind, 1910, would be assigned to *Eoschubertella* Thompson, 1937, by most of the American and Japanese authors. However, as the separation of the two genera has long been a matter of discussion that still remains unresolved (see Groves, 1991; Ueno *in* Fohrer *et al.*, 2007; Davydov, 2011; Villa & Merino-Tomé, 2016), we prefer to maintain the whole plexus within a single genus and, in this respect, *Schubertella* has nomenclatural priority.

Schubertella ex gr. *S. obscura* Lee & Chen *in* Lee *et al.*, 1930 (spp.?)
(Figs. 6a-6k)

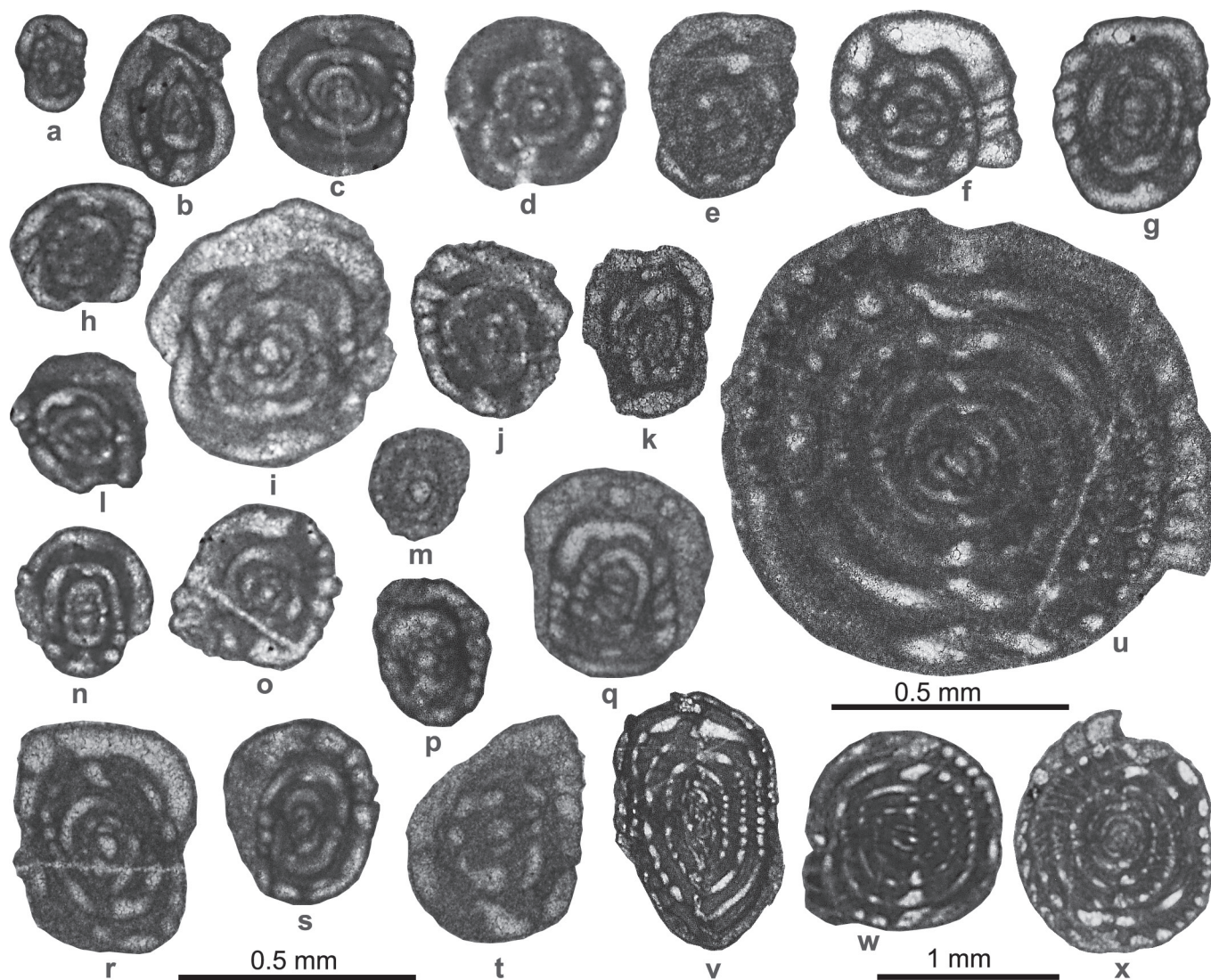


Figure 5. a) *Pseudostaffella* aff. *P. varsanofievae* Rauzer-Chernousova, 1951, CT24/48b. b-t) *Pseudostaffella* sp. A. (b) CT24/17a; (c) CT24/115a; (d) CT24/50; (e) CT24/32b; (f) CT24/24; (g) CT24/67a; (h) CT24/113b; (i) CT24/48a; (j) CT24/125c; (k) CT24/92d; (l) CT24/68a; (m) CT24/120c; (n) CT24/14b; (o) CT24/48e; (p) CT24/88f; (q) CT24/113e; (r) CT24/125a; (s) CT24/68b; (t) CT24/60b. u-x) *Neostaffella* cf. *N. rostovzevi* Rauzer-Chernousova, 1951. Scale bars: a-u = 0.5 mm; v-x = 1 mm.

Remarks. A number of species closely related to *Schubertella obscura* Lee & Chen in Lee *et al.*, 1930 have been introduced in the fusuline literature, most of them bearing such a notable resemblance to each other that one may wonder if they are different species. In other cases, when several specimens of a particular taxon are illustrated, a remarkable intraspecific variability in shape and development of secondary deposits appears.

Present specimens from the Tanes section share the features typical of the *Schubertella obscura* species group, such as a small and frequently globose test, first one to two whorls usually coiled at an angle with respect to the mature whorls, undifferentiated wall, and irregular chomata. We tentatively group them into two sets of morphotypes:

Morphotype A (Specimens illustrated in Figs 6a, 6d, 6g). L = 0.20-0.26 mm; D = 0.20-0.24 mm; L/D = 0.87-1.08; n = 2; d = 65-80 μ m; wth_{ult} = 10 μ m]. Characterized by having fewer whorls, larger proloculus, looser coiling, and fewer or no changes in the position of the axis of coiling. Somewhat similar species are *Schubertella toriyamai* Ishii, 1962, *S. australis* Thompson & Miller, 1949, and *S. sphaerica* Sulemainov, 1949.

