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Pennsylvanian Fauna of the Tarma Limestone, Central Andes, Peru Part 1. Introductory Remarks and Fusuline Paleontology

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Abstract A biostratigraphic study of the Pennsylvanian fauna in the Tarma Limestone, Central Andes, in Peru, made it possible for identifying 10 species, including one new species, in 3 genera of fusulines and 18 species, including five new species, in 13 genera of bryozoans. The fusuline fauna indicates a close relationship with those of the Arctic-Midcontinent province.

Key words: Fusulines, Biostratigraphy, Tarma Limstone, Pennsylvanian, Peru.

Introduction

During our field surveys carried out in Central Andean region from 1980 to 1986, stratigraphic measurement of the Pennsylvanian Tarma Group which consists mainly of limestone was made in 1982. Results of the field observation and the outline of faunal composition were preliminarily reported by the Research Group (Sakagami, ed., 1984). The present work is aimed to present the result of the paleontological study on the fusulines and bryozoans of the group. This study will be presented here dividing into two parts: Part 1 deals with the outline of the Tarma Limestone and its fusuline fauna, and Part 2 will deal with the bryozoan fauna.

The Tarma Limestone

The Pennsylvanian Tarma Limestone forms steep slope of Cerro Jarama, and is exposed along the southern side of the Tarma-Oroya road at about 4 km west of the center of Tarma City (Figs. 1 and 2).

After the classic investigations by Steinmann (1929) and Harrison (1943), Dunbar and Newell (1946 a) reported the result of the detailed geological measurement on the formations in the Tarma area, ranging in age from Devonian to Late Triassic. According to them, the Middle Pennsylvanian Tarma Group, composed of more than 1000 feet of dark-grey to black limy shales with interbedded fossiliferous limestones containing a Middle Pennsylvanian (Moscovian-Des Moines) fauna, overlies the Devonian shale formation with disconformity and is, in turn, overlain by the Permian(?) Yauli Group with disconformity.

We (Sakagami, ed., 1984) made the columnar section of the fossiliferous limestone part, which may correspond to the upper part of the Tarma Group of Dunbar

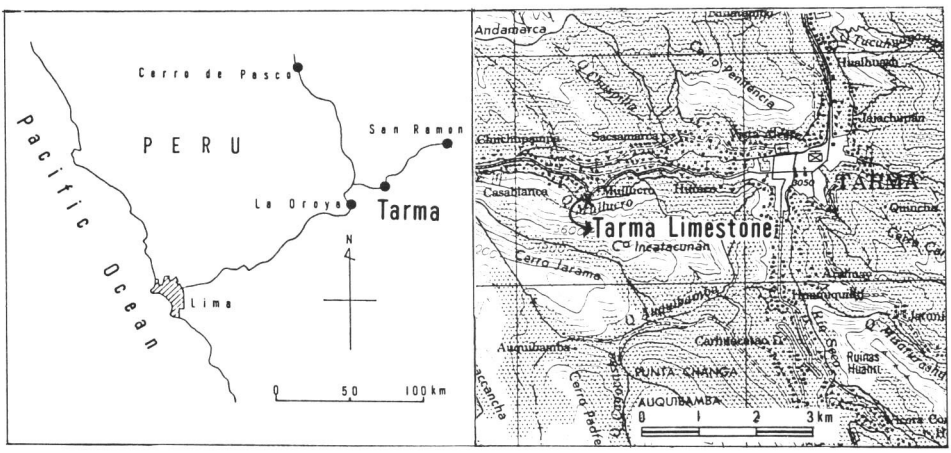

Fig. 1. Map showing location of the Tarma Limestone.

and Newell (1946 a), at an original scale of 1 : 100. Many kinds of fossils such as fusulines, bryozoans, brachiopods, corals, *etc.* in the limestone blocks collected from nearly 30 sampling points along the section. The Tarma Group observed in this section begins with yellowish brown, fine-grained sandstone, and consists mainly of limestones (including grainstone, wackestone, packstone) with mudstone and shale intercalations at some horizons. Attaining about 70 m in total thickness, lower half of the limestone is massive, but the upper part is intercalated with slate or shale layers. Among the fossil remains, fusulines are most prominent in grainstone and wackestone of several horizons throughout the section, but the other faunas, especially bryozoans, brachiopods and crinoid stems are very common in packstone of the upper half of the limestone. Thus, it can be estimated that the sedimentary paleoenvironment of the Tarma Limestone would have been changed from the shallow carbonate ramp to the deep carbonate ramp under relatively high energy condition.

In this section, it is assumed that the Tarma Limestone may be unconformably overlain by the non-marine Mitu Group (=Yauli Group of Dunbar and Newell, 1946 a) although direct relationship between the two formations could not be observed.

The Fusuline Fauna

Ten species (including two indeterminable species) belonging to three genera of fusulines were discriminated from the Tarma Limestone as shown in the range chart (Fig. 3).

Staffella pseudosphaeroidea is crowded only in three horizons of Nos. 09, 10 and 25, and other associated fusulines are very rare. It was described originally from

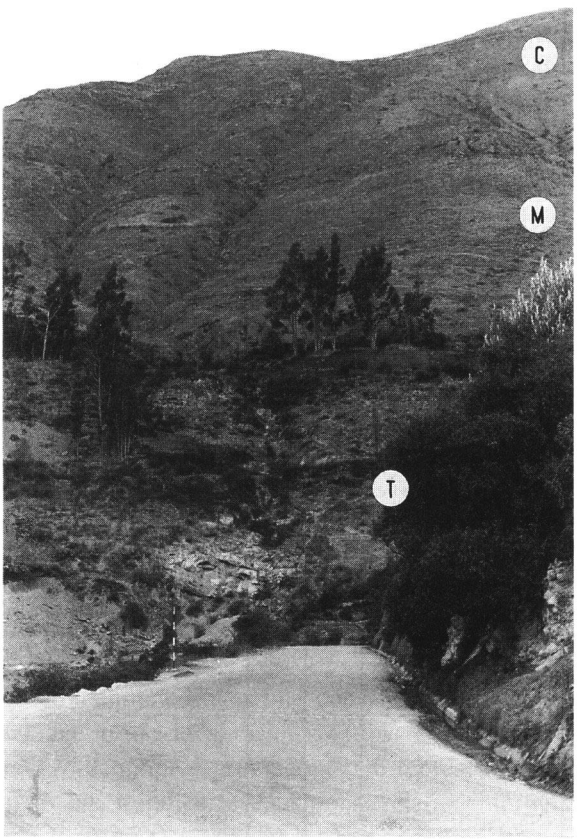

Fig. 2. Landscape of the Tarma Limestone. T: Tarma Limestone, M: Mitu Group (non-marine Permian), Chambara Group (Upper Triassic).

the Upper Carboniferous in the western side of the Middle Ural Mountains by Dutkevich (1934) and also known from the Bashkirian strata in the Russian Platform by Rauser-Chernoussova *et al.* (1951), the Myachkovsky horizon in the Urals by Chuvashov *et al.* (1984), the *Profusulinella prisoidea* Zone to the *Wedekindellina* Zone of the Lower Marine Group in Greenland by Ross and Dunbar (1962), the *Profusulinella* Zone to the base of B subzone of the *Fusulinella* Zone in Spain by Van Ginkel (1965), and the *Wedekindellina lata-Wedekindellina uralica longa* Zone (Podolian substage) in the Nansen Formation in the northern Ellesmere Island.

Fusulinella peruana originally described from this Tarma Limestone by Meyer (1914) was restudied and described in detail by Dunbar and Newell (1946 b). In the present study, *Fusulinella peruana* including a confer form is found very commonly in the lower half of the limestone. *Fusulinella incaica* n. sp. ranges from Horizon

