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THE VILLAMANкN MEMBER OF THE SAN EMILIANO FORMATION (CARBONIFEROUS, N SPAIN): ITS AGE AND FUSULINOIDEAN FORAMINIFERS

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The San Emiliano Formation [Carboniferous (Pennsylvanian), Northern Spain] consists of an alternation of marine and terrestrial strata yielding marine and continental fossils, respectively. Fusulinoidean foraminifers present at the top (Villaman n Member) of this formation indicate the upper part of the Profusulinella Zone. The species of the overlying Fusulinella Zone, in particular those assignable to the genus *Fusulinella*, are absent. Common are *Profusulinella, Eoschubertella* and *Pseudostaffella*, while Aljutovella is locally abundant. Although the occasional presence of mural pores in the wall of *Profusulinella* specimens may be suggestive of a posssible Kashirian age, this fusulinoidean assemblage indicates a late Vereyan age. The association of the present fusulinoidean fauna with other fossils from this member, notably brachiopods and plants, suggests that the uppermost Vereyan of East Europe corrrelates with the uppermost Westphalian B of West Europe.
Key words: Foraminifera, Fusulinoidea, San Emiliano Formation, Carboniferous, Profusulinella Zone, Cantabrian Mountains, Spain.

ПАЧКА ВІЛЛАМАНІН СВІТИ САН ЕМІЛІАНО (КАРБОН, ПІВНІЧНА ІСПАНІЯ): ЇЇ ВІК ТА ФУЗУЛІНОЇДНІ ФОРАМІНІФЕРИ

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Світа Сан Еміліано (карбон, пенсільваній, північна Іспанія) представлена чергуванням морських і континентальних товщ, що містять рештки морських та континентальних викопних організмів. Фузуліноїдні форамініфери з покрівлі цієї світи (пачка Вілламанін) визначають вік верхньої частини зони Profusulinella. Форамініфери вищезалягаючої зони Fusulinella, зокрема види роду *Fusulinella*, відсутні. Тут часто трапляються види родів *Profusulinella, Eoschubertella* та *Pseudostaffella*. Представники роду Aljutovella в деяких місцях численні. Незважаючи на те, що подекуди трапляються форми *Profusulinella* з муральними порами в стінці, що може свідчити про каширський вік порід, фузуліноїдний комплекс в цілому датується як пізньоверейський. Загалом дана фауна фузуліноїдей разом з іншими викопними рештками, такими як брахіоподи та рештки рослин, дозволяють корелювати верхню частину верейського горизонту Східної Європи із вестфалом Б Західної Європи.
Ключові слова: форамініферы, фузуліноідеї, світа Сан Еміліано, карбон, зона Profusulinella, Кантабрійські гори, Іспанія.

(*) The Dutch micropaleontoligist Adriaan K. van Ginkel passed away in September 2013, leaving this paper almost ready for publication. Several colleagues of him have helped in some ways to accomplish the original manuscript.

(*) Голландський мікропалеонтолог Адріаан С. ван Гінкел пішов з життя у вересні 2013 р., залишивши цю майже підготовлену до публікації статтю. Декілька його колег допомогли завершити оригінальний рукопис для подачі до публікації.

ПАЧКА ВИЛЛАМАНИН СВИТЫ САН ЭМИЛИАНО (КАРБОН, СЕВЕРНАЯ ИСПАНИЯ): ЕЕ ВОЗРАСТ И ФУЗУЛИНОИДНЫЕ ФОРАМИНИФЕРЫ

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Свита Сан Эмилиано (карбон, пенсильваний, северная Испания) представлена чередованием морских и континентельных отложений, содержащих остатки морских и континентальных ископаемых организмов. Фузулиноидные фораминиферы, встреченные в кровле этой свиты (пачка Вилламанин), указывают на возраст верхней части зоны Profusulinella. Фораминиферы вышележащей зоны Fusulinella, в частности виды рода *Fusulinella*, отсутствуют. Здесь часто встречаются виды родов *Profusulinella, Eoschubertella* и *Pseudostaffella*. Представители рода Aljutovella местами многочисленны. Несмотря на то, что здесь иногда встречаются экземпляры *Profusulinella* с муральными порами в стенке, что может свидетельствовать о каширском возрасте пород, этот фузулиноидный комплекс в целом определяет поздневерейский возраст. В общем данная фауна фузулиноидей вместе с другими фоссилиями, такими как брахиоподы и остатки растений, позволяет коррелировать верхи верейского горизонта Восточной Европы с вестфалом Б Западной Европы.

Ключевые слова: фораминиферы, фузулиноидеи, свита Сан Эмилиано, карбон, зона Profusulinella, Кантабрийские горы, Испания.

I. Introduction

The Villaman n Member (San Emiliano Formation) is a distinct unit of the Carboniferous System in the C rmenes Syncline (Sobia-Bod n structural unit, Cantabrian Mountains, N. Le n, NW Spain) (Fig. 1). In the Bernesga River valley, the upper part of the member contains a few thin limestone beds, in which foraminifers are common, or even abundant. The present paper deals with the fusulinoidean foraminifera and age of these limestones. The general age of the San Emiliano Formation, expressed in East European chronostratigraphic units, is Upper Baskhirian to Lower Moscovian (see Ginkel and Villa, 1996, for a compilation of biostratigraphic data).

The fossil content of the well-exposed uppermost 200 m of the Villaman n Member is of interest because of the possibility here to correlate the West European chronostratigraphic units with the East European one. The importance of this was evident after the investigations by Moore *et al*. (1971) on the marine fauna, in particular foraminifers, brachiopods, a few goniatites, and the associated continental flora. A recapitulation of the results regarding the age of the fossil flora and fauna of this uppermost part of the San Emiliano Formation was presented by Villa *et al*. (1988) and Ginkel and Villa (1996).

The first data of foraminifers from this member came from fusulinids (Ginkel, 1965) and was obtained from a sample collected by R. H. Wagner in the fifties in the Railway section, (locality L 353; Fig. 1 in the present paper). This data (top Bashkirian in Ginkel, 1965) was rejected by Schmerber (in Moore *et al*., 1971), and then also by others (compare with Wagner and Bowman, 1983, and Wagner *et al*. 1983).

The age of the microfaunas from L 353 is discussed again below (Chapter II), together with new materials from L 72, a new locality situated close to the hamlet of Barrio de la Tercia (Fig. 1). These new materials were presented by K. Maas in the early eighties and yielded specimens of the genera *Profusulinella*, *Eoschubertella*, *Pseudostaffella* and notably of *Aljutovella*, which are kept in “NCB Naturalis”, Museum of Natural History, Leiden, The

(*) Голландский микропалеонтолог Адриаан К. ван Гинкел ушел из жизни в сентябре 2013 г., оставив эту почти подготовленную к публикации статью. Несколько его коллег помогли завершить оригинальную рукопись для сдачи в печать.

Netherlands. The present initial study of these fusulinoidean foraminifers points to a Vereyan age (most probably a late Vereyan age) for the uppermost part of the Villaman n Member.

The final part of this paper (Chapter IV) deals with the correlations between West- and East Europe sequences, and is based on the fossils from the Villaman n Member.

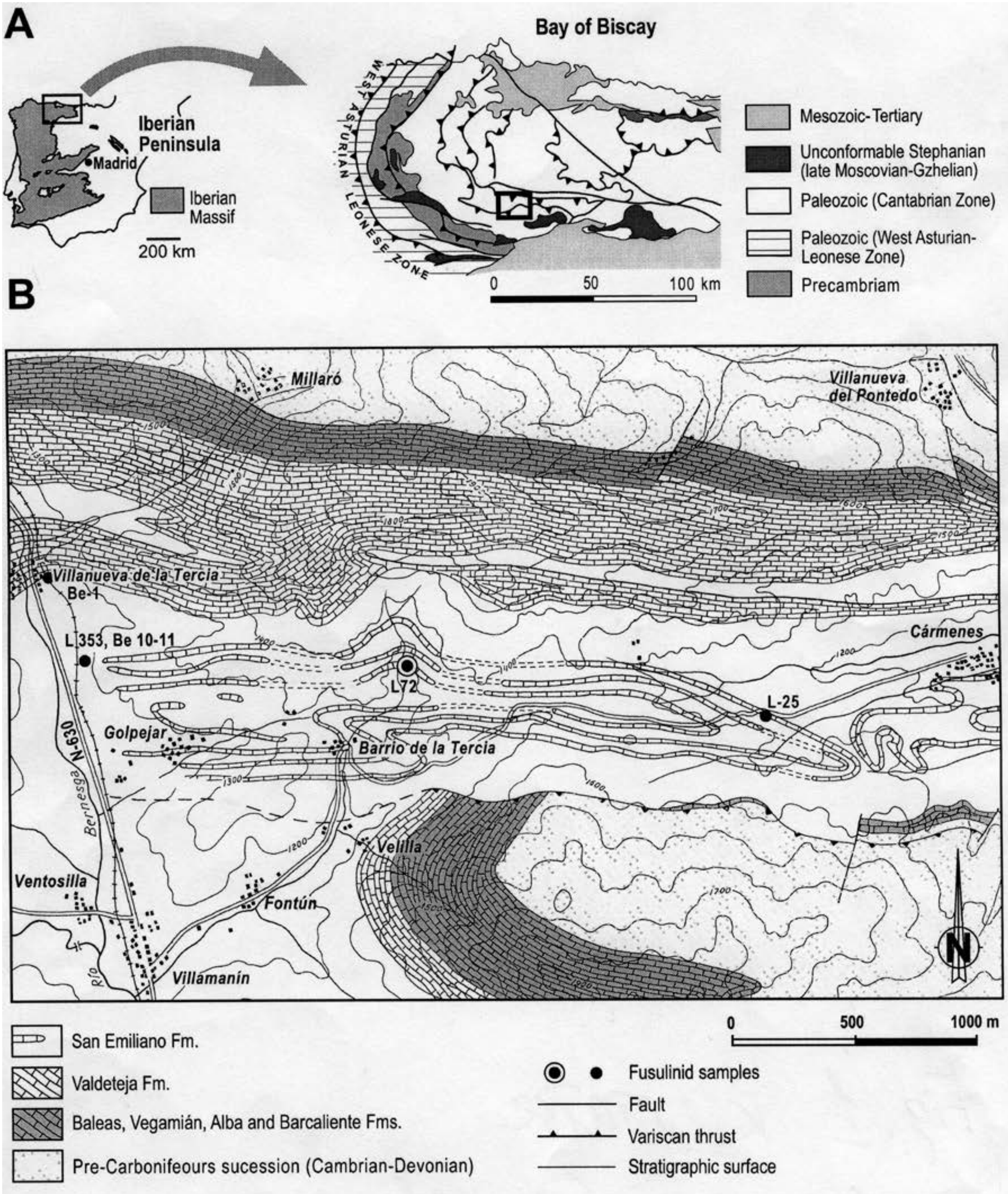


Figure 1
A) Geological sketch of the Cantabrian Zone (NW Spain) showing the location of the area enlarged below. B) Geological map of the Bernesga river valley near the village of Villaman n (northern part of the Le n province, Spain), showing the location of L72 and other relevant samples (after Ginkel, 1965, slightly modified)

II. The San Emiliano Formation

The San Emiliano Formation crops out in the Sobia-Bod n Structural Unit, Cantabrian Zone. This unit shows the prominent thrust folding and fault pattern of SW Asturias and N Le n regions and is distinct from the Central Asturian Coal Basin, the adjacent structural unit located to the north and east in the region of Asturias (Julivert, 1971).

