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SOME FUSULINIDS FROM CHANGHSING LIMESTONE

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(with 4 plates)

Introduction

The present paper deals with some specimens of *Palaeofusulina*, *Nankinella*, *Ozawainella* and *Reichelina* from the Changhsing limestone of Kiangsi, southern Szechuan and central Kweichow and *Gallowaiinella* from the ferruginous chert bed of Kiangsi. The Changhsing limestone is widespread in the middle and lower Yangtze valley and in southwestern China. It is usually underlain by the *Gigantopteris* Coal Series and is overlain by the lower Triassic thin-bedded limestone. According to Dr. T. K. Huang, the Changhsing limestone belongs to the upper part of the Upper Permian.

The only record of fusulines from the Meitien limestone of southern Hunan, probably equivalent to the Changhsing limestone, was made by Prof. S. Chen in 1934. In that paper, only one species of *Gallowaiinella* was described.

In the winter of 1949, while studying the geology and stratigraphy of the Loping coal field, Mr. Y. Wang collected a number of limestone pieces containing Fusulinids from Chienpao, some 20 km south of Loping city, Kiangsi province. The specimens were sent to the writer for identification. It is found that this limestone bed consists of abundant fossils of *Palaeofusulina* in association with a few *Nankinella*.

A great number of *Palaeofusulina* specimens were also found by Messrs. Y. Wang and H. Y. Liu in 1951 from the Changhsing limestone in central Kueichow and near the border of Szechuan and Kueichow provinces. In this region, the *Palaeofusulina* is also in close association with a few *Nankinella*. So far as the present knowledge goes, the genus *Palaeofusulina* is only restricted to the Changhsing limestone. It could be therefore considered as a zone fossil of the Upper Permian. The *Palaeofusulina* zone of China is most probably equivalent to the *Polydiexodina* zone of North America.

In the Mingshan region, about 5 km west of the Loping city, a ferruginous

chert bed is well distributed. In the chert bed, Y. Wang found in 1949 three scattered small limestone nodules containing *Gallowaiinella*. No *Palaeofusulina* were found. According to Wang, this chert bed might be correlated with the *Palaeofusulina*-bearing limestone of Chienpao. The stratigraphic relationship between *Gallowaiinella** and *Palaeofusulina* is unknown.

The writer is much indebted to Profs. S. Chen and H. C. Sze for instructions and critical reading of the manuscript. My thanks are also due to Messrs. Y. Wang and H. Y. Liu for offering him the specimens for study and to S. Y. Liu for microphotograph.

DESCRIPTION OF SPECIES

Subfamily Ozawainellinae Thompson and Foster, 1937

Genus *Ozawainella* Thompson 1935

Ozawainella sp.

(Pl. I, Figs. 1-4)

Test minute, lenticular, whorls highly vaulted with a sharply angular periphery. The largest form contains about five volutions measuring 0.27 mm and 0.73 mm in length and width respectively. The umbilical area is convex. The spirotheca is relatively thin, its composite nature is not observable because of ill preservation. Chomata are asymmetrical and are developed throughout most of the shell. Proloculum not seen.

Occurrence: *Palaeofusulina* zone, Upper Permian. Chienpao of Loping district, Kiangsi province and north of Tiaoshihyai, Chuan-Chien Highway, Tungtze district, Kueichow province.

Genus *Reichelina* Erk 1941 emend. K. M.-Maclay 1951

Reichelina simplex Sheng (sp. nov.)

(Pl. I, Figs. 5-6)

Test minute, lenticular, with short axis and very sharply angular periphery. The last whorl is highly vaulted to produce a stout, tail-like prolongation of the shell. The mature specimens contain 3 volutions measuring about 0.22 mm in axial length, and 0.46 mm to 0.6mm in median width. The form ratio is about 0.33:1

* The stratigraphic relationship of ***Gallowaiinella***, ***Palaeofusulina*** and ***Chusenella*** must also await further investigations and studies.

in the type specimen. The spirotheca is exceedingly thin in the last volution which is apparently composed of only one dense uniform layer, the tectum. In the inner volutions, the spirotheca is rather thick and consists of a compact tectum and the upper and lower tectoria of ill preservation. The outer tectorium is usually much thicker than the inner tectorium in all of the whorls. Septa are thin and straight. Chomata seem to be absent. The tunnel is slit-like, small. Proloculum is minute, spherical, only 0.04 mm in the outer diameter.

