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PERMIAN FUSULINIDS FROM PACIFIC NORTHWEST AND ALASKA

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CONTENTS

PART 1

PERMIAN FUSULINIDS FROM NORTHWESTERN NEVADA

ABSTRACT

Thirteen species of fusulinids, all but one of them new, are described from the Permian limestone section exposed near Quinn River Crossing, Humboldt County, Nevada. They are assigned to four genera. One of the species is characteristic of the upper middle part of the McCloud Limestone of northern California, and four other middle and upper McCloud species are present, but rare, in the Nevada section. This limestone sequence is middle to late Wolfcampian in age.

INTRODUCTION

A thick sequence of Permian limestones is exposed near Quinn River Crossing, in Humboldt County, northwestern Nevada (Fig. 1). Dr. John W. Harbaugh, of Stanford University, measured and collected from a section across this outcrop in 1957, and placed the fusulinid-bearing collections at our disposal for study. During the same year, Dr. Russell M. Jeffords, of the Esso Pro-

duction Research Company, visited the locality accompanied by HARBAUGH and made additional collections from the same section. Unfortunately, most of HARBAUGH's 37 collections were small, and the preservation of more than half of them is so poor that we have been unable to obtain suitable thin sections from them. We have, however, succeeded in getting good thin sections from 16 of his collections which are distributed through most of the slightly more than 2,100 feet of limestones which make up the measured section. JEFFORDS' 8 collections from the lower half of the section are larger, and most of the contained fusulinids are well preserved. Furthermore, they do not coincide with those made by HARBAUGH but serve to fill some of the gaps in the latter.

WILLDEN (1964, p. 31) briefly discussed an "unnamed limestone" at this locality. Fossils collected near the top of the sequence were submitted to HELEN DUNCAN, L. G. HENBEST, JAMES STEELE WILLIAMS, and ELLIS L. YOCHELSON for identification, and these specialists tentatively assigned an early Guadalupian age to them. It is possible, of course, that the collection in question came from a higher zone than any represented in our collections, but the latter show that most of the sequence is middle to late Wolfcampian in age.

A study of the Quinn River fusulinids indicates that the base of this section correlates with the middle part of the McCloud Limestone of the Shasta Lake area in northern California, and that the sequence continues upward through equivalents of all but the youngest beds of the McCloud Limestone. In age, it ranges from middle to late Wolfcampian. In addition to *Pseudofusulinella rotunda* SKINNER & WILDE, which is described here, we have found four other McCloud species to occur sparingly in the Quinn River Crossing section. These are *Pseudofusulinella dunbari* SKINNER & WILDE in collection Nev-16, *Schwagerina rotunda* SKINNER & WILDE in collection Nev-24, *Eoparafusulina spissa* SKINNER & WILDE in collection Nev-2, and *Chalaroschwagerina tumentis* SKINNER & WILDE in collection Nev-14. The first three are characteristic of the middle part of the McCloud Limestone; the fourth, which is also present in the Coyote Butte Limestone of east-central Oregon, occurs rather high in the McCloud section.

On the basis of field identifications it was thought at first that large, globular fusulinids in the lower part of the exposed section were species of *Pseudoschwagerina*. Thin sections, however, show that these forms belong in the genus *Chalaroschwagerina*. This genus, so far as is known at present, ranges through most of the upper half of the Wolfcampian.

Figure 1 is modified from HARBAUGH's map of the area, and Figure 2 is a simplified version of his measured section, with both his and JEFFORDS' collections plotted in their proper stratigraphic positions. We wish to express our indebtedness to both of these gentlemen for the help they have given us in supplying material and information. We also wish to thank the Humble Oil & Refining Company for permission to publish this study.

All figured specimens are deposited in files of the Humble Oil & Refining Company at Midland, Texas.

FUSULINID COLLECTIONS

Collections Nev-2 through Nev-17 were made by HARBAUGH from a section which he measured in sec. 1 and sec. 12, T. 42 N., R. 32 E., Humboldt County, Nevada. This locality lies to the east of State Highway 8A, about 36 miles southeast of Denio, Nevada, and about 6 miles southeast of Quinn River Crossing.

Collections Nev-18 through Nev-25 were made by JEFFORDS from essentially the same section as that measured by HARBAUGH.

Nev-2.—Permian limestone, 5 feet above base of exposed section. HARBAUGH's no. QR-1.

Nev-3.—Permian limestone, 60 feet above base of section. HARBAUGH's no. QR-3.

Nev-4.—Permian limestone, 105 feet above base of section. HARBAUGH's no. QR-5.

Nev-5.—Permian limestone, 125 feet above base of section. HARBAUGH's no. QR-6.

Nev-6.—Permian limestone, 170 feet above base of section. HARBAUGH's no. QR-7.

Nev-7—Permian limestone, 370 feet above base of section. HARBAUGH's no. QR-10.

Nev-8.—Permian limestone, 425 feet above base of section. HARBAUGH's no. QR-11.

Nev-9.—Permian limestone, 600 feet above base of section. HARBAUGH's no. QR-13.

Nev-10.—Permian limestone, 1,020 feet above base of section. HARBAUGH's no. QR-15.

Nev-11.—Permian limestone, 1,030 feet above base of section. HARBAUGH's no. QR-16.

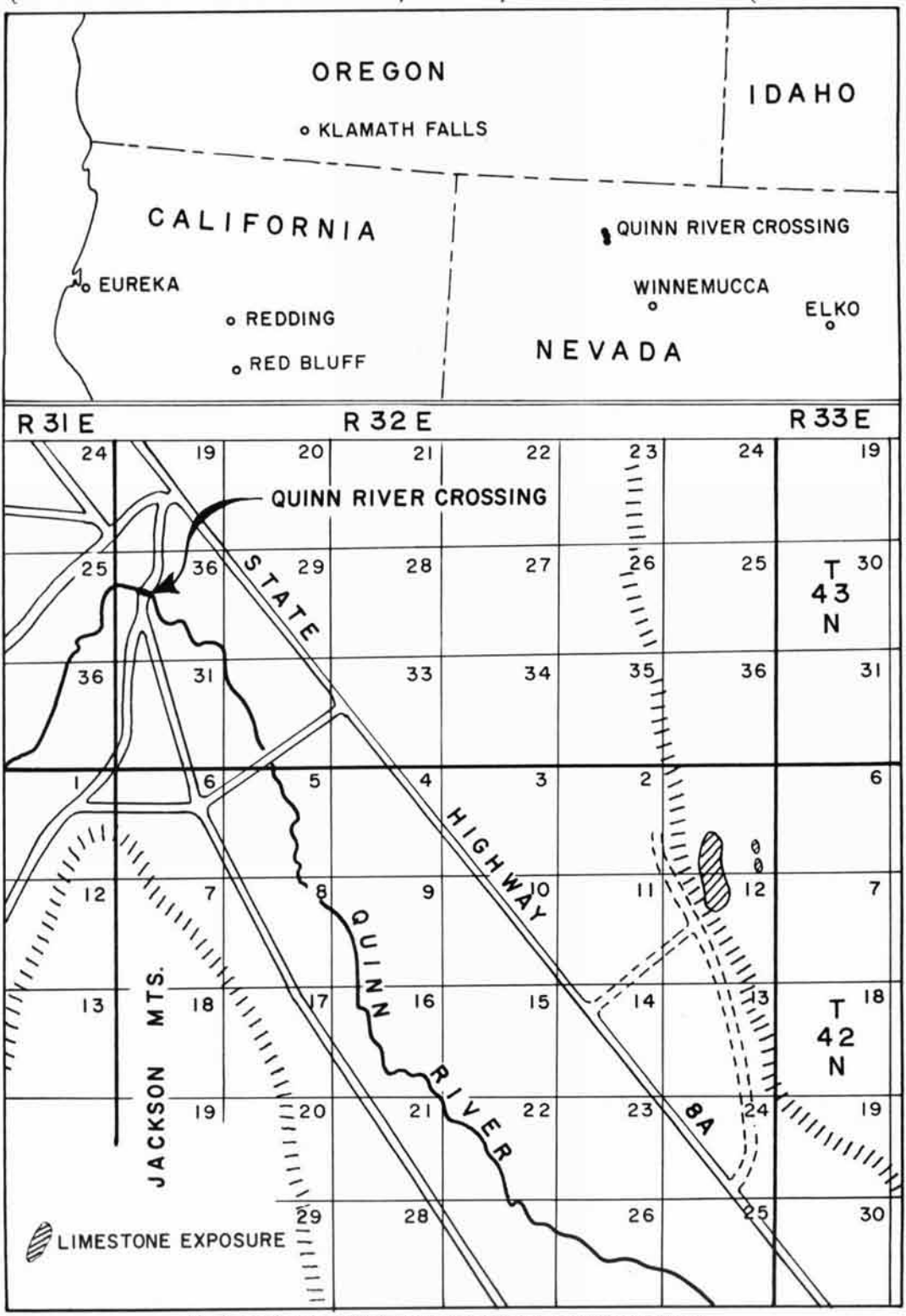

FIG. 1. Index map of Quinn River Crossing area, northwestern Nevada.

Nev-12.—Permian limestone, 1,070 feet above base of section. HARBAUGH's no. QR-18.

Nev-13.—Permian limestone, 1,415 feet above base of section. HARBAUGH's no. QR-22.

Nev-14.—Permian limestone, 1,470 feet above base of section. HARBAUGH's no. QR-25.

Nev-15.—Permian limestone, 1,495 feet above base of section. HARBAUGH's no. QR-26.

Nev-16.—Permian limestone, 1,510 feet above base of section. HARBAUGH's no. QR-27.

Nev-17.—Permian limestone, 1,925 feet above base of section. HARBAUGH's no. QR-30.

Nev-18.—Permian limestone, basal 20 feet of section.

Nev-19.—Permian limestone, 110 feet above base of section.

Nev-20.—Permian limestone, 240 to 255 feet above base of section.

Nev-21.—Permian limestone, 750 feet above base of section.

Nev-22.—Permian limestone, 765 feet above base of section.

Nev-23.—Permian limestone, 800 feet above base of section.

Nev-24.—Permian limestone, 900 feet above base of section.

Nev-25.—Permian limestone, 1,200 feet above base of section.

SYSTEMATIC PALEONTOLOGY

Genus PSEUDOFUSULINELLA Thompson, 1951

PSEUDOFUSULINELLA ROTUNDA Skinner & Wilde

Pseudofusulinella rotunda SKINNER & WILDE, 1965, Univ. Kansas Paleont. Contrib., Protozoa, art. 6, p. 36, pl. 36, figs. 4-8.

Shell small, inflated fusiform, with straight to slightly convex lateral slopes and bluntly to sharply pointed poles. Our Quinn River specimens have 8.5 to 9 whorls, and measure 3.85 to 4.80 mm. in length, and 2.70 to 2.75 mm. in diameter. Form ratio varies from 1.40 to 1.77.

Spirotheca composed of tectum and diaphanotheca, although spreading of chomata deposits across floor of tunnel and roof of chambers in tunnel area commonly produces false appearance of fusulinellid wall in equatorial region. In seventh volution spirotheca has thickness of 52 to 59 μ. Septa nearly plane across middle of shell, becoming moderately folded toward poles. They number 10 in 1st whorl, 13 to 14 in 2nd, 16 to 18 in 3rd, 20 to 21 in 4th, 23 to 26 in 5th, 24 to 25 in 6th, and 29 to 32 in 7th.

Proloculus quite small, its outside diameter ranging from 70 to 99 μ. Tunnel narrow, about half as high as chambers. In 8th volution tunnel angle measures 15 to 16 degrees. Chomata high and massive, reaching nearly to tops of chambers; on side adjacent to tunnel they are vertical or slightly overhanging, but on opposite side slope away gently and commonly extend nearly to poles, particularly in early whorls.

Discussion.—The foregoing description is based on our Quinn River Crossing specimens, which differ from the type specimens from the McCloud Limestone of northern California only in being somewhat smaller and having one or two fewer volutions. *Pseudofusulinella rotunda* SKINNER & WILDE has more massive chomata than any other member of the genus presently known.

Occurrence.—In the Quinn River Crossing section we have found this species in collections Nev-12 and Nev-24, and questionably in collections Nev-13 and Nev-15.

Illustrations.—Plate 1, figures *1-6*.——Fig. *1*. Axial section of holotype, ×10.——Figs. *2-4*. Axial sections, ×10.——Figs. *5, 6*. Sagittal sections, ×10. [*1* from upper middle part of the McCloud Limestone, Shasta County, California; *2-6* from collection Nev-12.] [All figures are unretouched photographs.]

PSEUDOFUSULINELLA JEFFORDSI Skinner & Wilde, n. sp.

Shell small, fusiform, with slightly concave to slightly convex lateral slopes and rather sharply pointed poles. Adult shells have about 8 whorls, and measure 4.75 to 5.80 mm. in length, and about 2.60 mm. in diameter. Form ratio varies from 1.83 to 2.23.

Spirotheca composed of tectum and diaphanotheca. In the 7th whorl its thickness varies from 48 to 58 μ. Septa gently wavy across middle of shell, becoming rather strongly folded toward poles; they number 8 to 9 in 1st whorl, 13 to 14 in 2nd, 15 to 16 in 3rd, 19 to 20 in 4th, 21 to 22 in 5th, 24 to 27 in 6th, 29 to 31 in 7th, and 29 to 32 in 8th.

Proloculus small, although above average in size for this genus. Its outside diameter varies

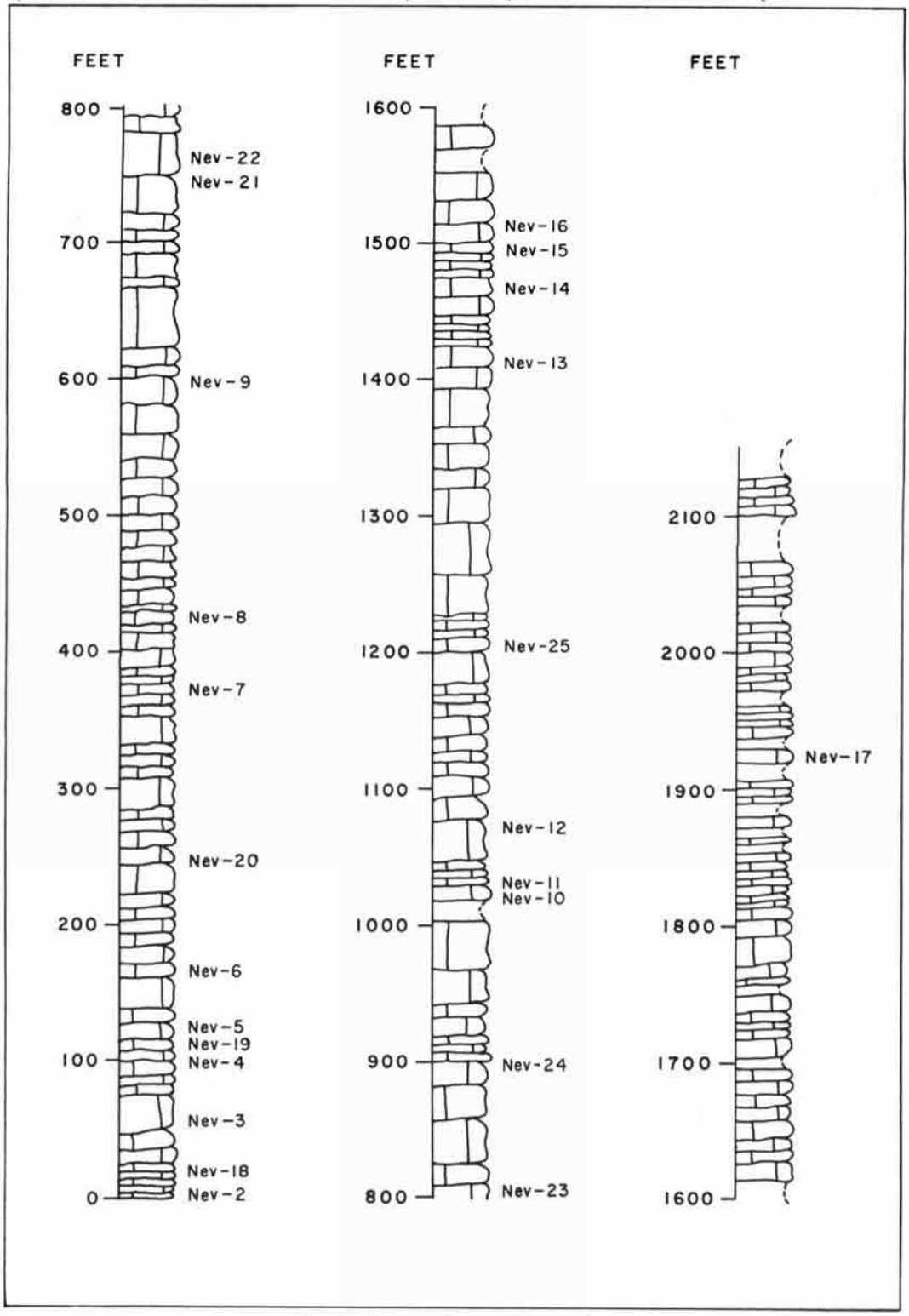

FIG. 2. HARBAUGH'S Quinn River section.

from 120 to 193 μ. Tunnel narrow and about half as high as chambers. In 8th volution tunnel angle measures 13 to 18 degrees. Chomata massive and nearly as high as chambers; they are vertical to slightly overhanging adjacent to tunnel and slope steeply on poleward side, giving blocky outline as seen in axial sections.