At the heads of the Bernesga River valley (N Le n; Bod n subunit of the Sobia-Bod n Structural Unit), the Carboniferous succession may be subdivided into two ensembles (Fig. 2). The formations of the lower ensemble (Mississipian in age, except the upper part of the Barcaliente Formation) were deposited in a generally tectonically stable interval, have a wider distribution, and, on average, a lower rate of deposition than those of the upper ensemble.

The upper ensemble, Early to Mid- Pennsylvanian in age, represents a period of more severe tectonic intervals. The San Emiliano Formation clearly shows the features of this ensemble: it is typically thick (up to about 2000 m in the type-area of the San Emiliano valley) and rapidly deposited (Late Bashkirian up to Early Moscovian). Also the underlying Valdeteja Formation (Winkler Prins, 1968, 1971), deposited in roughly Bashkirian time, points to ensemble 2, as do also the lateral lithological transitions that may occur between the San Emiliano Formation and the Valdeteja Formation (Fern ndez, 1993).

The San Emiliano Formation consists of three members that, from base to top, are: “Villanueva” (named “Pinos” in the present paper to identify it with the Pinos Member of Bowman, 1982), “Caliza Masiva”, and “Villaman n” members (Fig. 2). The stratigraphic data of these units were mainly provided by Moore *et al*. (1971), Bowman (1982), Villa *et al*. (1988), and Fern ndez (1993). The following discussion is about the biostratigraphy of the middle and upper members.

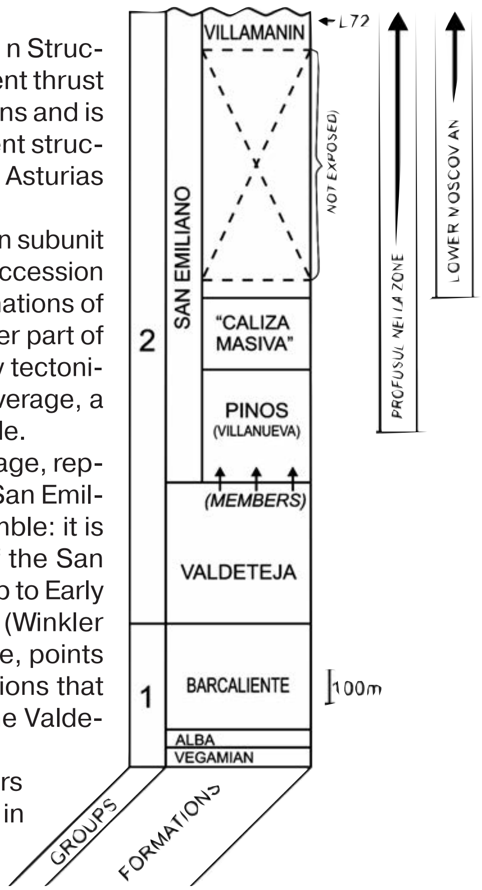


Figure 2
Scheme of the Carboniferous succession outcropping at the Bernesga river valley (N Le n). The top of the successon shows the exposed part of the Villaman n Member, including sampling locality L 72 (modified after Villa et al., 1988, fig. 1)

II.1 The Caliza Masiva Member

The Caliza Masiva Member is named after the *“caliza masiva”* (“massive limestone”) in the Asturian Ponga Nappes (Julivert, 1960). According to Fern ndez (1993), it is a lithosome and tongue of the Valdeteja Formation. The latter, studied by Winkler Prins (1968, 1971) in the Curue o River valley, is a relatively thick (up to 675 m) limestone unit, locally dolomitized, which underlies and is partly the lateral equivalent of the San Emiliano Formation. The investigations of the foraminifera by Villa *et al*. (1988, p. 340) and Ginkel and Villa (1996, p. 162, 164) have shown that the upper layers of the Caliza Masiva Member in the Bernesga River area contain numerous specimens of Archaediscidae as well as *Ozawainella* ex gr. *pseudorhomboidalis* of late Bashkirian (Asatausky) age. Therefore, the foraminifera of the Caliza Masiva in this locality do not contradict the Late Bashkirian to Early Moscovian age of the brachiopods identified by Mart nez-Chac n (1986, and *in* Villa *et al*., 1988). It is also of interest to note that, according to Horvath (in Villa *et al.,* 1988, p. 340), the microflora of the Caliza Masiva Member is most probably of Westphalian A age.

The boundary between the Caliza Masiva Member and the conformably overlying Villaman n Member yielded foraminifera at locality Be 1 that Schmerber (*in* Moore *et al*., 1971, text-fig. 5; p. 318-319, 333) considered of Early Moscovian (Kashirian) age. This age may be considered as probably too young, bearing in mind that, according to Lys (in Ivanova *et al*., 1978, p. 138), foraminifers from this same locality indicate either a Late Bashkirian or Early Moscovian age.

II. 2 The Villaman n Member

The highest unit of the San Emiliano Formation, the Villaman n Member, crops out poorly, with the exception of its uppermost part (Villa *et al.*, 1988, p. 339, fig.1), which is composed of mudstones, lenticular sandstone units, and, near the top, four limestone beds and two coal seams. This succession contains brachiopods, foraminifers and plants (miospores) that are of importance to establish the age of this member. Its main significance is that it represents the youngest preserved strata of the Sobia-Bod n Structural Unit.

Foraminifers were discussed by Ginkel (1965), Schmerber (in Moore *et al.*, 1971, p. 329, 331), Rumyantseva (in Wagner *et al.*, 1983, fig. 16, p. 35), Villa (in Villa *et al.*, 1988), and Ginkel and Villa (1996). The examination of these foraminifers resulted in quite different ages, ranging from the top Bashkirian to the lower Podolskian. Field data do not support such great differences in age. The brachiopods investigated by Winkler Prins (in Moore *et al.*, 1971), and by Mart nez-Chac n (1986) indicated ages that could be as young as late Kashirian or even early Podolskian. More recently, Mart nez-Chac n (in Villa *et al.*, 1988) lowered the maximum age of the brachiopod assemblage from the Kashirian to the Vereyan. Miospores investigated by Horvath (in Villa *et al.*, 1988) pointed to a Westphalian (middle B) age. This result roughly corresponds to previous microflora data obtained by Neves (in Moore *et al.*, 1971), although this author seemingly did not exclude the possibility of an early Westphalian C age for the uppermost strata of the Villaman n member.

III. Fusulinoideans of the Villaman n Member: taxonomy and age

III. 1 Taxonomy

This chapter starts with a list of fusulinoidean foraminifers identified from locality L 72 (Fig. 2). The list of species is followed by a brief description (measurements), discussion, and the possible chronostratigraphic positions of each of the taxa included. The foraminifers are illustrated in Plates 1-4.

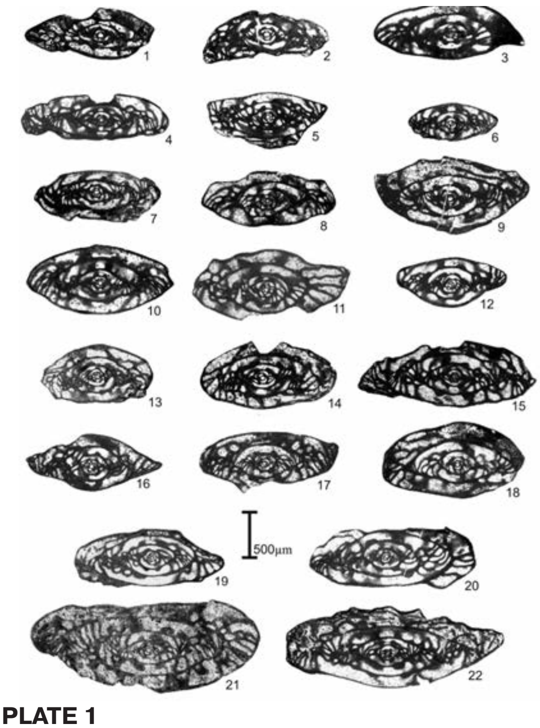


PLATE 1

Figs. 1-22. *Aljutovella* aff. *lazarensis* Sjerp, 1967. **1.** 14(1), **2**. 48(1), **3**. 39(2), **4**. 2(2), **5**. 29(2), **6**. 55(3), **7**. 52(1), **8**. 14(2). **9**. 85(1), **10**. 29(1), **11**. 2(3), **12**. 36(1), **13**. 70(1), **14**. 32(1), **15**. 86(3), **16**. 84(1), **17**. 78(1), **18**. 40(2), 19. 58(1), **20**. 54(3), **21**. 34(1), **22**. 20(1). Locality L72, Barrio de la Tercia

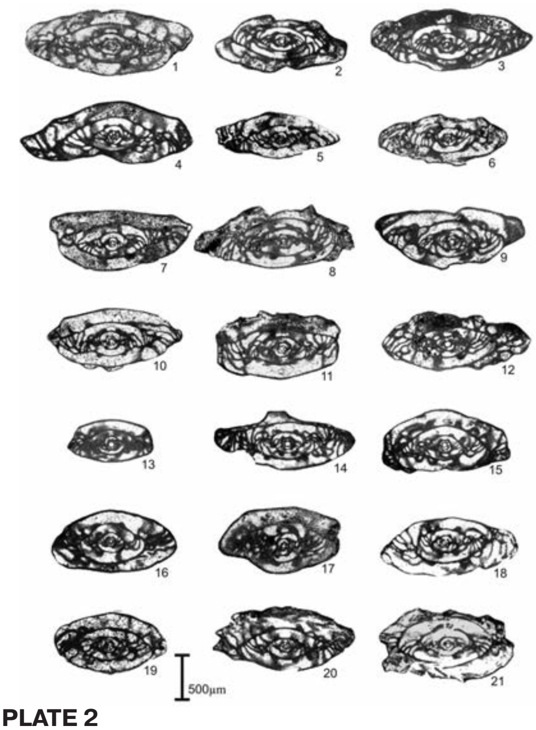


PLATE 2

Figs. 1-21: *Aljutovella* aff. *lazarensis* Sjerp, 1967. **1.** 16(1), **2**. 38(2), **3**. 79(1), **4**. 79(2), **5**. 30(1), **6**. 25(1), **7**. 72(1), **8**. 15(1), **9**. 43(1), **10**. 83(1), **11**. 24(1), **12**. 49(1), **13**. 62(1), **14**. 53(1), **15**. 55(2), **16**. 39(7), **17**. 41(1), **18**. 18(1), **19.** 33(1), **20**. 18(3), **21**. 18(2). Locality L72, Barrio de la Tercia