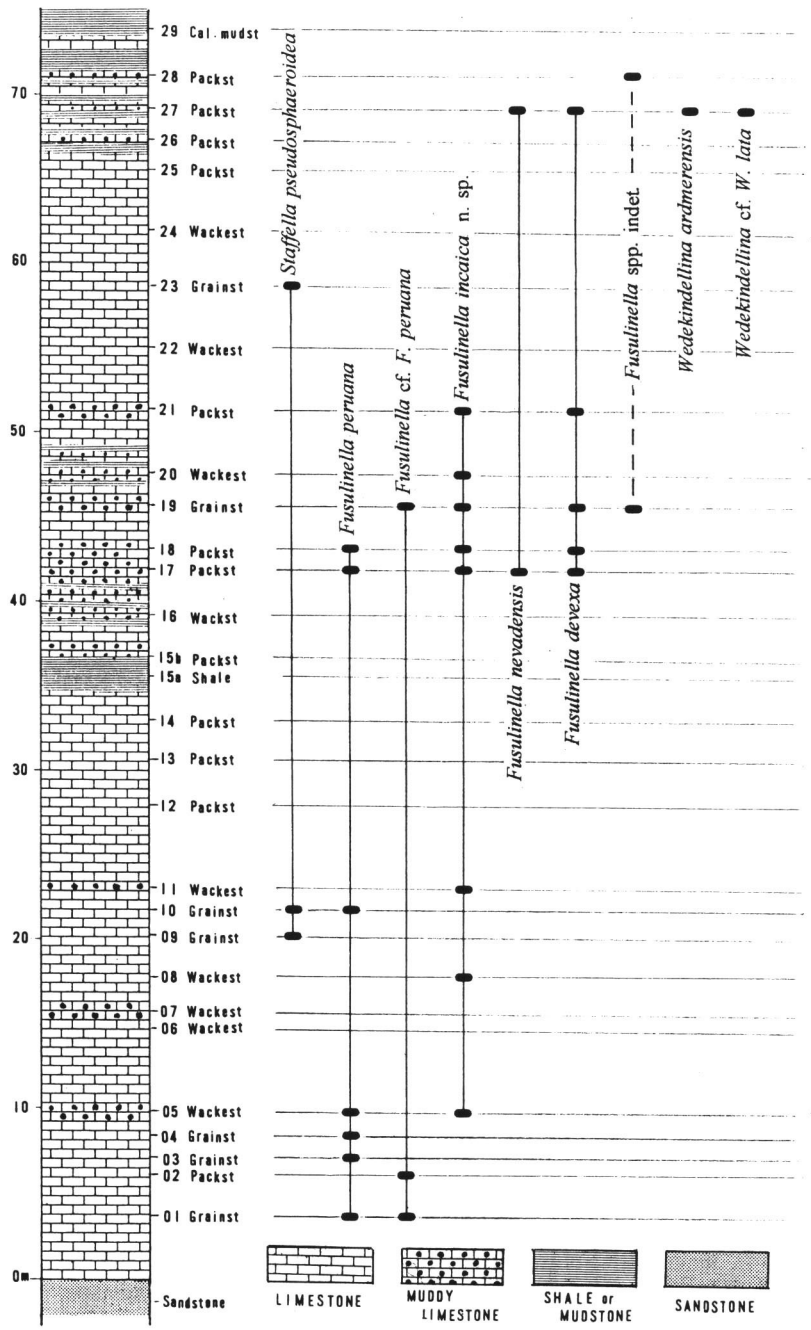

Fig. 3. Generalized columnar section of the Tarma Limestone showing stratigraphic distribution of fusulines.

Nos. 05 to 21, but is most abundant in No. 19. *Fusulinella nevadensis* was described originally from the Pennsylvanian Ely Limestone in the Cherry Creek Mountains, U.S.A. by Verville, Thompson and Lokke (1956) and later from the Nansen Formation in Ellesmere Island by Lin, Ross and Nassichuk (1991). *Fusulinella devexa* was originally described from the Cuchillo Negro Formation (lower Middle Pennsylvanian) in southern New Mexico by Thompson (1948), and it was also described from the lower part of Horquilla Limestone in the southeast Arizona, U.S.A. by Ross and Sabins (1965) and from the Nansen Formation in Ellesmere Island by Lin, Ross and Nassichuk (1991). The last two species of *Fusulinella* occur in the upper part of the limestone, namely from Horizon Nos. 17 to 27. Two indeterminable species of *Fusulinella*, not described here but distinctly distinguishable from the described species, are recognized in Horizon Nos. 19 and 27, but they may be less important.

Two species of *Wedekindellina*, *W. ardmerensis* and *W.* cf. *W. lata*, occur in association with *Fusulinella devexa* and *F. nevadensis* in the same limestone block. Thompson, Verville and Lokke (1956) stated that *Wedekindellina ardmerensis* is abundant in the Confederate Limesotone at many places in the Ardmore Basin of southern Oklahoma where it is not found in association with other fusulines. Accordingly, he did not show the exact geologic age of *W. ardmerensis*. *Wedekindellina* cf. *W. lata* described here may be identical with the specimens originally described by Thompson (1961) from the rocks correlated with the middle part of the Desmoinesian of Ward Hunt Island.

Taking the above mentioned facts into consideration, it is justifiable to say that the fusuline assemblage in the Tarma Limestone well agrees with the Desmoinesian faunas in the Arctic-Midcontinent province which represents a warm temperate climatic zone, that is to say, it indicates transitional relationship with the Ural-Russian Platform Province.

Systematic Descriptions on Fusulines

All specimens are deposited in the collections of the National Science Museum (NSM), Tokyo.

Order Fusulinida Fursenko, 1958
Superfamily Fusulinacea Moeller, 1878
Family Ozawainellidae Thompson and Foster, 1937
Subfamily Staffellinae M.-Maclay, 1949
Gunus *Staffella* Ozawa, 1925

Staffella pseudosphaeroidea Dutkevich, 1934

(Figs. 4–1~9)

Staffella pseudosphaeroidea Dutkevich, 1934, p. 17–22, pl. 3, figs. 2–10; Putrja, 1956, p. 394, 395, pl. 4, figs. 11, 12; Lin, Ross and Nassichuk, 1991, p. 38, 39, pl. 4, figs. 1–7.

Fig. 4. 1–9, *Staffella pseudosphaeroidea* Dutkevich, ×40, NSM PA-14119a. 14119b, 14121a, 14124, 14122a, 14122b, 14215a, 14215b and 14216, respectively.

Parastaffella pseudosphaeroidea Rauser-Chernoussova *et al.*, 1951, p. 152, 153, pl. 13, figs. 1, 2.
Pseudostaffella? pseudosphaeroidea Ross and Dunbar, 1962, p. 15–17, pl. 2, figs. 1–8.
Staffella cf. *pseudosphaeroidea* Van Ginkel, 1965, p. 14, 15, pl. 5, figs. 8–11.

Material and Horizon: Ten axial or nearly axial sections were selected as shown in the dimension table. Numbers in parentheses refer the horizons.

Description: Shell rather large for the genus, subspherical, periphery broadly rounded, poles broadly umbilicate. Mature specimens with five to six volutions are 0.80 to 0.96 mm long and 1.34 to 1.76 mm wide, and form ratios of 0.46 to 0.66. Proloculus small, spherical, and about 0.07 mm in outer diameter measured on two specimens. Shell planispirally coiled throughout, inner three volutions closely coiled, discoidal with narrowly rounded periphery, outer volutions expanded rapidly outward. Spirotheca is composed of a tectum, a thick diaphanotheca and upper and lower tectoria, but upper tectorium usually lacking in most volutions. Thickness of spirotheca 0.05 to 0.06 mm in outer volutions. Septa unfluted. Chomata low and asymmetrical. Tunnel low and broad with slightly irregular path.

Dimensions:

Specimen No. NSM PA-	Length (mm)	Width (mm)	Form Ratio	Diameter of Proloculus (mm)
14119a (09)	0.80	1.34	0.60	—
14119b (09)	0.90	1.47	0.61	0.07?
14121a (10)	0.67	1.41	0.46	0.07
14122a (10)	0.83	1.76	0.47	—
14122b (10)	0.83	1.44	0.58	—
14124 (10)	0.86	1.57	0.54	—
14215a (23)	—	1.38	—	—
14215b (23)	—	1.41	—	—
14216 (23)	0.96	1.63	0.59	—

Specimen No. NSM PA-	Width of Volutions (mm)					
	1	2	3	4	5	6
14119a (09)	—	0.42	0.69	0.99	1.34	
14119b (09)	0.26	0.50	0.68	1.00	1.47	
14121a (10)	0.24	0.41	0.62	0.87	1.26	1.41(5 1/2)
14122a (10)	—	0.32	0.58	0.90	1.28	1.76
14122b (10)	—	0.48	0.73	1.09	1.44	
14124 (10)	—	0.48	0.67	0.99	1.38	1.57(5 1/2)
14215a (23)	0.25	0.45	0.70	1.04	1.38	
14215b (23)	—	0.35	0.67	0.99	1.41	
14216 (23)	?	0.48	0.77	1.12	1.63	