Discussion.—Pseudofusulinella jeffordsi does not closely resemble any previously described species of this genus. It is named for Dr. R. M. Jeffords, who collected the limestone from which it was obtained.

Occurrence.—This species is abundant in collection Nev-22, but it has not been found in any of our other collections.

Illustrations.——Plate 1, figures *7-11.*——Fig. 7. Axial section of holotype, ×10.——Figs. *8, 9.* Axial sections of paratypes, ×10.——Figs. *10, 11.* Sagittal sections of paratypes, ×10. [All from collection Nev-22.] [All figures are unretouched photographs.]

PSEUDOFUSULINELLA PUSILLA Skinner & Wilde, n. sp.

Shell small, fusiform, with concave lateral slopes and sharply pointed poles. Mature individuals have 6.5 to 8 volutions and measure 3.20 to 3.80 mm. in length and 1.75 to 2.00 mm. in diameter. Form ratio varies from 1.70 to 2.00.

Spirotheca very thin, composed of tectum and diaphanotheca measuring 37 to 49 μ in thickness in 6th whorl. Septa nearly plane across middle of shell, becoming moderately fluted toward poles. They number 8 to 9 in 1st volution, 10 to 11 in 2nd, 12 in 3rd, 14 to 15 in 4th, 13 to 15 in 5th, 17 to 22 in 6th, 19 to 25 in 7th, and 23 in 8th.

Proloculus very small, its outside diameter ranging from 86 to 105 μ. Tunnel narrow, about half as high as chambers. In 6th volution tunnel angle varies from 17 to 21 degrees. Chomata narrow and about two-thirds as high as chambers.

Discussion.—Pseudofusulinella pusilla does not closely resemble any previously described member of this genus.

Occurrence.—This species appears to be restricted to the lower 450 feet of the section near Quinn River Crossing; we have found it in collections Nev-8, Nev-18, and Nev-20.

Illustrations.—Plate 1, figures *12-16.*——Fig. *12.* Axial section of holotype, ×10.——Figs, *13, 14.* Axial sections of paratypes, ×10.——Figs. *15, 16.* Sagittal sections of paratypes, ×10. [*12, 13, 16* from collection Nev-20; *14, 15* from collection Nev-8.] [All figures are unretouched photographs.]

Genus SCHWAGERINA von Möller, 1877

SCHWAGERINA MUNDA Skinner & Wilde, n. sp.

Shell small, fusiform, with bluntly pointed poles. Mature specimens have 6 to 6.5 volutions and measure 7.20 to 7.50 mm. in length and 2.90 to 3.10 mm. in diameter. Form ratio varies from 2.32 to 2.59.

Spirotheca, composed of tectum and coarsely alveolar keriotheca, measures 107 to 134 μ in thickness in 5th whorl. Septa strongly and regularly fluted from pole to pole. They number 12 to 13 in 1st volution, 19 to 23 in 2nd, 20 to 27 in 3rd, 30 to 31 in 4th, and about 31 in 5th. Septal folds high, reaching nearly to tops of septa.

Proloculus moderately large, its outside diameter varying from 195 to 309 μ. Tunnel low and narrow, tunnel angle measuring 26 to 28 degrees in 6th volution. Weak chomata present in 1st 2 whorls but absent thereafter.

Discussion.—Schwagerina munda is similar to *S. bellula* Dunbar & Skinner, but differs in its much larger proloculus and the absence of phrenothecae. It differs from *S. elkoensis* Thompson & Hansen in its tighter coiling, thicker spirotheca, and narrower tunnel.

Occurrence.—This species has a rather long range through the middle part of the Quinn River section. We have found it in collections Nev-13 and Nev-24.

Illustrations.—Plate 1, figures *17-20*; Plate 2, figure *1.*——Pl. 1, fig. *17.* Axial section of holotype, ×10.——Pl. 1, fig. *18.* Axial section of paratype, ×10.——Pl. 1, figs. *19, 20.* Sagittal sections of paratypes, ×10. [All from collection Nev-13.] ——Pl. 2, fig. *1.* Axial section of paratype, ×10. [From collection Nev-24.] [All figures are unretouched photographs.]

SCHWAGERINA JEFFORDSI Skinner & Wilde, n. sp.

Shell very large, thickly subcylindrical, with bluntly rounded poles. Mature specimens have 9 to 10.5 rather tightly coiled volutions and measure 15.80 to 19.10 mm. in length, and 4.10 to 5.10 mm. in diameter. Form ratio varies from 3.61 to 4.66.

Spirotheca composed of tectum and rather coarsely alveolar keriotheca, about 100 μ thick in 8th whorl. Septa very strongly and regularly fluted

from pole to pole. In some specimens very slight development of phrenothecae can be seen in central part of shell, but they are usually absent. Septa number 15 to 16 in 1st whorl, 21 to 23 in 2nd, 25 to 26 in 3rd, 28 to 29 in 4th, 30 to 35 in 5th, 32 to 36 in 6th, 37 to 39 in 7th, and 38 in 8th. Septal folds about two-thirds as high as chambers. Band of secondary deposits extends along axis from center of shell nearly to poles; it appears to have been deposited principally on septa.

Proloculus large, its outside diameter varying from 349 to 456 μ, averaging about 420μ. Tunnel about half as high as chambers and moderate in width. In 9th whorl tunnel angle measures 34 to 43 degrees. Weak chomata present in 1st 2 volutions, but absent thereafter.

Discussion.—This is one of the largest species of *Schwagerina* known. Only *S. setum* DUNBAR & SKINNER compares with it in size, but that species is even larger, attaining a length of more than 20 mm. It also has a larger form ratio and a somewhat smaller proloculus. *Schwagerina jeffordsi* bears a superficial resemblance to certain species of *Parafusulina*, but differs in the presence of chomata in the early whorls and in the absence of cuniculi. It is named for Dr. R. M. JEFFORDS, who collected the type material.

Occurrence.—This striking species is abundant in collection Nev-25, from near the middle of the Quinn River section. We have not found it in any other collection.

Illustrations.—Plate 2, figures *2-6;* Plate 3, figure *1.*——Pl. 2, fig. *2.* Axial section of holotype, ×10.——Pl. 2, fig. *3.* Axial section of paratype, ×10.——Pl. 2, fig. *4.* Tangential section of paratype showing absence of cuniculi, ×10.——Pl. 2, fig. *5, 6.* Sagittal sections of paratypes, ×10. [All from collection Nev-25.]——Pl. 3, fig. *1.* Axial section of paratype, ×10. [From collection Nev-25.] [All figures are unretouched photographs.]

Genus EOPARAFUSULINA Coogan, 1960

EOPARAFUSULINA CONCISA Skinner & Wilde, n. sp.

Shell small, cylindrical, with bluntly rounded poles. Mature specimens have 7 to 7.5 volutions and measure 3.65 to 3.85 mm. in length and 1.45 to 1.55 mm. in diameter. Form ratio varies from 2.38 to 2.57.

Spirotheca composed of tectum and coarsely alveolar keriotheca, 78 to 95 μ thick in the 7th volution. Septa strongly and regularly fluted from pole to pole. They number 7 to 9 in 1st whorl, 11 to 12 in 2nd, 12 in 3rd, 16 in 4th, 15 in 5th, and 18 to 19 in 6th. Septal folds about half as high as chambers, leaving upper part of each septum only broadly wavy or nearly plane. Narrow cuniculi developed in outer whorls (Pl. 3, fig. 8).

Proloculus very small, its outside diameter varying from 53 to 94 μ. Tunnel fairly wide, about half as high as chambers. In 7th volution tunnel angle measures 48 to 55 degrees. Narrow pseudochomata present in all except outermost whorls.

Discussion.—*Eoparafusulina concisa* is similar to *E. bellula* SKINNER & WILDE, n. sp., but differs in its smaller size and smaller proloculus. There is no other described species with which it might be confused.

Occurrence.—We have found this species in collections Nev-7 and Nev-8, about 400 feet above the base of the Quinn River section.

Illustrations.—Plate 3, figures *2-8.*——Figs. *2, 3.* Axial section of holotype, ×10, ×20.——Figs. *4, 5.* Axial sections of paratypes, ×20.——Figs. *6, 7.* Sagittal sections of paratypes, ×20.——Fig. *8.* Tangential section of paratype showing cuniculi, ×20. [*2-5, 8* from collection Nev-7; *6, 7* from collection Nev-8.] [All figures are unretouched photographs.]

EOPARAFUSULINA BELLULA Skinner & Wilde, n. sp.

Shell small, cylindrical, with bluntly rounded poles. Mature individuals have 6.5 to 7.5 volutions and measure 4.25 to 4.50 mm. in length and 1.65 to 2.00 mm. in diameter. Form ratio varies from 2.25 to 2.57.

Spirotheca composed of tectum and coarsely alveolar keriotheca, 78 to 84 μ thick in 7th volution. Septa strongly and regularly fluted from pole to pole. They number 7 in 1st whorl, 9 to 11 in 2nd, 11 to 12 in 3rd, 14 to 15 in 4th, 16 to 17 in 5th, 18 to 19 in 6th, and about 16 in 7th. Septal folds only about one-third as high as chambers in middle of shell, increasing to about half as high as chambers toward poles. Upper part of each septum only broadly wavy or nearly plane. Cuniculi present in outer whorls (Pl. 4, fig. 7).

Proloculus small, its outside diameter varying from 86 to 122 μ. Tunnel fairly broad, about half as high as chambers. In 7th volution tunnel angle

measures 48 to 56 degrees. Narrow pseudochomata present in all except 2 outermost whorls.

Discussion.—Eoparafusulina bellula is similar to *E. concisa* SKINNER & WILDE, n. sp., but differs from the latter in its larger size and somewhat larger proloculus.

Occurrence.—We have found this species in collections Nev-19 and Nev-20, about 100 to 250 feet above the base of the Quinn River section.

Illustrations.—Plate 4, figures *1-7.*——Figs. *1, 2.* Axial section of holotype, ×10, ×20.——Figs. *3, 4.* Axial sections of paratypes, ×20.——Figs. *5, 6.* Sagittal sections of paratypes, ×20.——Fig. *7.* Tangential section of paratype showing cuniculi, ×20. [All from collection Nev-20.] [All figures are unretouched photographs.]

Genus CHALAROSCHWAGERINA Skinner & Wilde, 1965

CHALAROSCHWAGERINA GLOBULARIS Skinner & Wilde, n. sp.

Shell small, inflated fusiform to subglobular, with strongly convex lateral slopes and bluntly rounded poles. Mature specimens have only 4 to 4.5 volutions and measure 5.10 to 7.20 mm. in length and 4.00 to 4.80 mm. in diameter. Form ratio varies from 1.25 to 1.70, averaging about 1.48. First volution rather tightly coiled, after which shell expands greatly and coiling becomes very loose.

Spirotheca composed of tectum and coarsely alveolar keriotheca, 87 to 114 μ thick in 4th volution. Phrenothecae strongly developed and conspicuous; in sagittal sections they commonly appear as thin partitions blocking off upper parts of chambers immediately above tunnel (Pl. 5, fig. 1). Septa broadly fluted from pole to pole, septal folds involving only lower half of each septum; upper half only gently wavy. Septa number 11 to 13 in 1st whorl, 15 to 19 in 2nd, 14 to 24 in 3rd, and about 21 in 4th.

Proloculus large, its outside diameter ranging from 289 to 403 μ, averaging about 340 μ. Tunnel low and narrow. In 3rd volution tunnel angle measures 19 to 22 degrees. Weak chomata extend from proloculus through 1st 0.5 whorl, but are absent thereafter.

Discussion.—Chalaroschwagerina globularis is one of the most distinctive members of this genus. Its small size and nearly globular shape serve to distinguish it from any other known species. It is similar to *C. decora* SKINNER & WILDE, n. sp., with which it occurs, but the latter is larger, has more volutions, and has a more elongate shape which gives it a larger form ratio.

Occurrence.—This interesting species is common in collections Nev-18 and Nev-19, from the basal 110 feet of the Quinn River section.

Illustrations.—Plate 4, figures *8-10;* Plate 5, figures *1, 2*—Pl. 4, fig. *8.* Axial section of holotype, ×10.——Pl. 4, fig. *9, 10.* Axial sections of paratypes, ×10. [All from collection Nev-19.] ——Pl. 5, fig. *1, 2.* Sagittal sections of paratypes, ×10. [*1* from collection Nev-19; *2* from collection Nev-18.] [All figures are unretouched photographs.]

CHALAROSCHWAGERINA DECORA Skinner & Wilde, n. sp.

Shell moderately large, inflated fusiform, with bluntly rounded poles. Mature individuals have 5 to 6 volutions and measure 8.00 to 10.80 mm. in length and 4.30 to 5.30 mm. in diameter. Form ratio varies from 1.86 to 2.16. First whorl tightly coiled, after which coiling becomes loose.

Spirotheca composed of tectum and coarsely alveolar keriotheca. In 5th volution its thickness measures 94 to 107 μ. Phrenothecae well developed and conspicuous. Septa strongly and regularly folded throughout shell; they number 8 to 9 in 1st whorl, 13 to 16 in 2nd, 14 to 17 in 3rd, 24 to 25 in 4th, and about 39 in 5th. Septal folds broad and unusually high for member of this genus, commonly reaching nearly to tops of septa.

Proloculus large, its outside diameter ranging from 295 to 463 μ. Tunnel low and narrow. In 5th volution tunnel angle measures 18 to 22 degrees. Weak chomata extend from proloculus to about end of 1st whorl.

Discussion.—Chalaroschwagerina decora is similar to *C. globularis* SKINNER & WILDE, n. sp., but differs in its larger size, larger form ratio, and greater number of volutions. It is distinguished from *C. eximia* SKINNER & WILDE, n. sp., by its larger proloculus and the more globular shape of its inner whorls.

Occurrence.—This species is common in collections Nev-18 and Nev-19, from the basal 110 feet of the Quinn River Section.

Illustrations.—Plate 5, figures *8-10;* Plate 6, figures *1, 2.*——Pl. 5, fig. *8.* Axial section of holo-

type, ×10.——Pl. 5, fig. *9*. Axial section of paratype, ×10.——Pl. 5, fig. *10*. Sagittal section of paratype, ×10. [*8, 9* from collection Nev-19; *10* from collection Nev-18.]——Pl. 6, fig. *1*. Axial section of paratype, ×10.——Pl. 6, fig. *2*. Sagittal section of paratype, ×10. [Both from collection Nev-19.] [All figures are unretouched photographs.]

CHALAROSCHWAGERINA SOLITA Skinner & Wilde, n. sp.

Shell small, fusiform, with bluntly pointed poles. Mature specimens have 4 to 6 volutions and measure 6.40 to 7.80 mm. in length and 2.20 to 2.90 mm. in diameter. Form ratio varies from 2.58 to 2.91. First 1 to 1.5 volutions rather tightly coiled, after which coiling becomes loose.

Spirotheca composed of tectum and coarsely alveolar keriotheca, about 94 μ thick in 4th volution. Phrenothecae strongly developed and conspicuous (Pl. 5, figs. 5-7). Septa strongly but irregularly folded from pole to pole, folding being mainly confined to lower half of each septum while upper half is only wavy. Septa number 9 to 12 in 1st whorl, 12 to 18 in 2nd, 15 to 22 in 3rd, 19 to 25 in 4th, 26 to 28 in 5th, and about 29 in 6th.