Morphotype B (Specimens illustrated in Figs. 6c, 6e, 6f, 6i, 6j, 6k). L = 0.13-0.21 mm; D = 0.17-0.20 mm; L/D = 0.76-0.95; n = 2.5-3; d = 25-40 μ m; wth_{ult} = 8-12 μ m; the possibly immature specimen in Fig. 6k is not included). This group is characterized by having more volutions (usually 3), distinct endothyroid juvenarium,

tighter coiling, and smaller proloculus, which result in a comparatively smaller test. They bear a resemblance to *Schubertella obscura mosquensis* Rauzer-Chernousova in Rauzer-Chernousova *et al.*, 1951.

Others. Specimens illustrated in Fig. 6b (L = 0.31 mm; D = 0.20 mm; L/D = 1.55; n = 2.5; wth_{ult} = 15 µm) and Fig. 6h (L = 0.20 mm; D = 0.16 mm; L/D = 1.25; n = 3; d = 40 µm; wth_{ult} = 10 µm) do not show clear enough affinities to the morphotypes described above. Fig. 6b somewhat recalls *S. quasiobscura* Sheng, 1958.

Genus *Fusiella* Lee & Chen in Lee *et al.*, 1930

Type species *Fusiella typica* Lee & Chen in Lee *et al.*, 1930

Fusiella cf. *F. pulchella* Safonova in Rauzer-Chernousova *et al.*, 1951
(Figs. 6l-m)

Measurements. L = 0.55 mm; D = 0.26 mm; L/D = 2.16; n = 4; d = 35 µm; wth_{ult} = 10 µm.

Remarks. This form resembles taxa included in the *Fusiella typica* group by Rauzer-Chernousova *et al.* (1951). Most similar are *F. pulchella* Safonova and *F.*

typica ventricosa Rauzer-Chernousova (both in Rauzer-Chernousova *et al.*, 1951). The Tanes form is closer to *F. pulchella* in shape, size of the outer shell and extent of the endothyroid stage, which is a bit longer than in the other species.

Genus *Taitzeoella* Sheng, 1951

Type species *Taitzeoella taitzeoensis* Sheng, 1951

Taitzeoella cf. *T. pseudolibrovitchi* (Safonova, in Rauzer-Chernousova, 1951)
(Figs. 6n-o)

Measurements. L = 1.47 mm; D = 0.59 mm; L/D = 2.49; n = 5.5?; wth_{ult} = 15 µm.

Remarks. Sample studied provided a dozen badly orientated specimens that, although not allowing us to make precise comparisons, show characteristics that point to either *T. pseudolibrovitchi* (Safonova in Rauzer-Chernousova *et al.*, 1951) or *T. librovitchi* (Dutkevich 1934). Their size, number of whorls, and type of chomata, which are distinct but not as high as in *T. librovitchi*, indicate their close affinity to *Taitzeoella pseudolibrovitchi*.

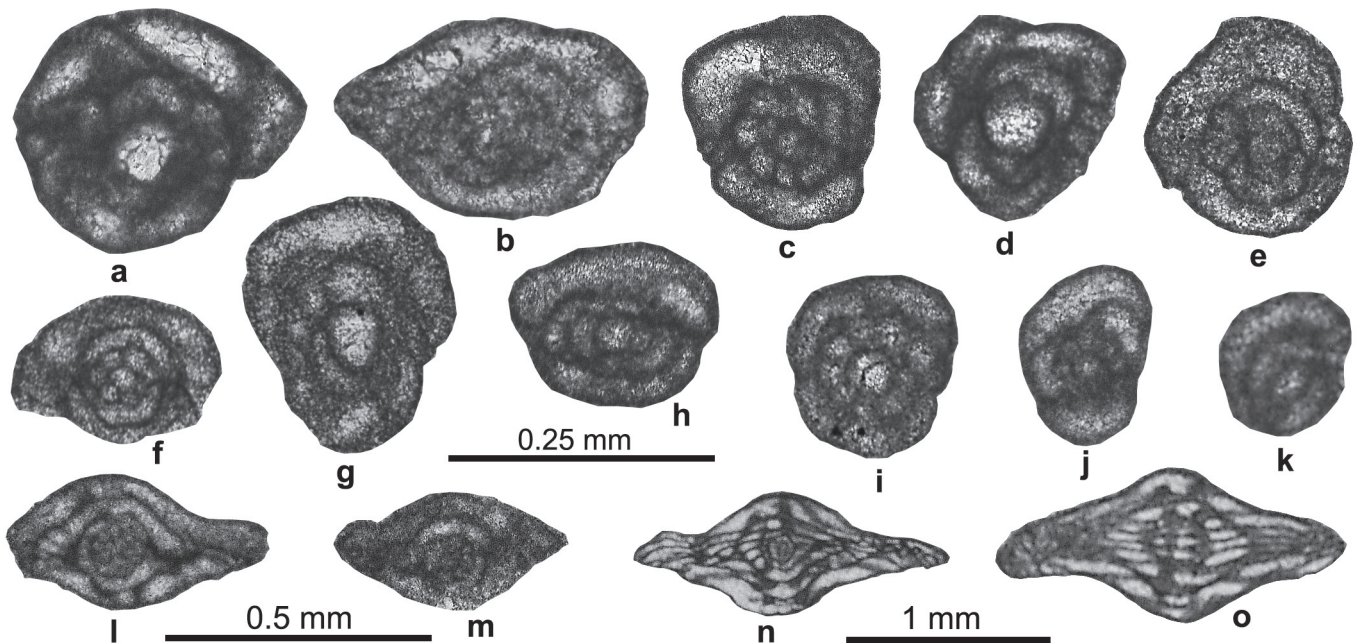


Figure 6. a-k) *Schubertella* ex gr. *S. obscura* Lee & Chen 1930 (spp.?). (a) CT24/109a; (b) CT24/57; (c) CT24/48g; (d) CT24/48i; (e) CT24/33b; (f) CT24/20c; (g) CT24/112b; (h) CT24/109d; (i) CT24/48h; (j) CT24/125d; (k) CT24/60c. l-m) *Fusiella* cf. *F. pulchella* Safonova, 1951. (l) CT24/82; (m) CT24/116b. n-o) *Taitzeoella* cf. *T. pseudolibrovitchi* (Safonova, 1951). (n) CT24/32a; (o) CT24/119a. Scale bars: a-k = 0.25 mm; l-m = 0.5 mm; n-o = 1 mm.

Genus *Fusulinella* von Möller, 1877

Type species *Fusulinella bocki* von Möller, 1878

Fusulinella aff. *F. bockiformis* Bogush, 1963
(Figs. 7l-7s)

Measurements. L = 2.08-4.00 mm; D = 1.05-2.00 mm;
L/D = 1.41-2.00; n = 4.5-6; d = 50-70 μ m; D_{IV} = 0.36-1.10
mm; with_{pen} = 30-70 μ m; with_{ult} = 20-40 μ m.