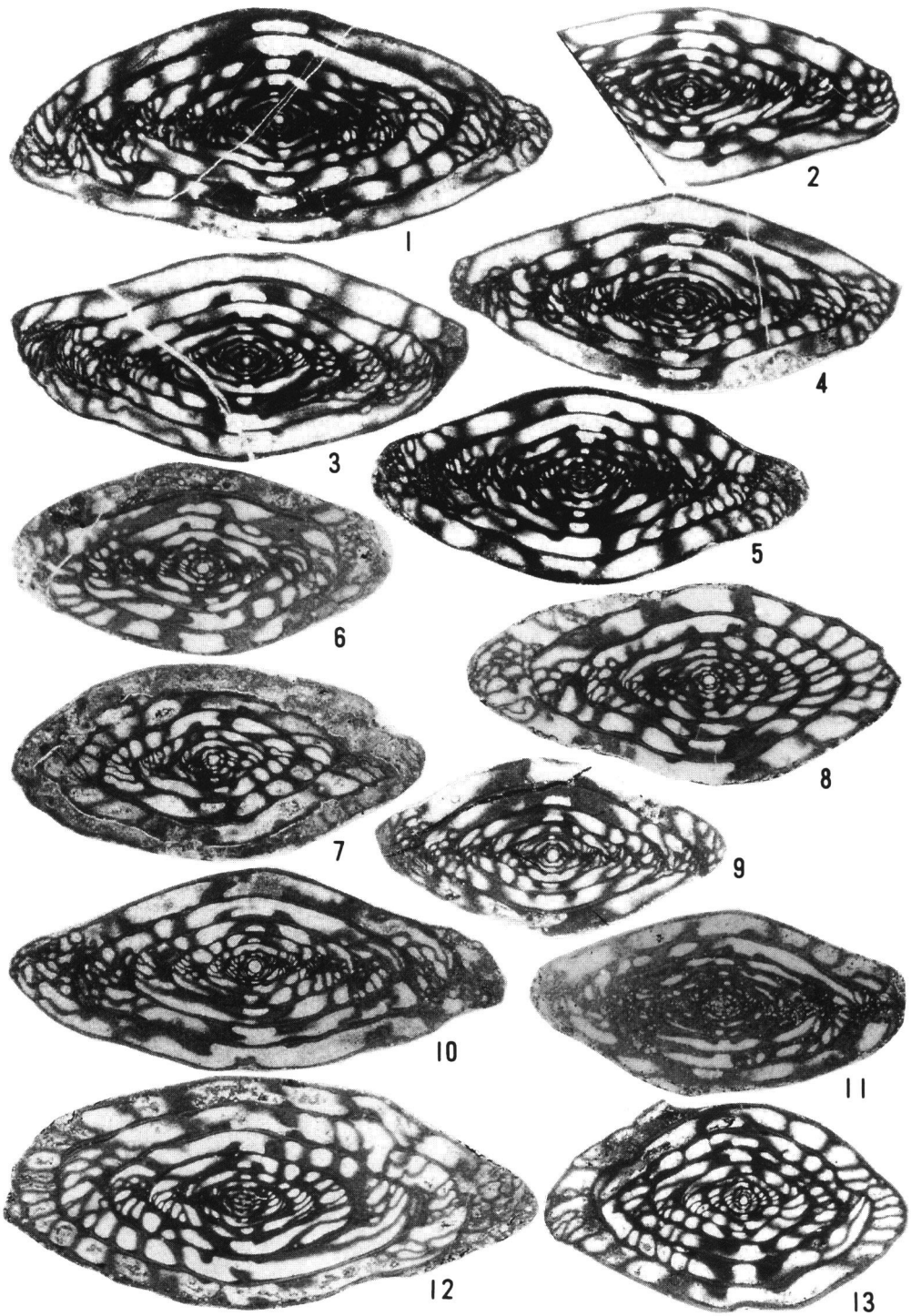

Fig. 5. 1–13, *Fusulinella peruana* (Meyer), ×20, NSM PA-14084, 14085c, 14079, 14086b, 14086c, 14093, 14097, 14106a, 14121b, 14122c, 14179, 14154 and 14155, respectively.

Remarks: *Staffella pseudosphaeroidea* has been known from Ural, Spain, Greenland, and Ellesmere Island. The specimens which were questionably referred to *S. pseudosphaeroidea* by Kanmera (1954) may be another species as mentioned by Lin, Ross and Nassichuk (1991). They considered that the Kanmera's specimens may belong to *S. mochaensis* Van Ginkel (1965).

Genus *Fusulinella* Moeller, 1878

Fusulinella peruana (Meyer, 1914)

(Figs. 5–1～13)

Schellwienia peruana Meyer, 1914, p. 623, pl. 14, figs. 3 a, b (referred from the free translation by Dunbar and Newell, 1946 b).

Fusulinella peruana (Meyer), Dunbar and Newell, 1946 b, p. 486–489, pl. 9, fig. 17; pl. 12, figs. 1–7; Roberts (in Newell *et al.*) 1953, p. 178, pl. 36, figs. 12, 13.

Material and Horizon: Thirteen axial sections were selected as shown in the dimension table. Numbers in parentheses refer the horizons.

Description: Shell rather large for the genus, inflated fusiform, lateral slopes almost straight or slightly convex, and poles rather bluntly rounded. Mature specimens of six and a half to eight volutions are 2.60 to 4.10 mm long and 1.34 to 1.76 mm wide, with form ratios of 1.94 to 2.45. Proloculus spherical, and medium in size, ranging from 0.08 to 0.10 mm in outside diameter. All volutions regularly coiled, inner two to three volutions tightly coiled, then becoming rather loosely coiled in outer volutions. First volutions is spheroidal, then becoming gradually thickly fusiform to elongate fusiform in outer volutions. Spirotheca, typical of the genus, is composed of a tectum, diaphanotheca, and upper and lower tectoria, and the thickness of spirotheca about 0.01 mm in inner volutions and gradually thickened to about 0.03 mm in outer volutions. Septa weakly fluted in central part but broadly fluted in axial regions. Many septal pores prominent, less than 0.013 mm in diameter. Chomata well developed symmetrically, as high as about half of the chamber's height in the center of chambers. Width of tunnel narrow in inner volutions, becoming wider to outer voulutions, about 30°.

Dimensions:

Specimen No. NSM PA-	Length (mm)	Width (mm)	Form Ratio	Diameter of Proloculus (mm)
14079 (01)	3.52	1.54	2.29	0.10
14084 (01)	4.01	1.76	2.28	0.09
14085c (01)	ca. 3.20	1.38	ca. 2.32	0.10
14086b (01)	3.39	1.50	2.26	0.08
14086c (01)	3.20	1.47	2.18	—
14093 (03)	2.82	1.44	1.96	0.10

14097 (04)	ca. 3.20	1.51	ca. 2.12	0.10
14106a (05)	3.58*	1.54	2.32	0.09
14121b (10)	2.60	1.34	1.94	0.10
14122c (10)	3.78	1.54	2.45	0.10
14154 (17)	—	1.73	—	—
14155 (17)	—	1.60	—	0.09
14179 (18)	2.82	1.34	2.10	—

* half length×2.

Specimen NSM PA-	No. Width of Volutions (mm)							
	1	2	3	4	5	6	7	8
14079n (01)	0.15	0.23	0.33	0.50	0.74	1.00	1.38	1.54(7 1/2)
14084 (01)	0.15	0.24	0.36	0.50	0.71	0.92	1.27	1.76
14085c (01)	0.18	0.23	0.35	0.49	0.72	1.00	1.38	
14086b (01)	0.14	0.22	0.33	0.45	0.62	0.83	1.12	1.50
14086c (01)	0.18	0.28	0.42	0.62	0.81	1.13	1.50	
14093 (03)	0.17	0.27	0.44	0.64	0.92	1.26	1.47(6 1/2)	
14097 (04)	0.18	0.31	0.49	0.73	1.03	1.41	1.51(6 1/2)	
14106a (05)	0.15	0.23	0.35	0.49	0.71	0.99	1.34	1.54(7 1/2)
14121b (10)	0.18	0.26	0.39	0.56	0.82	1.15	1.34(6 1/2)	
14122c (10)	0.15	0.23	0.32	0.47	0.72	1.00	1.34	1.54(7 1/2)
14154 (17)	0.13	0.24	0.37	0.56	0.83	1.18	1.57	1.76(7 1/2)
14155 (17)	0.13	0.21	0.31	0.45	0.64	0.89	1.21	1.60
14179 (18)	0.17	0.22	0.35	0.45	0.68	0.90	1.15	1.34(7 1/2)

Remarks: *Fusulinella peruana* (Meyer) was reexamined in detail and redescribed by Dunbar and Newell (1946b) because the original description by Meyer (1914) was based on inadequate material. The present specimens quite agree with the specimens described and illustrated by Dunbar and Newell (1946 b) who found near the top of the Tarma Group in the section at the present locality (Tarma) in all essential characters and measurements. *Fusulinella peruana* is near to *Fusulinella alta* and *Fusulinella nevadensis*, both of which was described from the Ely Limestone of Nevada, U.S.A., but the present species can be distinguished from the latters by the shell form.

Fusulinella sp. cf. ***F. peruana*** (Meyer, 1914)

(Figs. 6–1~8)

(Synonym list: see the preceding species)

Material and Horizon: Eight axial sections were selected as shown in the dimension table. Numbers in parentheses refer the horizons.