Proloculus moderately large, its outside diameter varying from 195 to 289 μ. Tunnel low and narrow, tunnel angle measuring 24 to 28 degrees in 4th volution. Weak chomata present on proloculus and continuing to about end of 1st volution.

Discussion.—The small size and relatively slender proportions of *Chalaroschwagerina solita* serve to distinguish it from any other known member of the genus.

Occurrence.—This species is common in collections Nev-3, Nev-4, and Nev-5, and it is questionably present in Nev-8 and Nev-20, all within the lower 425 feet of the Quinn River section.

Illustrations.—Plate 5, figures *3-7*.——Fig. *3*. Axial section of holotype, ×10.——Figs. *4, 5*. Axial sections of paratypes, ×10.——Figs. *6, 7*. Sagittal sections of paratypes, ×10. [*3, 4, 6, 7* from collection Nev-4; *5* from collection Nev-5.] [All figures are unretouched photographs.]

CHALAROSCHWAGERINA FORMOSA Skinner & Wilde, n. sp.

Shell moderate in size, inflated fusiform, with bluntly pointed poles. Mature individuals have 4.5 to 5 volutions and measure 7.00 to 9.80 mm. in length and 3.30 to 3.80 mm. in diameter. Form ratio varies from 1.94 to 2.58. First volution rather tightly coiled, after which coiling becomes loose.

Spirotheca composed of tectum and coarsely alveolar keriotheca. In 4th whorl its thickness measures 94 to 101 μ. Phrenothecae strongly developed and conspicuous (Pl. 6, fig. 4-6). Septa strongly but irregularly folded throughout shell. They number 8 in 1st volution, 17 to 18 in 2nd, 21 to 22 in 3rd, and 25 to 33 in 4th. Septal folds largely confined to lower two-thirds of each septum, upper part being only wavy.

Proloculus rather large, its outside diameter varying from 228 to 336 μ. Tunnel low and narrow. In 4th volution tunnel angle measures 23 to 27 degrees. Weak chomata present on proloculus and extend through about first half whorl.

Discussion.—*Chalaroschwagerina formosa* is similar to *C. solita* Skinner & Wilde, n. sp., but differs from the latter in its larger size and thicker proportions.

Occurrence.—This species is common in collections Nev-5 and Nev-6, and questionably present in Nev-18. It apparently is restricted to the basal 170 feet of the Quinn River section.

Illustrations.—Plate 6, figures *3-7*.——Fig. *3*. Axial section of holotype, ×10.——Figs. *4, 5*. Axial sections of paratypes, ×10.——Figs. *6, 7*. Sagittal sections of paratypes, ×10. [*3-5* from collection Nev-5; *6, 7* from collection Nev-6.] [All figures are unretouched photographs.]

CHALAROSCHWAGERINA AMPLA Skinner & Wilde, n. sp.

Shell large, inflated fusiform, with straight to slightly concave lateral slopes and bluntly pointed poles. Mature individuals have about 6.5 volutions and measure 10.80 to 13.80 mm. in length and 5.80 to 6.50 mm. in diameter. Form ratio varies from 1.69 to 2.38. First 0.5 to 1 whorl rather tightly coiled, after which coiling becomes loose.

Spirotheca composed of tectum and coarsely alveolar keriotheca, 87 to 128 microns thick in 5th volution. Phrenothecae are well developed. Septa strongly but irregularly fluted from pole to pole. They number 9 to 13 in 1st whorl, 19 to 23 in 2nd, 25 to 26 in the 3rd, 33 to 39 in the 4th, 43 to 46 in 5th, and about 40 in 6th. The septal folds are narrow and involve the lower two-thirds of

each septum, the upper part being broadly wavy. Septal pores are common.

The proloculus is very large, its outside diameter ranging from 342 to 597 microns, averaging about 460 microns. The tunnel is low and narrow, the tunnel angle in the sixth whorl measuring 20 to 29 degrees. Weak chomata are present only on the proloculus.

Discussion.—Its large size and very large proloculus serve to distinguish *Chalaroschwagerina ampla* from all the other species described here. The type species of the genus, *C. inflata* Skinner & Wilde, from the McCloud Limestone of northern California, is similar but even larger and with more extreme inflation.

Occurrence.—This species is common in collections Nev-15 and Nev-16, from about 1500 feet above the base of the Quinn River section.

Illustrations.—Plate 7, figures *1-4*; Plate 8, figure *1*.——Pl. 7, fig. *1*. Axial section of holotype, ×10.——Pl. 7, fig. *2*. Axial section of paratype, ×10.——Pl. 7, figs. *3, 4*. Sagittal sections of paratypes, ×10. [*1-3* from collection Nev-16; *4* from collection Nev-15.]——Pl. 8, fig. *1*. Axial section of paratype, ×10. [From collection Nev-15.] [All figures are unretouched photographs.]

CHALAROSCHWAGERINA EXIMIA
Skinner & Wilde, n. sp.

Shell moderately large, inflated fusiform, with convex lateral slopes and bluntly pointed poles. Mature specimens display 5.5 to 6 volutions, and measure 9.80 to 11.00 mm. in length, and 4.60 to 5.20 mm. in diameter. The form ratio varies from 2.11 to 2.16. The first 1 to 1.5 whorls are relatively tightly coiled, after which an abrupt expansion takes place and the shell becomes loosely coiled.

The spirotheca, composed of a tectum and coarsely alveolar keriotheca, measures 81 to 94 microns in thickness in the fifth volution. Phrenothecae are well developed, especially in the central part of the shell. The septa are broadly fluted from pole to pole, the folds involving the lower two-thirds of each septum while the upper one-third is broadly wavy. The septa number 11 to 13 in the first whorl, 14 to 19 in the second, 22 to 25 in the third, 18 to 33 in the fourth, and about 26 in the fifth.

The proloculus is moderately large, its outside diameter varying from 235 to 282 microns. The tunnel is low and narrow. In the fifth volution the tunnel angle ranges from 17 to 30 degrees. Weak chomata are present on the proloculus and continue through the first 0.5 whorl.

Discussion.—We know of no other species with which *Chalaroschwagerina eximia* is likely to be confused.

Occurrence.—This species is common in collections Nev-18 and Nev-19, from the basal 110 feet of the Quinn River section, where it is associated with *Chalaroschwagerina globularis* Skinner & Wilde, n. sp. and *C. decora* Skinner & Wilde, n. sp.

Illustrations.—Plate 8, figures *2-6*.——Fig. *2*. Axial section of holotype, ×10.——Figs. *3, 4*. Axial sections of paratypes, ×10.——Figs. *5, 6*. Sagittal sections of paratypes, ×10. [*2, 3, 6* from collection Nev-18; *4, 5* from collection Nev-19.] [All figures are unretouched photographs.]

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PART 2

PERMIAN FUSULINIDS FROM SUPLEE AREA, EAST-CENTRAL OREGON

ABSTRACT

Seven species of fusulinids, belonging to three genera, are described from the Coyote Butte Limestone exposed in the vicinity of Suplee, east-central Oregon. Three of the species, all referred to *Schwagerina*, are new. The faunas indicate a late Wolfcampian age for the part of the Coyote Butte Limestone from which they were collected.

INTRODUCTION

In 1954 we visited the Suplee area, northwest of Burns, Oregon, and collected from a number of localities on the outcrop of the Coyote Butte Limestone (Fig. 3). Later, field parties of the Humble Oil & Refining Company supplied us with additional collections from this area, and still later we received more material collected by Dr. John W. Harbaugh and Dr. Russell M. Jeffords. Most of these were duplicates of collections already in our possession, or large erratic boulders from the overlapping Quaternary gravels. Consequently, the total number of fusulinid localities represented in our collections remains small. After a preliminary study of the fusulinid faunas, we concluded that they indicate a Wolfcampian age for at least that part of the formation. Most of the samples of Coyote Butte Limestone which we have seen consist of several types of limestone conglomerate. The fact that some species occur both in the cobbles and in the cementing matrix suggests that no great time interval elapsed between deposition of the source of the cobbles and formation of the conglomerate. We have seen similar conditions in the fore-reef talus of Permian limestone reefs or banks in West Texas. The fact that some of the Coyote Butte exposures consist of massive, reeflike limestone suggests that the conglomerates were formed immediately basinward from a carbonate shelf or bank, and are essentially contemporaneous with the limestones of the latter.

The exposures of the Coyote Butte Limestone are not continuous, but consist of a series of ridges and knobs which display a certain amount of alignment. In most of them the bedding is obscure.

Cooper (1957), working with material collected by Merriam & Berthiaume (1943), described a brachiopod fauna from the Coyote Butte Limestone. He stated that the fossils studied by him cannot be older than latest Leonardian and probably are early Guadalupian in age. We have been able to discuss the matter with Dr. Cooper and learn that his brachiopod material did not contain fusulinids, although part of it was collected near some of our fusulinid localities. We have concluded that he was dealing with a younger zone, or perhaps even a younger formation, than that from which we obtained our fusulinids. This view has been strengthened by the discovery of a Devonian fauna in two exposures of so-called Coyote Butte Limestone (Kleweno & Jeffords, 1962). It seems probable that, because of structural complexity, several similar limestones of widely different ages have been included in the formation. The structural complexity of rocks in the area is partially obscured by the discontinuous nature of the exposures.

We wish to thank our colleagues who have supplied us with material and information on this interesting area, and the Humble Oil & Refining Company for permission to publish this paper.

All figured specimens are deposited in the files of the Humble Oil & Refining Company at Midland, Texas.

FUSULINID COLLECTIONS

OR-3.—Coyote Butte Limestone. Along ridge on east side of small tributary which enters Grindstone Creek

from the north in the north-central part of sec. 32, T. 18 S., R. 25 E., Crook County, Oregon. Collected by SKINNER & WILDE.

OR-4.—Coyote Butte Limestone. Isolated limestone mass about one mile northeast of A. Bernard ranch house, in the northeast corner of sec. 12, T. 17 S., R. 25 E., near the west line of Grant County, Oregon. Collected by SKINNER & WILDE.

OR-5.—Coyote Butte Limestone. Isolated limestone mass about one-half mile northeast of OR-4. NE¼ SW¼, sec. 6, T. 17 S., R. 26 E., Grant County, Oregon. Collected by SKINNER & WILDE.

OR-12.—Boulder in Quaternary gravel, two miles south of Suplee, Oregon. South-central part of sec. 36, T. 17 S., R. 25 E.

SYSTEMATIC PALEONTOLOGY

Genus PSEUDOFUSULINELLA Thompson, 1951

PSEUDOFUSULINELLA PINGUIS Skinner & Wilde

Pseudofusulinella pinguis SKINNER & WILDE, 1965, Univ. Kansas Paleont. Contrib., Protozoa, art. 6, p. 38, pl. 53, figs. 6-10.

Shell small, inflated fusiform, with convex lateral slopes and bluntly pointed poles. Mature specimens have 9 to 10 volutions, are 4.92 to 5.02 mm. in length and 3.09 to 3.56 mm. in diameter. Form ratio varies from 1.36 to 1.64, averaging about 1.55.

Spirotheca composed of tectum and diaphanotheca; in 7th whorl its thickness is about 73 μ. In outer whorls minute mural pores often are seen traversing wall. Massive chomata deposits commonly spread across inner surface of spirotheca in equatorial portion of shell, producing false appearance of fusulinellid wall structure in that area. Septa nearly plane across middle of shell, becoming moderately fluted toward poles. They number 8 to 10 in 1st whorl, 12 to 16 in 2nd, 13 to 17 in 3rd, 18 to 22 in 4th, 21 to 29 in 5th, 25 to 29 in 6th, 28 to 31 in 7th, and about 32 in 8th.

Proloculus, though small, larger than common in members of this genus, its outside diameter ranging from 124 to 196 μ. Tunnel narrow and about half as high as chambers, tunnel angle averaging about 15 degrees in 8th volution. Chomata massive and asymmetrical, with vertical to overhanging margins adjacent to tunnel and less steep slopes on poleward side. Chomata extend more than half distance from tunnel to poles in many specimens, particularly in early whorls.

Discussion.—The above description is based on specimens from the Coyote Butte Formation, although types of the species came from the upper part of the McCloud Limestone of northern California. The similarity between the specimens from the two areas is so close that we are convinced they are conspecific. The major difference lies in the slightly smaller size of the Oregon specimens, but this falls well within the limits of individual variation expectable within a species.

Occurrence.—*Pseudofusulinella pinguis* is one of the most common species in our Coyote Butte collections. We have found it in collections OR-3, OR-4, and OR-12.

Illustrations.—Plate 9, figures *1-5*.——Fig. *1*. Axial section of holotype, ×10.——Figs. *2-4*. Axial sections, ×10.——Fig. *5*. Sagittal section, ×10. [*1* from upper part of McCloud Limestone of northern California; *2-5* from collection OR-3.] [All figures are unretouched photographs.]

PSEUDOFUSULINELLA PULCHELLA Skinner & Wilde

Pseudofusulinella pulchella SKINNER & WILDE, 1965, Univ. Kansas Paleont. Contrib., Protozoa, art. 6, p. 39, pl. 5, fig. 4; pl. 54, figs. 6-10.

Shell small, inflated fusiform, with slightly concave to slightly convex lateral slopes and rather sharply pointed poles. Mature individuals usually have 8.5 to 9.5 whorls, such specimens measuring 3.53 to 4.11 mm. in length, and 2.49 to 2.66 mm. in diameter. Form ratio varies from 1.42 to 1.76, averaging about 1.60.

Spirotheca composed of tectum and diaphanotheca averaging about 52 μ in thickness in 7th volution. In some specimens fine mural pores can be observed traversing wall in outer volutions. Septa rather strongly but irregularly fluted except across middle of shell where they are nearly plane. They number 8 to 9 in 1st whorl, 12 to 13 in 2nd, 13 to 15 in 3rd, 15 to 20 in 4th, 17 to 20 in 5th, 20 in 6th, 22 to 27 in 7th, 25 to 26 in 8th.

Proloculus small, with outside diameter varying from 65 to 144 μ. Tunnel narrow, about half as high as chambers. In 8th volution tunnel angle averages about 17 degrees. Chomata massive and high, presenting blocky outline as seen in axial sections. Tunnel side commonly steeper than poleward side.

FIG. 3. Index map showing location of Suplee area, east-central Oregon.

Discussion.—The above description, based on our Coyote Butte specimens, shows minor variations from the types which were obtained from the upper part of the McCloud Limestone of northern California. The Oregon specimens are slightly smaller than their California counterparts and have a slightly smaller form ratio. In all other respects the agreement is so close that we are convinced of their identity.

Occurrence.—Pseudofusulinella pulchella is fairly abundant in collections OR-3, OR-4, and OR-12.

Illustrations.—Plate 9, figures *6-10.*——Fig. *6.* Axial section of holotype, ×10.——Figs. *7-9.* Axial sections, ×10.——Fig. *10.* Sagittal section, ×10. [*6* from upper part of McCloud Limestone of northern California; *7-10* from collection OR-3.] [All figures are unretouched photographs.]

Genus SCHWAGERINA von Möller, 1877

SCHWAGERINA AMOENA Skinner & Wilde

Schwagerina amoena SKINNER & WILDE, 1965, Univ. Kansas Paleont. Contrib., Protozoa, art. 6, p. 53, pl. 55, figs. 9-12; pl. 56, fig. 1.

Shell large, central portion thickly cylindrical, with bluntly pointed, conical ends. Equatorial part of shell commonly somewhat constricted. Mature individuals possess 7 to 8 whorls and measure 9.88 to 12.48 mm. in length and 3.14 to 4.13 mm. in diameter. Form ratio varies from 3.01 to 3.21, averaging about 3.15.

Spirotheca composed of tectum and finely alveolar keriotheca averaging about 78 μ in thickness in 7th volution. Septa strongly and regularly fluted from pole to pole. They number 13 to 14 in 1st whorl, 16 to 21 in 2nd, 22 to 27 in 3rd, 30 to 37 in 4th, 37 to 41 in 5th, 44 to 45 in 6th, and 44 to 50 in 7th. Axial filling massive, commonly occupying more than half of shell between tunnel area and poles. Septal folds high, extending to tops of chambers.

Proloculus of moderate size, with outside diameter varying from 177 to 268 μ. Tunnel low and rather narrow, tunnel angle in 7th whorl averaging about 25 degrees. Very weak chomata present only on proloculus.