Remarks. Two morphotypes can be observed within this *Fusulinella* population: most of the specimens exhibit a rapid expansion of the spire in the last one or two volutions (particularly, Fig. 7r) and have a short and almost globular test, whereas a couple of individuals (Figs. 7l and 7n) have a more gradual spiral growth, as well as more elongated outer volutions that result in a fusiform shape. However, both morphotypes show similar tightly coiled and globular inner whorls, similar proloculus size, similar massive chomata (extending to the poles in the

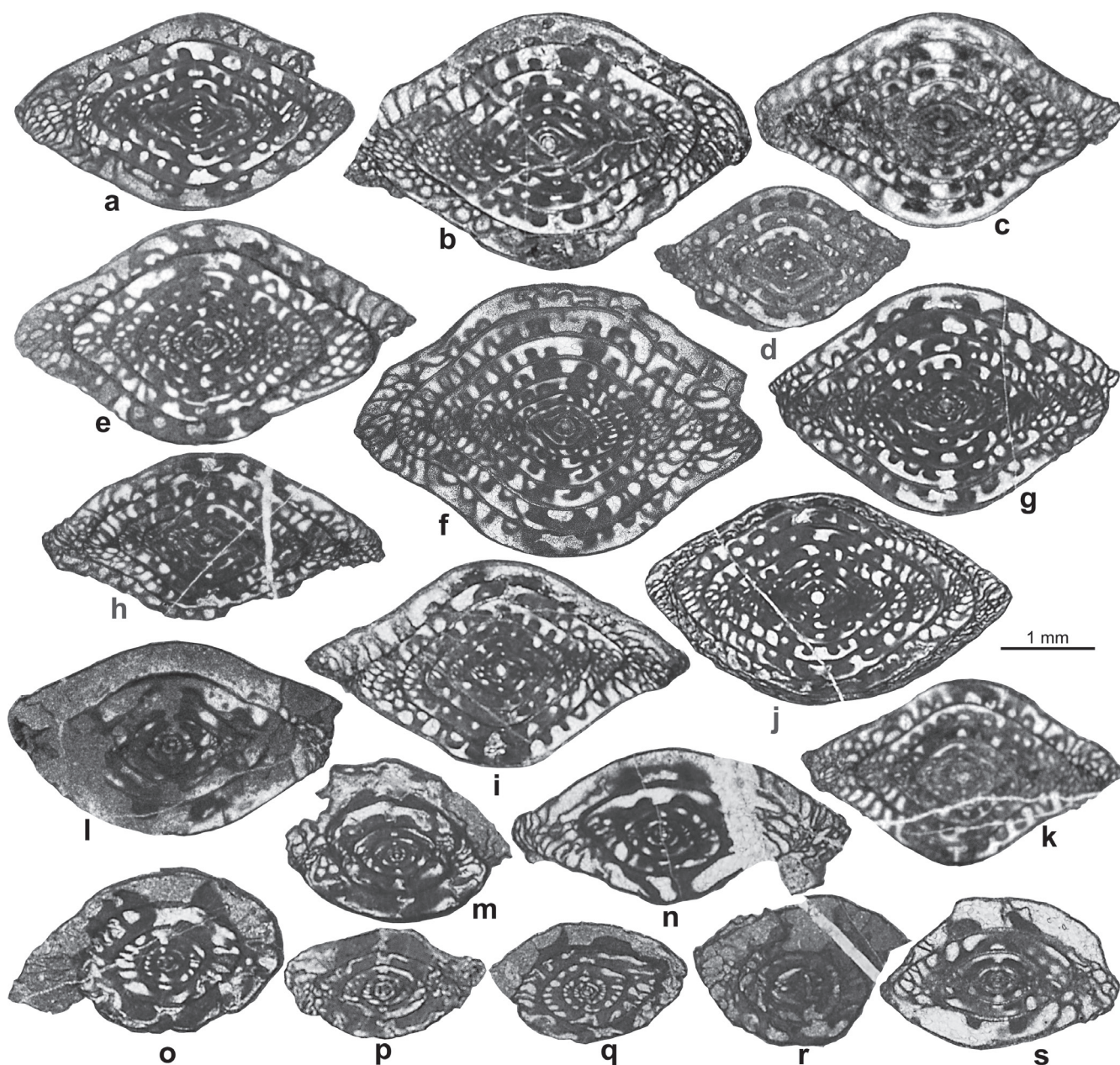


Figure 7. a-k) *Beedeina* cf. *B. samarica* (Rauzer-Chernousova & Belyaev, 1940). (a) CT24/64a; (b) CT24/56; (c) CT24/127; (d) CT24/72; (e) CT24/61a, microspheric specimen; (f) CT24/76; (g) CT24/11b; (h) CT24/106; (i) CT24/99b; (j) CT24/97; (k) CT24/95. l-s) *Fusulinella* aff. *F. bockiformis* Bogush, 1963. (l) CT24/15a; (m) CT24/107b; (n) CT24/62; (o) CT24/109b; (p) CT24/23a; (q) CT24/120a; (r) CT24/12c; (s) CT24/102.

first volutions and becoming narrower and higher in the subsequent ones), similar septal folding, and an identical four-layered wall with relatively thick tectoria.

The massive supplementary deposits and the globular or inflated test of the Cantabrian species suggest a relationship between this form and the *Fusulinella bocki* species group. Most similar is *Fusulinella bockiformis* Bogush, 1963, described from the lower Moscovian of the Alay Mountains (Central Asia), which has a globular shape and also shows a loose spiral growth. However, the Cantabrian species, which is late Moscovian in age, differs in having more massive chomata and more pronounced, abrupt spiral growth in the final stage. Other forms exhibiting a certain, albeit lesser resemblance with our specimens are *Fusulinella bocki timanica* and *Fusulinella bocki pauciseptata* (both described from the Myachkovian of the Russian Platform by Rauzer-Chernousova, in Rauzer-Chernousova, 1951). These observations lead us to consider *Fusulinella* aff. *F. bockiformis* as probably being a new species related, as other many Cantabrian species of Moscovian to Gzhelian age (Villa *et al.*, 2002, 2015, among others), to Central Asian forms. However, given the fact that the number of specimens is so small, we feel we cannot confidently describe this population formally as a new species.

Genus *Beedeina* Galloway, 1933

Type species *Fusulina girtyi* Dunbar & Condra, 1928

Beedeina cf. *B. samarica* (Rauzer-Chernousova & Belyaev, in Rauzer-Chernousova *et al.*, 1940)
(Figs. 7a-7k)

Measurements. L = 2.50-4.25 mm; D = 1.48-2.85 mm; L/D = 1.46-1.92; n = 6-9; d = 70-240 μ m; D_{IV} = 0.65-1.10 mm; wth_{pen} = 30-50 μ m; wth_{ult} = 25-50 μ m. Microspheric specimen: L = 4.25; D = 2.32; L/D = 1.83; n = 10; d = 20 μ m; D_{IV} = 0.65-1.10 mm; wth_{pen} = 40 μ m; wth_{ult} = 45 μ m.