Remarks: This form much resembles *Reichelina media* K. M.-Maclay in the size of the test and in the shape of the expanded last whorl, but differs from the latter in having fewer whorls, a sharply angulate periphery and in the extraordinary thin spirotheca in the outermost whorl.

Occurrence: *Palaeofusulina* zone, Upper Permian. Between Peishihtan and Lungtsangtze, along Sungkan river, Chikiang district, Szechuan province.

Measurements (in mm) of ***Reichelina simplex*** Sheng

specimen	L.	W.	F. R.	Diam. Prol.	Width of volution				Form ratio of volution			
					1	2	3	4	1	2	3	4
7939	0.2	0.6	0.33	0.04	0.15	0.3	0.6	—	0.6	0.5	0.33	—
7940	0.2	0.46	0.43	0.04	0.15	0.27	0.46	—	0.6	0.5	0.43	—

Genus *Nankinella* Lee 1934

Nankinella minor Sheng (sp. nov.)

(Pl. I, Fig. 7.)

This new species is represented by a single, incomplete specimen. The shell is small in size, discoidal and planispiral throughout, with a short but straight axis of coiling. Mature specimen of seven volutions measured 1.8 mm and 2.68 mm in length and width respectively. Form ratio 0.67: 1. The structure of the spirotheca cannot be clearly determined because it is ill preserved. The thickness of the spirotheca in the median part is greater than that near the

The half length and half width of the successive volutions are as follows:-

specimen	Half Length								Half width							
	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
7941	0.1	0.17	0.27	0.39	0.53	0.67	0.77	0.9	0.1	0.27	0.47	0.63	0.83	1.03	1.20	1.39

poles. Measurement made from axial section gives 0.03, 0.031, 0.05, 0.06, 0.07, 0.08 and 0.08 mm from first to seventh volutions.

Septa unfluted, chomata asymmetrical, developed in all of the volutions, with the steep side facing the tunnel, and the gentle slope toward the poles.

Tunnel singular, broad, two-thirds the height of the chamber. Tunnel path not straight.

Remarks: This form is characterized by its small size, fewer whorls, shorter axis, more inflated shell and higher tunnel as compared with the known species.

Occurrence: *Palaeofusulina* zone, Upper Permian. Chienpao of Loping district, Kiangsi province.

Nankinella sp.

(Pl. I, Figs. 8-11)

Test small, with broadly angular periphery throughout the shell. Axial length much shorter than the median width, the former is measured 1.5 mm and the latter 2.17 mm from a para-axial section (Pl. I, fig. 8). Spirotheca relatively thin, highly silicified, details unknown.

Proloculum not seen, because all of the sections are not centered.

Septa plane, as thick as the spirotheca.

Occurrence: In association with *Palaeofusulina* from Chienpao, Loping district, Kiangsi province.

Genus *Pisolina* Lee 1934

? *Pisolina* sp.

(Pl. I, Fig. 12)

This silicified specimen represents a single sagittal section with an extraordinarily large proloculum measuring 0.45 mm in the longest diameter. Whorls about 9 in number. Spirotheca thin, and apparently composed of a tectum and an ill-defined keriotheca in the outer volutions. Septa numerous, straight.

Occurrence: The fossil is associated with *Gallowaiinella meitienensis* Chen in the limestone nodules derived from the chert bed, probably Upper Permian. Shihtzekou, Mingshan coal field, Loping district, Kiangsi province.

Subfamily Boultoninae Skinner and Wilde 1954

Genus *Gallowaiinella* Chen 1937

Gallowaiinella meitienensis Chen

(Pl. II, Figs. 1-8)

1934. *Gallowaiina meitienensis* Chen, Bull. Geol. Soc. China, Vol. 13, No. 2, p. 237-238, Pl. I, figs. 1-10.

1937. *Gallowaiinella meitienensis* Chen (In Dunbar and Skinner) Texas Univ. Bull. 3701, p. 571-572.