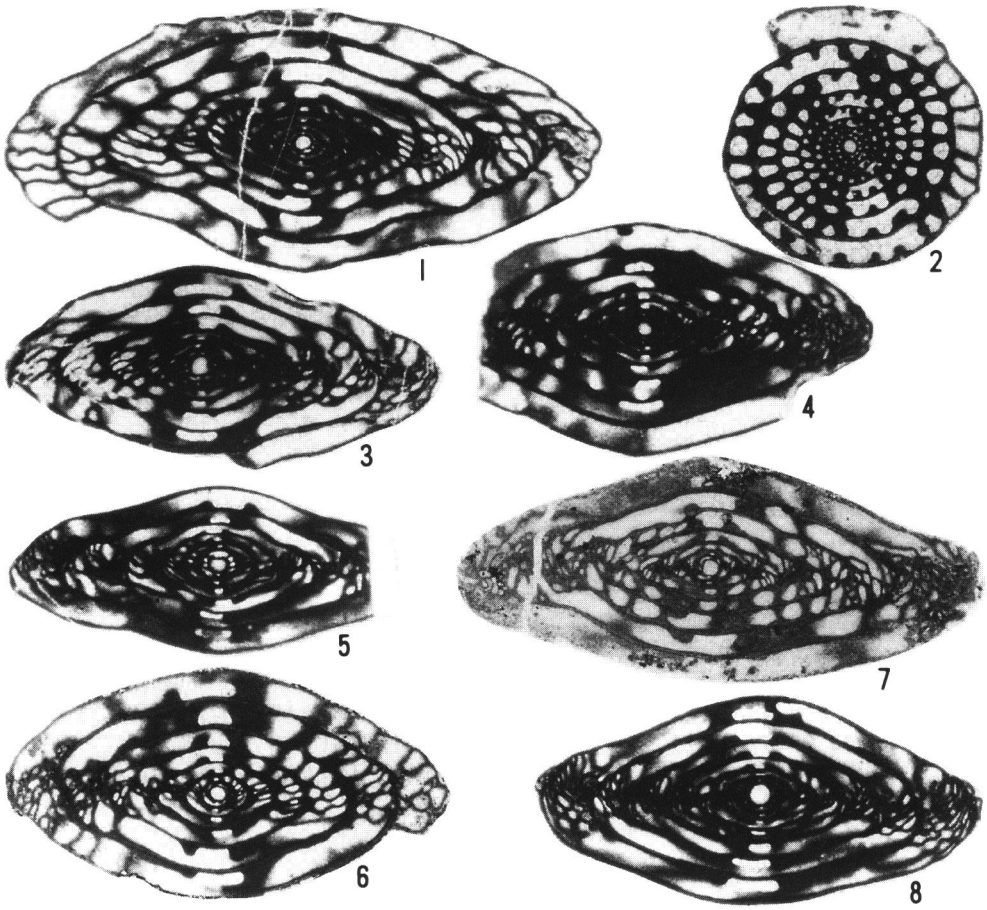

Fig. 6. 1–8, *Fusulinella* cf. *F. peruana* (Meyer), ×20, NSM PA-14078, 14080, 14083a, 14083b, 14085b, 14194a, 14088 and 14085a, respectively.

Description: Shell rather large for the genus, inflated fusiform, lateral slopes almost straight or slightly covnex, and with bluntly pointed poles. Mature specimens of seven to eight volutions are 2.89 to 4.03 mm long and 1.44 to 1.86 mm wide, with form ratios of 1.97 to 2.32. Proloculus spherical and large in size, varying 0.12 to 0.17 mm, averaging 0.13 mm for eight specimens in outside diameter. All volutions expand gradually and rather slowly. First volution is spheroidal but becoming gradually thickly fusiform to elongate fusiform in outer volutions. Spirotheca, typical for the genus, is composed of a tectum, diaphanotheca, and upper and lower tectoria, and the thickness about 0.01 mm in inner volutions and gradually thickened to about 0.03 mm in outer volutions. Septa almost plane in central part and folded in axial regions. Chomata developed symmetrically about half as high as the chambers in the

center of chambers. Width of tunnel about 20° in inner volutions, gradually becoming wider to outer volutions, reaching up to about 30° to 35°.

Dimensions:

Specimen No. NSM PA-	Length (mm)	Width (mm)	Form Ratio	Diameter of Proloculus (mm)
14078 (01)	4.03	1.86	2.17	0.12
14080 (01)	—	1.86	—	0.12
14083a (01)	2.89	1.47	1.97	0.14
14083b (01)	ca. 3.20	1.60	ca. 2.00	0.12
14085a (01)	3.00	1.44	2.08	0.17
14085b (01)	ca. 2.90	1.15	ca. 2.52	0.12
14088 (03)	3.58	1.54	2.32	0.13
14194a (19)	3.01	1.57	1.98	0.12

Specimen No. NSM PA-	Width of Volutions (mm)								
	1	2	3	4	5	6	7	8	9
14078 (01)	0.18	0.27	0.41	0.59	0.81	1.08	1.47	1.86	
14080 (01)	0.19	0.28	0.39	0.54	0.77	1.06	1.41	1.86	
14083a (01)	0.23	0.33	0.49	0.69	0.95	1.28	1.47(6 1/2)		
14083b (01)	0.17	0.26	0.39	0.56	0.74	1.06	1.41	1.60(7 1/2)	
14085a (01)	0.25	0.36	0.51	0.72	0.96	1.27	1.44(6 1/2)		
14085b (01)	0.22	0.33	0.46	0.63	0.85	1.15			
14088 (03)	0.18	0.31	0.42	0.54	0.87	1.21	1.54		
14194a (19)	0.20	0.31	0.47	0.77	1.03	1.38	1.57		

Remarks: The present specimens is identical with *Fusulinella peruana* in all essential characters except for having the larger proloculus.

Fusulinella incaica n. sp.

(Figs. 7–1~10; 8–1~11; 9–1~4)

Material and Horizon: Twenty two axial sections and three near-axial sections were selected as shown in the dimension table (Holotype: NSM PA-14103a; paratypes: the other 24 specimens). Numbers in parentheses refer the horizons.

Description: Shell large for the genus, elongate fusiform, and distinctly inflated in central region, terminated with sharply pointed poles, and lateral slopes almost straight or slightly concave. Mature specimens of seven to eight volutions are 2.94 to 4.86 mm long and 1.41 to 2.11 mm wide, with form ratios of 2.05 to 2.59. Proloculus spherical and rather large in size, ranging from 0.10 to 0.16 mm, averaging 0.13 mm

in outside diameter. The first volution is almost spherical in shape and becoming gradually a thick fusiform to elongate fusiform in outer volutions. Spirotheca, typical for the genus, is composed of a tectum, diaphanotheca and upper and lower tectoria. The thickness of spirotheca about 0.016 to 0.02 mm in inner two to three volutions and increases upto about 0.04 mm in outer volutions. Septa weakly fluted in central part and distinctly fluted only in the extreme polar ends. The septal counts of the first to seventh volution of one specimen (05-3c, not photo) are 8, 11, 13, 17, 21, 18 and 21, respectively. Chomata developed symmetrically and as high as about half of the chamber's height in the center of chambers. Width of tunnel narrow in inner volutions, and becoming wider about 30° in outer volutions.

Dimensions:

Specimen No. NSM PA-	Length (mm)	Width (mm)	Form Ratio	Diameter of Proloculus (mm)
14102a (05)	4.23	1.76	2.40	0.16
14102b (05)	ca. 3.52	1.66	ca. 2.12	0.12
14103a (05)	4.86	2.05	2.37	0.16
14103b (05)	4.48	2.05	2.19	0.13
14104 (05)	—	2.11	—	0.12
14114 (08)	2.72	1.34	2.03	0.12
14116 (08)	—	1.76	—	0.13
14125 (11)	4.10	1.76	2.33	0.11
14132 (11)	3.97	1.63	2.44	0.13
14134a (11)	4.30	1.54	2.79	0.12
14135 (11)	3.65	1.41	2.59	0.12
14151 (17)	3.46	1.57	2.20	—
14178b (18)	3.52	1.63	2.16	—
14182 (19)	4.16	1.92	2.17	0.12
14184 (19)	3.20	1.47	2.18	0.13
14187 (19)	3.07	1.50	2.05	0.13
14189 (19)	2.94	1.34	2.19	0.12
14190a (19)	3.64	1.47	2.48	0.14
14190b (19)	3.58	1.54	2.32	0.15
14191a (19)	3.20	1.44	2.22	0.10
14191b (19)	3.46	ca. 1.54	ca. 2.25	0.14
14193 (19)	3.84	1.57	2.45	0.13
14205 (20)	3.71	1.60	2.32	—
14206 (21)	—	1.31	—	0.14
14209 (21)	4.48	2.08	2.15	0.13

Specimen No. NSM PA-	Width of Volutions (mm)							
	1	2	3	4	5	6	7	8
14102a (05)	0.22	0.39	0.59	0.83	1.15	1.50	1.76	
14102b (05)	0.18	0.28	0.41	0.58	0.81	1.08	1.41	1.66
14103a (05)	0.24	0.37	0.55	0.75	1.00	1.31	1.70	2.05?
14103b (05)	0.24	0.39	0.62	0.87	1.15	1.44	1.79	2.01(7 1/2)
14104 (05)	0.22	0.30	0.50	0.73	1.00	1.31	1.70	2.11
14114 (08)	0.21	0.32	0.49	0.71	1.00	1.34		
14116 (08)	0.23	0.36	0.55	0.78	1.08	1.38	1.76?	
14125 (11)	0.17	0.28	0.42	0.62	0.85	1.13	1.44	1.76
14132 (11)	0.24	0.39	0.62	0.86	1.15	1.50	1.63(6 1/2)	
14134a (11)	0.21	0.35	0.53	0.76	1.04	1.34	1.54(6 1/2)	
14135 (11)	0.23	0.39	0.56	0.80	1.27	1.41		
14151 (17)	0.22	0.36	0.51	0.71	0.96	1.24	1.57	
14178b (18)	0.18	0.31	0.44	0.62	0.88	1.22	1.63	
14182 (19)	0.22	0.36	0.54	0.77	1.08	1.38	1.73	1.92(7 1/2)
14184 (19)	0.22	0.33	0.51	0.73	1.00	1.31	1.47(6 1/2)	
14187 (19)	0.24	0.39	0.60	0.89	1.19	1.50(5 1/2)		
14189 (19)	0.21	0.33	0.53	0.77	1.04	1.34		
14190a (19)	0.26	0.39	0.55	0.77	1.04	1.34	1.47(6 1/2)	
14190b (19)	0.24	0.39	0.51	0.72	0.99	1.34	1.54(6 1/2)	
14191a (19)	0.19	0.30	0.44	0.64	0.89	1.14	1.44	
14191b (19)	0.26	0.39	0.56	0.78	1.05	ca. 1.34	ca. 1.54(6 1/2)	
14193 (19)	0.24	0.39	0.56	0.81	1.05	1.38	1.57(6 1/2)	
14205 (20)	—	0.27	0.47	0.77	1.08	1.44	1.60	
14206 (21)	0.23	0.34	0.51	0.68	0.91	1.18	1.31(6 1/2)	
14209 (21)	0.28	0.42	0.62	0.94	1.28	1.63	2.08	