Discussion.—This description is based on our

Coyote Butte specimens which differ from the types from the upper part of the McCloud Limestone of northern California only in being a little larger than the latter. This species is similar to *Schwagerina superba,* SKINNER & WILDE, n. sp., in general appearance, but differs in its slightly smaller size, smaller proloculus, less numerous septa, and different pattern produced by the axial filling as seen in axial sections.

Occurrence.—Schwagerina amoena is common in our Coyote Butte collections OR-3, OR-4, and OR-12.

Illustrations.—Plate 9, figures *11, 12*; Plate 10, figures *1-3.*——Pl. 9, fig. *11.* Axial section of holotype, ×10.——Pl. 9, fig. *12.* Axial section, ×10. [*11* from upper part of McCloud Limestone, northern California; *12* from collection OR-3.] ——Pl. 10, fig. *1.* Axial section, ×10.——Pl. 10, fig. *2, 3.* Sagittal sections, ×10. [All from collection OR-3.] [All figures are unretouched photographs.]

SCHWAGERINA MINIMA Skinner & Wilde, n. sp.

Shell small, subcylindrical, with rounded to bluntly pointed poles. Fully grown individuals have 6.5 to 7.5 volutions, and measure 3.20 to 3.75 mm. in length, and 1.05 to 1.45 mm. in diameter. Form ratio varies from 2.48 to 3.05.

Spirotheca composed of tectum and keriotheca. In early whorls it is very thin and minute structure is obscure, but at end of about 4.5 volutions wall begins to thicken rather rapidly and moderately coarse alveolar structure becomes evident. Thickness of spirotheca in 6th whorl varies from 34 to 47 μ. Septa regularly folded from pole to pole. They number 7 to 8 in 1st volution, 8 to 10 in 2nd, 10 to 12 in 3rd, 12 to 16 in 4th, 12 to 18 in 5th, 18 to 21 in 6th, and 19 to 20 in 7th. Septal folds about half as high as chambers and about as wide as they are high. Consequently, septal loops as seen in axial sections are nearly semicircular. Axial filling slight and confined to narrow band along axis.

Proloculus small and commonly ellipsoidal in shape rather than spherical. Its outside diameter varies from 74 to 107 μ. Tunnel very low and rather wide. In 6th whorl tunnel angle measures 47 to 53 degrees. Weak chomata present in 1st 3 or 4 volutions, but absent in outer ones.

Discussion.—Schwagerina minima does not closely resemble any other known American species. It is similar to *S. gregaria* (LEE) from the Lower Permian of the Nanking Hills in Kiangsu Province, China. The latter species, however, has stronger chomata, heavier axial filling, and a slightly thicker spirotheca.

Occurrence.—This species is abundant in collection OR-3.

Illustrations.—Plate 10, figures *4-11.*——Figs. *4, 5.* Axial section of holotype, ×10, ×20.——Figs. *6-8.* Axial sections of paratypes, ×20.——Figs. *9-11.* Sagittal sections of paratypes, ×20. [All from collection OR-3.] [All figures are unretouched photographs.]

SCHWAGERINA SUPERBA Skinner & Wilde, n. sp.

Shell large, central portion thickly cylindrical, with bluntly pointed, conical poles. Middle of shell commonly somewhat constricted. Mature specimens have about 8, rarely 9, volutions. Such individuals measure 13.70 to 15.00 mm. in length and 4.25 to 5.00 mm. in diameter. Form ratio varies from 2.76 to 3.57, averaging about 3.10.

Spirotheca composed of tectum and rather finely alveolar keriotheca measuring 67 to 74 μ in thickness in 7th volution. Septa strongly and regularly fluted from pole to pole. They number 17 to 23 in 1st whorl, 25 to 34 in 2nd, 30 to 38 in 3rd, 41 to 46 in 4th, 45 to 51 in 5th, 48 to 59 in 6th, 52 to 63 in 7th, and about 53 in 8th. Septal folds high, extending to tops of septa. [Perhaps the most distinctive character of this species is the pattern produced in axial sections by the secondary deposits or axial filling. These deposits nearly fill the shell in narrow zones on either side of the tunnel area, while a less massive development extends in a narrow band along the axis. In axial sections this produces a characteristic X-shaped pattern with a less conspicuous horizontal band extending laterally from either side of the intersection of the two limbs of the X (Pl. 11, fig. 1-3).]

Proloculus large, with outside diameter ranging from 282 to 425 μ. Tunnel low and narrow, tunnel angle in 7th volution measuring 22 to 34 degrees, averaging about 27 degrees. No chomata observed, even on proloculus.

Discussion.—Schwagerina superba is the largest and biologically the most advanced member of the genus in our Coyote Butte collections. In size and general appearance it is similar to *S.*

figueroai THOMPSON & MILLER from Chiapas, Mexico. It differs from that species in its smaller proloculus, thinner spirotheca, and finer texture of its keriotheca. It also resembles *S. amoena* SKINNER & WILDE, but differs from the latter in its larger proloculus, larger size, more numerous septa, and the distinctive pattern of its axial filling.

Occurrence.—We have found this species in collections OR-3, OR-4, and OR-5.

Illustrations.—Plate 11, figures *1-5.*——Fig. *1.* Axial section of holotype, ×10.——Figs. *2, 3.* Axial sections of paratypes, ×10.——Figs. *4, 5.* Sagittal sections of paratypes, ×10. [*1, 2, 4, 5* from collection OR-3; *3* from collection OR-5.] [All figures are unretouched photographs.]

SCHWAGERINA OREGONENSIS Skinner & Wilde, n. sp.

Shell large, inflated fusiform, with convex lateral slopes and bluntly pointed poles. Mature specimens have 7.5 to 8.5 volutions and measure 7.80 to 12.60 mm. in length and 5.00 to 7.00 mm. in diameter. Form ratio varies from 1.41 to 1.80.

Thick spirotheca composed of tectum and coarsely alveolar keriotheca measuring 154 to 168 μ in thickness in 7th whorl. Septa strongly and regularly fluted from pole to pole, thickened by coating of epitheca which covers both anterior and posterior faces. They number 14 to 18 in 1st volution, 19 to 23 in 2nd, 23 to 32 in 3rd, 30 to 36 in 4th, 38 to 42 in 5th, 38 to 60 in 6th, 38 to 54 in 7th, and about 48 in 8th. Septal folds high, extending to tops of septa. Septal pores abundant and conspicuous. They usually appear as dark spots on septa because they have been plugged by secondary deposits. Phrenothecae present but not prominent.

Proloculus large, with outside diameter varying from 470 to 530 μ. Tunnel narrow and about half as high as chambers. Tunnel angle averaging 13 degrees in 6th whorl, and 14 degrees in 7th. Weak chomata present only on proloculus.

Discussion.—Schwagerina oregonensis bears some resemblance to *S. chiapasensis* THOMPSON & MILLER, from Chiapas, Mexico, but the latter is more elongate, has a wider tunnel, and possesses conspicuous phrenothecae.

Occurrence.—This species is common in collection OR-3.

Illustrations.—Plate 12, figures *1-5.*——Fig. *1.* Axial section of holotype, ×10.——Figs, *2, 3.* Axial sections of paratypes, ×10.——Figs. *4, 5.* Sagittal sections of paratypes, ×10. [All from collection OR-3]. [All figures are unretouched photographs.]

Genus CHALAROSCHWAGERINA Skinner & Wilde, 1965

CHALAROSCHWAGERINA TUMENTIS Skinner & Wilde

Chalaroschwagerina tumentis SKINNER & WILDE, 1965, Univ. Kansas Paleont. Contrib., Protozoa, art. 6, p. 72, pl. 57, figs. 1-5.

Shell large, subglobular, with strongly convex lateral slopes and bluntly pointed poles. Mature specimens have 6 to 7 whorls measuring 7.95 to 9.42 mm. in length and 6.38 to 7.32 mm. in diameter. Form ratio varies from 1.16 to 1.48, averaging about 1.30. First 1 or rarely 1.5 whorls rather tightly coiled, after which rate of expansion increases and coiling becomes relatively loose.

Thick spirotheca composed of tectum and coarsely alveolar keriotheca. In 6th volution its thickness averages about 165 μ. Septa strongly but somewhat irregularly fluted throughout shell and septal folds high, many reaching tops of chambers. Septa number 13 to 16 in 1st volution, 24 to 30 in 2nd, 28 to 42 in 3rd, 50 to 51 in 4th, 56 to 66 in 5th, and about 56 in 6th. Phrenothecae well developed and conspicuous. Axial filling in form of thin film of secondary material may be present on septa in outer whorls. Septal pores numerous.

Proloculus large and thick-walled, its outside diameter ranging from 386 to 530 μ. Tunnel low and narrow, tunnel angle averaging about 15 degrees in the sixth volution. Weak chomata are present only on the proloculus.

Discussion.—The above description, while based on our Coyote Butte specimens, agrees almost perfectly with that of the type specimens from the upper part of the McCloud Limestone of northern California.

Occurrence.—Chalaroschwagerina tumentis is one of the more common species in collection OR-4.

Illustrations.—Plate 13, figure *1-5.*——Figs. *1-3.* Axial sections, ×10.——Figs. *4, 5.* Sagittal sections, ×10. [All from collection OR-4.] [All figures are unretouched photographs.]

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PART 3

PERMIAN FUSULINIDS FROM NORTHEASTERN WASHINGTON

ABSTRACT

Seven species of fusulinids belonging to three genera are described from limestone lenses in the Permian Mission Argillite near Kettle Falls, Washington, and from a large limestone lens or bioherm exposed about 12 miles northeast of Republic, Washington. All but one of these species indicate a Wolfcampian age. The exception is a large species of *Parafusulina* which can hardly be older than early Guadalupian. It is concluded that the Leonardian is either absent in the area or represented by a very thin unfossiliferous section of clastic rocks.

INTRODUCTION

Immediately northeast of Kettle Falls, Stevens County, Washington, several limestone lenses or bioherms are intercalated in the section of predominantly clastic rocks of the Mission Argillite (Fig. 4). From one of these McLAUGHLIN & SIMONS (1951) described a large species of *Parafusulina* which they incorrectly assigned to *Parafuslina dunbari* NEEDHAM. The latter is a synonym of *Parafusulina rothi* DUNBAR & SKINNER, and it is not conspecific with the Washington species. Both, however, are about equally advanced and probably do not differ greatly in age.

In 1955 WALTER P. KLEWENO sent us material collected from the same bed and locality as that from which McLAUGHLIN & SIMONS obtained their specimens. This species can hardly be older than early Guadalupian and the limestone in which it occurs should correlate with part of the Nosoni Formation of northern California and with part of the Word Formation of West Texas.

In 1957 Dr. L. R. LAUDON, while working as a consultant for the Humble Company, visited the locality and collected from several limestone lenses in the Mission Argillite. From one, which he labelled "lowest limestone on the hill," we have obtained a Wolfcampian fusulinid fauna, including *Schwagerina amoena* SKINNER & WILDE, which is also present in the upper part of the McCloud Limestone of northern California and in the Coyote Butte Limestone of east-central

FIG. 4. Index map showing location of Republic and Kettle Falls areas, northeastern Washington.

Oregon. This particular lens is exposed in the NW¼ of sec. 16, T. 36 N., R. 38 E., Stevens County, Washington. Another lens, exposed in the northeast quarter of the same section, yielded two species of *Pseudofusulinella* which occur in the middle part of the McCloud Limestone. These are *P. montis* (THOMPSON & WHEELER) and *P. opima* SKINNER & WILDE. A still higher lens at this last locality contains the large *Parafusulina* described by MCLAUGHLIN & SIMONS.

In 1957 KLEWENO collected fossils from a limestone lens exposed in the southeast quarter of this same section. This collection contains several species of *Pseudofusulinella* and *Schwagerina,* including one species of the latter which is also present in LAUDON's "lowest limestone on the hill."

The fossiliferous limestone masses are separated by unfossiliferous argillites and siltstones. MILLS & DAVIS (1962) collected from several limestone lenses or bioherms in this area, including three located two to three miles farther north. From all of their collections, except one, they obtained the same large species of *Parafusulina.* The sole exception, located in the SE¼ of sec. 34, T. 37 N., R. 38 E., contained species of *Pseudofusulinella* and *Schwagerina.* They considered the exposed section to consist of about 4,000 feet of siltstone, in which the limestone masses occur, overlain by argillite and graywacke in that order. They interpreted the structure as a north-plunging syncline with the siltstone, which is exposed only on the east limb, overturned to the west in the northern part of its exposure. A diabase dike "has been intruded along and close to the contact of the argillite and siltstone" (p. 41).

A line drawn from one to another of their localities containing *Parafusulina* extends south-

ward from the SW¼ of sec. 27, T. 37 N., R. 38 E. to the NE¼ of sec. 16, T. 36 N., R. 38 E., and then swings southwestward to the SE¼ of sec. 17, T. 36 N., R. 38 E. Their single collection containing the older fauna lies to the east of this line, as does our collection from the SE¼ of sec. 16. This indicates a generally westward dip. Two of our collections, however, west of this line also contain the older fauna, suggesting that at least locally, the structure is more complex.

About 22 miles west-northwest of the Kettle Falls exposure and about 12 miles northeast of Republic, in Ferry County, Washington, LAUDON found a large limestone mass which he referred to as "a reef" and from which he made several collections. All of these contain Wolfcampian fusulinids, including one species of *Schwagerina* which is also present in the older fauna at Kettle Falls. Thus, equivalents of the upper part of the McCloud Limestone of northern California are known to be represented by fossiliferous limestone at two localities in northeastern Washington, as well as in east-central Oregon, and middle McCloud equivalents, also, are present in northeastern Washington.

Since one of the lenses in the NE¼ of sec. 16, T. 36 N., R. 38 E. contains a lower Guadalupian *Parafusulina,* while another lens only 75 to 100 feet lower in the section contains a Wolfcampian fusulinid fauna, there is a marked faunal hiatus within the siltstone member which contains the lenses. Either the Leonardian is absent here or it is represented by only a few feet of unfossiliferous clastic rocks.

We wish to thank Mr. W. P. KLEWENO and Dr. L. R. LAUDON for supplying us with material and information from this area, and the Humble Oil & Refining Company for permission to publish this paper. All figured specimens are deposited in the files of the Humble Oil & Refining Company at Midland, Texas.

FUSULINID COLLECTIONS

WA-15.—Limestone lens in Mission Argillite. NE¼ sec. 16, T. 36 N., R. 38 E., Stevens County, Washington. Collected by W. P. KLEWENO.

WA-32.—Limestone lens in Mission Argillite. NW¼ sec. 16, T. 36 N., R. 38 E., Stevens County, Washington. Collected by L. R. LAUDON who called it "lowest limestone on the hill."

WA-33.—Limestone lens in Mission Argillite. Same locality and zone as WA-32. Collected by L. R. LAUDON.

WA-34.—Permian limestone. Copper Mountain, NW¼ sec. 5, T. 37 N., R. 34 E., about 12 miles northeast of Republic, Ferry County, Washington. Collected by L. R. LAUDON.

WA-35.—Permian limestone. Same locality as WA-34. Collected by L. R. LAUDON.

WA-36.—Permian limestone. Same locality as WA-34. Collected by L. R. LAUDON.

WA-49.—Limestone lens in Mission Argillite. Same locality and zone as WA-15. Collected by L. R. LAUDON.

WA-50.—Limestone lens in Mission Argillite. Same locality as WA-49, but a separate lens about 75 to 100 feet lower in the section. Collected by L. R. LAUDON.

WA-51.—Limestone lens in Mission Argillite. SE¼ of sec. 16, T. 36 N., R. 38 E., Stevens County, Washington. [This appears to be a little younger than WA-50, but older than WA-49.] Collected by W. P. KLEWENO.

SYSTEMATIC PALEONTOLOGY

Genus PSEUDOFUSULINELLA Thompson, 1951

PSEUDOFUSULINELLA STEVENSI Mills & Davis

Pseudofusulinella stevensi MILLS & DAVIS, 1962, Cushman Found. Foram. Research, Contr., v. 13, p. 44, 45, pl. 7, figs. 1-5.

Shell small, thickly fusiform, with concave lateral slopes and bluntly pointed poles. Mature specimens have 7.5 to 8.5 whorls and measure 3.90 to 4.50 mm. in length and 2.40 to 2.80 mm. in diameter. Form ratio varies from 1.56 to 1.79.