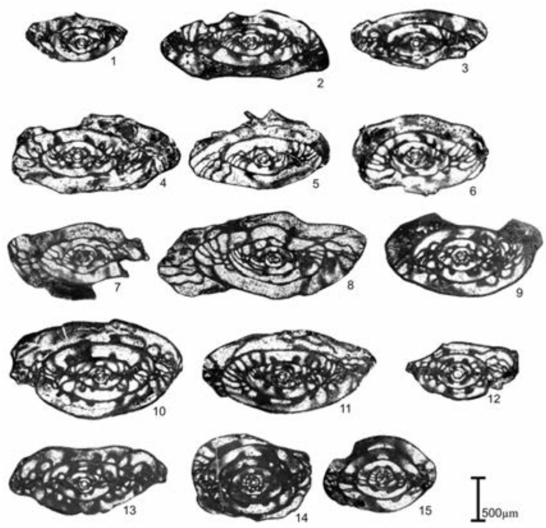
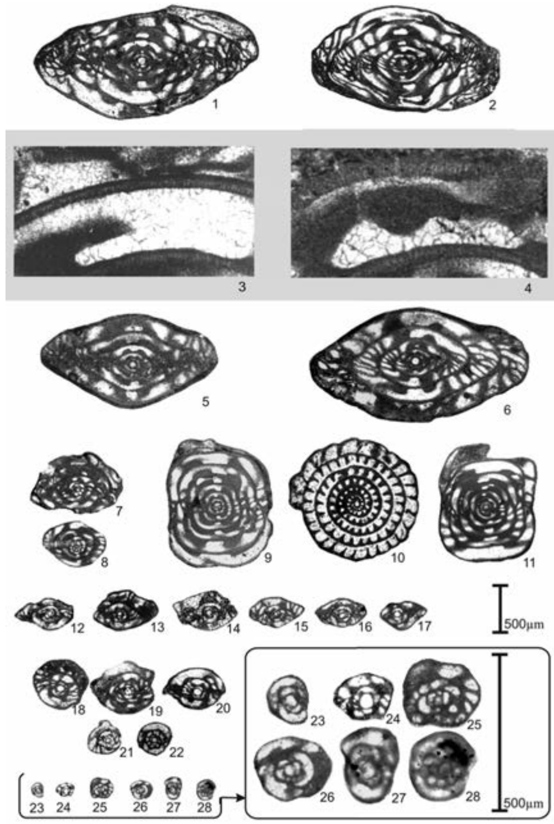


PLATE 3

Figs. 1-8: *Aljutovella* aff. *lazarensis* Sjerp, 1967. **1.** 30(2), **2**. 44(1), **3**. 22a(2), **4**. 22b(2), **5**. 47(1), **6**. 46(1), **7**. 18(4), **8**. 63(1). **Figs. 9-13:** *Aljutovella wagneri* Ginkel, 1965. **9**. 35(1), **10.** 22b(1), **11.** 23(1), **12.** 73(3), **13**. 1(9). **Figs 14-15**: *Profusulinella* ex gr. *prisca* (Deprat, 1912). **14**. 8(1)-80M72b, **15.** 27(1). Locality L72, Barrio de la Tercia

PLATE 4

Figs. 1-6: *Profusulinella* ex gr. *rhomboides* (Lee and Chen, 1930). **1.** 11(1)-80M72b, **2.** 2(1)-80M72b, **3** and **4.** 12-80M72b: display mural pores in two specimens, **5.** 2(1)-80M71, **6.** 4(1)-80M71. **Figs. 7-8:** *Profusulinella* cf. *parva* (Lee and Chen, 1930). **7.** 37**(**1**)**, **8.** 77(1). **Figs. 9-11**: *Pseudostaffella* cf. *quadrata* (Deprat, 1912). **9.** 4(1)-80M72b, **10.** 7(1)-80M72b (sagittal section) **11.** 13**(**1)-80M72b. **Figs. 12-17:** *Eoschubertella* cf. *glendalensis* Cassity and Langenheim, 1966. **12.** 54(6), **13.** 41(2), **14.** 48(3), **15.** 29 (3), **16.** 53(4), **17.** 53(5). **Figs. 18-20**: *Eoschubertella* ex gr. *texana* Thompson, 1947. **18.** 54**(**4), **19**. 56(3), **20**. 46(2). **Figs**. **21-22** : *Eoschubertella* cf. *obscura* (Lee and Chen, 1930) subsp. *mosquensis* (Rauzer 1951). **21**. 45(3), **22**. 6(2)-80M71. **Figs. 23-28:** *Eoschubertella* ex gr. *obscura* (Lee and Chen, 1930). **23**. 39(4), **24**. 86(1), **25**. 2(5), **26.** 2(6), **27**. 12(2)-80M71, **28**. 12(3)-80M71. Locality L72, Barrio de la Tercia



Numerical data with regard to description of foraminifers are abbreviated as follows:

N	number of (measured) specimens
Nr. wh.	number of whorls of test*
D(0)	diameter of proloculus**
D(4)	diameter of 4^{th} whorl
D	diameter of test
L/D	length/diameter of test
R.v.	radius vector of test
F. r.	form ratio of test (half-length/ radiusvector)
W. th. (p.)	wall thickness of penultimate whorl
W. th. (u.)	wall thickness of ultimate whorl

* The number of whorls of some specimens are presented by two consecutive counts, the last of which is between brackets and indicates the real and initial (that is greater) number of whorls. If specimens are damaged the measurements corresponding to the outermost whorl(s) can often not be presented in which case the measurements correspond to the first count, i.e. the smaller number of whorls.

** Measurements, such as for diameter, radius vector, proloculus, or wall thickness, are presented in microns (µm).

Foraminiferal taxa identified from locality L 72:
Aljutovella aff. *lazarensis* Sjerp, 1967 (spp.?)
Aljutovella wagneri Ginkel, 1965
Profusulinella ex gr. *prisca* (Deprat, 1912)
Profusulinella ex gr. *rhomboides* (Lee and Chen, 1930)
Profusulinella cf. *parva* (Lee and Chen, 1930)
Pseudostaffella cf. *quadrata* (Deprat, 1913)
Eoschubertella ex gr. *texana* Thompson, 1947
Eoschubertella cf. *glendalensis* Cassity and Langenheim, 1966
Eoschubertella cf. *obscura* (Lee and Chen, 1930) subsp. *mosquensis* (Rauzer, 1951)
Eoschubertella ex gr. *obscura* (Lee and Chen, 1930)

Aljutovella aff. *lazarensis* Sjerp, 1967 (spp.?)

Plate 1, figs. 1-22; Plate 2.

1967, *Aljutovella elongata* Rauzer-Chernousova and Safonova, 1951, subsp. *lazarensis* subsp. nov.; Sjerp, p. 89

Material: 51 axial sections (sample 80M72, locality L72).

Measurements:

	Nr.wh.	D(0)	D(4)	D	L/D	R. v.	F. r.	W.th. (p.,	u.)
m	4.10	50	635	686	2.34	383	2.10	19	17
S	0.53	11	78	138	0.28	75	0.23	3.5	3

m = mean; s = standard deviation; n = 51 (number of specimens).

Description: From the first to the fifth whorl, the test changes from nautiloid (1st wh.), spherical or ovoid (2nd wh.), short fusiform or subrhomboidal (3rd wh.) to fusiform or fusiform to subrhomboidal (4-5th whorl). The number of whorls is commonly 4-4.5, rarely 5-5.5. The more loosely coiled specimens, with a relatively wider last whorl, generally show a smaller form ratio, weaker chomata, and a relatively thinner wall in the outer whorls. The first whorl is usually skew-coiled (up to 90°). The septa are irregularly folded; regular septal loops along the lateral slopes are not common and, if present, are few in number and relatively large and irregular. Septal folding is moderately intense at the poles and extends along the lateral slopes sometimes up to the chomata. The chomata are usually low or moderately high and narrow. The tunnel path is symmetrical; on average about 60°, ranging from 35-85°. The wall is relatively thin and consists of the protheca overlain by the upper tectorium. The upper tectorium is about as thin as the protheca and only locally present, observed notably in the central area between the chomata.

Comparison and Remarks: The most similar taxon to the present form is *Aljutovella elongata* (Rauzer-Chernousova) subsp. *lazarensis* Sjerp, 1967 from the L zaro Limestone Lens of the Bele o Formation (NE Le n), which differs from both *Aljutovella elongata* (Rauzer-Chernousova, 1938) and the probably closely related genotype *Aljutovella aljutovica* (Rauzer-Chernousova, 1938) in exhibiting fewer and somewhat wider whorls and less intense and more irregular septal folding extending over a larger part of the lateral slopes. This subspecies proposed by Sjerp (1967) is here elevated to species level. The present related species from locality L 72 differs from *Aljutovella lazarensis* in its often distinctly skew inner whorls, a smaller average value of the radius vector of the proloculus and the inner two whorls, and a higher percentage increase of the radius vector of inner whorls (more loosely coiled). The form ratio is slightly smaller throughout growth. Its thin, two or three-layered wall differs from the occasionally four-layered wall (displaying a weakly differentiated diaphanotheca) of *Aljutovella lazarensis* (compare with Sjerp, 1967; p. 89). The variation of the present population is considerably large and one may indeed wonder if only one species is involved in the present assemblage. This taxon is by far the most common fusulinoidean foraminifer of the Villaman n locality. Its high variability is probably the result of an environment of shallow marine, near-shore currents, which could have caused a mixture of specimens from related populations of a single species (the limestone is crowded with bioclasts). It should be noted that specimens of the present species are often damaged in the outer whorl(s) and collisions of specimens sometimes resulted, as it seems, by partially entering one specimen into another.

Other similar species are *Aljutovella pseudoelongata* Sheng, 1958, and *A. venusta* Sheng, 1958, which were reported from the Moscovian (lower Vereyan?) *Eostaffella subsolana* zone in the Hsiaoshih (=Xiaoshih) limestone of the lower Penchi series, North China. Also similar are *Aljutovella dagmarae* Safonova, 1951 and *A. pseudoaljutovica* Rauzer, 1951, both reported in Rauzer-Chernousova *et al*. (1951) from the Russian Platform area and found in uppermost Kayalian [= upper Upper Bashkirian] and Lower Moscovian (Vereyan) strata. Most similar is perhaps the Russian Platform species *Aljutovella devexa* Safonova (in Rauzer-Chernousova *et al*., 1951), which occurs in upper Vereyan but notably also in lower Kashirian strata. This latter species is more advanced with respect to its wall structure displaying a (thin) diaphanotheca.

The above-mentioned taxa similar to *Aljutovella* aff. *lazarensis* Sjerp, 1967 indicate a top Upper Bashkirian to Lower Moscovian (lower Kashirian) chronostratigraphic level.

Aljutovella wagneri Ginkel, 1965

Plate 3, figs. 9-13.

1965, *Aljutovella wagneri* sp. nov.; Ginkel, p. 125, pl. XXIX.

Material: 9 axial sections (sample 80M72, locality L72).