Remarks: *Fusulinella incaica* n. sp. is most abundant in the Tarma Limestone, and closely similar to *Fusulinella alta* and *Fusulinella nevadensis*, both of which were originally described from the Pennsylvanian rocks of eastern Nevada, U.S.A. by Verville, Thompson and Lokke (1956), in the shell size, form and other essential characters, but differs from these two species in having much smaller proloculus. According to the original description by them (V. T. & L), the average diameter of proloculus is 0.09 mm (less than 0.11 mm) in *F. alta* and 0.08 mm (less than 0.10 mm) in *F. nevadensis*, but 0.13 mm (in average) in *Fusulinella incaica* n. sp.

The present species is similar also to the precedingly described *Fusulinella peruana*, but it can be distinguished easily from the latter species by the concave shell form.

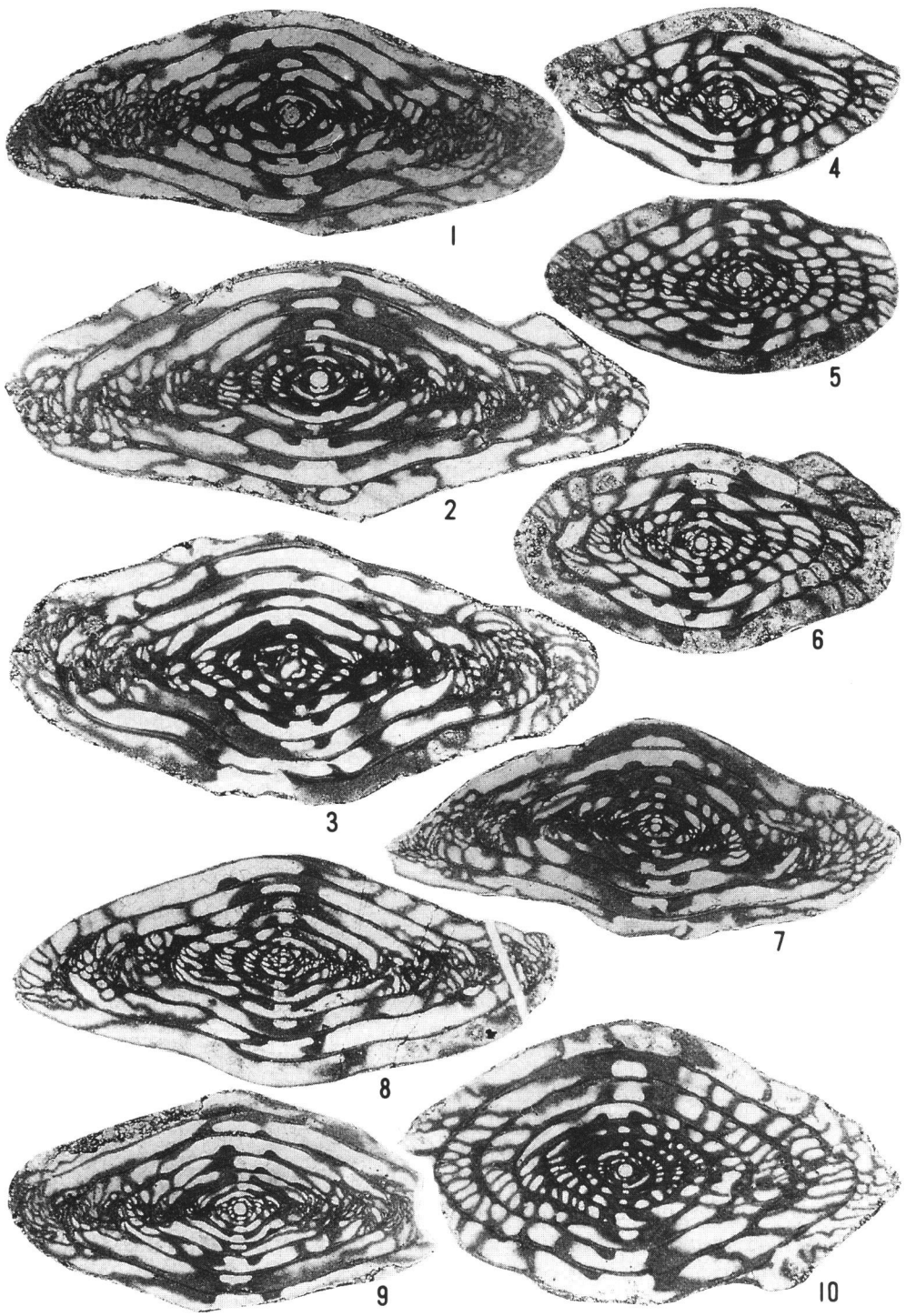

Fig. 7. 1–10, *Fusulinella incaica* n. sp., ×20, NSM PA-14102a, 14103a (holotype), 14103b, 14114, 14206, 14116, 14132, 14125, 14102b and 14104, respectively.

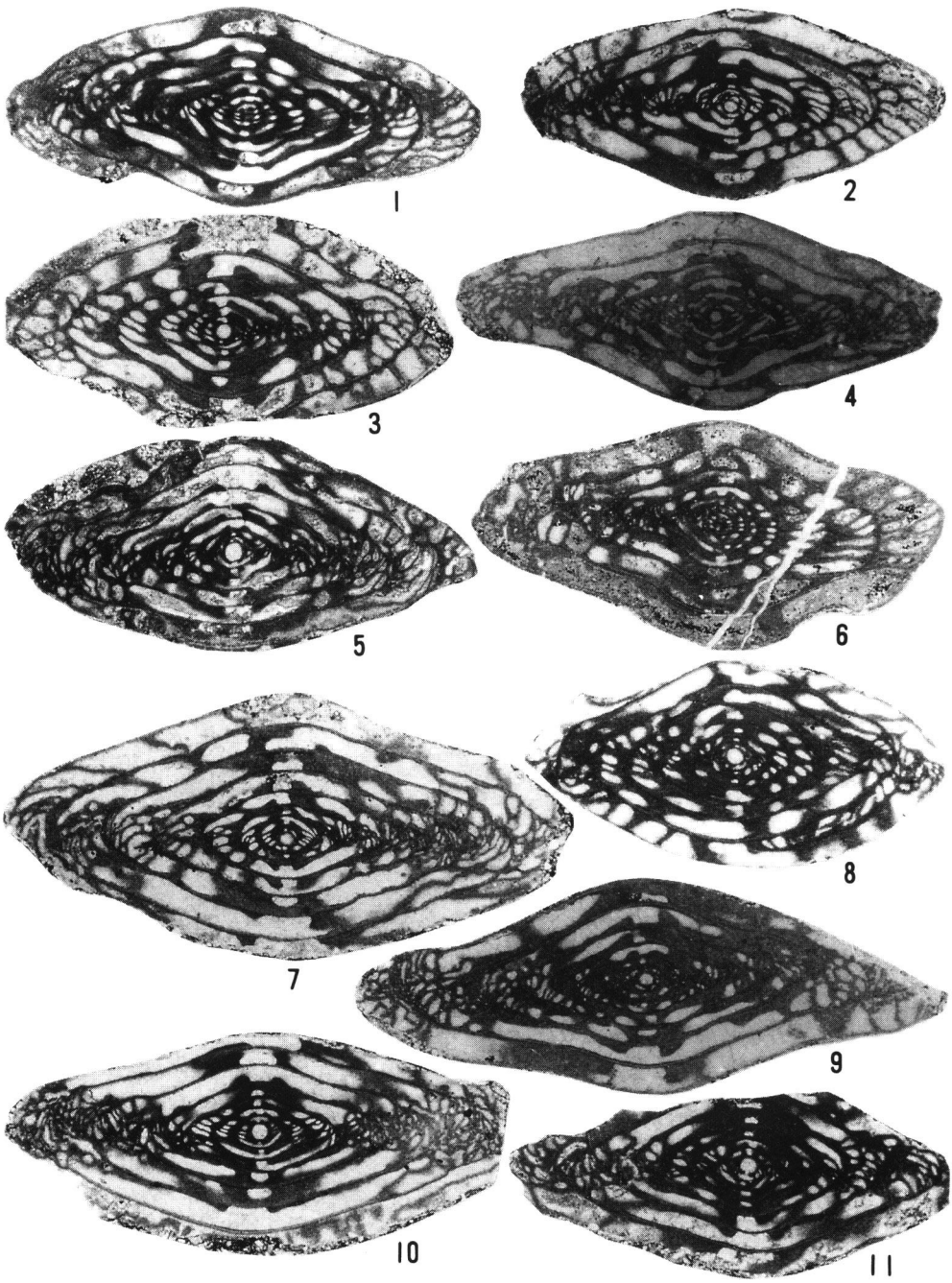

Fig. 8. 1–11, *Fusulinella incaica* n. sp., ×20, NSM PA-14151. 14189. 14187, 14135, 14190b, 14178b, 14182, 14184, 14134a, 14190a and 14191b, respectively.