Spirotheca composed of tectum and diaphanotheca, measuring 43 to 55 μ in thickness in 7th volution. Septa strongly but irregularly fluted from pole to pole. They number 9 to 10 in 1st whorl, 15 to 16 in 2nd, 17 in 3rd, 18 to 20 in 4th, 18 to 22 in 5th, 23 to 24 in 6th, and 24 to 27 in 7th.

The proloculus is small, its outside diameter ranging from 114 to 139 μ. Tunnel low and very narrow; in 7th whorl tunnel angle varies from 9 to 11 degrees. Chomata narrow, about two-thirds as high as chambers.

Discussion.—This description of *Pseudofusulinella stevensi* is based on our own specimens. They agree so closely, however, with the type

specimens described by MILLS & DAVIS (1962) that we have no doubt as to their being conspecific. *P. stevensi* does not closely resemble any other known member of the genus.

Occurrence.—This species is common in our collection WA-51, from one of the lower limestones near Kettle Falls. The type specimens came from a locality approximately 3 miles to the north-northeast. At both places it is associated with *Schwagerina missionensis* MILLS & DAVIS.

Illustrations.—Plate 14, figures *1-5.*——Figs. *1-3.* Axial sections, ×10.——Figs. *4, 5.* Sagittal sections, ×10. [All from collection WA-51.] [All figures are unretouched photographs.]

PSEUDOFUSULINELLA MUCRONATA Skinner & Wilde, n. sp.

Shell small, slender fusiform, with straight to slightly concave lateral slopes and acutely pointed poles. Mature individuals have 6.5 to 8 whorls and measure 4.10 to 5.20 mm. in length and 1.40 to 1.60 mm. in diameter. Form ratio varies from 2.87 to 3.25.

Spirotheca composed of tectum and diaphanotheca, in 6th volution measuring 36 to 42 μ in thickness. Septa nearly plane across middle of shell, becoming moderately folded toward poles. They number 8 to 9 in 1st whorl, 12 to 14 in 2nd, 14 to 19 in 3rd, 17 to 20 in 4th, 20 to 21 in 5th, 22 to 23 in 6th, and 26 in 7th.

Proloculus small, although above average for members of this genus, its outside diameter measuring 104 to 184 μ. Tunnel narrow and about half as high as chambers. In 6th volution tunnel angle varies from 15 to 19 degrees. Chomata rather broad but low, seldom exceeding half height of chambers.

Discussion.—Pseudofusulinella mucronata is distinguished by its slender shape, sharply pointed poles, and rather large proloculus.

Occurrence.—This is a rather rare species. We have found only a few specimens in collection WA-51 associated with *Pseudofusulinella stevensi* MILLS & DAVIS and *Schwagerina missionensis* MILLS & DAVIS.

Illustrations.—Plate 14, figures *6-10.*——Fig. *6.* Axial section of holotype, ×10. Figs. *7, 8.* Axial sections of paratypes, ×10.——Figs. *9, 10.* Sagittal sections of paratypes, ×10. [All from collection WA-51.] [All figures are unretouched photographs.]

Genus SCHWAGERINA von Möller, 1877

SCHWAGERINA TENUITHECA Skinner & Wilde, n. sp.

Shell small, slender subcylindrical, with bluntly pointed poles. Mature specimens have 5 to 5.5 volutions measuring 6.90 to 7.80 mm. in length and 1.60 to 2.20 mm. in diameter. Form ratio varies from 3.45 to 4.31, averaging about 3.95.

Spirotheca composed of tectum and finely alveolar keriotheca, measuring 54 to 60 μ in thickness in 4th whorl, and 60 to 74 μ in 5th. Septa strongly and regularly fluted from pole to pole. They number 13 in 1st volution, 21 to 23 in 2nd, 26 to 34 in 3rd, and 29 to 33 in 4th. Septal folds high, reaching nearly to tops of septa. Axial filling present in first 3.5 to 4 whorls.

Proloculus fairly large, its outside diameter varying from 181 to 302 μ. Tunnel low and moderately wide. In 5th volution tunnel angle measures 43 to 47 degrees. No chomata present.

Discussion.—Schwagerina tenuitheca SKINNER & WILDE, n. sp., does not closely resemble any previously described species. Its most outstanding character is the marked thinness of the spirotheca.

Occurrence.—We have found this species only in collection WA-51, where it is associated with *Pseudofusulinella mucronata* SKINNER & WILDE, n. sp., *P. stevensi* MILLS & DAVIS, and *Schwagerina missionensis* MILLS & DAVIS.

Illustrations.—Plate 14, figures *11-15.*——Fig. *11.* Axial section of holotype, ×10.——Figs. *12, 13.* Axial sections of paratypes, ×10.——Figs. *14, 15.* Sagittal sections of paratypes, ×10. [All from collection WA-51.] [All figures are unretouched photographs.]

SCHWAGERINA DENSA Skinner & Wilde, n. sp.

Shell of moderate size, thickly subcylindrical, with bluntly pointed, conical ends. Mature individuals have 6.5 to 7 volutions and measure 9.30 to 11.00 mm. in length and 3.00 to 3.60 mm. in diameter. Form ratio varies from 3.04 to 3.10.

Spirotheca composed of tectum and moderately coarse-textured keriotheca measuring 67 to 81 μ in thickness in 5th whorl. Septa intensely fluted from pole to pole. They number 11 to 13 in 1st volution, 20 to 23 in 2nd, 22 to 27 in 3rd, 32 to 36 in 4th, 33 to 34 in 5th, and 39 to 44 in 6th. Septal folds high, reaching to tops of septa. Axial filling in form of secondary deposit on septa

present throughout shell outside of tunnel area. It is particularly massive in 1st 3 or 4 volutions.

Proloculus moderate in size, with outside diameter varying from 174 to 295 μ. Tunnel low and rather narrow. In 5th whorl tunnel angle measures 29 to 34 degrees. No chomata are developed.

Discussion.—*Schwagerina densa* resembles *S. missionensis* MILLS & DAVIS, with which it occurs. It differs from that species in its slightly greater length, larger form ratio, and thinner spirotheca. It is similar in general appearance to *S. amoena* SKINNER & WILDE, but differs in its smaller size and less massive secondary deposits.

Occurrence.—We have found this species only in collection WA-51, where it is associated with *Pseudofusulinella mucronata* SKINNER & WILDE, n. sp., *P. stevensi* MILLS & DAVIS, *Schwagerina tenuitheca* SKINNER & WILDE, n. sp., and *S. missionensis* MILLS & DAVIS.

Illustrations.—Plate 14, figures *16-18;* Plate 15, figures *1, 2.*——Pl. 14, fig. *16.* Axial section of holotype, ×10.——Pl. 14, fig. *17.* Axial section of paratype, ×10.——Pl. 14, fig. *18.* Sagittal section of paratype, ×10. [All from collection WA-51.] ——Pl. 15, fig. *1.* Axial section of immature paratype, ×10.——Pl. 15, fig. *2.* Sagittal section of immature paratype, ×10. [Both from collection WA-51.] [All figures are unretouched photographs.]

SCHWAGERINA MISSIONENSIS Mills & Davis

Schwagerina missionensis MILLS & DAVIS, 1962, Cushman Found. Foram. Research, Contr., v. 13, p. 45-47, pl. 8, figs. 1-5.

Shell moderate in size, central part thickly cylindrical, with bluntly pointed, conical ends. Our specimens have 5.5 to 6 volutions and measure 6.60 to 9.30 mm. in length and 3.20 to 3.90 mm. in diameter. Form ratio varies from 2.06 to 2.39.

Spirotheca composed of tectum and moderately coarse keriotheca, measuring 94 to 107 μ in thickness in 5th whorl. Septa intensely fluted throughout shell. They number 13 to 14 in 1st volution, 23 to 27 in 2nd, 26 to 35 in 3rd, 33 to 34 in 4th, 36 to 37 in 5th, and about 39 in 6th. Septal folds high, extending to tops of septa. Massive secondary deposits nearly fill shell on either side of tunnel area, but extend only one-half to two-thirds of distance from tunnel toward poles.

Proloculus large, its outside diameter varying from 282 to 369 μ. Tunnel low and not very wide. In 5th volution tunnel angle varies from 18 to 27 degrees, increasing to about 35 degrees in 6th. Very weak chomata can sometimes be seen on proloculus.

Discussion.—Our specimens are slightly smaller than those described by MILLS & DAVIS, but agreement in every other respect is so close that we are convinced that they are conspecific. *Schwagerina missionensis* MILLS & DAVIS is similar to *S. densa* SKINNER & WILDE, n. sp., but differs in its lesser length, smaller form ratio, and thicker spirotheca.

Occurrence.—We have found this species in our collection WA-51. The type specimens came from a locality about three miles to the north-northeast. At both places *S. missionensis* is associated with *Pseudofusulinella stevensi* MILLS & DAVIS.

Illustrations.—Plate 15, figures *3-7.*——Figs. *3-5.* Axial sections, ×10.——Figs. *6, 7.* Sagittal sections, ×10. [All from collection WA-51.] [All figures are unretouched photographs.]

SCHWAGERINA ARMSTRONGI (Thompson & Verville)

Parafusulina armstrongi THOMPSON & VERVILLE, 1950, Cushman Found. Foram. Research, Contr., v. 1, p. 69, 70, pl. 9, figs. 1-7.

Shell small, elongate subcylindrical, with bluntly rounded poles. Mature shells have 7.5 to 9 volutions measuring 4.10 to 5.00 mm. in length and 1.25 to 1.40 mm. in diameter. Form ratio varies from 3.28 to 4.32, averaging about 3.70.

Spirotheca very thin, its thickness in 7th whorl measuring only 47 μ. In 1st 5 volutions minute structure of spirotheca is obscure and it is only from 6th whorl outward that finely alveolar texture can be distinguished in the keriotheca. Septa regularly fluted from pole to pole. They number 8 to 11 in 1st volution, 12 to 16 in 2nd, 16 to 20 in 3rd, 18 to 21 in 4th, 19 to 21 in 5th, 20 to 24 in 6th, 20 to 28 in 7th, 24 in 8th, and 32 in 9th. Septal folds high, extending nearly to tops of septa. Except in outer 2 volutions, secondary deposits on septa nearly fill shell outside of tunnel area. No cuniculi have been observed.

Proloculus very small, its outside diameter varying from 67 to 107 μ. Tunnel low and wide. In 8th whorl tunnel angle varies from 43 to 64 degrees, averaging about 53 degrees. Weak chomata are present in 1st 6 volutions, but absent thereafter.

Discussion.—THOMPSON & VERVILLE described this species as *Parafusulina armstrongi,* although they stated that they had been unable to find cuniculi in it and assigned it somewhat questionably to *Parafusulina.* Their specimens were obtained from a limestone in the Cache Creek Group northeast of Kamloops, British Columbia. The absence of cuniculi and presence of chomata definitely remove this species from *Parafusulina.* The Canadian specimens tend to be a little larger than ours, whorl for whorl, but they are so similar in every other respect that we do not feel justified in erecting a separate species for our specimens.

Occurrence.—*Schwagerina armstrongi* is common in collections WA-32, WA-33, and WA-51, from the Kettle Falls area, and in collections WA-35 and WA-36, from the Republic area. *Pseudofusulinella* occurs with *S. armstrongi* in both the Washington and British Columbia outcrops.

Illustrations.—Plate 15, figures *8-13.*——Figs. *8, 9.* Axial section, ×10, ×20.——Figs. *10, 11.* Axial sections, ×20.——Figs. *12, 13.* Somewhat oblique sagittal sections, ×20. [*8, 9* from collections WA-35; *10, 11* from collection WA-36; *12, 13* from collection WA-51.] [All figures are unretouched photographs.]

Genus PARAFUSULINA Dunbar & Skinner, 1931

PARAFUSULINA MCLAUGHLINI Skinner & Wilde, n. sp.

Parafusulina dunbari MCLAUGHLIN & SIMONS, 1951, Jour. Paleontology, v. 25, no. 4, p. 518, pl. 76, fig. 1-6.
Parafusulina antimonioensis MILLS & DAVIS *(partim)*, 1962, Cushman Found. Foram. Research, Contr., v. 13, p. 45-49, pl. 9, figs. 1-5, pl. 10, figs. 1-4, pl. 11, figs. 1-3 (*not* pl. 10, figs. 5-6).

Shell large, highly elongate cylindrical, with bluntly pointed poles. Mature specimens have 7 to 7.5 volutions measuring 21.60 to 24.00 mm. in length and 3.40 to 4.00 mm. in diameter. Form ratio varies from 5.40 to 7.06.

Spirotheca composed of tectum and coarsely alvealor keriotheca, measuring 74 to 101 μ in thickness in 6th volution. Septa strongly and regularly fluted from pole to pole. They number 12 in 1st whorl, 23 to 24 in 2nd, 28 to 30 in 3rd, 31 to 32 in 4th, 29 to 31 in 5th, and 37 to 39 in 6th. Septal folds about one-half to two-thirds as high as chambers and about as wide as high. Septa thickened by coating of secondary material, particularly in band along axis. Well-developed cuniculi present at all stages of growth (Pl. 17, fig. 5).

Proloculus very large, its outside diameter varying from 450 to 671μ. Tunnel moderately wide, about half as high as chambers. Tunnel angle measures 47 to 57 degrees in 5th whorl, and 44 to 54 degrees in 6th. Chomata are absent.

We have a sagittal section of a microspheric individual which measures 4.50 mm. in diameter, and which has 14 volutions (Pl. 17, fig. 3, 4). Its proloculus has an outside diameter of only 50 μ.

Discussion.—MCLAUGHLIN & SIMONS described this species as *Parafusulina dunbari* NEEDHAM. That name, however, is a junior synonym of *P. rothi* DUNBAR & SKINNER. *P. mclaughlini* is distinct from *P. rothi,* differing in its greater length, larger form ratio, and larger proloculus. It is similar to *P. californica* (VON STAFF), but differs from that species in its smaller form ratio and narrower tunnel. MILLS & DAVIS redescribed this species and assigned it to *P. antimonioensis* DUNBAR. They stated (p. 47) that the form ratio "commonly ranges from 7.9 to 11.1 and has a maximum of 12.5." Measurements of their illustrated specimens, however, give form ratios ranging from 6.7 to 7.7, with a single exception. This is the specimen illustrated as figures 5 and 6 of their plate 10. It is much more tightly coiled than the others, and measurement of the photographs give a form ratio of nearly 12. It almost certainly belongs to a different species. A comparison of the Kettle Falls specimens with topotypes of *P. antimonioensis* shows that the latter is a more advanced species than *P. mclaughlini.* The species is named for K. P. MCLAUGHLIN.

Occurrence.—This species is abundant in our collections WA-15 and WA-49. MILLS & DAVIS reported it from several other localities in the same vicinity.

Illustrations.—Plate 16, figures *1-3*; Plate 17, figures *1-5.*——Pl. 16, fig. *1.* Axial section of holotype, ×10.——Pl. 16, figs. *2, 3.* Axial sections of paratypes, ×10. [All from collection WA-49.] ——Pl. 17, fig. *1, 2.* Sagittal sections of paratypes, ×10.——Pl. 17, figs. *3, 4.* Sagittal section of microspheric paratype, ×10, ×100.——Pl. 17, fig. *5.* Tangential section of paratype showing cuniciuli, ×10. [All from collection WA-49.] [All figures are unretouched photographs.]

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PART 4

PERMIAN FUSULINIDS FROM CANYON CREEK QUARRIES, NORTHWESTERN WASHINGTON

ABSTRACT

Five species of fusulinids, three of which are new, are described from Permian limestone exposed in the Canyon Creek quarries near Granite Falls, northwestern Washington. They belong to the genera *Dunbarula, Schwagerina,* and *Yabeina,* and probably are late Guadalupian in age.

INTRODUCTION

Permian limestone containing a Tethyan fusulinid fauna is exposed in a number of isolated outcrops in northwestern Washington. The exposures lie in a general northwest-southeast trending line and probably do not differ greatly in age. The ones considered in the present paper are located about 3.5 miles northeast of Granite Falls in Snohomish County, Washington, and about four miles south-southeast of the southeasternmost Twin Lakes exposures (Fig. 5).