Shell small, elongate, subcylindrical to fusiform in shape. The axis of coiling is slightly arcuate and has a sharply to bluntly pointed poles. The axial length measures 2.54 mm to 3.64 mm and width 0.8 mm to 1.34 mm with form ratio 2.71 to 3.44:1. Whorls usually 6 in number, all being fusiform, compactly but regularly coiled and expanding uniformly outward. Spirotheca exceedingly thin, consisting of two layers, a thin compact tectum and a rather thick translucent diaphanotheca. Septa thin, narrowly and regularly fluted from pole to pole. Axial fillings well developed throughout all the volutions except the outer one. Proloculum small, spherical, with its outer diameter usually about 0.1 mm.

Remarks: This form agrees fairly well with *Gallowaiinella meitienensis* Chen in all important characters, but differs from the latter in having more subcylindrical profile and biconvex median part. It is thought that the present form might be a new variety of *Gallowaiinella meitienensis* Chen.

Occurrence: The limestone nodules derived from the chert bed are probably of Upper Permian. Shihtzekou, Mingshan coal field, Loping district, Kiangsi province.

Table of Measurements (in mm) of *Gallowaiinella meitienensis* Chen

specimen	L.	W.	F. R.	Diam. Prol.	Width of volutions						Form ratio of volutions					
					1	2	3	4	5	6	1	2	3	4	5	6
7957	3.64	1.34	2.71	0.12	0.25	0.38	0.58	0.84	1.14	—	3.2	3.7	3.47	3.26	3.0	—
7952	3.72	1.08	3.44	0.1	0.22	0.36	0.56	0.8	1.08	—	3.54	3.33	3.57	3.37	3.44	—
7951	2.54	0.8	3.17	0.1	0.23	0.36	0.56	0.8	—	—	3.78	3.7	3.53	3.17	—	—

Genus *Palaeofusulina* Deprat 1912

Early in 1912, Deprat proposed the genus *Palaeofusulina* but the type species was described in the following year as *Palaeofusulina prisca* Deprat. A

part of his original statement may be quoted here: "Ce genre nouveau offre les caractéristiques suivantes: Coquille petite, presque globulaire, tours de spire à enroulement de rapidité moyenne, structure des parois semblable à celle de *Fusulina* avec réseau alvéolaire……". In 1948, while discussing the genus *Palaeofusulina*, M. L. Thompson denoted: "Deprat stated that the original specimens of the genotype of *Palaeofusulina* were silicified, His illustrations seeminly are a combination of photographs, retouched photographs, and drawings. The spirotheca of the illustrations that do not seem to be retouched is composed of a single thin dense layer. In other illustrations, including that of the holotype, obvious retouching of a photograph has produced rather abnormal structural features. For instance, a thick keriotheca having coarse alveoli is shown across the shell of most volutions, but the keriotheca abruptly ends laterally and is continuous with a spirotheca composed of only a single dense layer. Other illustrations of paratypes show a spirotheca composed of only a single layer throughout the length of the shell. Colani's specimens from the same general locality as the holotype seem silicified. All her photographic illustrations show a thin spirotheca. Keriotheca possessing an alveolar structure is not observed in any of them. The type specimens of *Palaeofusulina nana* Likharev (1926) from the Caucasus seem largely replaced by secondary mineralization. The spirotheca is thin and is composed of a tectum and the structureless lower layer." Thus, the spirotheca of *Palaeofusulina* both in *P. prisca* and *P. nana* is according to M. L. Thompson, composed of two layers, the tectum and the diaphanotheca. The same conclusion has been arrived at by the present writer.

Palaeofusulina wangi Sheng (sp. nov.)

(Pl. III, Figs. 1-5a, 7)

A rather large, thickly fusiform or subglobular species of 5 volutions attaining a length of 2.2 mm to 2.48 mm and a diameter of 1.4 mm to 1.68 mm with a form ratio of about 1.5:1. The poles are bluntly pointed. The proloculum is small, commonly about 0.1 mm in outer diameter. The whorls expand gradually but rather rapidly. The septa are intensely folded. The septal folds are narrow and high throughout the length of the shell, and so strong that the folds of one septum meet those of the next, dividing the lower part of each meridional chamber into cell-like chamberlets. Thus, in axial sections the septal loops are high, narrow, and abundant throughout all the whorls. The spirotheca

is very thin, being 0.02 mm as measured on the fourth volution. It consists of an upper dense tectum and a structureless lower layer, the diaphanotheca. The tunnel is narrow and somewhat irregular in width and in its course. Chomata is not present, Axial filling is lacking.