Measurements:

Range and average (N=9):

Nr.wh.	D(0)	D	L/D	R. v.	F. r.	W. th.
3.5-5	60-109	735-1200	1.80-2.35	405-660	1.63-2.09	15-37
4.3	78	951	2.02	523	1.84	24

Type material (Villaman n Member at locality L 353)

Range and average (N=21):

Nr.wh.	D(0)	D	L/D	R. v.	F. r.	W. th.
3.5-5	54-110	–	–	289-710	1.46-.37	13-32
4.2	86			493	1.91	22.5

Comparison and Remarks: *Aljutovella wagneri* specimens from the present locality L 72 and from the type locality L 353 are considered conspecific despite the differences in the measurements presented above for the two localities. The only more important difference is possibly the wall structure, which often exhibits a wall of four layers including a diaphanotheca and a thin lower tectorium in the type material, whereas at locality L 72 the wall seems more primitive: only three layers have been observed. Typical is the relatively large and rather regular folding which distinguishes this species from the associated *Aljutovella* aff. *lazarensis* Sjerp, 1967. The septal loops usually extend along the lateral slopes up to the tunnel except in the innermost two whorls, which show plane septa or weak folding restricted to the poles.

The most similar species to this form are *Aljutovella eoaljutovica* Safonova (in Rauzer-Chernousova *et al*., 1951), *Aljutovella succincta* Sheng, 1958, and *Hemifusulina concepta* Chernova, 1961. These three species all exhibit relatively regular septal folding reminiscent of *Hemifusulina*. However, it should be noted that typical *Hemifusulina* display a four-layered wall pierced by simple (straight) pores, even more regular and intense folding, and a tighter coiled fusiform shape. *Aljutovella wagneri* seems to be less related to typical *Hemifusulina* than to the type species of *Aljutovella* [=*Aljutovella aljutovica* (Rauzer, 1938)]. Still, it is quite possible that species similar to *Aljutovella wagneri* evolved to early species of *Hemifusulina* ex gr. *communis* Rauzer (in Rauzer-Chernousova *et al*., 1951). With respect to intensity and regularity of septal folding, *Aljutovella wagneri* is very similar to *Hemifusulina concepta*. Yet, *Hemifusulina concepta* is a smaller and a more slender species. *Aljutovella eoaljutovica* exhibits a more rhomboidal shape and have smaller proloculus, more volutions, and slightly smaller diameter of inner whorls. *Aljutovella succincta* is a smaller species and the septal folding seems to be less regular and less intense.

The following table of measurements presents a comparison of these similar species with *Aljutovella wagneri*.

	Nr.wh	D(0)	D(4)	D	L/D	W.th.
Aljutovella eoaljutovica	5-6.5	35-90	490-820	1130-1200	1.9-2.1	15-30
Hemifusulina concepta	3.5-5	41-83	470-670	500-870	2.6-2.9	20-32
Aljutovella succincta	4-5	70-90	520-710	520-880	1.7-2.3	–
Aljutovella wagneri (L 72)	3.5-5	60-109	600-895	735-1200	1.8-2.4	15-37
Aljutovella wagneri (L 353)	4-5	54-110	–	–	–	18-32

Aljutovella eoaljutovica and *Hemifusulina concepta* were reported from the lower part of the Vereyan (Rauzer-Chernousova *et al.,* 1951; Chernova, 1961). The Chinese *Aljutovella succincta* occurs in the lower Penchi series in the same biozone as *Verella prolixa* (Sheng, 1958), which suggests an age not younger than the basal part of the Vereyan.

Profusulinella ex gr. *prisca* (Deprat, 1912)

Plate 3, figs. 14, 15.

Material: two axial sections (samples 80M72b and 80M72, locality L72).

Measurements:

Specimen	Nr.wh.	D(0)	D(4)	D	L/D	Rv	Fr	W. th.	(p.,u.)
8(1)-80M72b	5(6)	58	593	900	1.48	480	1.39	30	19
27(1)-80M72	5	–	653	975	1.46	510	1.40	–	–

Comparison and Remarks: The two available specimens differ from *Profusulinella prisca* (Deprat, 1912) (Moscovian; Indo-China) in test shape, which seems less subrhomboidal (more ovoidal) in the present specimens. In addition, there is septal folding at the poles of outer whorls, apparently absent in the single axial section presented by Deprat (1912, pl. 4, fig. 11) but clearly present in the Russian specimens of *Profusulinella prisca* (Deprat, 1912) in Rauzer-Chernousova *et al*. (1951, pl. XV, figs. 1-4). In fact, the rather intense folding at the poles of the outer two whorls illustrated in Plate 3, fig. 14 is reminiscent of the genus *Aljutovella*. The diameter of the proloculus and consecutive whorls [D(0), D(4), D(5)] of the present two specimens in comparison with Deprat's (1912) type specimen is also slightly larger but the maximum diameter is closely the same being about 1250 µm (versus 1280 µm in the type specimen). It is of interest also that Deprat (1912) reported fine mural pores in the spirotheca, which are also observed in the outer whorls of the present material. Two other similar species are the quite variable *Profusulinella sitteri* Ginkel, 1987 [e.g. figs. 7(27), 8(13), 8(20)] and the somewhat smaller *Profusulinella terskeica* Dzhentchuraeva, 1979.

These three similar forms were originally reported from strata of Early Moscovian age; their range was initially presented as Vereyan for *Profusulinella sitteri* and Vereyan-Kashirian for *Profusulinella prisca* in Rauzer-Chernousova *et al*. (1951) and for *Profusulinella terskeica*.

Profusulinella ex gr. *rhomboides* (Lee and Chen, 1930)

Plate 4, figs. 1-6.

1996, *Profusulinella* sp.; Ginkel and Villa, pl. 22, figs. 11, 13.

Form 1 (Plate 4, figs. 1-4)

Material: two axial sections (sample 80M72b, L72; Plate 4, figs. 1, 2) and two sections of the spirotheca (sample 80M72b, L72; Plate 4, figs. 3, 4).

Measurements:

Specimen	Nr.wh.	D(0)	D(4)	D	L/D	R. v.	FF. r	W. th.	(p., u.)
11(1); Pl. 4, fig. 1	5.5(6)	92	735	1170	2.10	630	11.9	30	22
2(2); Pl. 4, fig. 2	5(5.5)	94	870	1140	1.81	615	11.6	34	36

Form 2 (Plate 4, figs. 5, 6)

Material: two axial sections (sample 80M71, L72).

Measurements:

Specimen	Nr. wh.	D(0)	D(4)	D	L/D	R. v.	F. r	W. th.	(p., u.)
2(1); Pl. 4, fig. 5	4.5	81	833	1035	1.88	540	1.81	26	–
4(1); Pl. 4, fig. 6	5	90	840	1230	–	653	–	30	26

Comparison and Remarks: Two forms are distinguished among the specimens assigned here to *Profusulinella* ex gr. *rhomboides* (group name in the sense of Rauzer-Chernousova *et al.*, 1951). The difference between them is that form 1 usually shows mural pores in the outer two whorls, whereas pores are absent in form 2. Anyway, as they share the rest of features, the two forms are considered to be conspecific. The present species occurs also in the Railway section (locality L 353). The first form, including one of the present axial sections with mural pores, was discussed and illustrated in Ginkel and Villa (1996, pl. 22, figs. 11, 13; pl. 23, figs. 3–6). The shell shape is subrhomboidal and occasionally displays slightly concave lateral sides. The septa at the polar ends of the outer two whorls are very tightly and irregularly folded; arches (also known as loops) cannot be distinguished. The chomata are moderately wide in the inner whorls and relatively narrow in the outer whorls; they are wedge-shaped or (sub)symmetrical in the outer whorls and moderately high throughout growth. The juvenarium is planispiral.

Related species are *Profusulinella pararhomboides* Rauzer and Beljaev, 1936, *P. postpararhomboides* Dzhentchuraeva, 1979, *P. rhombiformis* Brazhnikova and Potievska, 1948, *P. rhombiformis* subsp. *nibelensis* Rauzer in Rauzer-Chernousova *et al.*, 1951 and *P. rhombiformis* var. *ferganensis* Bogush, 1963. The present taxon is possibly a new subspecies of *Profusulinella rhombiformis*. Some subrhomboidal species of *Aljutovella* are also similar, such as *Aljutovella acuminulata* Dzhentchuraeva, 1979 and the younger (Kashirian) *Aljutovella cafirniganica* Bensh, 1969. These similar and supposedly related species of the genus *Aljutovella* do not exhibit regular septal loops, but have in common with the present species the intense and irregular plication at the poles. One of the most similar taxa, *Profusulinella rhombiformis* subsp. *nibelensis* Rauzer, 1951, was reported to occur in and just below Vereyan beds. It is important to note that mural pores in the spirotheca of the genus *Profusulinella* were uncommon in Vereyan forms but, according to Solovieva (1955), these pores occasionally occur in specimens of the genus *Profusulinella* of Kashirian age.

On the basis of the similarity with the above mentioned taxa, the age of the upper part of the Villaman n Member at locality L 72 could be as low as upper Upper Bashkirian (maximum age) or as high as Kashirian (minimum age).

Profusulinella cf. *parva* (Lee and Chen, 1930)

Plate 4, figs. 7, 8.

Material: two axial sections (sample 80M72, locality L72).

Measurements:

Specimen	Nr. wh.	D(0)	D(4)	D*	L/D	R. v.*	F. r.	W. th.	(p.,u.)
37(1); Pl. 4, fig. 7	3.5 (4.5)	45	–	495	1.45	278	1.30	20	–
77(1); Pl. 4, fig. 8	4-4.5	–	488	540	1.33	293	1.23	19	–

Comparison and Remarks: A quite similar species to the examined form is *Profusulinella parva* (Lee and Chen, 1930) from the Lower Huanglung Limestone (China). Also similar is an specimen from the Perapert limestone/shale unit identified as *Profusulinella* cf. *parva* and considered of Vereyan age (Ginkel, 1965, locality P 70, p. 109), and *Profusulinella parva*

* The diameter and the radiusvector of whorl 4.5 of the damaged specimen 37(1) are estimated to be no less than 700 µm and 390 µm respectively.

from uppermost Bashkirian, Vereyan and Kashirian strata reported by Rauzer-Chernousova *et al*, (1951, p. 157). The forms compared with or identified as *Profusulinella parva* differ from the present species in that they exhibit slightly more whorls and a slightly smaller L/D ratio. *Profusulinella* sp. A of Toriyama (1958, p. 35; pl. 1, figs. 20, 21) and *Profusulinella toriyamai* Sada, 1961, which are most probably conspecific, are most similar to the present species. Slightly less similar to, and definitely younger than the present Spanish species, is *Profusulinella ohioensis* Douglass, 1987 from the Upper Atokan beds of North America (USA), which differs in a more rounded shell, slightly more whorls and a larger proloculus.

Pseudostaffella cf. *quadrata* (Deprat, 1913)

Plate 4, figs. 9-11.

Material: 4 axial sections, 1 sagittal section (sample 80M72b).