Fusulinids from this locality were first described by ANDERSON (1941), and later by THOMPSON, WHEELER, & DANNER (1950). According to DANNER (1959), "There are really two quarries here. One extends south from the highway into a small hill and the second, a higher one, is located on the south side of this same hill. This latter quarry seems to be abandoned, but the one on the highway is worked from time to time. . . . The fusulinids are found in the southern quarry

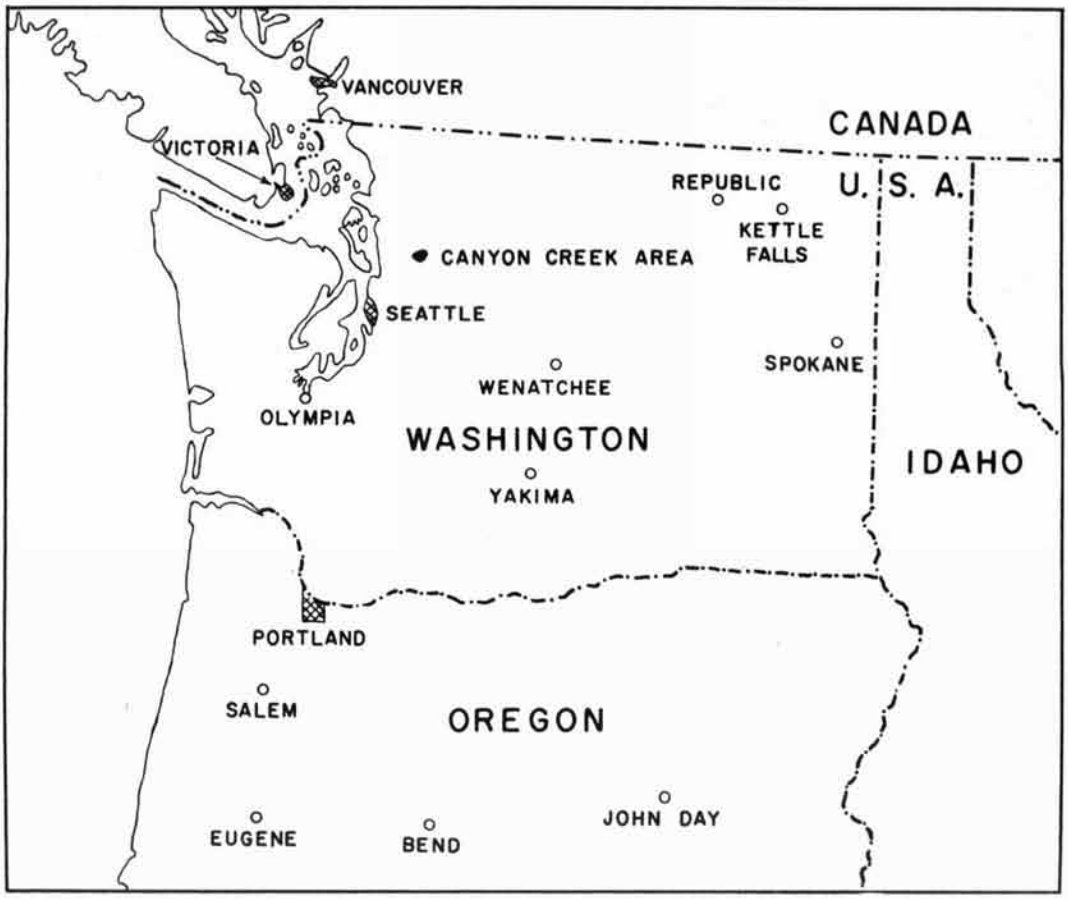

FIG. 5. Index map showing location of Canyon Creek area, northwestern Washington.

apparently only in its northeast corner near where a dike of volcanic rock intrudes the limestone."

Previous references to the presence of a "higher and lower quarry" have been confusing since the one beside the highway has two levels. When we visited the locality we had the impression that these levels represented the two quarries. The confusion was heightened by the fact that an igneous intrusion cuts the limestone of the upper level. Furthermore, we found the two fusulinid species described by ANDERSON in the upper level of this quarry, but the rock has been so thoroughly shattered and recemented by crystalline calcite that it is very difficult to obtain good specimens. The limestone is fine-grained and varies in color from nearly white to light tan. The fusulinids were found only in thin lenses of the darker limestone.

In 1957 Dr. L. R. LAUDON visited the locality and made a series of collections from the upper quarry. His collections consist mainly of brown, somewhat argillaceous limestone which has undergone very little deformation. As a result, the fossils are in relatively good condition. That the two exposures are probably part of the same limestone body is evidenced by the fact that at least two species are found in both quarries.

The genera *Dunbarula, Schwagerina,* and *Yabeina* are represented, indicating a probable late Guadalupian age.

We wish to express our thanks to Dr. LAUDON and Dr. W. R. DANNER for supplying us with material and information, and to the Humble Oil & Refining Company for permission to publish this paper. All figured specimens are deposited in the files of the Humble Oil & Refining Company at Midland, Texas.

FUSULINID COLLECTIONS

Collections WA-40 through WA-47 were collected by L. R. LAUDON from the southern, or upper, quarry near the center of the E½ of sec. 5, T. 30 N., R. 7 E.

WA-1.—Permian limestone. Canyon Creek quarry, 3.8 miles by road northeast of Granite Falls, Snohomish County, Washington. This is the northern, or lower, quarry, immediately beside the road in the E½ of sec. 5, T. 30 N., R. 7 E. Collected by W. R. DANNER.

WA-5.—Permian limestone. Same locality as WA-1. West wall of upper level of quarry. Collected by J. W. SKINNER.

WA-40.—Permian limestone. LAUDON's collection PA-1.

WA-41.—Permian limestone. LAUDON's collection PA-2.

WA-42.—Permian limestone. LAUDON's collection PA-3.

WA-43.—Permian limestone. LAUDON's collection PA-4.

WA-44.—Permian limestone. LAUDON's collection PA-5.

WA-45.—Permian limestone. LAUDON's collection PA-6.

WA-46.—Permian limestone. LAUDON's collection PA-7.

WA-47.—Permian limestone. LAUDON's collection PA-8.

SYSTEMATIC PALEONTOLOGY

Genus DUNBARULA Ciry, 1948

DUNBARULA LAUDONI Skinner & Wilde, n. sp.

Shell minute, fusiform, with sharply to bluntly pointed poles. Mature specimens have 4 to 5.5 volutions, the first 2.5 to 4 being discoidal in shape and coiled nearly at right angle to later whorls. Consequently, a sagittal section of outer volutions invariably presents an axial section of inner ones (Pl. 18, figs. 6-8). Fully grown individuals measure 0.90 to 1.20 mm. in length and 0.48 to 0.50 mm. in diameter. The form ratio varies from 1.80 to 2.45, averaging about 2.25.

Spirotheca very thin, composed of tectum and diaphanotheca, measuring 17 to 24 μ in thickness in 4th whorl. Septa rather strongly fluted from pole to pole. They number 9 to 10 in 1st volution, 13 to 16 in 2nd, 16 in 3rd, 18 to 19 in 4th, and 20 to 23 in 5th.

Proloculus minute, its outside diameter varying from 37 to 64 μ. Tunnel narrow, about one-third as high as chambers. Tunnel angle varies from 22 to 27 degrees in 4th whorl, and from 22 to 37 degrees in 5th. Chomata low but rather prominent because of thinness of spirotheca.

Discussion.—Dunbarula laudoni SKINNER & WILDE, n. sp., is the only known representative of the genus in North America. It differs from the type species, *Dunbarula mathieui* CIRY, in its smaller size and more fusiform shape. *Boultonia cascadensis* THOMPSON, WHEELER, & DANNER was transferred by THOMPSON (1954) to the genus *Dunbarula*. While it is true that *B. cascadensis* is not closely similar to *B. willsi* LEE, the type species of *Boultonia*, we believe that its resemblance to members of that genus is greater than its similarity to the type species of *Dunbarula*.

Occurrence.—Dunbarula laudoni SKINNER & WILDE, n. sp., occurs in profusion in collections WA-42, WA-43, WA-44, and WA-45, from the higher Canyon Creek quarry, where it is associated with *Schwagerina royandersoni* THOMPSON, WHEELER, & DANNER, *Yabeina decora* SKINNER & WILDE, and *Y. fusiformis* SKINNER & WILDE. It is particularly abundant in collection WA-42. This species is named for Dr. L. R. LAUDON, who collected the material.

Illustrations.—Plate 18, figures *1-8*.——Figs. *1, 2*. Axial section of holotype, ×40, ×100.——Figs. *3-5*. Axial sections of paratypes, ×40.——Figs. *6-8*. Sagittal sections of paratypes, ×40. [All from collection WA-42.] [All figures are unretouched photographs.]

Genus SCHWAGERINA von Möller, 1877

SCHWAGERINA ROYANDERSONI Thompson, Wheeler, & Danner, 1950

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Schwagerina andersoni THOMPSON, WHEELER, & DANNER, 1950, Cushman Found. Foram. Research, Contr., v. 1, p. 55, 56, pl. 4, figs. 1-5, (?) pl. 8, fig. 13.

Schwager na royandersoni THOMPSON, WHEELER, & DANNER in THOMPSON, PITRAT, & SANDERSON, 1953, Jour. Paleontology, v. 27, p. 547.

Shell moderate in size, inflated fusiform, with concave lateral slopes and acutely pointed poles. Mature individuals have 7.5 to 9 volutions and measure 7.90 to 10.00 mm. in length and 3.99 to 5.30 mm. in diameter. Form ratio varies from 1.74 to 2.16. Coiling is tight in inner whorls, becoming rather loose in the outer ones.

Spirotheca composed of tectum and coarsely

alveolar keriotheca, which is quite thin in inner whorls, but thickens rather abruptly to about 195 μ in 7th whorl. Septa strongly fluted throughout shell. They number 10 to 13 in 1st volution, 12 to 18 in 2nd, 14 to 16 in 3rd, 18 to 22 in 4th, 19 to 25 in 5th, 21 to 30 in 6th, 25 to 33 in 7th, and 32 to 34 in 8th. Septal folds high, reaching nearly to tops of septa. Axial filling present but confined to narrow band along axis.

Proloculus small, its outside diameter varying from 150 to 235 μ. Tunnel low and narrow, tunnel angle measuring 26 to 29 degrees in 7th volution. Weak chomata are present only in 1st three whorls.

Discussion. — *Schwagerina royandersoni* THOMPSON, WHEELER, & DANNER does not closely resemble any other described American species. In some respects it is similar in appearance to certain species of *Chusenella,* but the septal fluting of the inner whorls and the thick spirotheca of the outer ones serve to separate it from that genus.

Occurrence.—This species is abundant in the limestone exposed in both Canyon Creek quarries. We have found it in collections WA-1, WA-5, WA-40, WA-41, WA-45, and WA-47. Specimens which we believe to be conspecific are present in the thick limestone at Marble Canyon, southern British Columbia.

Illustrations.—Plate 18, figures *9-11*; Plate 19, figures *1, 2.*——Pl. 18, figs. *9, 10.* Axial sections of topotypes, ×10.——Pl. 18, fig. *11.* Sagittal section of a topotype, ×10.——Pl. 19, fig. *1, 2.* Axial and sagittal sections of topotypes, ×10. [All from collection WA-5.] [All figures are unretouched photographs.]

Genus YABEINA Deprat, 1914

YABEINA CASCADENSIS (Anderson)

Neoschwagerina cascadensis ANDERSON, 1941, Washington State College Res. Studies, v. 9, p. 190-194, pl. 1, figs. 1, 2; pl. 2, fig. 1.

Yabeina cascadensis THOMPSON & WHEELER, 1942, Jour. Paleontology, v. 16, p. 703.

Yabeina cascadensis THOMPSON, WHEELER, & DANNER *(partim)*, 1950, Cushman Found. Foram. Research, Contr., v. 1, p. 61, pl. 7, fig. 1 [not pl. 7, figs. 2-5].

Shell large, highly inflated fusiform to subglobular, with convex lateral slopes and bluntly rounded poles. Mature specimens have 20.5 to 21 volutions and measure 9.50 to 10.60 mm. in length and 8.00 to 8.10 mm. in diameter. Form ratio varies from 1.19 to 1.33.

Spirotheca is composed of tectum and finely alveolar keriotheca. In 19th volution its thickness measures 39 to 50 μ. Septa plane, numbering about 6 in 1st whorl, 8 in 2nd, 8 in 3rd, 10 in 4th, 9 in 5th, 10 in 6th, 9 in 7th, 10 in 8th, 13 in 9th, 11 in 10th, 13 in 11th, 16 in 12th, 14 in 13th, 14 in 14th, and 14 in 15th. Axial septula first appear in 3rd whorl, with maximum of 1 per chamber in 3rd and 4th volutions, 2 in 5th, 3 in 6th and 7th, and 4 in 8th; after about 14th whorl as many as 6 axial septula per chamber may occur. Tips of septula consolidated and dense because of plugging of elongated alveoli with secondary material. In outer half of shell very thin, dense partition angles forward and upward to connect tip of each septum to tip of next forward axial septulum. These partitions closely resemble phrenothecae.

Proloculus minute, its outside diameter measuring 45 to 86 μ. Row of low, elliptical foramina present along basal margin of each septum from pole to pole, adjacent foramina being separated by narrow, moderately high parachomata which first appear in 2nd volution and number 2 to 4 in 2nd whorl, 5 to 6 in 3rd, 6 to 9 in 4th, 9 to 12 in 5th, 10 to 16 in 6th, 16 to 19 in 7th, 17 to 21 in 8th, 22 to 25 in 9th, 22 to 30 in 10th, 27 to 30 in 11th, 30 to 34 in 12th, 33 to 40 in 13th, 35 to 44 in 14th, 44 to 52 in 15th, 45 to 59 in 16th, about 64 in 17th, and about 72 in 18th.

Primary transverse septulum positioned directly above each parachoma, and basal margins of septula joined to tops of parachomata to form partitions which divide meridional chambers into rectangular chamberlets. These partitions pierced by irregularly rounded lateral foramina located immediately behind and in front of each septum, providing lateral communication within shell. In outer whorls, another lateral foramen may be present near middle of chamber. Secondary transverse septula first appear in 8th whorl, but are sporadic until 10th whorl is reached. Thereafter, usually 1 (but never more) secondary transverse septulum occurs between each pair of primary transverse septula.

Discussion.—This species was originally described by ANDERSON (1941) as *Neoschwagerina cascadensis.* THOMPSON, WHEELER & DANNER (1950) redescribed it as *Yabeina cascadensis* (ANDERSON), but only one of the five specimens figured by them appears to be conspecific with the holotype of ANDERSON's species, which is sub-

globular in shape, whereas the other four figured belong to a fusiform, more advanced species which is described below as *Yabeina decora* SKINNER & WILDE, n. sp. *Y. cascadensis* more nearly resembles *Y. packardi* THOMPSON & WHEELER than any other described species. It differs from the latter principally in its thicker spirotheca and less numerous axial septula per chamber in corresponding whorls.

Occurrence.—This species is abundant in collections WA-1 and WA-5, where it is associated with *Schwagerina royandersoni* THOMPSON, WHEELER & DANNER.

Illustrations.—Plate 19, figures *3-5*; Plate 20, figures *1, 2*.——Pl. 19, figs. *3, 4*. Axial sections of topotypes, ×10.——Pl. 19, fig. *5*. Sagittal section of topotype, ×10.——Pl. 20, figs. *1, 2*. Axial and sagittal sections of topotypes, ×10. [All from collection WA-5.] [All figures are unretouched photographs.]

YABEINA DECORA Skinner & Wilde, n. sp.

Yabeina cascadensis THOMPSON, WHEELER & DANNER, 1950 (*partim*), Cushman Found. Foram. Research, Contrib., v. 1, p. 61, pl. 7, figs. 2-5 (*not* pl. 7, fig. 1).

Shell large, fusiform, with straight to slightly convex lateral slopes and bluntly rounded poles. Mature individuals have 18 to 20.5 volutions, measuring 11.00 to 13.60 mm. in length and 4.70 to 6.70 mm. in diameter. Form ratio varies from 1.98 to 2.34. First 1 or 2 whorls discoidal and usually coiled askew to later ones.

Spirotheca composed of tectum and finely alveolar keriotheca. In 17th volution its thickness measures 26 to 30 μ. Septa plane, numbering 6 in 1st volution, 9 in 2nd, 8 to 10 in 3rd, 10 to 12 in 4th, 10 to 12 in 5th, 12 to 13 in 6th, 11 to 12 in 7th, 12 in 8th, 13 in 9th, 12 to 15 in 10th, 15 in 11th, 15 to 17 in 12th, 17 to 20 in 13th, 19 to 22 in 14th, 21 to 27 in 15th, 22 to 27 in 16th, 26 to 34 in 17th, and about 31 in 18th. Axial septula first appear in 3rd volution with maximum of 1 per chamber in 3rd and 4th whorls, 2 in 5th and 6th, 3 in 7th, 4 in 8th, 5 in 9th, 6 in 10th, as many as 9 in 11th to 17th, and 10 in 18th. Ends of elongated alveoli which make up septula plugged with dark secondary deposits, giving tips of septula consolidated, nearly opaque appearance. After 8th whorl very thin, dense partition angles forward and upward from basal margin of each septum to tip of next forward axial septulum. These partitions closely resemble phrenothecae seen in some species of schwagerinids.