Remarks. Shell inflated rhomboidal, with straight or, more rarely, slightly concave lateral sides, and blunt polar ends. Coiling expanding gradually and very slowly (diameter of the fourth volution between 0.65 and 1.10 mm). Chomata massive, extending to the poles in the first one or two volutions, and narrower (frequently becoming subquadratic in section) in the subsequent ones; apparently, the chomata tend to pseudochomata in the penultimate one or two whorls. Septa intensively folded throughout the shell, their height usually reaching two thirds of the chamber height.

These features closely match those of *Beedeina samarica* described by Rauzer-Chernousova & Belyaev (in Rauzer-Chernousova *et al.*, 1940) from the Samara Bend of the Volga river, except in that our material presents a

wider variability in size, number of volutions (up to 9 whorls, 10 in a microspheric specimen), and exhibits a shorter shell on average (L/D ratio 1.46-1.92, versus 1.80-2.00 in *B. samarica*). *Beedeina paradistenta* (Safonova in Rauzer-Chernousova *et al.*, 1951), described from South Pre-Timan, is also very similar to *Beedeina* cf. *B. samarica*, but our form might be distinguished from the Russian species in lacking axial fillings and having, on average, a more elongated shell.

A striking fact in this *Beedeina* collection is that the specimens described coexist in the same sample with others that seem to belong to the same species but apparently exhibit a strong compressive deformation. Unfortunately, we cannot provide a hypothesis explaining why one part of the population was affected by deformation and the other was not. A relevant point is that none of the specimens, whether 'normal' or deformed, show evidence of reworking.

Genus *Putrella* Rauzer-Chernousova, in Rauzer-Chernousova *et al.*, 1951

Type species *Pseudotriticites brazhnikovae* Putrja, 1948

Putrella sp. A
(Figs. 8a-8i)

Measurements. L = 3.60-6.50 mm; D = 1.30-2.10 mm; L/D = 2.19-3.08; n = 4-5.5; d = 50-90 μ m; D_{IV} = 0.71-1.37 mm; wth_{pen} = 40-50 μ m; wth_{ult} = 50-80 μ m.

Remarks. Large sized *Putrella* specimens, whose most peculiar feature is a thick spirotheca consisting of tectum and a thick primatheca pierced by distinct pores. At first glance, this spirotheca could recall a keriothecal wall, an impression that in this species is stronger than in other *Putrella* forms. However, more careful observations show that the pores piercing the wall do not branch, as often they do in a keriotheca, but are simple. It is pertinent to remember here that the apparent resemblance of the *Putrella* wall to a schwagerinid wall (*Triticites*) was already noted by Elias, 1959.

The thickness of the wall and the large size of the shell of some specimens distinguish *Putrella* sp. A from previously described *Putrella* morphotypes. Compared with the holotype of genotype *Putrella brazhnikovae* (Putrja, 1948), *Putrella* sp. A also has tighter coiling, a larger number of whorls, more pointed polar ends, chomata developed sometimes up to the second volution, and higher septal folding. *Putrella korobcheevi* Rauzer-Chernousova, a Myachkovian form described initially as a variety of *P. brazhnikovae* by Rauzer-Chernousova *et al.* (1951), resembles *Putrella* sp. A in that some specimens also exhibit a considerable shell elongation (cf. Rauzer-Chernousova specimen in fig. 7, pl. LVII with our

specimen in Fig. 8e), but the Russian form differs in having less intense septal folding and less prominent chomata. Other *Putrella* species have been described or recorded by different authors [e.g. Putrja (1956); Dalmatskaya (1961); Ivanova (2008); Leven & Gorjig (2008); Villa *et al.* (2018), among many others], all differing from *Putrella* sp. A in size and spirotheca thickness, besides other aspects.

The large size and the thick spirotheca suggest that *Putrella* sp. A represents an advanced evolutionary stage of the genus, and is probably a dead end phylogenetic branch. The size of the proloculus, smaller in relation to shell size when compared with the rest of the *Putrella* species, could also be typical of *Putrella* sp. A. Other features, such as the gradually expansion of the coil, chomata developed on the proloculus and one or two innermost whorls, and high and irregular septal folding, are common in all *Putrella* species.

This morphotype could represent a new species, but we refrain from creating a new taxon because the poor

preservation of the available specimens (some of them are crushed and others are eroded) prevent us from proposing a suitable holotype.

5. CONCLUDING REMARKS

The CTA-24 sample recovered from the Fito Formation contains species belonging to genera that usually make up the Moscovian assemblages. Nevertheless, they exhibit some uncommon features. Most striking is a large *Putrella* species whose wall microstructure, pierced by thick pores, might at first glance appear to be reminiscent of the keriothecal wall of late Kasimovian or Gzhelian schwagerinids. However, a more careful observation of its microstructure indicates that the pores, although thicker than in other contemporaneous species, are simple and