Measurements:

Axial sections	Nr. wh.	D(0)	D(4)	D	L/D	R. v.	F. r.	W. th.	(p., u.)
Specimen									
15(1)	5	101	878	1200	0.83	638	0.78	29	28
5(2)	4(4.5)	97	653	653	1.03	353	0.96	15	–
13(1); Pl. 4, fig. 11	6.5	66	623	1375	0.81	705	0.78	29	–
4(1); Pl. 4, fig. 9	6.5(7)	54	615	1300	0.90	698	0.84	34	28
Specimen									
7(1); Pl. 4, fig. 10	6.5	71	765	1455		780		28	–

Septal count per whorl	1st	2nd	3rd	4th	5th	6th
7(1); Pl. 4, fig. 10	8	13	15	21	22	28

Description: The outer whorls of the two figured axial sections are subrectangular, display a straight periphery and very weak concavities at the axial ends. These two axial sections and one sagittal section (Plate 4, figs. 11, 9, 10) have small proloculi (54-71 µm), slightly skew innermost whorls and a large number of whorls (6.5-7). Specimens 15(1) and 5(2), not figured here, have a larger proloculous and a somewhat looser coiling than the rest of the collection. The chomata are well-developed, wide and fairly high in the inner whorls, becoming relatively narrower and lower in the outer whorls. The tunnel angle is small in the inner whorls but becomes rapidly larger in the outer whorls; its path becomes slightly more irregular in the outer two whorls. The wall structure apparently consists of three layers including the upper tectorium and the protheca; the latter consists of a tectum and a thicker, relatively clear layer below it. This structure is reminiscent of *Profusulinella*.

Comparison and Remarks: The present species differs from the perhaps most similar species *Pseudostaffella quadrata* (Deprat, 1913) in the latter having a larger diameter, 1560 µm, whereas the diameter of the present sagittal section is 1455 µm and of one of the axial sections is up to 1375 µm (see table of measurements). This agrees with the slightly lower number of whorls (5-7) in the present material as compared with the two sections of 7 whorls in *Pseudostaffella quadrata*. Moreover, the present species have a smaller L/D ratio on average and the chomata are better developed. Another related, but more remotely similar, Eurasian species is *Pseudostaffella latispiralis* Kireeva (in Rauzer-Chernousova *et al.*, 1951); it has a smaller diameter and smaller diameter per whorl, a smaller L/D ratio and possibly a more rounded periphery. Of the species from North America, the most similar is the rather variable Canadian species *Pseudostaffella ettrainensis* Ross, 1967.

The ages reported originally for these most similar species are: probably Moscovian for *Pseudostaffella quadrata* and Upper Moscovian for *Pseudostaffella ettrainensis*. The less similar *Pseudostaffella latispiralis* was initially reported to range from upper Upper Bashkirian to Upper Moscovian, and is most frequently present in upper Upper Bashkirian and Lower Moscovian (Vereyan and Kashirian) strata (Kireeva in Rauzer-Chernousova, 1951).

Eoschubertella ex gr. *texana* Thompson, 1947

Plate 4, figs. 18-20.

Material: three axial sections (sample 80M72, locality L72).

Measurements:

Specimen	Nr. wh.	D(0)	D(3)	D	L/D	R. v.	F. r.	W. th.	(p., u.)
54(4); Pl.4, fig.18	2-2.5	84	–	570	1.16	345	0.96	13	15
56(3); Pl.4, fig.19	3.5	84	469	600	1.32	330	1.20	23	–
46(2); Pl.4, fig.20	2.5	81	–	460	1.39	270	1.19	20	19

Comparison and Remarks: This species is very similar to the species described in Ginkel (1965) from locality L 353 (Railway section) as *Schubertella* cf. *pseudoglobulosa* Safonova in Rauzer-Chernousova *et al*., 1951, but it resembles the North American *Eoschubertella texana* Thompson, 1947 even more. *Eoschubertella texana* displays a rather rounded median area which it shares with the Villaman n specimens from the localities L 353 and L 72. The specimens from L 353 and L 72 differ from *Eoschubertella pseudoglobulosa* and *E. texana* in their somewhat larger L/D ratio (up to 1.4 versus up to 1.2 in the other two species). Very similar is also *Eoschubertella* sp. A from Japan (Toriyama 1958, p. 27, 28, pl. 1, figs. 15, 16). The two most similar species, *Eoschubertella texana* and the Japanese form, were originally described from strata which may correlate with some level not below the upper Upper Bashkirian and not above the lower Kashirian. The Russian species *Eoschubertella pseudoglobulosa* (Safonova) was originally reported from the Kashirian.

Eoschubertella cf. *glendalensis* Cassity and Langenheim, 1966

Plate 4, figs. 12-17.

Material: 6 axial sections (sample 80M72).

Measurements:

Specimen	Nr. wh.	D(0)	D(3)	D	L/D	R. v.	F. r.	W. th.	(p., u.)
Form 1									
48(3); Pl. 4, fig. 14	3	64	431	431	1.75	248	1.54	13	15
41(2); Pl. 4, fig. 13	3	57	450	450	1.69	255	1.45	17	–
Form 2									
54(6); Pl. 4, fig. 12	3	47	375	375	1.77	195	1.75	11	–
53(5); Pl. 4, fig. 17	2.5	75	–	345	1.69	203	1.46	9	–
Form 3									
29(3); Pl. 4, fig. 15	3	49	368	368	1.76	195	1.55	13	15
53(4); Pl. 4, fig. 16	2.5	70	–	330	1.85	191	1.47	19	15

Comparison and Remarks: Three forms are distinguished among the specimens examined. Specimens 48(3) and 41(2) (Form 1) of the table display a relatively wide last half whorl. Because of this wider whorl they are reminiscent of *Eoschubertella majiaobensis* (Chang, 1964) but differ in being smaller and having a larger L/D ratio. Specimens 54(6) and 53(5) (Form 2) may be juvenile forms of Form 1. Specimens 29(3) and 53(4) (Form 3) are slightly smaller than Form 1 and resemble especially *Eoschubertella fusiformis* (Rui, 1983) from the *Profusulinella parva* Zone of the Quanwangtou Limestone in Jiangsu, China, *Eoschubertella porrecta* (Ivanova, 2000) reported from the Asatausky Horizon (Upper Bashkirian) in the Urals, and *Eoschubertella glendalensis* Cassity and Langenheim, 1966 reported from Desmoinesian strata of the Arrow Canyon in Nevada, U.S.A. This species is also somewhat similar to *Eoschubertella obscura* (Lee and Chen, 1930) and *E. obscura penchiensis* (Sheng, 1958), but has have less rounded poles and a more fusiform shell as well as a larger diameter of shell and larger diameter for corresponding whorls (D = 300-340 µm).

The combined chronostratigraphic range of the three most similar species (i.e. *Eoschubertella glendalensis, E. fusiformis* and *E. porrecta*) expressed in Russian chronostratigraphic units is the Upper Bashkirian to Upper Moscovian.

Eoschubertella cf. *obscura* (Lee and Chen) subsp. *mosquensis* (Rauzer, 1951)

Plate 4, figs. 21, 22.

Material: two axial sections (sample 80M71, specimen 6(2); sample 80M72, specimen 45(3).

Measurements:

Specimen	Nr. wh.	D(0)	D(3)	D	L/D	R. v.	F. r.	W. th.	(p., u.)
6(2); Pl. 4, fig. 22	3 (3.5)	60	360	360	1.00	207	0.87	–	10
45(3); Pl. 4, fig. 21	2.5	56	–	368	1.10	225	0.90	7.5	11

Comparison and Remarks: The two sections of the present taxon are most similar to the small *Eoschubertella obscura* subsp. *mosquensis* (Rauzer) (in Rauzer-Chernousova *et al*., 1951). The diameter of the present form is slightly larger than that reported for the subspecies, which is 230-330 μm and rarely up to 370 μm. The L/D ratio of the present two specimens (1.0-1.1) conforms to the values of the Upper Bashkirian to Vereyan forms of this subspecies and is smaller than the ratio in Kashirian forms (= 1.2 or even higher) (Rauzer in Rauzer-Chernousova *et al*., 1951). The subspecies was reported to be common in the Upper Kayalian (about Upper Bashkirian) and the Vereyan but rare in the Lower Kayalian and the Kashirian (Rauzer-Chernousova *et al*., 1951, p. 72). Another similar species is the Lower Moscovian (mainly Vereyan) *Eoschubertella ishii* (Lebedeva in Grozdilova *et al*., 1975). Less resembling are *Eoschubertella pauciseptata* subsp. *diversa* (Kireeva, 1949), *Eoschubertella bluensis* Ross and Sabins, 1965 and *Eoschubertella rotunlata* Ross, 1978.

Eoschubertella ex gr. *obscura* (Lee and Chen, 1930)

Plate 4, figs. 23-28.

Material: 6 axial sections [sample 80M72: specimens 39(4), 86(1); 2(5), 2(6); sample 80M71: specimens 12(2), 12(3)].

Measurements:

Specimen	Nr. wh.	D(0)	D(3)	D	L/D	R. v.	F. r.	W. th.	(p., u.)
39(4); Pl. 4, fig. 23	2	46	–	165	0.84	86	0.80	5	6
86(1); Pl. 4, fig, 24	2	79	–	225	1.12	154	1.00	13	12
2(5); Pl. 4, fig. 25	3	34	270	270	0.98	139	0.95	8	9
2(6); Pl. 4, fig. 26	2.5	43	–	229	1.15	131	1.00	7	8
12(2); Pl. 4, fig. 27	2.5	56	–	225	0.79	143	0.70	6	8
12(3); Pl. 4, fig. 28	2.5	47	–	248	0.85	137	0.77	6	7

Comparison and Remarks: The present taxon is very small. Its diameter is a mere 165 to 270 μm and in this respect is between *Eoschubertella obscura* subsp. *compressa* (Rauzer) (in Rauzer-Chernousova e*t al.,* 1951) from the Moscow Basin, which has a diameter of 250-330 μm, and the even smaller specimens of *E*. *obscura* subsp. *compressa* from the central part of the Moscow Basin which have a diameter of 150-220 μm. The most conspicuous difference is the smaller proloculum and the greater number of volutions (= 3-5) of the Russian subspecies. It occurs in Upper Moscovian (Podolskian and Myachkovian) strata and is rare in the Lower Moscovian (Kashirian).

Even more similar could be some North American species such as *Schubertina circulus* Marshall, 1969 (D = 230-270 μm) and *S*. *circulus* subsp. *compacta* Marshall, 1969 (D = 210-290 μm), both from Nevada. *Schubertina* Marshall, 1969 occurs mainly in the *Fusulinella* Zone and the *Fusulina* Zone, which is definitely in younger strata than the Villaman n Member. Another similar but slighly larger species (D = 300 μm) is *Eoschubertella rotunlata* Ross, 1978 from Canada, which also has a slightly larger proloculus (60-80 μm) and a subglobose form with a less variable form ratio. This Canadian species occurs in strata which are considered to be of early Moscovian age (Ross and Bamber, 1978).

The total range of the three similar species, probably all assignable to the *Eoschubertella obscura* group, is the Moscovian, from the Vereyan/Kashirian up to as high as the Myachkovian.