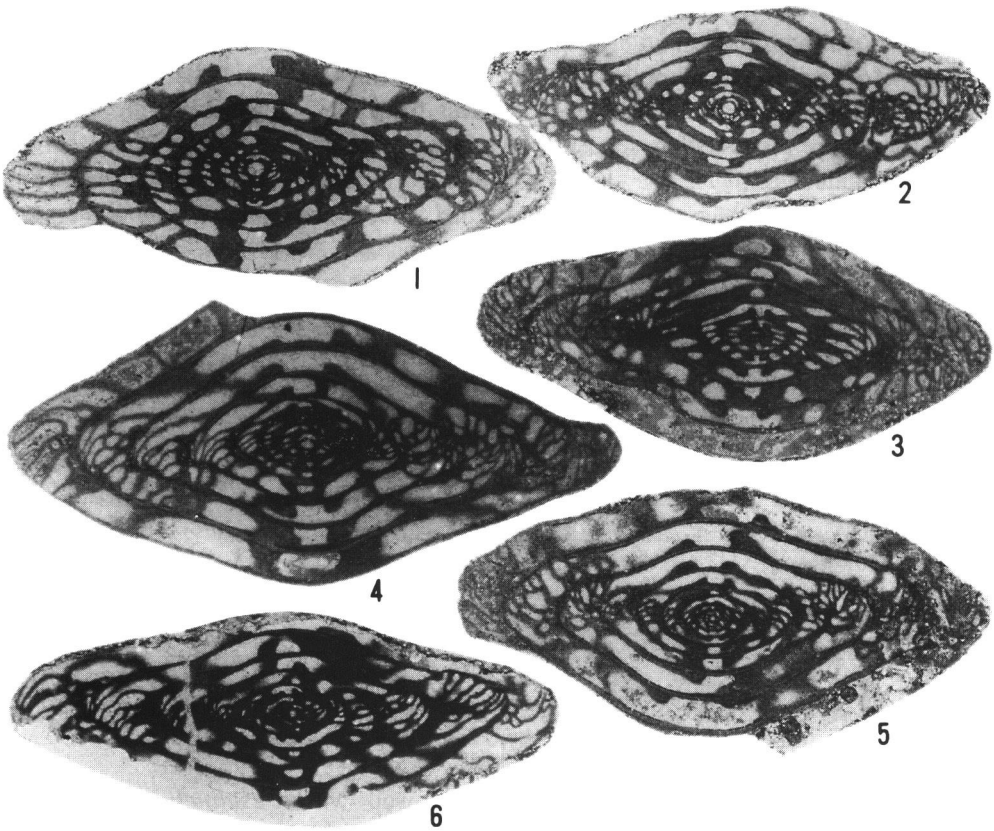

Fig. 9. 1–4, *Fusulinella incaica* n. sp., ×20, NSM PA-14193, 14191a, 14205 and 14209, respectively. 5, 6, *Fusulinella nevadensis* Verville, Thompson and Lokke, ×20, NSM PA-14236a and 14156, respectively.

Fusulinella nevadensis Verville, Thompson and Lokke, 1956

(Figs. 9–5, 6)

Fusulinella nevadensis Verville, Thompson and Lokke, 1956, p. 1283–1285, pl. 135, figs. 1–6; Lin, Ross and Nassichuk, 1991, p. 50, 51, pl. 15, figs. 1–10, pl. 16, figs. 1–6.

Material and Horizon: Only two axial sections were selected as shown in the dimension table. Numbers in parentheses refer the horizons.

Description: Shell rather large for the genus, elongate fusiform in shape and distinctly inflated in central region, with extended polar ends and concave lateral slopes. Axis of coiling straight. Mature specimens of seven and a half to eight volutions are 3.65 and 3.84 mm long, 1.60 and 1.70 mm wide, with form ratios of 2.28 and 2.26, respectively. Proloculus small, 0.05 to 0.08 mm in outside diameter. The first volution is ellipsoidal in shape, and beyond the first volution the axis becomes

rapidly extended. Inner three to four volutions coiled rather tightly, but becoming rapidly expand to outer volutions. Spirotheca, typical for the genus, is thin and composed of a tectum, diaphanotheca, and upper and lower tectoria. Its thickness increases from inner to outer volutions, but less than 0.032 mm even in the thickest part. Septa are almost plane except for extreme polar regions where they are irregularly fluted. Chomata are almost half as high as the chambers in the center of the chambers, with steep to overhanging tunnel sides in some cases. Tunnel narrow, with a slightly irregular path.

Dimensions:

Specimen No. NSM PA-	Length (mm)	Width (mm)	Form Ratio	Diameter of Proloculus (mm)
14156 (17)	3.84	1.70	2.26	0.05
14236a (27)a	3.65	1.60	2.28	0.08

Specimen No. NSM PA-	Width of Volutions (mm)							
	1	2	3	4	5	6	7	8
14156 (17)	0.12	0.19	0.30	0.42	0.63	0.90	1.26	1.70
14236a (27)	0.13	0.19	0.30	0.46	0.69	0.94	1.27	1.60(7 1/2)

Remarks: The present specimens agree well with *Fusulinella nevadensis* which was originally described from the Ely Limestone of Nevada, U.S.A. in the microscopic measurements and all of essential characters. This species can be distinguished easily from *Fusulinella incaica* n. sp. by the smaller proloculus.

Fusulinella devexa Thompson, 1948

(Figs. 10–1～12)

Fusulinella devexa Thompson, 1948, p. 94, 95, pl. 32, figs. 6, 10, pl. 35, figs. 1–15, pl. 36, figs. 7–10, 12–17; Rich, 1961, pl. 143, figs. 6–9; Ross and Sabins, 1965, p. 186, pl. 24, figs. 6–9; Lin, Ross and Nassichuk, 1991, p. 51, pl. 14, figs. 10–19.

Material and Horizon: Twelve axial sections were selected as shown in the dimension table. Numbers in parentheses refer the horizons.

Description: Shell medium-sized, elongated fusiform having sharply pointed poles, slightly concave or nearly straight lateral slopes, and straight axis of coiling. Mature specimens of five and a half to seven volutions are 2.27 to 3.20 mm long, 0.90 to 1.38 mm wide, with form ratios ranging from 1.93 to 3.10, averaging 2.35 for twelve specimens. Proloculus spherical, moderate in size, varying from 0.08 to

0.14 mm, averaging 0.11 mm in outside diameter for twelve specimens. Inner one to two volutions are spherical in profile and then becoming ellipsoidal to elongated fusiform. Spirotheca, typical for the genus, is composed of four layers: a tectum, diaphanotheca, and lower and upper tectoria, rather thin, less than 0.025 mm even in the thickest part. Septa are irregularly fluted in the extreme polar regions and almost plane or weakly fluted in the central part of shell. Chomata developed asymmetrically about half as high as the chamber in the center of chambers. Tunnel narrow in inner three volutions but becoming wider in outer volutions, attaining about 30°.

Dimensions:

Specimen No. NSM PA-	Length (mm)	Width (mm)	Form Ratio	Diameter of Proloculus (mm)
14153b (17)	2.27	ca. 0.90	ca. 2.52	0.08
14157 (17)	3.20	1.38	2.32	—
14158 (17)	3.10	1.17	2.65	0.10
14159a (17)	2.53	1.28	1.98	0.09
14178a (18)	2.90*	1.13	2.57	0.10
14194b (19)	2.56*	1.13	2.27	0.09
14207 (21)	2.37	1.15	2.06	0.13
14208 (21)	2.95	1.52	1.94	0.12
14210 (21)	2.43	1.26	1.93	0.14
14233a (27)	3.20*	1.31	2.44	0.12
14233b (27)	2.72	1.10	2.47	0.14
14233c (27)	3.10*	1.00	3.10	0.12

*half length×2.