Remarks: This species is named in honor of Mr. Y. Wang. It differs from *Palaeofusulina prisca* Deprat in the smaller size, in the larger form ratio and less globular shape, and in the septal folds, which are less strongly and regularly fluted. In *P. prisca* Deprat, the septal folds are equally strong from top to bottom margin, so that the section of the septa appears as pillar-like in the axial sections of the shell. It superficially resembles *Palaeofusulina nana* Likharev, but it is easily distinguished by its wall structure, its larger size, its irregular septal fluting and absence of septal pores. In *P. wangi*, the spirotheca is composed of tectum and diaphanotheca. No any trace of keriotheca has been found even under high magnification. *P. wangi* differs from *P. weberi* (Schubert) mainly in the subglobular shape, and its spirotheca is thicker than that of the latter.

Occurrence: Upper Permian. Chumipu and north of Tiaoshihyai, Tungtze district, Kueichow province; between Peishihtan and Lungtsangtze, along Sungkan river, Chikiang district, Szechuan province.

Measurements (in mm) of *Palaeofusulina wangi* Sheng

specimen	L.	W.	F. R.	Diam. Prol.	Width of volutions					Form ratio of volutions				
					1	2	3	4	5	1	2	3	4	5
7959	2.24	1.5	1.5	0.1	0.22	0.48	0.74	1.1	1.5	1.8	1.5	1.56	1.55	1.5
7965	2.48	1.68	1.47	0.1	0.24	0.48	0.84	1.24	1.68	1.7	1.6	1.43	1.6	1.47
7962	2.35	1.56	1.5	0.12	0.22	0.44	0.76	1.14	1.56	1.8	1.6	1.51	1.45	1.5
7963	2.2	1.44	1.52	0.17	0.26	0.46	0.72	1.08	1.44	1.8	1.7	1.66	1.6	1.52

Palaeofusulina wangi var. *Chumipuensis* Sheng (var. nov.)

(Pl. III, Fig. 6)

Test rather large, thickly fusiform in shape. The axial length and median width are measured 2.64 mm and 1.56 mm respectively. The axial ratio is 1.7:1. Whorls thickly fusiform except the last one. They are loosely and regularly coiled increasing slowly and gradually in height. The spirotheca is exceedingly thin,

consisting of two layers, an outer dark layer, the tectum, and an inner lighter layer of which the alveolar structure is entirely wanting. Septa as thin as the spirotheca, intensely fluted throughout the length of the shell. The tunnel is wide and low in the outer volutions but narrower in the inner ones.

Remarks: This variety is separated from the type form of *P. wangi* by the rather slender fusoid shape, the smaller form ratio of the successive volutions and the lower and wider tunnel in the outer whorls.

Occurrence : Chumipu of Tungtze district, Kueichow province, Upper Permian.

Measurements of *P. wangi* var. *Chumipuensis* Sheng

specimen	L.	W.	F. R.	Diam. Prol.	Width of volutions					Form ratio of volutions				
					1	2	3	4	5	1	2	3	4	5
7964	2.64	1.56	1.7	0.1	0.2	0.4	0.76	1.16	1.56	2	2.2	2	1.9	1.7

Palaeofusulina sinensis Sheng (sp. nov.)

(Pl. IV, Figs. 1-15; Pl. I, Figs. 13,16)

Test small, rather thickly fusiform in shape. The poles are extended and pointed. The mature shells having 4 volutions attain a length of 1.7 mm to 2 mm and a width of 1.08 mm to 1.18 mm. The average form ratio of 5 specimens is about 1.7. The spirotheca is thin, consisting of tectum and diaphanotheca. The septa are highly and narrowly fluted, with its parallel-sided folds sometimes reaching the ceilings of the chamber. Number of septa in the successive whorls counted 12 in the first whorl, 17 in the second, 20 in the third and 16 in the fourth. The proloculum is small, spherical, commonly about 0.1 mm in the outer diameter. The tunnel is narrow and high; the tunnel path is not straight. No trace of Chomata has been observed.

Remarks: This species is closely similar to *Palaeofusulina nana* Likharev, but differs from the latter in the absence of the keriotheca and the septal pores, and in the less inflated shape of the shell. From *P. wangi* it is distinguished by the fewer volutions, smaller size, smaller form ratio, the less inflated shell and the comparatively regular septal folds.