Proloculus minute, its outside diameter varying from 50 to 104 μ. Row of small, rounded foramina present along basal margin of each septum from pole to pole, adjacent foramina being separated by narrow parachomata which are about half as high as chambers. Parachomata usually first appear in 2nd volution, although in some 1 may occur in 1st whorl; they number 2 to 3 in 2nd whorl, 5 to 6 in 3rd, 7 in 4th, 8 to 10 in 5th, 10 to 13 in 6th, 13 to 20 in 7th, 17 to 25 in 8th, 21 to 29 in 9th, 27 to 32 in 10th, 32 to 43 in 11th, 33 to 43 in 12th, 39 to 51 in 13th, 45 to 53 in 14th, 56 to 64 in 15th, 57 to 67 in 16th, 64 to 72 in 17th, 63 to 77 in 18th, and about 77 in 19th.

Primary transverse septulum positioned directly above each parachoma, and basal margins of septula joined to tops of parachomata to produce partitions which divide meridional chambers into rectangular chamberlets. Lateral communication within shell provided by irregularly rounded lateral foramina which perforate each primary transverse septulum. Ordinarily 2 such lateral foramina per chamber, located immediately behind and in front of each septum. Secondary transverse septula first appear in 7th volution and are common from 8th whorl outward. From 7th through 11th whorls only 1 secondary transverse septulum occurs between each pair of primary transverse septula, but from 12th volution outward commonly 2, and in outermost whorls as many as 3 may be present.

Discussion.—THOMPSON, WHEELER & DANNER (1950) figured 4 specimens of this species as *Yabeina cascadensis* (ANDERSON). *Yabeina decora* SKINNER & WILDE, n. sp., differs from *Y. cascadensis* in its fusiform shape, larger form ratio, and more numerous axial septula and secondary transverse septula. It is a more advanced species than *Y. cascadensis*.

Occurrence.—*Yabeina decora* occurs in collections WA-1, WA-40, WA-41, WA-43, WA-45, WA-46, and WA-47. In addition, we have found a few specimens in the limestone at Marble Canyon, southern British Columbia.

Illustrations.—Plate 20, figures *3, 4*; Plate 21, figures *1-4*.——Pl. 20, fig. *3*. Axial section of holotype, ×10.——Pl. 20, fig. *4*. Sagittal section of paratype, ×10. [Both from collection WA-47.] ——Pl. 21, figs. *1, 2*. Axial sections of paratypes,

×10.——Pl. 21, fig. *3*. Sagittal section of paratype, ×10.——Pl. 21, fig. *4*. Part of specimen shown in *1*, ×20. [*1, 4* from collection WA-47; *2, 3* from collection WA-40.] [All figures are unretouched photographs.]

YABEINA FUSIFORMIS Skinner & Wilde, n. sp.

Shell moderate in size, fusiform, with convex lateral slopes and bluntly rounded poles. Mature specimens have 17.5 to 22.5 volutions measuring 7.90 to 10.10 mm. in length and 4.30 to 4.80 mm. in diameter. Form ratio varies from 1.84 to 2.10. First 2 or 3 volutions discoidal and coiled askew to later ones.

Spirotheca composed of tectum and finely alveolar keriotheca. In 14th whorl its thickness measures 25 to 30 μ. Septa essentially plane, but commonly curved forward so that anterior face is somewhat concave. They number 4 to 5 in 1st whorl, 8 to 11 in 2nd, 12 to 13 in 3rd, 13 to 15 in 4th, 14 to 16 in 5th, 13 to 15 in 6th, 11 to 14 in 7th, 13 to 15 in 8th, 14 to 16 in 9th, 17 to 18 in 10th, 16 to 20 in 11th, 17 to 19 in 12th, 19 to 21 in 13th, 20 to 24 in 14th, about 27 in 15th, 26 in 16th, and 27 in 17th. Axial septula may appear as early as 3rd whorl, but usually none until 4th, with maximum of 1 per chamber in 4th volution, 2 in 5th and 6th, 3 in 7th, 4 in 8th and 9th, 5 in 10th and 11th, 6 in 12th and 13th, and 7 from 14th outward. Tips of longer septula usually consolidated by deposit of secondary material which plugs ends of component alveoli. After about 8th volution very thin, dense partition or lamella either connects basal margin of each septum with tip of next forward septulum or cuts across arc of anterior concavity of septum to connect basal margin with upper part of anterior face of same septum (Pl. 22, fig. 7). These lamellae resemble phrenothecae seen in some species of schwagerinids.

Proloculus minute, its outside diameter varying from 62 to 79 μ. Row of low, rounded foramina present along basal margin of each septum from pole to pole, foramina alternating with high, narrow parachomata which first appear in 2nd volution. Parachomata number 1 to 2 in 2nd whorl, 3 to 4 in 3rd, 6 to 9 in 4th, 8 to 11 in 5th, 11 to 17 in 6th, 14 to 20 in 7th, 16 to 23 in 8th, 18 to 25 in 9th, 23 to 31 in 10th, 31 in 11th, 31 to 38 in 12th, 42 in 13th, 45 in 14th, 50 in 15th, and 54 in 16th.

Thin primary transverse septulum positioned directly above each parachoma, and basal margins of septula joined to tops of parachomata to form partitions dividing meridional chambers into rectangular chamberlets. Small, rounded lateral foramina pierce these partitions at junctions of septula and parachomata to provide communication from end to end of shell. Such lateral foramina are located immediately behind and in front of each septum. Secondary transverse septula first appear in 8th whorl and are common from 10th volution outward. Usually only 1 secondary transverse septulum occurs between each pair of primary transverse septula, but in some another may be present in outer whorls.

Discussion—*Yabeina fusiformis* is similar in shape to *Y. decora*, Skinner & Wilde, n. sp., but may be distinguished from the latter by its smaller size and less numerous axial septula and secondary transverse septula.

Occurrence.—We have found this species in collections WA-40, WA-42, and WA-44.

Illustrations.—Plate 22, figures *1-7*.——Fig. *1*. Axial section of holotype, ×10.——Fig. *2*. Axial section of paratype, ×10.——Fig. *3*. Axial section of immature paratype, ×10.——Figs. *4, 5*. Sagittal sections of paratypes, ×10.——Fig. *6*. Part of holotype, ×20.——Fig. *7*. Part of specimen shown in *4*, ×40. [All from collection WA-42.] [All figures are unretouched photographs.]

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PART 5

NEW PERMIAN FUSULINIDS FROM TWIN LAKES AND SAN JUAN ISLAND AREAS, NORTHWESTERN WASHINGTON

ABSTRACT

Ten new species of fusulinids, representing the genera *Schwagerina, Chusenella, Verbeekina, Pseudodoliolina, Cancellina,* and *Neoschwagerina,* are described from Permian limestones exposed in the Twin Lakes area and on San Juan Island in northwestern Washington. No species of *Cancellina* previously has been described from North America.

INTRODUCTION

THOMPSON, WHEELER & DANNER (1950) described six species of Permian fusulinids from the areas under consideration. Their materials came from three exposures in the Twin Lakes area and from one on San Juan Island, Washington (Fig. 6). The largest and most important exposure in the former was the limestone quarry of the Morcrop Lime Company, located near the center of sec. 2, T. 31 N., R. 6 E., Snohomish County. The other two Twin Lakes localities were a small limestone outcrop on the south side of the Skagit Power Line road near the center of sec. 10, T. 31 N., R. 6 E., and their South Twin Lakes limestone deposit, located on the southwest side of the southern member of Twin Lakes in the SE¼ of sec. 18, T. 31 N., R. 7 E. The San Juan Island locality was the Cowell limestone quarry on the southwest coast of San Juan Island in the NE¼ of sec. 23, T. 34 N., R. 4 W., San Juan County.

Since 1950 the Morcrop quarry has been considerably enlarged, exposing additional fossiliferous beds. Also, a smaller quarry was opened by the company in the southeast quarter of the same section. For convenience we shall refer to the larger quarry as Morcrop quarry 1 and to the smaller as Morcrop quarry 2. During the summer of 1955 we visited the area and collected from both quarries and from the Skagit Power Line locality. Still later, Dr. W. R. DANNER sent us numerous collections from both quarries and from smaller outcrops extending southeastward to South Twin Lake. Figure 7 shows these outcrops and the locations of the various collections.

Our best material came from Morcrop quarry 1, where several lithologic and faunal units could be recognized. The beds here dip rather steeply to the east.

The lowest bed exposed in the quarry at the time of our visit consists of about 10 feet of brown, fine-grained limestone containing *Neoschwagerina brevis* THOMPSON, WHEELER & DANNER, *N. peculiaris,* SKINNER & WILDE, n. sp., and *Cancellina danneri,* SKINNER & WILDE, n. sp. A single specimen of *Verbeekina* was found in our collections from this zone. Nearly every fusulinid is surrounded by a dark gray halo.

This unit is overlain by 5 feet of light gray, nearly white calcarenite in which *Pseudodoliolina cylindrica* SKINNER & WILDE, n. sp., is sparingly common. This, in turn, grades upward into 10

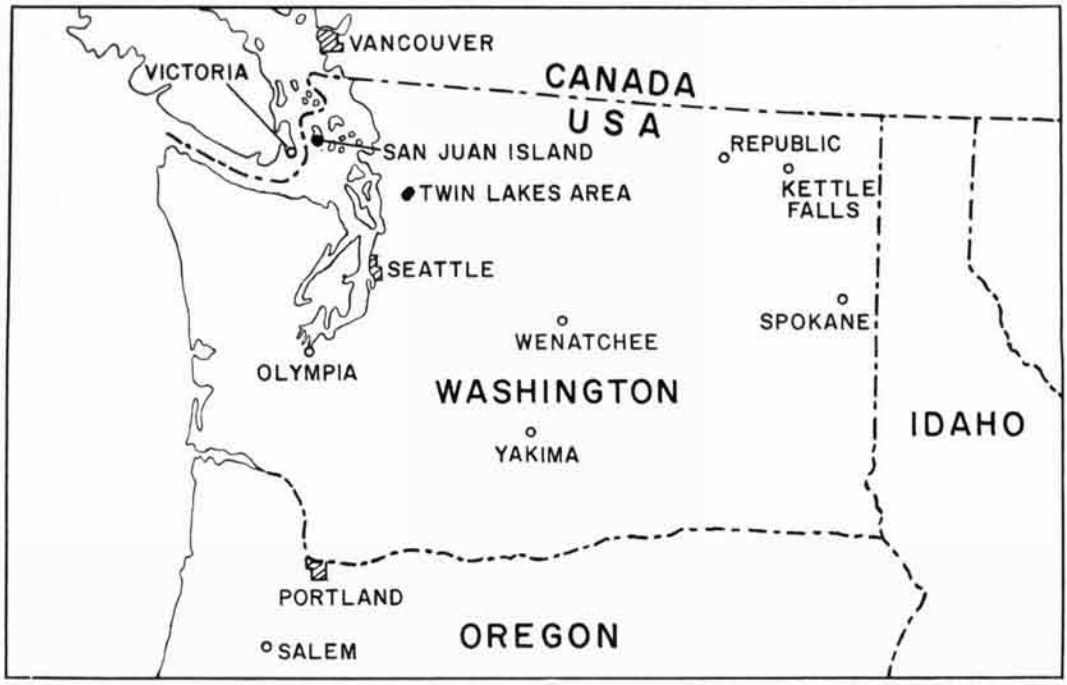

FIG. 6. Index map showing location of Twin Lakes and San Juan Island areas, northwestern Washington.

feet of brown, oolitic calcarenite containing abundant well preserved specimens of *P. cylindrica* and *Boultonia cascadensis* THOMPSON, WHEELER & DANNER.

The next higher zone is a bed, about 5 feet thick, of tan, partly oolitic calcarenite. *Pseudodoliolina cylindrica* SKINNER & WILDE, n. sp., is abundant, but most specimens appear to have been broken or abraded prior to burial.

Overlying this zone is about 10 feet of thick-bedded, brown, fine-grained limestone similar to the lowest zone. For the most part it is barren of fusulinids, but locally in the lower portion are small lenses of more granular limestone which are crowded with specimens of *Neoschwagerina brevis*. This is probably the zone from which DANNER collected the types of *Verbeekina americana* THOMPSON, WHEELER & DANNER, although this species is not present in the collections which we made. DANNER has supplied us with part of the original collection from which the types of *V. americana* were obtained, and the lithology closely matches that of this zone. He stated (personal communication) that his collection was made at a time when the quarry was much smaller, and it seems probable that the lens in which *V. americana* occurred now has been removed.

The highest unit exposed in the quarry at the time of our visit is composed of thick-bedded, brown, oolitic calcarenite. If any fusulinids are present they must be rare, for we found none. About 30 feet of this material had been uncovered at that time.

The same faunas were found in Morcrop quarry 2, as well as a few specimens of *Yabeina cascadensis* (ANDERSON) and *Verbeekina rotunda* SKINNER & WILDE, n. sp.

In 1955 and again in 1957 DANNER sent us collections from the Cowell quarry, located northeast of the lighthouse on the north side of Deadman Bay, western San Juan Island. Fusulinids from this locality were included by THOMPSON, WHEELER & DANNER in their *Neoschwagerina morcropensis*.

We wish to express our deepest appreciation to Dr. DANNER for the material and information which he has so kindly shared with us. We also thank the Humble Oil & Refining Company for permission to publish this study. All type specimens are deposited in the files of the Humble Oil & Refining Company at Midland, Texas.

FUSULINID COLLECTIONS

The fusulinids described in the present paper came from the following collections.

WA-3.—Skagit Power Line locality. Small limestone exposure on southeast side of Skagit Power Line road, about 160 yards southwest of crest of hill near the center of sec. 10, T. 31 N., R. 6 E., Snohomish County, Washington.

WA-6.—Morcrop Lime Company quarry No. 1. Lowest zone on right (southwest) side of entrance to quarry, near the center of sec. 2, T. 31 N., R. 6 E., Snohomish County, Washington.

WA-6A.—Immediately above WA-6.

WA-7.—Same locality and zone as WA-6.

WA-8.—Southwest wall of Morcrop quarry 1, and about 15 feet stratigraphically above WA-6.

WA-9.—Northeast wall of Morcrop quarry 1, and about 8 feet stratigraphically above WA-8.

WA-12.—Morcrop Lime Company quarry 2, in the SE¼ of sec 2, T. 31 N., R. 6 E., Snohomish County, Washington. At end of road near center of quarry.

WA-14.—Skagit Power Line locality. Same locality as WA-3.

WA-17.—North side of Morcrop quarry 2. Collected by W. R. Danner.

WA-18.—South side of Morcrop quarry 2. Collected by W. R. Danner.

WA-21.—East end of Cowell quarry. NE¼ of sec. 23, T. 34 N., R. 4 W., San Juan County, Washington. This is northeast of the lighthouse on the north shore of Deadman Bay, western San Juan Island. Collected by W. R. Danner.

WA-30.—Same locality and zone as WA-21. Collected by W. R. Danner.

SYSTEMATIC PALEONTOLOGY

Genus SCHWAGERINA von Möller, 1877

SCHWAGERINA PINGUIS Skinner and Wilde, n. sp.

Shell large, inflated fusiform, with bluntly pointed to rounded poles. Fully grown individuals have 7 to 8 volutions, and measure 10.30 to 13.40 mm. in length and 4.80 to 6.40 mm. in diameter. Form ratio varies from 1.95 to 2.39.

Spirotheca composed of coarsely alveolar keriotheca, and a tectum, with thickness in 7th whorl varying from 114 to 134 μ. Septa strongly and regularly fluted from pole to pole. They number 6 to 10 in 1st volution, 18 to 22 in 2nd, 25 to 29 in 3rd, 33 in 4th, 35 to 36 in 5th, and 41 to 44 in 6th. Septal folds high, reaching nearly to tops of chambers. Moderate amount of epitheca thickens septa throughout most of shell. Phrenothecae have not been observed.