Specimen No. NSM PA-	Width of Volutions (mm)						
	1	2	3	4	5	6	7
14153b (17)	0.13	0.22	0.34	0.53	0.77	ca. 0.90	
14157 (17)	0.15	0.24	0.37	0.53	0.74	1.03	1.38
14158 (17)	0.17	0.28	0.45	0.69	1.01	1.17(5 1/2)	
14159a (17)	0.16	0.27	0.41	0.62	0.92	1.28	
14178a (18)	0.15	0.26	0.36	0.53	0.71	0.95	1.13(6 1/2)
14194b (19)	0.15	0.23	0.36	0.51	0.73	0.97	1.13(6 1/2)
14207 (21)	0.23	0.34	0.53	0.74	1.00	1.15(5 1/2)	
14208 (21)	0.22	0.32	0.45	0.64	0.89	1.17	1.52
14210 (21)	0.22	0.36	0.51	0.71	0.97	1.26	
14233a (27)	0.18	0.26	0.40	0.55	0.74	1.00	1.31
14233b (27)	0.21	0.31	0.42	0.58	0.77	0.97	1.10
14233c (27)	0.18	0.27	0.40	0.55	0.76	1.00	

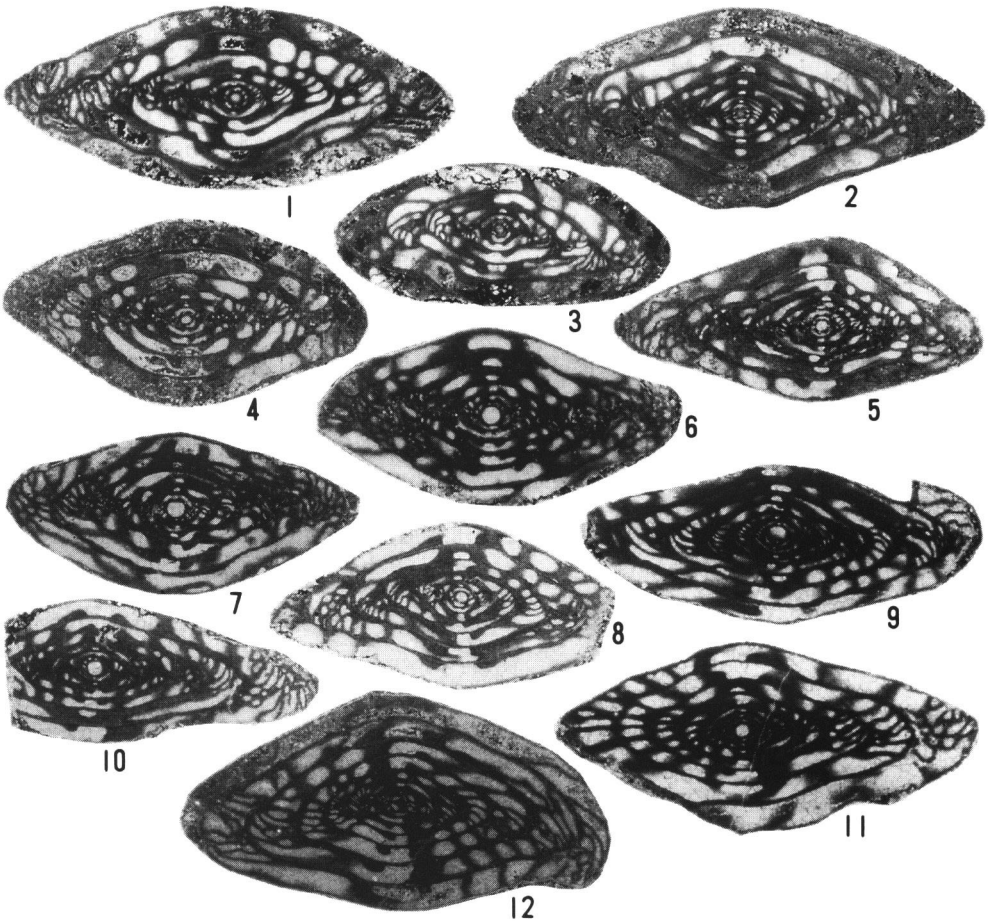

Fig. 10. 1–12, *Fusulinella devexa* Thompson, ×20, NSM PA-14158, 14157, 14153b, 14159a, 14178a, 14210, 14207, 14194b, 14233b, 14233c, 14233a and 14208, respectively.

Remarks: *Fusulinella devexa* is characterized by the medium sized shell having sharply pointed poles and slightly concave lateral slopes. The present specimens are identical with the original specimens described from the Cuchillo Negro Formation of Mud Springs Mountains, U.S.A. by Thompson (1948) in the essential characters except for the slightly smaller size and larger proloculus.

Genus *Wedekindellina* Dunbar and Henbest, 1933

Wedekindellina ardmorensis Thompson, Verville and Lokke, 1956

(Figs. 11–1~9)

Wedekindellina ardmorensis Thompson, Verville and Lokke, 1956, p. 803, 806, 807, pl. 92, figs. 1–12.

Material and Horizon: Eight axial (including slightly oblique) and one tangential sections selected as shown in the dimension table. Numbers in parentheses refer the horizons.

Description: Shell medium size for the genus, elongate fusiform in shape, having pointed polar ends and straight axis of coiling, and almost straigtht or sligthtly convex lateral slopes. Mature specimens of seven to nine volutions measure 2.72 to 4.03 mm long, 1.14 to 1.60 mm wide, with form ratios of 2.25 to 2.80, averaging 2.61 for seven specimens. Proloculus spherical and small, ranging from 0.06 to 0.09 mm in outside diameter. Shell coiled tightly in inner three to four volutions, but expanded rapidly in outer volutions. Spirotheca composed of a tectum, diaphanotheca, and upper and lower tectoria, becoming thicker to the outer volutions about 0.02 mm in the thickest part. Septa very weakly fluted or almost flat in central region of the shell but slightly irregular in the extreme polar areas. Septal counts of the first to seventh volutions of one specimen are 9, 14, 18, 21, 22, 27 and 25, respectively. Chomata about half as high as the chambers in the center of chambers and broad, and have vertical to overhanging tunnel sides and low polarward slopes. Tunnel narrow, gradually increases from about 20° in the inner to about 30° in the outer volutions. Axial filling very thin.

Dimensions:

Specimen No. NSM PA-	Length (mm)	Width (mm)	Form Ratio	Diameter of Proloculus (mm)
14235a (27)	3.20	1.15	2.78	0.06
14235b (27)	3.14	1.14	2.75	—
14237a (27)	3.20	1.28	2.50	0.08
14237b (27)	ca. 4.16	1.60	2.60	—
14238a (27)	3.58	1.28	2.80	0.09
14240a (27)	2.72	1.21	2.25	0.08
14240b (27)	4.03	1.54	2.62	0.08
14241a (27)	—	1.31	—	0.07
14241b (27)	—	1.31	—	—

Specimen No. NSM PA-	Width of Volutions (mm)								
	1	2	3	4	5	6	7	8	9
14235a (27)	0.09	0.15	0.23	0.36	0.49	0.68	0.91	1.15	
14235b (27)	0.10	0.15	0.26	0.35	0.49	0.69	0.90	1.14	
14237a (27)	0.14	0.21	0.31	0.41	0.58	0.77	1.04	1.28	
14237b (27)	—	—	—	—	0.48	0.80	0.96	1.28	1.60
14238a (27)	0.17	0.21	0.39	0.59	0.81	1.06	1.28		
14240a (27)	0.14	0.22	0.32	0.46	0.64	0.90	1.21		
14240b (27)	0.13	0.19	0.32	0.40	0.62	0.88	1.14	1.54	
14241a (27)	0.13	0.19	0.31	0.44	0.60	0.85	1.15	1.31(7 1/2)	
14241b (27)	0.13	0.18	0.26	0.36	0.50	0.64	0.91	1.17	1.31