III. 2 The age of the upper part of the Villaman n Member. Previous data

Data obtained from research concerning the age of the foraminifers (mainly Fusulinoidea) from the upper part of the Villaman n Member of the San Emiliano Formation varied from latest Bashkirian (Ginkel, 1965) to late Kashirian or early Podolskian (Schmerber in Moore *et al*., 1971). The age given by Ginkel (1965) was mainly based on the new species *Aljutovella wagneri*.

Schmerber (in Moore *et al*., 1971) emended the age of locality L 353 given by Ginkel (1965). His investigations of the foraminifers from the sampling localities BE 10 and BE 11 (collected from the same stratigraphic interval as locality L 353) resulted in a notably younger age: either late Kashirian or early Podolskian. This much younger age (in comparison with the latest Bashkirian age of Ginkel, 1965) was apparently based mainly on the presence of *Fusulinella bocki* var. *delepinei* G bler (in Del pine, 1943) and *Fusulinella praebocki* Rauzer (in Rauzer-Chernousova *et al.*, 1951). The presence of the genus *Fusulinella* would point to strata not older than Kashirian. However, this "variety" of *Fusulinella bocki,* or any other *Fusulinella,* was neither found at locality L 353 of the Railway section, nor at locality L 72 (close to Barrio de la Tercia) studied in the present paper. According to Wagner and Bowman (1983, p. 150), Schmerber's conclusions (in Moore *et al*., 1971) regarding identification and age of the foraminifers of the Railway section at locality L 353, were supported by several Russian specialists. The generic assignment of *Aljutovella wagneri* Ginkel, 1965 was also questioned by Dr. M. N. Solovieva (Carboniferous Congress, Moscow 1975, personal communication), who considered this form as possibly being a *Hemifusulina* species. Indeed, a typical species of *Hemifusulina* is never older than Moscovian.

A quite different conclusion was reached by Rumyantseva in Wagner *et al*. (1983; p. 35, fig. 16). From samples BE 6, BE 7, and BE 8 (Railway section, same interval as locality L 353) and from locality 2155 (very top of the section), she identified species of notably *Profusulinella* and *Aljutovella*, but no species at all of the more advanced and usually younger *Fusulinella* and *Hemifusulina*. She also considered that the assemblages in these samples should be regarded as of Early Moscovian (Vereyan) age.

Villa (in Villa *et al*., 1988) collected new samples from the Railway section and considered the foraminiferal assemblages as of late Vereyan age, which confirms the conclusion of Rumyantseva (in Wagner *et al*., 1983). From her material, Villa mentioned the presence of the late Vereyan species *Aljutovella artificialis* Leontovich (in Rauzer-Chernousova *et al*., 1951). After reexamination of these samples, Ginkel and Villa (1996) confirmed the late Vereyan age.

III. 3 The age of the present locality L 72 near Barrio de la Tercia

The present investigation of the fusulinoidean foraminifers from locality L 72 has resulted in the identification of a number of taxa listed at the beginning of chapter III.1. This list and the list of foraminifers from locality L 353 at the Railway section of Rumyantseva in Wagner *et al*. (1983, fig. 16) show a striking similarity in that species of the Kashirian to Myachkovian genera *Fusulinella*, *Hemifusulina* and *Taitzehoella* are absent from both. Present at locality L 72 are species of the genera *Aljutovella*, *Profusulinella*, *Pseudostaffella* and *Eoschubertella*. The significance of these latter genera for establishing the age of locality L 72 is as follows:

Aljutovella. – Rauzer-Chernousova *et al*. (1951), in their introduction of the new genus *Aljutovella* Rauzer*,* distinguished Vereyan from Kashirian *Aljutovella* species partly by a difference in wall structure. The Vereyan species would be three-layered as in *Profusulinella* (a two-layered protheca and an upper tectorium), but outer whorls of Kashirian species would usually be four-layered (as a result of the presence of a primordial diaphanotheca and a lower tectorium below it as in primitive *Fusulinella*). Moreover, the wall of Kashirian species might occasionally be finely porous (compare with Rauzer-Chernousova *et al*., 1951; fig. 8, p. 21). The *Aljutovella* population from locality L 72 included neither forms with a primordial diaphanotheca nor those with mural pores. On the other hand, a weakly differentiated diaphanotheca was observed occasionally in *Aljutovella wagneri* reported by Ginkel (1965) from locality L 353

(Railway section). The abundant *Aljutovella* aff. *lazarensis* at locality L 72 is similar to a number of Vereyan species but is also similar to *Aljutovella devexa* Safonova (in Rauzer-Chernousova *et al.*, 1951), a species ranging from the upper Vereyan (rare) to the lower Kashirian (common). Safonova described the wall structure of *Aljutovella devexa* as locally differentiated into four layers, including a very thin, hardly discernable, diaphanotheca. Because the present *Aljutovella* specimens from locality L 72 do not even have primordial diaphanotheca, *Aljutovella* aff. *lazarensis* should be considered less evolved in this respect than *Aljutovella devexa* and *Aljutovella wagneri*. The evolutionary stage of the two *Aljutovella* species at locality L 72 indicates a Vereyan age, more likely a late Vereyan age, but not an early Kashirian age. Moreover, lower Kashirian levels are marked by the appearance of such advanced *Aljutovella* as, for instance, *Aljutovella priscoidea* (Rauzer, 1938) and *Aljutovella znensis* Rauzer (in Rauzer-Chernousova *et al.,* 1951), which are absent in the samples from locality L 72.

Profusulinella. – With regard to the three species of *Profusulinella* listed (Fig. 3), their association indicates levels from the upper part of the Upper Bashkirian to Kashirian (see ranges of species of these groups in Rauzer-Chernousova et al., 1951). Thin mural pores, rare in the genus *Profusulinella*, were observed in two of the species, i.e. *Profusulinella* ex gr. *prisca,* and, especially, *P*. ex gr. *rhomboides*. Considering this wall structure, a Kashirian age seems more likely, but a late Vereyan age cannot be excluded (Ginkel and Villa, 1996; p. 166). The presence of pores, as well as that of an incipient diaphanotheca, seems to indicate exceptional conditions of preservation.

Pseudostaffella. – The single species of *Pseudostaffella* in the list indicates a Late Bashkirian to Moscovian age. The characteristics of this form (e. g., size and shape of shell and number of volutions) are closer to those of the Lower Moscovian species, so the Late Bashkirian age seems to be less probable.

Eoschubertella. – The four taxa of *Eoschubertella*, which include the most primitive fusulinoideans of the list, may range from the Upper Bashkirian to the Upper Moscovian. With respect to *Eoschubertella* ex gr. *obscura*, its presence rather suggests a Moscovian age.

The result of these considerations regarding the age of locality L 72 is presented in Fig. 3 which points to an Early Moscovian (Vereyan or Kashirian) age for the upper part

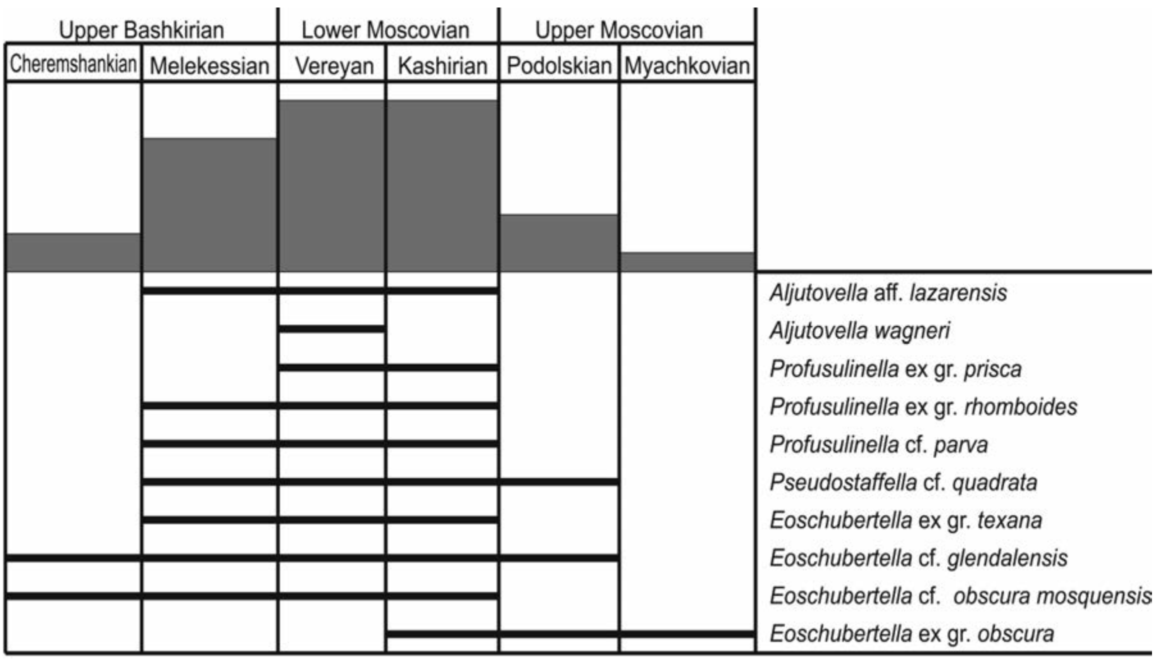


Figure 3
Ten fusulinoidean taxa of the Villaman n Member at locality L 72 and their estimated stratigraphic distribution

of the Villamanin Member. However, overall data seem to be slightly in favour of a late Vereyan age, with a minimum age at the Vereyan/Kashirian limit and a maximum age of late Vereyan.

This age is higher than the top Bashkirian level recorded by the present author (cf. Ginkel, 1965; Appendix 2, localities L 25 and L 353) and slightly younger than the Vereyan age of locality L 353 indicated by Rumyantseva in Wagner *et al*. (1983). However, it closely corresponds to the late Vereyan age for this same locality of Villa *et al*. (1988) (see samples 231 and 232 of the University of Oviedo collection; Dr. E. Villa, personal communication, 2011).

The foraminifers from localities L 353 and the present L 72 are considered here to be of the same age. This estimation is based on the presence of mural pores in the outer whorls of *Profusulinella* specimens at both localities. Apparently, mural pores were never observed by Russian authors in species of *Profusulinella* of Vereyan age (compare Solovieva, 1955; p. 163, 164 on porous walls in *Profusulinella* and *Eofusulina*, and also Rauzer-Chernousova *et al*., 1951, p. 21, fig. 8, on the occasionally porous walls in *Aljutovella* of Kashirian age).

However, a level as high as the lowest part of the lower Kashirian, which corresponds to the Tsninsky Horizon of Solovieva in Solovieva *et al*., (1985a), is not very likely either, for none of the fusulinoidean species mentioned by Solovieva (1985) as being common or typical for her Tsninsky Horizon occur in localities L 72 and L 353.