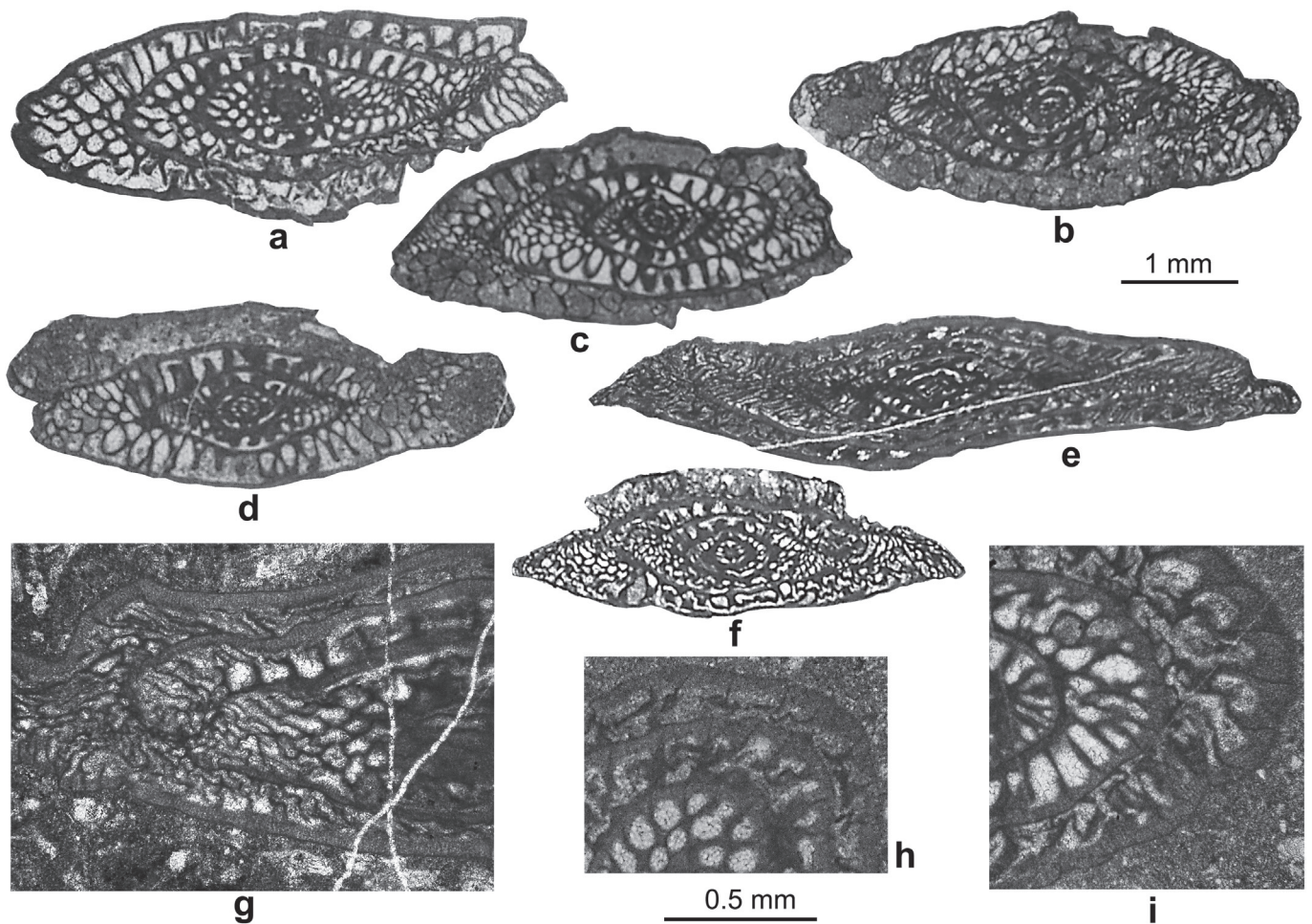


Figure 8. a-f) *Putrella* sp. A (a) CT24/55; (b) CT24/93g; (c) CT24/60a; (d) CT24/123; (e) CT24/122a; (f) CT24/96c. g-i) Enlargement of three specimens of *Putrella* sp. A to observe their wall microstructure. (g) CT24/2e; (h) CT24/113a; (i) CT24/96a. Scale bars: a-f = 1 mm; g-i = 0.5 mm.

straight, and are not as complicated in basic structure as the schwagerinid keriotheca.

Another notable occurrence in the assemblage is abundant specimens of *Pseudostaffella* sp. A, whose small test size and somewhat irregular position of the axis of coiling do not differ much from those of the typical Bashkirian *Pseudostaffella*. Moreover, this finding, along with other *Pseudostaffella* occurrences scattered throughout the fusuline literature, evidences a continuous record of *Pseudostaffella* species from the Bashkirian to the Krevyakinian, which probably invalidates the status of *Quasistaffella* Solovieva as a separate genus.

Among the taxa recovered from CTA-24, *Beedeina* cf. *B. samarica* has yielded the largest collection of specimens, a fact that has allowed us to observe the intraspecific variability existing within this Cantabrian population. As often occurs when a large collection is available, the variability is larger than in any related species, including specimens that exceed the known morphological range of the nominal species.

The characteristics of *Beedeina* cf. *B. samarica*, and *Fusulinella* aff. *F. bockiformis*, and their resemblance to species originally described from the upper Moscovian of the Russian Platform and Central Asia (Alay Mountains), respectively, point to a probable correlation of the CTA-24 bed with the lower part of the uppermost Moscovian Myachkovian horizon (or substage) of Russia. This assumption is reinforced by the occurrence of species of *Fusiella*, *Taitzeoella* and *Neostaffella* that are of unequivocal Myachkovian age in beds above and below the CTA-24 bed in the same section.

Within the Cantabrian Zone, this bed is correlatable with the Entrerregueras Formation of the Central Asturian Coalfield, with an undeterminate level within the middle or the upper part of the Fito Formation in the eastern part of the Ponga Nappe (Espinaredo thrust-unit), and with the Myachkovian strata of the upper member of the Picos de Europa Formation in the Picos de Europa Unit.

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REFERENCES

- Águeda, J.A., Bahamonde, J.R., Barba, F.J., Barba, P., Colmenero, J.R., Fernandez, L.P., Salvador, C.I. & Vera de la Puente, C. 1991. Depositional environments in Westphalian coal-bearing successions of the Cantabrian Mountains, northwest Spain. *Bulletin de la Société Géologique de France*, 162, 325–337.
- Alonso, J.L., Marcos, A. & Suárez, A. 2009. Paleogeographic inversion resulting from large out of sequence breaching thrusts: The Leon Fault (Cantabrian Zone, NW Iberia). A new picture of the external Variscan Thrust Belt in the Ibero-Armorican Arc. *Geologica Acta*, 7, 451–473. doi: 10.1344/105.000001449
- Bahamonde, J.R. & Colmenero, J.R. 1993. Análisis estratigráfico del Carbonífero medio y superior del manto del Ponga (Zona Cantábrica). *Trabajos de Geología*, Universidad de Oviedo, 19, 155–193.
- Bahamonde, J.R., Merino-Tomé, O., Della Porta, G. & Villa, E. 2015. Pennsylvanian carbonate platforms adjacent to deltaic systems in an active marine foreland basin (Escalada Fm., Cantabrian Zone, NW Spain). *Basin Research*, 27, 208–229. Doi: 10.1111/bre.12068
- Bahamonde, J.R., Della Porta, G. & Merino-Tomé, O. 2017. Lateral variability of shallow-water facies and high-frequency cycles in foreland basin carbonate platforms (Pennsylvanian, NW Spain). *Facies*, 63, 6. doi:10.1007/s10347-016-0487-3
- Bogush, O.I. 1963. *Foraminifera and stratigraphy of the Middle and Upper Carboniferous of the eastern part of the Alay Mountains*. Akademiya Nauk SSSR, Sibirskoe Otdelenie, Institut Geologii i Geofiziki, Izdatelstvo Akademii Nauk SSSR, 132 p. (in Russian).
- Dan'shin, V.M. 1947. Geology and mineral resources of the region of the Moscow Basin. *Transactions of the Moscow Society of Natural Studies*, Moscow (in Russian).
- Colani, M. 1924. Nouvelle contribution à l'étude des Fusulinidés de l'Extrême-Orient. *Mémoires du Service Géologique de l'Indochine, Hanoi-Haiphong*, 11, 9-191.
- Dalmatskaya, I.I. 1961. Stratigraphy and Foraminifera from the Middle Carboniferous of the Volga region near Gorki and Uljanovsk. *Akademiya Nauk SSSR, Geologicheskii Institut, Regionalnaya Stratigrafiya*, 5, 7–54 (in Russian).
- Davydov, V.I. 2011. Taxonomy, nomenclature, and evolution of the early schubertellid fusulinids. *Acta Palaeontologica Polonica*, 56, 181–194. doi:10.4202/app.2010.0026
- Davydov, V.I., Korn, D. & Schmitz, M.D. 2012. The Carboniferous Period. In: *The Geologic Time Scale 2012* (eds. Gradstein, F.M., Ogg, J.G., Schmitz, M.D. & Ogg, G.M.). Elsevier, 603–651. doi:10.1016/B978-0-444-59425-9.00023-8
- Dunbar, C.O. & Condra, G.E. 1928. The Fusulinidae of the Pennsylvanian System in Nebraska. *Bulletin of the Nebraska Geological Survey*, ser. 2, 1–135.
- Dutkevich, G.A. 1934. Some new species of Fusulinidae from the Upper and Middle Carboniferous of Verkhne-