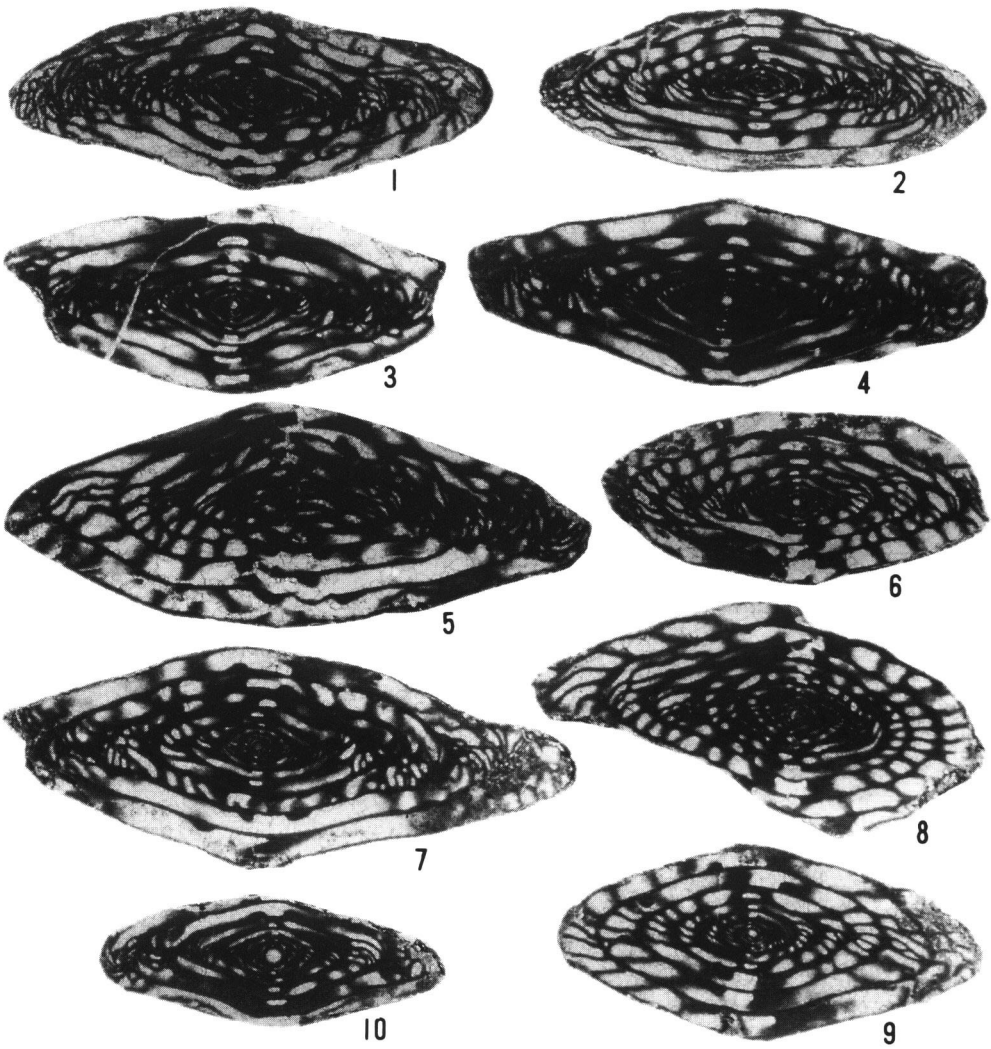

Fig. 11. 1–9, *Wedekindellina ardmorensis* Thompson, Verville and Lokke, ×20, NSM PA-14235a. 14235b. 14237a, 14238a, 14237b, 14240a, 14240b, 14241b and 14241a, respectively. 10, *Wedekindellina* cf. *W. lata* Thompson, ×20, NSM PA-14236b.

Remarks: *Wedekindellina ardmorensis* is characterized by the very thin axial fillings and smaller chomata of any form of the genus. The present specimens agree well with the type species described from the Confederate Limestone in the Ardmore Basin of southern Oklahoma in all of essential characters and measurements. The present specimens seem to be very closely similar to the specimens described as *Wedekindellina lata* Thompson (1961) by Lin, Ross and Nassichuk (1991) from the

Nansen Formation of Ellesmere Island.

Wedekindellina cf. ***W. lata*** Thompson, 1961

(Fig. 11–10)

Compared Wedekindellina lata Thompson, 1961, p. 1134, pl. 136, figs. 1–7.

Material and Horizon: Only one axial section, Specimen No. NSM PA-14236b (Horizon no. 27).

Description: Shell rather small, elongate fusiform in shape, having pointed polar ends, straight axis of coiling, and almost straight or slightly concave lateral slopes in outer volutions. A mature shell of five and a half volutions is 2.37 mm long, 0.90 mm wide, with form ratio of 2.63. Proloculus relatively large and spherical in shape, its outside diameter 0.14 mm. Shell coiled tightly in the inner two volutions but expanded rather rapidly in the outer volutions. Width of volutions from the first to last volutions are 0.21, 0,30, 0.41, 0.58, 0.80 and 0.90, respectively. Septa are almost plane in the central regions of the shell, but are slightly irregular in the extreme polar areas. The septal fluting is indistinct in any part of the shell. Spirotheca is composed of a tectum, diaphanotheca, and upper and lower tectoria, about 0.022 mm thick in the outer volutions. Chomata developed asymmetrically, broad and about half as high as the chambers in the center of chambers. Tunnel is relatively narrow, about 25°, with steep tunnel sides. Tunnel path is almost straight.

Remarks: In spite of only one specimens observed at hand, the present form may be identified with *Wedekindellina lata* which was originally described from Ward Hunt Island, located at a few miles north of Ellesmere Island. This species is characterized by its larger proloculus and indistinct septal fluting in any part of the shell. This species was described also from the Nansen Formation of Ellesmere Island by Lin, Ross and Nassichuk (1991), but the specimens described by them seem to be different from the type specimens of *Wedekindellina lata* in having a larger shell with smaller proloculus.

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References Cited

Chuvashov, B. I., Ivanova, R. M. and Kolchina, A. N., 1984. Upper Paleozoic deposits of the eastern slope of the Urals—Stratigraphy and geological history. *Uralian Sci. centre, Acad. Sci. U.S.S.R., Sverdlovsk*, 230 p., 31 pls.

Dunbar, C. O. and Newell, N. D., 1946 a. Marine Early Permian of the central Andes and its fusuline faunas. Part I. *Amer. Jour. Sci.*, **244** (6): 377–402.

Dunbar, C. O. and Newell, N. D., 1946 b. Marine Early Permian of the central Andes and its fusuline faunas. Part II. *Amer. Jour. Sci.*, **244** (7): 457–491.

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 middle Ural). *Trans. Geol. Oil Inst.*, Ser. A, **36**: 3–98, 6 pls. (In Russian with English summary)

Harrison, J. V., 1943. Geology of the Central Andes in part of the Department of Junin, Peru. *Geol. Soc. London, Quart. Jour.*, **99**: 1–36 (Spanish translation in *Bol. Soc. Geol. Peru*, 16, p. 1–97.)

Kanmera, K., 1954. The fusulinids from the Yayamadake Limestone of the Hikawa Valley, Kumamoto Prefecture, Kyushu, Japan. Part I. *Jap. Jour. Geol. Geogr.*, **25** (1–2): 117–144, pls. 12–14.

Lin, R., Ross, C. A. and Nassichuk, E. W., 1991. Upper Moscovian (Desmoinesian) fusulinaceans from the type section of the Nansen Formation, Ellesmere Island, Arctic Aarchipelago. *Geol. Surv. Canada, Bull.*, (418): 1–121 (incl. 24 pl.).

Meyer, H. L., 1914. Carbonfaunen aus Bolivia und Peru. *N. Jahrb. Min., Geol. Palaeont.*, Beil.-Bd. **37**: 590–652, pls. 13, 14.

Newell, N. D., Chronic, J. and Roberts, T. G., 1953. Upper Paleozoic of Peru. *Geol. Soc. Amer. Mem.* **58**: 276 p., 44 pl.

Putrja, F. S., 1956. Stratigrafiya i foraminifery srednekamennougolnykh otlozheniy vostochnogo Donbassa. *VNIGRI, Trudy, N.S., (98), Mikrofauna SSSR*, **8**: 333–485, 17 pl. [Stratigraphy and foraminifera of the Middle Carboniferous deposits of the eastern Don Basin.]

Rauser-Chernoussova, D. M., Gryzlova, N. D., Kireeva, G. D., Leontovich, G. E., Safonova, T. P. and Chernova, E. I., 1951. Srednekamennougolnye fusulinidy russkoi platformy i sopredelnykh oblastey. *Akad. Nauk SSSR, Inst. Geol. Nauk, Minist. Neft. Promyshlennosti SSSR*, 380 p., 58 pl. [Middle Carboniferous fusulinids of the Russian Platform and adjacent regions.]

Rich, M., 1961. Stratigraphic section and fusulinids of the Bird Spring Formation near Lee Canyon, Clark County, Nevada. *Jour. Paleont.*, **35** (6): 1159–1180, pls. 142–146.

Ross, C. A. and Dunbar, C. O., 1962. Faunas and correlation of the Late Paleozoic rocks of Northeast Greenland. Part II. Fusulinidae. *Medd. om Grønland*, **167** (5): 1–55, pls. 7.

Ross, C. A. and Sabin, F. F. Jr., 1965. Early and Middle Pennsylvanian fusulinids from southeast Arizona. *Jour. Paleont.*, **39** (2): 173–209, pls. 21–28.

Sakagami, S., ed. (The Research Group), 1984. *Biostratigraphic study of Paleozoic and Mesozoic Groups in Central Andes —An Interim Report—*. 82 p. (incl. 29 pl.). Dept. Earth Sci., Fac. Sci., Chiba Univ.

Steinmann, G., 1929. *Geologie von Peru*. 448 p., 9 pl., Heidelberg. (Spanish ed.: Geologia del Peru, Heidelberg, 1930).

Thompson, M. L., 1948. Studies of American fusulinids. *Univ. Kansas, Paleont. Contr., Protozoa*, Art. 1, p. 1–184, pls. 1–38.

Thompson, M. L., 1961. Pennsylvanian fusulinids from Ward Hunt Island. *Jour. Paleont.*, **35** (6): 1130–1136, pls. 135, 136.

Thompson, M. L., Verville, G. J. and Lokke, D. H., 1956. Fusulinids of the Desmoinesian–Missourian contact. *Jour. Paleont.*, **30** (4): 793–810, pls. 89–93.

Van Ginkel, A. C., 1965. Carboniferous fusulinids from the Cantabrian Mountains (Spain). *Leidse Geol. Mededelingen*, **34**: 1–225, pls. 1–53.

Verville, G. J., Thompson, M. L. and Lokke, D. H., 1956: Pennsylvanian fusulinids of eastern Nevada. *Jour. Paleont.*, **30** (6): 1277–1287, pls. 133–136.