The Tsninsky Horizon (stratotype: Tsna River Basin, eastern part of the Moscow Basin, in a broad sense) is possibly the equivalent of the strata including the youngest K Limestones (K 7, K 8 and K 9) of the Donets Basin (compare with Poletaev, p. 13, table 1, in Solovieva *et al*., 1985b). The introduction of the Tsninsky level as a new "horizon" between the Vereyan and the Kashirian "horizons" seems to be an unnecessary complication of the chronostratigraphic subdivision of the Moscovian Stage. The species introduced as new taxa and claimed to be typical for the Tsninsky horizon (Solovieva, 1985), came from lower Kashirian to upper Moscovian strata, and only a small minority occurred as low as in Vereyan strata. Because of the common presence of typical Tsninsky species in strata which were formerly generally considered to be of early Kashirian age (although still below the type section of the Kashirian Horizon), the proposal of Solovieva (in Solovieva *et al*., 1985a) is not followed in the present paper. Here, the more conservative chronostratigraphic scheme of Makhlina *et al*. (2002) is adopted. This scheme considers the *Priscoidella priscoidea* Zone, which corresponds to the foraminiferal assemblage of Solovieva's (1985) Tsninsky Horizon, as the lowest of four consecutive foraminiferal zones of the Kashirian (compare also with Ivanova, 2008, p. 83, table 8).

Besides the Railway section, there is another section, closer to the hamlet of Barrio de la Tercia and the present locality L 72, that yielded foraminifers (localities Ba 23 and Ba 27 of Moore *et al*., 1971; p. 329-331; text figures 1 and 4). According to Schmerber (in Moore *et al*., 1971), the lower sample, Ba 27, contained, among other forams, *Pseudostaffella topilini* Putrya 1939, which would point to either a Kashirian or an early Podolskian age. As for Ba 23, this sample yielded *Profusulinella librovitchi* (Dutkevich, 1934), a species currently assigned to *Taitzehoella* Sheng, 1951, which would indicate an age not older than Kashirian. Therefore, Schmerber assigned a Kashirian to early Podolskian age to the assemblages from these localities; that is, an age not as low as the "upper part of the upper Vereyan" level of the present paper for locality L 72. Unfortunately, Moore et al. (1971) did not provide additional data (measurements and, especially, illustrations) for the foraminiferal fauna from Ba 23 and Ba 27 investigated by Schmerber.

IV. Correlation of Western European continental strata with Eastern-European marine successions

The upper part of the Villaman n Member consists of marine strata containing foraminifers and brachiopods as well as terrestrial strata with leaf flora and, particularly, spores. Such an alternation of fossil flora and fauna provides data enabling a correlation between Western European continental successions and Eastern European marine ones. To make a contribution to the correlation of the Upper Carboniferous (=Pennsylvanian) of Eastern and Western

Europe is the purpose of the present chapter. For easier comparisons with correlations made in previous papers, the initial A, B, C and D subdivisions of the Westphalian Stage are chosen here rather than the more recently introduced corresponding terms of Langsettian, Duckmantian, Bolsovian and Asturian (see, for instance, Heckel, 2004).

Initially, it was generally assumed that the Moscovian Stage of the Carboniferous of Eastern Europe should be correlated with the complete Westphalian (A, B, C and D) of Western Europe, and that the strata immediately below the Moscovian Stage should be correlated with the West European Namurian Stage. This originally quite plausible correlation was probably first proposed by Munier-Chalmas and de Lapparent (1893, p. 449). Investigations by Russian authors (Aisenverg *et al.*, 1960; Stepanov *et al.*, 1962) clearly showed that in Eastern Europe (Moscow Basin, Donets Basin) the Moscovian Stage should be correlated with the Upper Westphalian (Westphalian C and D) and that the underlying Upper Bashkirian can be correlated with the Lower Westphalian (Westphalian A plus B).

The correlations proposed by geologists working on the Cantabrian Carboniferous (Ginkel, 1965; Wagner, 1971; Wagner & Bowman, 1983) differ from those offered by investigators in the Donets Basin. An important difference concerns the position of the Bashkirian/Moscovian boundary. Russian stratigraphers have correlated this boundary with that of the Westphalian B/C, whereas data from the Cantabrian Mountains suggest that it is located within the Westphalian A.

The microflora close to the top of the Railway section was investigated by Neves (in Moore *et al.* 1971) and by Horvath (in Villa *et al.*, 1988). According to Neves, the age of the top layers of the Villaman n Member is Westphalian B or possibly up to and including basal Westphalian C levels. However, according to Horvath (in Villa *et al.*, 1988), who confirmed a Westphalian B age for the Villaman n Member, there is no evidence of Westphalian C microfloras in these beds. A latest Westphalian B age is more likely to be acceptable in view of the slightly younger age (early Westphalian C) advocated by Mart nez-Chac n (1986) as to be possible for the brachiopod fauna.

If, as mentioned above, the fusulinoideans near the top of the Villaman n Member indicate a top Vereyan age, and if, indeed, it is acceptable that the microflora near the top of the Railway section (above locality L 353) poins to the top of the Westphalian B, the Western European Westphalian B/C boundary would also be correlated with the Russian Vereyan/Kashirian boundary (Fig. 4). This result would not contradict "the most probable correlation" of the Western and Eastern European stratigraphic scales showed by Ginkel and Villa (1996, Fig. 5D). Interestingly, closely similar is also the correlation of Western European and Eastern European strata established by Mart nez-D az *et al.* (1985). In this study, the stratigraphic position of continental and marine fossils is shown in an Asturian composite section (Villoria – Los Tornos – Colladona Section; p. 277, table I). These similar correlations by Mart nez-D az *et al.* (1985) and by Ginkel and Villa (1996) differ from an earlier correlation by van Ginkel (1965), which is closer to the "classical" correlation of Munier-Chalmas and de Lapparent (1893).

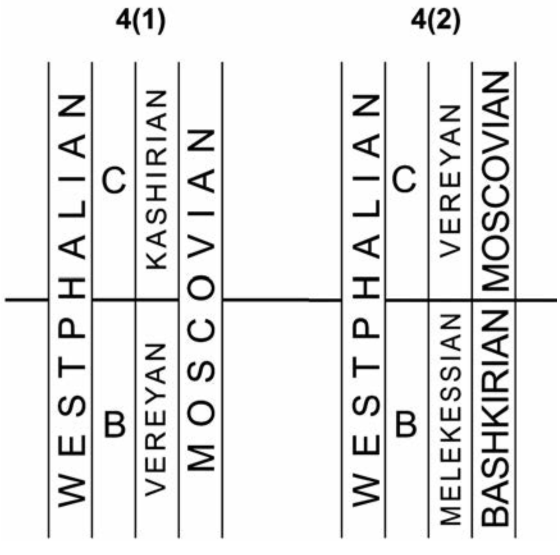


Figure 4
Correlations of the Westphalian B/Westphalian C boundary with the East European chronostratigraphic units. Fig. 4(1), according to data from the San Emiliano Formation of Northern Spain (present paper). Fig. 4(2), according to data from the Carboniferous of Eastern Europe (after Aisenverg et al., 1960 and Stepanov et al., 1962)

References

Aisenverg, D.E., Brazhnikova, N.E., Novik, E.O., Rotai, A.P. & Shulga, P.L. 1960. Carboniferous stratigraphy of the Donetz Basin. *Compte Rendu, quatri me Congr s Carbonif re, Heerlen, 1958,* **1**, 1-12.

Bensh, F.R. 1969. Stratigraphy and foraminifers of the Carboniferous deposits of the Upper Paleozoicum of southern Fergana (in Russian). *Akademiya Nauk, Instituta Geologii i Geofiziki., Tashkent Izdatel'stvo "Fan" Uzbekskoij SSR* , 174 pp.

Bogush, O.I. 1963. Foraminifera and stratigraphy of Middle and Upper Carboniferous of the eastern part of the Alay Range (in Russian). *Akademiya Nauk SSSR, Sibirskoe otdelenie, Institut Geologii i Geofiziki*, 132 pp.

Bowman, M.B.J. 1982. The stratigraphy of the San Emiliano Formation and its relationship to the other Namurian /Westphalian sequences in the Cantabrian Mountains, NW Spain. *Trabajos de Geolog a, Universidad de Oviedo*, **12,** 23-35.

Brazhnikova, N.E. & Potievskaya, P.D. 1948. Results of the examination of foraminifers from borehole samples in western parts of the Donbass (in Ukrainian). *Trudy*, *Akademiya Nauk Ukraina*, *Geological*. *Institute*. *Series Stratigraphy and Palaeontology*, **1, 2,** 76-101.

Cassity, P.E. & Langenheim R.L. 1966. Pennsylvanian and Permian fusulinids of the Bird Spring Group from Arrow Canyon, Clark County, Nevada. *Journal of Paleontology*, **40**, **4**, 931-968.

Chang, L.H. 1964. Middle and Upper Carboniferous fusulinids from Jiangyou district, northwestern Szechuan (Chinese with English summary). *Akademia Sinica, Acta Palaeontologica Sinica*, **12**, **2**, 221-235.

Chernova, E.I. 1961. Biostratigraphy based on foraminifers of the Middle Carboniferous at the right bank of the Volga near Saratov (in Russian). *Akademiya Nauk SSSR, Geologicheskii Institut, Regionalnaya Stratigrafiya, SSSR*, **5**, 261-286.

Del pine, G. 1943. Les faunes marines du Carbonif re des Asturies. *Acad mie de Sciences, M moires, Paris*, S rie **2, 66**, **3**, 1-122.

Deprat, J. 1912. Etude g ologique du Yun-Nan oriental; Partie III: Etude des Fusulinides de Chine et d'Indochine et classification des calcaires Fusulines. *Indochine Francaise, Service G ologique, M moires; Hanoi-Haiphong*, **1**, **3**, 76 pp.

1913. Les Fusulinid s des calcaires Carbonif - riens et Permien du Tonkin, du Laos et du Nord-Annam. *Indochine Fran aise. Service G ologique., M moires; Hanoi-Haiphong,* **2**, **1**, **2**, 74 pp.

Douglass, R.C. 1987. Fusulinid biostratigraphy and correlations between the Appalachian and Eastern Interior Basins. *U.S. Geological Survey, Professional Paper, Washington, D.C.,* **1451,** 95 pp.

Dutkevich, G.A. 1934. Some new species of Fusulinidae from the Upper and Middle Carboniferous of Verkhnechussovskye Gorodki on the Chussovaya river (western slope of the middle Ural) (in Russian with English summary). *Trudy Neftyanogo Geologo-Razvedochnogo Instituta, Leningrad, Moskva, Novosibirsk, U.S.S.R.*, **A**, **36**, 98 pp.

Dzhentchuraeva, A.V. 1979. Stratigraphy and foraminifers from Middle Carboniferous deposits on the north side of Turkestan Alaja (in Russian). *Akademiya Nauk, Kirgisk SSR*, 100 pp.

Fern ndez, L.P. 1993. La Formaci n San Emiliano (Carbon fero de La Zona Cant brica, NO de Espa a): Estratigraf a y extensi n lateral. Algunas implicaciones paleogeogr ficas. *Trabajos de Geolog a,*, *Universidad de Oviedo*, **19**, 97-122.

Ginkel, A.C.van 1965. Carboniferous fusulinids from the Cantabrian Mountains (Spain). *Leidse Geologische Mededelingen*, **34,** 5-225.