- Chussovskye Gorodki on the Chussovaya River (western slope of the Central Urals). *Trudy Neftyanogo Geologo-Razvedochnogo Instituta, ser. A*, 36, 1–98 (in Russian).
- Ehrenberg, C.G. 1842. Der Bergkalk am Onega See aus Polythalamien bestehend. *Bericht über die zu Bekanntmachung geeigneten Verhandlungen der Königlichen Preussischen Akademie der Wissenschaften zu Berlin*, 1842, 273–275.
- Elias, M.K. 1959. Fusulinid genera *Protriticites*, *Pseudotriticites*, and *Putrella*. *Oklahoma Geological Notes*, 19, 165–178.
- Fohrer, B., Nemyrovska, T.I., Samankassou, E. & Ueno, K. 2007. The Pennsylvanian (Moscovian) Izvarino section, Donets Basin, Ukraine: a multidisciplinary study on microfacies, biostratigraphy (conodonts, foraminifers, and ostracodes), and paleoecology. *The Paleontological Society Memoir 69, Supplement to Journal of Paleontology*, 81, 1–85.
- Galloway, J.J. 1933. *A manual of Foraminifera*. Principia Press, Bloomington, Indiana.
- Ginkel, A.C. van 1965. Carboniferous fusulinids from the Cantabrian Mountains (Spain). *Leidse Geologische Mededelingen*, 34, 1–225.
- Ginkel, A.C. van 2010. Systematics of the Eostaffellidae (Late Paleozoic Foraminifera). *Cushman Foundation for Foraminiferal Research, Special Publication*, 42, 1–130.
- Golonka, J. 2002. Plate-tectonic maps of the Phanerozoic. In: *Phanerozoic Reef Patterns* (eds. Kiessling, W., Flügel, E. & Golonka, J.). *SEPM Society for Sedimentary Geology Special Publication*, 72, 21–75.
- Groves, J.R. 1984. Taxonomic, nomenclatural, and stratigraphic notes on the primitive fusulinid *Pseudostaffella* Thompson, 1942. *Journal of Foraminiferal Research*, 14, 69–76.
- Groves, J.R. 1991. Fusulinacean biostratigraphy of the Marble Falls Limestone (Pennsylvanian), western Llano region, central Texas. *Journal of Foraminiferal Research*, 21, 67–95.
- Grozdilova, L.P. & Lebedeva, N.S. 1950. Some species of *Staffella* from the Middle Carboniferous strata of the western slope of the Urals. *Trudy Vsesoyuznogo Neftyanogo Nauchno-issledovatel'skogo Geologoeazvedochnogo Instituta (VNIGRI)*, 50, 5–46 (in Russian).
- Grozdilova, L.P. & Lebedeva, N.S. 1954. Foraminifers from the Lower Carboniferous and Bashkirian Stage of the Middle Carboniferous of the Kolvo-Vishera area. *Vsesoyuznii Neftyanoi Nauchno-Issledovatel'skii Geologo-razvedochnii Institut (VNIGRI), Trudy, Mikrofauna SSSR, Sbornik 8*, 81, 4–236 (in Russian).
- Grozdilova, L.P. & Lebedeva, N.S. 1960. Foraminifera from the Carboniferous strata on the western slope of the Urals and Timan. Atlas of the most characteristic species. *Trudy Vsesoyuznogo Neftyanogo Nauchno-issledovatel'skogo Geologoeazvedochnogo Instituta (VNIGRI)*, 150, 1–264 (in Russian).
- Ishii, K. 1962. Fusulinids from the middle Upper Carboniferous Itadorigawa Group in western Shikoku, Japan, Part 2. Genus *Fusulinella* and other fusulinids. *Journal of Geosciences, Osaka City University*, 6, 1–58.
- Ivanov, A.P. 1926. Middle and Upper Carboniferous of the Moscow Province. *Bulletyn Moskovskoe Obshchestvo Ispytately Prirody, Otdelny Geologia*, 36, 133–180 (in Russian).
- Ivanova, R. M. 2008. *Fusulinids and algae of the Urals Middle Carboniferous (zonal stratigraphy, paleobiogeography, paleontology)*. Rossiiskaya Akademiya Nauk, Uralskoye Otdelenie, Ekaterimburg. (in Russian).
- Julivert, M. 1978. Hercynian orogeny and Carboniferous paleogeography in NW Spain: a model of deformation-sedimentation relationships. *Zeitschrift der Deutschen Geologischen Gesellschaft*, 129, 565–592.
- Kanmera, K. 1952. The Lower Carboniferous Kakisako Formation of southern Kyushu, with a description of some corals and fusulinids. *Kyushu University (Hukuoka), Faculty of Science, Memoirs, Series D*, 3, 155–177.
- Kireeva, G.D. 1949. Some new species of fusulinids from the Carboniferous of Central Donbass. *Trudy Geologo-Issledovatel'skie (Glavuglerazvedka), Ugletekhizdat*, 6, 25–55 (in Russian).
- Kulagina, E.I. & Sinitsyna, Z.A. 2003. Evolution of the Pseudostaffellidae in the Bashkirian stage (Middle Carboniferous). *Rivista Italiana di Paleontologia e Stratigrafia*, 109, 213–224.
- Lee, J.S., Chen, S. & Chu, S. 1930. The Huanglung limestone and its fauna. *Memoirs of the National Research Institute of Geology, Nanking*, 9, 85–143.
- Leven, E.Ja. & Gorjig, M.N. 2008. New fusulinids of the Moscovian stage found in Iran. *Stratigrafiya, Geologicheskaya Korrelyatsiya*, 16, 40–56. (English translation in *Stratigraphy and Geological Correlation*, 16, 383–399).
- Leyva, F., Gervilla, M., Martínez-Díaz, C., Granados, L.F., Santamaría, J.A., Luque, C., García Cortés, A., Laveine, J.P., Loboziak, Brousmiche, C., Candilier, A.M., Solovieva, M.N., Reitlinger, K.A., Esnaola, J.M. & Pendás, F. 1983. El Carbonífero Medio de la Cuenca Central Asturiana y zonas adyacentes. In: *Libro Guía de la Excursión W. X Congreso Internacional de Estratigrafía y Geología del Carbonífero*. Empresa Nacional Adaro de Investigaciones Mineras.
- Leyva, F., Granados, L.F., Solovieva, M.N., Laveine, J.P., Lys, M., Loboziak, S., Martínez-Díaz, C., Brousmiche, C., Candilier, A.M. & García Cortés, A. 1985. La estratigrafía del Carbonífero Medio en el área de Los Tornos-Villoria-Colladona (sector oriental de Cuenca Central). *Compte Rendu Xe Congrès International de Stratigraphie et de Géologie du Carbonifère*, 1, 249–268.
- Lotze, F. 1945. Zur Gliederung der Varisziden der Iberischen Meseta. *Geotektonische Forschungen*, 6, 78–92.
- Marcos, A. & Pulgar, J.A. 1982. An approach to the tectonostratigraphic evolution of the Cantabrian foreland thrust and fold belt, Hercynian Cordillera of NW Spain. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 163, 256–260.
- Martín-Llaneza, J. 1979. Estratigrafía y Sedimentología del tramo carbonífero comprendido entre Coballes y Tanes (Asturias). *Tesis de Licenciatura*, Universidad de Oviedo (unpublished).