Occurrence: Upper Permian. North of Tiaoshihyai, Chuan-Chien Highway, Tungtze district, Kueichow province; between Peishihtan and Lungtsangtze, Chikiang district, Szechuan province and Chienpao of Loping district, Kiangsi province.

Measurements (in mm) of *Palaeofusulina sinensis* Sheng

specimen	L.	W.	F. R.	Diam. Prol.	Width of volutions				Form ratio of volutions			
					1	2	3	4	1	2	3	4
7967	2.0	1.16	1.72	0.1	0.26	0.47	0.8	1.16	1.62	1.7	1.6	1.72
7969	1.8	1.06	1.7	0.1	0.26	0.5	0.84	—	1.7	1.84	1.73	—
7970	1.52	0.9	1.7	0.1	0.27	0.54	0.9	—	1.8	1.8	1.7	—
7974	1.72	1.0	1.72	0.1	0.28	0.55	0.83	—	1.9	1.9	1.68	—
7971	1.4	0.82	1.71	0.1	0.23	0.5	0.82	—	1.9	1.72	1.71	—
7975	1.8	1.16	1.55	0.12	0.28	0.52	0.82	1.16	1.86	1.8	1.71	1.55

Palaeofusulina sinensis var. *fusiformis* Sheng (var. nov.)

(Pl. I, Figs. 14,15)

Similar to *P. sinensis*, but more slender and elongate. The middle part is rather inflated. The poles are extended. Whorls in the first two volutions are rather closely coiled and distinctly fusoid in shape, thence becoming rather evolute and thickly fusiform in profile. In a microspheric individual, the whorls are all fusiform with depressed poles. The fully grown shell having 4 volutions measures 2.04 mm in length and 1.16 mm in width with a form ratio about 1.76: 1. The tunnel is narrow and high. The proloculum is small, spherical, being 0.14 mm in outer diameter, only 0.05 mm in the microspheric form. The spirotheca is thin, only 0.02 mm in the thickest part. It consists of tectum and lower structureless layer, the diaphanotheca. Septa are as thin as the spirotheca, intensely fluted throughout the whole length of the shell. Chomata is not seen.

Remarks: From the typical form of *Palaeofusulina sinensis*, this variety is characterized by its fusoid shape, depressed poles and smaller form ratio.

Occurrence: Upper Permian. North of Tiaoshihyai, Tungtze district, Kueichow province; Chienpao of Loping district, Kiangsi province.

Measurements (in mm) of *P. sinensis* var. *fusiformis* Sheng

specimen	L.	W.	F. R.	Diam. Prol.	Width of volutions				Form ratio of volutions			
					1	2	3	4	1	2	3	4
7948	2.04	1.16	1.76	0.14	0.27	0.45	0.78	1.16	2.1	2.3	2.0	1.76
7949	1.6	0.75	2.13	0.05	0.18	0.4	0.77	—	2.22	2.25	2.13	—

Explanation of Plates

The specimens and slices described in this paper are all preserved in the Institute of Paleontology, Academia Sinica. All figures are unretouched photographs. Photo by S. Y. Liu.

Plate I

Figs. 1-4. *Ozawainella* sp.

1, 2, 4, Three para-axial sections (× 50) from the Changhsing limestone at Chienpao, Loping district, Kiangsi province. Cat. No. 7935, 7936, 7938.

3, Tangential section (× 50) from the Changhsing limestone north of Tiaoshihyai, Tungtze district, Kueichow province. Cat. No. 7937.

Figs. 5-6. *Reichelina simplex* Sheng (sp. nov.)

5, 5a, Axial section (× 25 and × 50) of the holotype. The enlargement showing the extraordinary thin spirotheca in the outermost whorl. Changhsing limestone, between Peishihtan and Lungtsangtze. Chikiang district, Szechuan province. Cat. No. 7939.

6, Axial section (× 50) of a paratype from the same locality. Cat. No. 7940.

Fig. 7 *Nankinella minor* Sheng (sp. nov.)

Axial section (× 20) of the holotype, showing the blunt periphery. Changhsing limestone, Chienpao of Loping district, Kiangsi province. Cat. No. 7941.

Figs. 8 11. *Nankinella* sp.