1987. Systematics and biostratigraphy of fusulinids of the Lena Formation (Carboniferous) near Puebla de Lillo (Le n, NW Spain). Proceedings Koninklijke Nederlandse Akademie van Wetenschappen, Amsterdam, **90**, 189-276.

& Villa E. 1996. Palaeontological data of the San Emiliano Formation (Cantabrian Mountains, Spain) and their significance in the Carboniferous chronostratigraphy. *Geobios,* **29**, **2**, 149-170.

Grozdilova, L.P., Lebedeva, N.S., Lipina, O.A., Malakhova, Z.P., Chermnych, V.A., Postoyalko, M.V., Simonova, Z.G., Sinitsina, Z.A. & Cherbakova, M.B. 1975. Foraminifera, *in*:Atlas of Paleontology D.L. Stepanov *et al*. (eds.) (in Russian). *Trudy VNIGRI, SSSR*, **383**, 27-64.

Heckel, P. H. 2004. Chairman's column. *Newsletter on Carboniferous Stratigraphy*, **22**, 1-3.

Ivanova, E.A., Solovieva & Shik, E.M. 1978. Moscovian stage and general problems of the stratigraphy of Carboniferous deposits. *Huiti me Congr s International de Stratigraphie et de G ologie du Carbonif re (Moscou 1975),* **1**, 128-144.

Ivanova, R.M. 2000. New taxa of foraminifers from the Bashkirian Stage of the Ural (in Russian). *Paleontologichesky Zhurnal,* **2,** 34-40.

2008. Fusulinids and algae of the Middle Carboniferous of the Ural (zonal stratigraphy, paleobiogeography, paleontology) (in Russian). *Akademiya*

Nauk; Uralskoe otdelenie, Institut Geologii i Geokhimi; Akademika A.N. Zavaritskogo, Ekaterinburg, 205 pp.

Julivert, M. 1960. Estudio Geol gico de la Cuenca de Bele o, vallos altos del Sella, Ponga, Nal n y Esla de Cordillera Cant brica. *Bolet n Instituto Geol gico y Minero de Espa a*, **71,** 346 pp.

1971. D collement tectonics in the Hercynian Cordillera of Northwest Spain. *American Journal of Sciences*, **270**, 29 pp.

Kireeva, G.D. 1949. Some new fusulinid species from the Carboniferous limestones of the central part of the Donbass area (in Russian). *Trudy, Geological Institute for Coal Exploration*, **6,** 25-55.

Lee, J.S., Chen S. & Chu S. 1930. Huanglung limestone and its fauna. *Academia Sinica, Memoirs of the National Research Institute of Geology*, **9**, 85-144.

Makhlina, M.X., Alekseev, A.C., Goreva, H.B. & Isakova, T.H. 2002. Carboniferous Moscovian synclinorium (in Russian) (in Stratigraphy and Paleogeography of the Carboniferous of Eurasia). *Sb. nauch. statei. Ekaterinburg: IGGCHrORAN*, 207-212.

Marshall, F.C. 1969. Lower and Middle Pennsylvanian fusulinids from the Bird Spring Formation near Mountain Springs Pass, Clark County, *Nevada*, *Brigham Young University*, *Geological Studies*, *Provo*, *Utah*, **16**, **1,** 97-154.

Mart nez-Chac n, M.L. 1986. Nota sobre la edad de los materiales carbon feros de la regi n de Villaman n (N. de Le n ; Espa a). *Breviora Geol gica Ast rica*, **27, 3-4**, 17-20.

Mart nez-D az, C., Granados, L.F., Leyva, F., Laveine, J.P., Solovieva, M.N, Reitlinger, E.A., Gervilla, M., Loboziak, S., Brousmiche, C., Candilier, A.M., Pendas, F. & Horvath, V. 1985. Aportaciones a la cronoestratigraf a del Carbon fero Medio de Asturias y nuevos datos para un intento de correlaci n de las escalas marinas y continentales. *Compte Rendu du dixi me Congr s sur le Carbonif re, Madrid, 1983*, **I,** 269-279.

Moore, L.R., Neves, R., Wagner, R.H. & Wagner-Gentis, C.H.T. 1971.The stratigraphy of Namurian and Westphalian rocks in the Villaman n area of Northern Le n, N.W. Spain; in: The Carboniferous of Northwest Spain, Part I. *Trabajos de Geolog a,* No **3**, 307-363, *Facultad de Ciencias*, *Universidad de Oviedo*.

Munier-Chalmas, C.P.E. & Lapparent, A.de. 1893. Note sur la nomenclature des terrains s dimentaires. *Bulletin de la Soci t G ologique, France*, **3 (21),** 438-489.

Putrya, F.S. 1939. On the study of the Middle Carboniferous foraminifers of the Donets Basin (in Russian). *Materialy Azovo-Chernomorskogo geologicheskogo upravleniya,* **8,** 175-188.

Rauzer-Chernousova, D.M. 1938. The Upper Palaeozoic foraminifera of the Samara Bend and the Trans-Volga region (in Russian with English summary). *Akademiya Nauk SSSR, Trudy Instituta Geologii, Leningrad*, **7**, 69-167.

Belyaev, G.M. & Reitlinger, E.A. 1936. Die oberpalaeozoischen Foraminiferen aus dem Petschoralande der Westabhang des Nord Urals (in Russian and German). *Akademiya Nauk SSSR, Trudy Poliarnaya Komissii, Leningrad*, **28,** 159-232.

Kireeva, G.D., Leontovich, G.E., Grizlova, N.D., Safonova, T.P. & Chernova, E.I. 1951. Middle Carboniferous fusulinids of the Russian platform and adjacent regions (in Russian). *Izdatel'stvo Akademii Nauk SSSR, Trudy Instituta Geologicheskikh Nauk, Ministerstvo Neftyanoy Promyshlennosti SSSR*, *Moskva*, 229 pp.

Ross, C.A. 1967. Late Paleozoic Fusulinacea from northern Yukon Territory. *Journal of Paleontology*, **41**, **3**, 709-725.

& Bamber, E.W. 1978. Middle Carboniferous and Early Permian Fusulinaceans from the Monkman Pass Area, Northeastern Bristish Columbia. *Geological Survey of Canada*, **267,** 25-41.

& Sabins, F.F. 1965. Early and Middle Pennsylvanian fusulinids from Southeast Arizona. *Journal of Paleontology*, **39**, **2,** 173 -209.

Rui, L. 1983. Fusulinacean fauna from the Quanwangtou Limestone (early Upper Carboniferous) in Jiawang coal field, northern Jiangsu (Chinese with English abstract). *Acta Palaeontologica Sinica, Beijing, China*, **22**,.**2**, 170-182.

Sada, K. 1961. *Profusulinella* of Atetsu Limestone. *Hiroshima University, Journal of Sciences, Hiroshima, Japan*, *series C (Geology/ Mineralogy),* **4, 1**, 95-116.

Sheng, J.C. 1951. *Taitzehoella*, a New Genus of Fusulinid. *Bulletin of Geological Society, China*, **31, 1-4,** 79 (Chinese), 79-84 (English).

1958. Fusulinids from the Penchi Series of the Taitzeho valley, Liaoning, China (in Chinese with English summary). *Acta Palaeontologica Sinica, Peking*. **B, 7**, **143,** 56-119.

Sjerp, N. 1967. The geology of the San Isidro-Porma area (Cantabrian Mountains, Spain). *Leidse Geologische Mededelingen*, **39**, 55-128.

Solovieva, M.N. 1955. On the question of the fusulinid wall structure and the significance of this feature (in Russian). *Doklady Akademii Nauk SSSR,* **101**, **1**, 163-164.

1985. Correction of the USSR general Carboniferous scale in connection with restudying the Moscovian stage stratotype and a new model for the correlation of the Lower Moscovian substage. *Compte Rendu du dixi me Congr s sur le Carbonif re, Madrid*, *1983*, **I,** 21-26.

Chizhova, V.A., Einor, O.L., Grigorieva, A.D., Reitlinger, E.A. & Vdovenko, M.V. 1985. Review of recent data of the Carboniferous stratigraphy of the USSR (Geological Institute of the USSR Academy of Sciences, Moscow, USSR). *Compte Rendu du dixi me Congr s sur le Carbonif re, Madrid, 1983*, **I,** 3-10.

Fisunenko, O.P., Goreva, N.V., Barskov, I.S., Gubareva, V.S., Dzhentchuraeva, A.V., Dalmatskaya, I.I., Ivanova ,E.A., Poletaev, V.I., Popov, A.V., Rumyantseva, Z.S., Teteryuk, V.K. & Shik E.M. 1985. New data on stratigraphy of the Moscovian stage. *Compte Rendu du dixi me Congr s sur le Carbonif re, Madrid, 1983*, **1,** 11-20.

Stepanov, D.L. et al. 1962. The Carboniferous System and its main stratigraphic subdivisions. Report of the Commission on the Stratigraphy of the Carboniferous of the National Committee of Soviet Geologists. *Compte Rendu du quatri me Congr s sur le Carbonif re, Heerlen, 1958,* **III,** 645-656.

Thompson, M.L. 1947. Stratigraphy and fusulinids of Pre-Desmoinesian Pennsylvanian rocks, Llano Uplift, Texas. *Journal of Paleontology,* **21**, **2,** 147-164.

Toriyama, R. 1958. Geology of Akiyoshi, Part III: Fusulinids of Akiyoshi. *Memoirs of the Faculty of Science, Kyushu University,* Series **D**, Geology,**VII**, 261 pp.

Villa, E., Horvath, V., Mart nez Chac n, M.L. & S nchez de Posada, L.C. 1988. Datos paleontol gicos y edad de la secci n de Villaman n (Carbon fero, Cordillera Cant brica, NO de Espa a). *Congreso Geol gico de Espa a*, *Granada 1988*, *Comunicaciones*, **1,** 337-341.

Wagner, R.H. 1971. Account of the International Field Meeting on the Carboniferous of the Cordillera Cant brica, 19-26 Sept. 1970. *Trabajos de Geolog a de la Universidad de Oviedo*, **3**, 1-39

& Bowman, M.B.J. 1983. The position of the Bashkirian/Moscovian boundary in Western European chronostratigraphy. *Newsletter on Stratigraphy*, **12** (**3**), 132-161.

Mart nez-Garc a, E., Winkler Prins, C.F. & Lobato L. 1983. Carboniferous stratigraphy and geology of the Cantabrian Mountains. *Guide Field Trip A of the Xth International Congress of Carboniferous Stratigraphy and Geology, Madrid,* 212 pp.

Winkler Prins, C.F. 1968. Carboniferous Productina and Chonetidina of the Cantabrian Mountains (NW Spain): Systematics, Stratigraphy and Paleoecology. *Leidse Geologische Mededelingen*, **43**, 41-126.

1971. The road section east of Valdeteja with its continuation along the Arroya de Barcaliente (Curue o valley, Le n) (in: The Carboniferous of Northwest Spain). *Trabajos de Geolog a*, **4**, *Facultad Ciencias*, *Universidad de Oviedo*, 677-686.

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