- Maslo, A. & Vachard, D. 1997. Inventaire critique des Eostaffellinae (Foraminifères) du Carbonifère. *Revue de Micropaléontologie*, 40, 39–69.
- Merino-Tomé, O., Gutiérrez-Alonso, G., Villa, E., Fernández, J., Martín Llana, J. & Hofmann, M. 2017. LA-ICP-MS U-Pb dating of Carboniferous ash layers in the Cantabrian Zone (N Spain): stratigraphic implications. *Journal of the Geological Society*, 174, 836–849. doi: 10.6084/m9.figshare.c.3768701
- Merino-Tomé, O., Alonso, J.L., Bahamonde, J.R., Fernández, L.P., Marcos, A., Colmenero, J.R., Villa, E. & Suárez, A. 2019. Foreland Basin at the Cantabrian Zone: Evolution from the Distal Foreland Basin Successions to Wedge-Top Deposition and the Tightening of the Ibero-Armorican Arc. In: *The Geology of Iberia: A Geodynamic Approach. Volume 2: The Variscan Cycle* (eds. C. Quesada, & J.T. Oliveira), Springer, Cham, Suiza, 356–361. doi: 10.1007/978-3-030-10519-8_11
- Miklukho-Maklay, A.D. 1959. On the stratigraphic distribution, systematics and phylogeny of staffelloid foraminifera. *Doklady Akademii Nauk SSSR*, 125, 628–631.
- Möller, V. von 1877. Ueber Fusulinen und ähnliche Foraminiferen-Formen des russischen Kohlenkalkes. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 1877, 139–146.
- Möller, V. von 1878. Die spiral-gewundenen Foraminiferen des russischen Kohlenkalkes. *Mémoires de l'Académie Imperiale des Science*, VII Série, 25, 1–47.
- Nikitin, S. 1890. Carboniferous deposits and artesian waters in the Moscow region. *Trudy Geologicheskogo Komiteta*, 5, 1–181 (in Russian).
- Ogg, J.G., Ogg, G.M. & Gradstein, F.M. 2016. *A Concise Geological Time Scale 2016*. Elsevier. doi: 10.1016/8978-0-444-59467-9.00003-0
- Orlova, O.B. 1996. On the problem of systematics and diagnostics of some Ozawainellida (according to data obtained from correlative relations). *Uzbekskii Geologicheskii Zhurnal*, 3, 3–8 (in Russian with English summary).
- Pogrebnyak, V.A. 1975. Characteristic foraminifera from the gas containing deposits of the Middle and Lower Carboniferous of the northern peripheral areas of the Donbass, and their stratigraphical significance. In: *Stratigraphy of the Upper Paleozoic and Lower Mesozoic of the Dnieper-Donets area*. Ukrainski Nauchno-Issledovatel'skii Institut Prirodny Gazov, Nedra, Moskva, 40–69 (in Russian).
- Putrja, F.S. 1948. Pseudotriticitinae, a new fusulinid subfamily. *Trudy L'vovskogo Geologicheskogo Obshchestva pri Gosudarstvennoo Universitete im. Ivana Franko, Ser. Paleontologia*, 1, 97–101.
- Putrja, F.S. 1956. Stratigraphy and Foraminifers from the Middle Carboniferous of the eastern Donbass. *Trudy Vsesoyuznogo Neftyanogo Nauchno-Issledovatel'skogo Geologo-Razvedochnogo Instituta (VNIGRI), nov. ser.*, 98, 333–485 (in Russian).
- Rauzer-Chernousova, D.M. 1948. Material concerning the foraminiferal fauna of Carboniferous strata of central Kazakhstan. *Trudy Instituta Geologicheskikh Nauk, Akademiya Nauk SSSR*, 66, 1–27 (in Russian).
- Rauzer-Chernousova, D.M., Belyaev, G.M. & Reitlinger, E.A. 1940. On the Carboniferous Foraminifera of the Samara Bend. *Trudy Neftyanogo Geologo-Razvedochnogo Instituta, Novaya Seriya*, 7, 1–87 (in Russian).
- Rauzer-Chernousova, D.M., Gryzlova, N.D., Kireeva, G.D., Leontovich, G.E., Safonova, T.P. & Chernova, E.I. 1951. *Middle Carboniferous fusulinids of the Russian Platform and adjacent regions*. Akademiya Nauk SSSR, Institut Geologicheskikh Nauk, Ministerstvo Neftianoy Promyshlennosti SSSR (in Russian).
- Rauzer-Chernousova, D.M., Bensch, F.R., Vdovenko, M.V., Gibshman, N.B., Leven, E.Ya., Lipina, O.A., Reitlinger, E.A., Solovieva, M.N. & Chediya, I.O. 1996. *Reference Book on the systematics of Paleozoic foraminifers (Endothyroida, Fusulinoida)*. Rossiyskaya Akademiya Nauk, Geologicheskii Institut, Moskva, “Nauka” (in Russian).
- Roth, R. & Skinner, J. 1930. The fauna of the McCoy Formation, Pennsylvanian of Colorado. *Journal of Paleontology*, 4, 332–352.
- Lin, R., Ross, C.A. & Nassichuk, W.W. 1991. Upper Moscovian (Desmoinesian) fusulinaceans from the type section of the Nansen Formation, Ellesmere Island, Arctic Archipelago. *Bulletin of the Geological Survey of Canada*, 418, 1–121.
- Schmitz, M.D. & Davydov, V.I. 2012. Quantitative radiometric and biostratigraphic calibration of the Pennsylvanian-Early Permian (Cisuralian) time scale and pan-Euramerican chronostratigraphic correlation. *Geological Society of America Bulletin*, 124, 549–577. doi: 10.1130/B30385.1
- Scotese, C.R. 2001. *Atlas of Earth History, Vol. 1, Paleogeography*. PALEOMAP Project, Arlington, Texas, 1.
- Sheng, J.Z. 1951. *Taitzeoella*, a new genus of fusulinids. *Bulletin of the Geological Society of China*, 31, 79–85.
- Sheng, J.Z. 1958. Fusulinids from the Penchi Series of the Taitzeo Valley, Lianoning. *Palaeontologica Sinica*, 143, 1–119.
- Sjerp, N. 1967. The geology of the San Isidro-Porma area (Cantabrian Mountains, Spain). *Leidse Geol. Mededelingen*, 39, 55–128.
- Solovieva, M.N. 1986. Fusulinid zonal scale of the Moscovian stage from a restudy of stratotype materials of intrastage subdivisions. *Voprosy Mikorplaontologii* 28, 3–23 (in Russian).
- Staff, H. von & Wedekind, R. 1910. Der Oberkarbon Foraminiferen sapropelit Spitzbergens. *Bulletin of the Geological Institution of the University of Upsala*, 10, 81–123.
- Suleimanov, I.S. 1949. New species of Fusulinidae of the subfamily Schubertellinae Skinner from the Carboniferous and Lower Permian of the Bashkirian Cis-Urals. *Trudy Instituta Geologicheskikh Nauk, Akademiya Nauk SSSR, ser. geol.* 105, 22–40 (in Russian).
- Teodorovich, G. 1949. On subdividing of the Upper Carboniferous into stages. Reports of the Academy of Sciences of the U.S.S.R., 67, 537–540 (in Russian).