8, 9, Para-axial sections (× 20), Changhsing limestone, Chianpao of Loping district, Kiangsi province. Cat. No. 7942, 7943.

10, 11, Oblique sections (× 20) from the same locality. Cat. No. 7944, 7945.

Fig. 12 ?*Ptsolina* sp.

Sagittal section (× 10) with an extraordinary large proloculum. The limestone nodules derived from the chert bed, probably Upper Permian. Shihtzekou, Mingshan coal field, Loping district, Kiangsi province. Cat. No. 7946.

Figs. 13, 16. *Palaeofusulina sinensis* Sheng (sp. nov.)

Axial sections (× 25) of two paratypes. Changhsing limestone, north of Tiaoshihyai, Tungtze district, Kueichow province. Cat. No. 7947, 7950.

Figs. 14, 15. *Palaeofusulina sinensis* var. *fusiformis* Sheng (var. nov.)

14, Axial section (× 25) of the holotype. Changhsing limestone, north of Tiaoshihyai, Tungtze district, Kueichow province. Cat. No. 7948.

15, Axial section (× 25) of a paratype of a microspheric shell from the Changhsing limestone at Chienpao, Loping district, Kiangsi province. Cat. No. 7949.

Plate II

Figs. 1-8. *Gallowaitnella meitienensis* Chen

1, Axial section (× 25) of an immature form. Cat. No. 7951.

2, 2a, Axial section (× 15 and × 25). Cat. No. 7952.

3, Tangential section (× 25) showing the septal fluting in plan. Cat. No. 7953.

4, Axial section (× 25). Cat. No. 7954.

4a, Portion of fig. 4, enlarged (× 100) to show the wall structure.

5, 6, 7, Obliquely axial sections (× 15). Cat. No. 7955-7957.

8, Axial section of a young form (× 25). Cat. No. 7958.

The specimens figured in this plate are found from the limestone nodules in the chert bed probably of Upper Permian. Shihtzekou, Mingshan coal field, Loping district, Kiangsi province.

Plate III

Figs. 1-5a, 7. *Palaeofusulina wangi* Sheng (sp. nov.)

1, Axial section (× 25) of the holotype from the Changhsing limestone at Chumipu of Tungtze district, Kueichow province. Cat. No. 7959.

2, Axial section (× 25) of a paratype. Cat No. 7960.

3, 3a, A paratype, external view, (× 5) and enlarged (× 13). Changhsing limestone, north of Tiaoshihyai, Tungtze district, Kueichow province. Cat. 7961.

5, 5a, Obliquely axial section of paratype, (× 25) and enlarged (× 100), showing the wall structure. From the same locality. Cat. No. 7963.

4, 7, Axial sections (× 25) of two paratypes from the Changhsing limestone between Peishihtan and Lungtsangtze of Chikiang district, Southern Szechuan province. Cat. No. 7962, 7965.

Fig. 6. *Palaeofusulina wangi* var. *chumipuensis* Sheng (var. nov.)

Axial section (× 25) of the holotype, showing the tunnel in the outer volution is wider than in the inner. Changhsing limestone, Chumipu of Tungtze district, Kueichow province. Cat. No. 7964.

Plate IV

Figs. 1-15 *Palaeofusulina sinensis* Sheng (sp. nov.)

1, A paratype (× 13), external view. Changhsing limestone, north of Tiaoshihyai, Tungtze district, Kueichow province. Cat. No. 7966.

3, 6-9, Axial sections (× 25) of five paratypes from the same locality. Cat. No. 7968, 7971, 7972, 7973, 7974.

2, Axial section (× 25) of the holotype. Changhsing limestone, between Peishihtan and Lungtsangtze, Chikiang district, southern Szechuan province. Cat. No. 7967.

4, 5, Axial sections (× 25) of two paratypes from the same locality. Cat. No. 7969, 7970.

10, Axial section (× 25) of a paratype. Changhsing limestone, Chienpao of Loping district, Kiangsi province. Cat. No. 7975.

11, An aberrant form (× 25) with double proloculum, from the same locality. Cat. No. 7976.

13, 14, Axial sections (× 25) of two paratypes from the same locality. Cat. No. 7978, 7979.

12, 15, Sagittal sections (× 25) of two paratypes from the same locality. Cat No. 7977, 7980.