- Thompson, M.L. 1935. The fusulinid genus *Staffella* in America. *Journal of Paleontology*, 9, 111–120.
- Thompson, M.L. 1937. Fusulinids of the subfamily Schubertillinae. *Journal of Paleontology*, 11, 118–125.
- Thompson, M.L. 1942. New genera of Pennsylvanian fusulinids. *American Journal of Science*, 240, 403–420.
- Thompson, M.L. 1951. New genera of fusulinid foraminifera. *Contributions from the Cushman Foundation for Foraminiferal Research*, 2, 115–119.
- Thompson, M.L. & Foster, C.L. 1937. Middle Permian fusulinids from Szechuan, China. *Journal of Paleontology*, 11, 126–144.
- Thompson, M.L. & Miller, A.K. 1949. Permian fusulinids and cephalopods from the vicinity of the Maracaibo Basin in northern South America. *Journal of Paleontology*, 23, 1–24.
- Vachard, D., Krainer, K. & Lucas, S.G. 2013. Pennsylvanian (Late Carboniferous) calcareous microfossils from Cedro Peak (New Mexico, USA). Part 2: Smaller foraminifers and fusulinids. *Annales de Paléontologie*, 99, 1–42. doi: 10.1016/j.annpal.2012.08.002
- Vera de la Puente, C., Martín Llana, J. & Colmenero Navarro, J.R. 1984. Estudio sedimentológico de algunos bancos carbonatados presentes en la serie moscoviense de Coballes-Tanes (Región de Mantos, Zona Cantábrica). *Trabajos de Geología*, Universidad de Oviedo, 14, 45–52.
- Villa, E. & Ginkel, A.C. van 2000. Some late Moscovian and Kasimovian fusulinaceans from the Las Llacerias section (Cantabrian Mountains, Spain). *Journal of Foraminiferal Research*, 30, 219–243.
- Villa, E., Dzhenchuraeva, A., Forke, H.C. & Ueno, K. 2002. Distinctive features of Late Carboniferous fusulinoid faunas from the western Paleo-Tethyan realm. In: *Carboniferous and Permian of the World* (eds. Hills, L.V., Henderson, C.M. & Bamber, E.W.). Canadian Society of Petroleum Geologists Memoir, 19, 609–615.
- Villa, E. & Merino-Tomé, O. 2016. Fusulines from the Bashkirian/Moscovian transition in the Carboniferous of the Cantabrian zone (NW Spain). *Journal of Foraminiferal Research*, 46, 237–270. doi: 10.2113/gsjfr.46.3.237
- Villa, E., Merino-Tomé, O., Bahamonde, J.R. 2015. Late Moscovian to Early Kasimovian Fusulinids from the Ándara Massif, Picos de Europa (Pennsylvanian, Cantabrian Zone, Northern Spain). *Journal of Foraminiferal Research*, 45, 264–292. doi: 10.2113/gsjfr.45.3.264
- Villa, E., Merino-Tomé, O. & Martín Llana, J. 2018. Fusulines from the Central Asturian Coalfield (Pennsylvanian, Cantabrian Zone, Spain) and their significance for biostratigraphic correlation. *Spanish Journal of Paleontology*, 33, 231–260. doi: 10.7203/sjp.33.1.13252
- Wagner, R.H. & Higgins, A.C. 1979. The Carboniferous of the USSR: its stratigraphic significance and outstanding problems on worldwide correlation. In: Wagner, R.H., Higgins, A.C. & Meyen, S.V. (eds.). *The Carboniferous of the World*. Yorkshire Geological Society, Occasional Publication, 4, 5–22.
- Wagner, R.H. & Winkler Prins, C.F. 1994. General overview of Carboniferous stratigraphy. *Annales de la Société Géologique de Belgique*, 116, 163–174.
- Wagner, R.H. & Álvarez-Vázquez, C. 2010. The Carboniferous floras of the Iberian Peninsula. A synthesis with geological connotations. *Review of Palaeobotany and Palynology*, 162, 239–324. doi: 10.1016/j.revpalbo.2010.06.005