Proloculus very large and somewhat irregular in shape, its outside diameter in holotype measuring 617 by 812 μ, and 584 by 638 μ and 550 by 738 μ in 2 paratypes. Tunnel low and narrow, tunnel angle measuring only 20 to 21 degrees in 7th volution. Chomata are absent.

Discussion.—Schwagerina pinguis bears a superficial resemblance to *S. chiapasensis* Thompson & Wheeler, from the Grupera Formation of southern Mexico. It differs from that species in its tighter coiling, narrower tunnel, and absence of phrenothecae.

Occurrence.—This species is common in collections WA-6, WA-7, and WA-17, where it is associated with *Cancellina danneri* Skinner & Wilde, n. sp., *Neoschwagerina peculiaris* Skinner & Wilde, n. sp., and *N. brevis* Thompson, Wheeler & Danner.

Illustrations.—Plate 23, figures *1-5*.——Fig. *1*. Axial section of holotype, ×10.——Figs. *2, 3*. Axial sections of paratypes, ×10.——Figs. *4, 5*. Sagittal sections of paratypes, ×10. [*1, 5* from collection WA-7; *2-4* from collection WA-6.] [All figures are unretouched photographs.]

Genus CHUSENELLA Hsu, 1942

[*emend.* Chen, 1956]

The name *Chusenella* was published by J. S. Lee (1942) for a new genus which he described at that time. Unfortunately, he neither described a type species nor listed any described species as belonging to the genus. In a paper published on immediately following pages of the same volume, Y. C. Hsu described *C. ishanensis* and designated it as the type species of *Chusenella*. The International Rules of Zoological Nomenclature require the designation of a type species in order to establish a genus, and, since Lee did not comply with this rule he cannot be considered as having established the genus. Apparently Hsu must be regarded as the author of the genus since he first described a species of *Chusenella* and designated it as the type species.

Although Lee described *Chusenella* in considerable detail, some of the characters attributed to

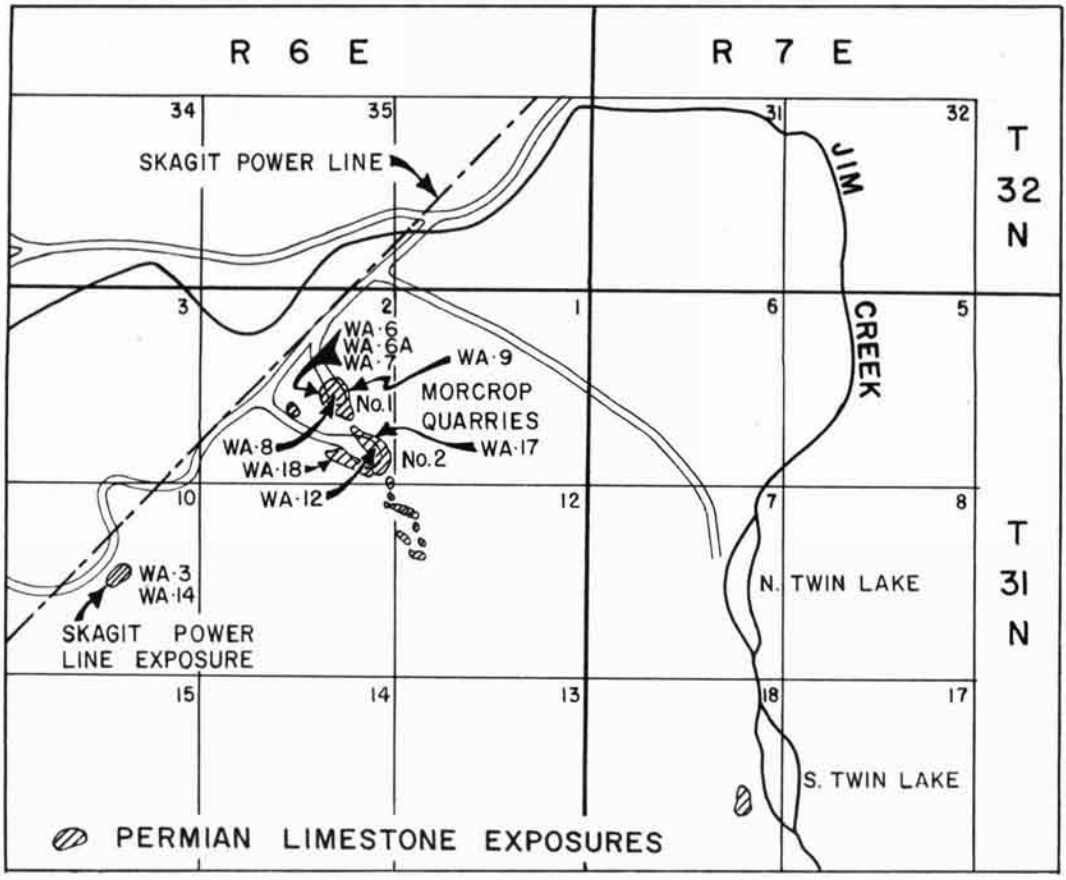

FIG. 7. Collection localities in Twin Lakes area, northwestern Washington.

it seemed highly improbable. It was said to have a median tunnel, with relatively plane septa and *fluted and dichotomous parachomata*! Since no fusulinid genus, with the possible exception of *Eoverbeekina,* is known to have both a median tunnel and parachomata, it seemed probable that LEE's description was inaccurate. This probability was heightened by the camera lucida drawings with which HSU illustrated his description of *C. ishanensis.* These showed part of an axial section which apparently belonged to a schwagerinid with strongly and regularly fluted septa and a sagittal section which closely resembled that of some species of *Misellina* or *Pseudodoliolina.* While it seemed improbable that an experienced student of the fusulinids, such as LEE, could be so mistaken in his interpretation of a species, at the same time the description and illustrations were completely unconvincing.

It was not until S. CHEN (1956) restudied the type specimens of *Chusenella ishanensis* and published his findings that a proper understanding of the genus was obtained. Concerning it CHEN wrote (p. 41),

> Test moderate in size, inflated fusiform, with ventricose median portion and pointed ends; whorls numerous, attaining to 9 or 10 in mature forms, the inner whorls very tight, the outer ones rather loosely and regularly expanded; spirotheca consisting of a tectum and fine keriotheca, thin, slender and increasing slowly in thickness; septa not fluted in the inner tight volutions, but strongly and regularly fluted almost for the whole septal surface (in the outer looser volutions); the folds are tight, sometimes with nearly parallel sides, and forming fine networks in the polar regions of the volutions; chomata only developed as two fine spirals in the juvenile whorls but entirely absent in the outer whorls; axial fillings are developed only in the proximity of the proloculum; aperture singular; proloculum small and spherical.
>
> Range: Higher Permian.
>
> Remarks: This genus was established by J. S. Lee and Y. C. Hsu in 1942. They diagnosed this genus on the

deceptive structures of the tight septal folds which were then considered as parachomata. I have closely reexamined the type specimens and discovered that the so-called dichotomous and perforated parachomata are truly the basal part of the very tight septal folds but not true parachomata.

The median section of *Chusenella ishanensis* Hsu given in a paper by Mr. Hsu has quite different structures from the axial section of the genotype. The spirotheca is composed distinctly of a tectum, a fine keriotheca and an inner tectorium; this last figure, although very thin, is constant for all the whorls. The septa are rather distant-spaced and slightly undulated. I believe that this median section does not belong to the genus of *Chusenella* but belongs to a certain species of *Misellina*.

CHEN then assigned several previously described species to *Chusenella*, and described two new species. The genus, as thus emended, appears to be rather widespread geographically in the Permian, occurring usually, but not always, in association with verbeekinids and neoschwagerinids.

More recently, STEWART (1963) published a study of *Chusenella*, assigning to it several new species and a larger number of previously described ones. At the same time he broadened the concept of *Chusenella* to include a number of species which we do not believe properly belong in the genus.

CHUSENELLA LEEI Skinner & Wilde, n. sp.

Shell small, fusiform, with slightly convex to slightly concave lateral slopes and sharply pointed poles. Mature specimens have 7 to 8 volutions, the first 3 to 3.5 of which are tightly coiled while later ones are more loosely coiled. Such individuals measure 6.40 to 6.90 mm. in length, and 2.30 to 2.45 mm. in diameter. Form ratio varies from 2.78 to 2.96.

Spirotheca composed of tectum and moderately coarse keriotheca, with slight amount of "rugosity" similar to that of *Pseudofusulina* developed in places, but not consistent in its occurrence. Thickness of spirotheca in 7th whorl 67 to 87 μ. Septa nearly plane or gently undulating in tightly coiled inner whorls, becoming strongly folded from pole to pole in more loosely coiled outer ones. They number 8 to 9 in 1st volution, 11 to 13 in 2nd, 14 in 3rd, 14 to 16 in 4th, 18 to 21 in 5th, 20 to 25 in 6th, 24 to 26 in 7th, and about 29 in 8th. Septal folds of outer whorls high, commonly reaching tops of chambers. Narrow band of secondary material extends along axis, tending to fill chambers in that zone.

Proloculus small, with outside diameter measuring 148 to 181 μ. Tunnel low and rather narrow, tunnel angle measuring 27 to 34 degrees in 7th volution. Weak chomata present in early whorls but absent in later ones.

Discussion.—Chusenella leei SKINNER & WILDE, n. sp., rather closely resembles *C. conicocylindrica* CHEN, from the Chingsichung Limestone of Hunan Province, China. It differs from that species in its less numerous whorls, larger proloculus, thicker spirotheca, and stronger development of the chomata. It differs from *C. referta* SKINNER & WILDE, n. sp., with which it occurs, in its larger proloculus, wider tunnel, less well-developed secondary deposits, and larger form ratio. This species is named for Dr. J. S. LEE.

Occurrence.—This species occurs in collections WA-6A, WA-8, and WA-12, where it is associated with *Boultonia cascadensis* THOMPSON, WHEELER & DANNER, *Chusenella referta* SKINNER & WILDE, n. sp., *C. cheni* SKINNER & WILDE, n. sp., and *Pseudodoliolina cylindrica* SKINNER & WILDE, n. sp.

Illustrations.—Plate 24, figures *1-6*.——Figs. *1, 2*. Axial section of the holotype, $\times 10$, $\times 20$. ——Figs. *3, 4*. Axial sections of paratypes, $\times 10$. ——Figs. *5, 6*. Sagittal sections of paratypes, $\times 10$. [All from collection WA-8.] [All figures are unretouched photographs.]

CHUSENELLA REFERTA Skinner & Wilde, n. sp.

Shell small, middle portion cylindrical, with conical, sharply pointed poles. Mature individuals have 8.5 to 10 volutions with 1st 4 or 5 tightly coiled and slender cylindrical in shape; later whorls more loosely coiled and equatorially inflated. Such specimens measure 4.60 to 6.70 mm. in length and 1.90 to 2.70 mm. in diameter. Form ratio varies from 2.42 to 2.48.

Spirotheca composed of tectum and moderately coarse keriotheca with thickness in 7th whorl measuring 60 to 87 μ. Septa nearly plane in tightly coiled inner volutions but strongly fluted in later ones. They number 8 to 10 in 1st whorl, 11 to 12 in 2nd, 13 to 14 in 3rd, 18 to 20 in 4th, 20 to 25 in 5th, and about 26 in 6th. Septal folds high, usually reaching tops of chambers. Heavy deposit of secondary material nearly fills most of shell outside equatorial zone.

Proloculus very small, its outside diameter

ranging from 87 to 134 μ. Tunnel low and narrow, tunnel angle measuring 23 to 26 degrees in 7th volution. Narrow chomata present in first 4 or 5 volutions but absent thereafter.

Discussion.—Chusenella referta differs from *C. leei* SKINNER & WILDE, n. sp., with which it occurs, in its smaller proloculus, smaller form ratio, narrower tunnel, and more strongly developed secondary deposits.

Occurrence.—This species is common in collections WA-6A, WA-8, and WA-9, where it is associated with *Boultonia cascadensis* THOMPSON, WHEELER & DANNER, *Chusenella leei* SKINNER & WILDE, n. sp., *C. cheni* SKINNER & WILDE, n. sp., and *Pseudodoliolina cylindrica* SKINNER & WILDE, n. sp.

Illustrations.—Plate 24, figures *7-12.*——Figs. *7, 8.* Axial section of holotype, ×10, ×20.——Figs. *9-10.* Axial sections of paratypes, ×10.——Figs. *11, 12.* Sagittal sections of paratypes, ×10. [*7, 8, 10* from collection WA-8; 9 from collection WA-6A; *11, 12* from collection WA-9.] [All figures are unretouched photographs.]

CHUSENELLA CHENI Skinner & Wilde, n. sp.

Shell small, subcylindrical, with rather sharply pointed poles. Mature specimens have 6.5 to 7.5 volutions, first 3 or 4 of which are more tightly coiled than later ones. Such individuals measure 4.60 to 4.80 mm. in length, and 1.60 to 1.70 mm. in diameter. Form ratio varies from 2.71 to 2.94.

Spirotheca composed of tectum and moderately coarse keriotheca with thickness in 6th volution measuring about 67 μ. Septa only slightly fluted in inner whorls, becoming strongly folded in outer ones. They number 8 to 9 in 1st volution, 13 in 2nd, 14 to 19 in 3rd, 18 to 20 in 4th, and 19 to 23 in 5th. Septal folds high, usually reaching tops of chambers. Heavy deposit of secondary material nearly fills chambers in zone along axis.

Proloculus small, its outside diameter varying from 141 to 208 μ. Tunnel low and rather narrow, tunnel angle measuring about 27 degrees in 7th volution. Narrow chomata present only in first 3 or 4 whorls.

Discussion.—Chusenella cheni differs from both *C. leei* SKINNER & WILDE, n. sp., and *C. referta* SKINNER & WILDE, n. sp., with which it occurs, in its more cylindrical shape. In addition, it may be distinguished from *C. leei* by greater development of its secondary deposits. It also differs from *C. referta* in its larger proloculus and the lesser development of the secondary deposits. This species is named for Dr. S. CHEN.

Occurrence.—We have found this species in collections WA-6A, WA-8, and WA-9, where it is associated with *Boultonia cascadensis* THOMPSON, WHEELER & DANNER, *Chusenella leei, C. cheni,* and *Pseudodoliolina cylindrica* SKINNER & WILDE, n. sp.

Illustrations.—Plate 25, figures *1-6.*——Figs. *1, 2.* Axial section of holotype, ×10, ×20.——Figs. *3, 4.* Axial sections of paratypes, ×10.——Figs. *5, 6.* Saggital sections of paratypes, ×10. [*1, 2, 4-6* from collection WA-9; 3 from collection WA-8.] [All figures are unretouched photographs.]

Genus VERBEEKINA von Staff, 1909

VERBEEKINA ROTUNDA Skinner & Wilde, n. sp.

Shell moderately large, subspherical, with slightly umbilicate poles. Mature individuals have 15.5 to 18 whorls, and measure 7.50 to 10.10 mm. in length and 7.00 to 8.40 mm. in diameter. Form ratio varies from 1.04 to 1.25. First 5 or 6 volutions tightly coiled to form distinct juvenarium, followed by more loosely coiled adult stage.

Thin spirotheca composed of tectum and finely alveolar keriotheca. In 15th volution its thickness measures only 33 to 37 μ. Plane septa closely spaced in juvenarium, but widely spaced in adult part of shell. They number about 4 in 1st whorl, 9 in 2nd, 10 in 3rd, 12 in 4th, 13 in 5th, 11 in 6th, 13 in 7th, 12 in 8th, 13 in 9th, 14 in 10th, 14 in 11th, 19 in 12th, 21 in 13th, 26 in 14th, and 30 in 15th.

Proloculus minute, its outside diameter measuring only 42 to 55 μ. Row of small, rounded foramina present along basal margin of each septum from pole to pole. Adjacent foramina separated by low parachomata which are most strongly developed at their intersections with septa, tending to die out near middle of each chamber, especially in adult stage of shell. When axial section cuts midway between 2 septa in adult portion of shell discontinuity of parachomata commonly causes them to appear to be absent. Oppositely, in juvenarium where septa are closely spaced, parachomata are always evident in axial sections.

Discussion.—Verbeekina rotunda can be distinguished from *V. americana* THOMPSON, WHEELER & DANNER, the only other described American species, by its larger size, greater number of volutions, and thinner spirotheca.

Occurrence.—We have found this species only in collection WA-18, where it is associated with a few poorly preserved specimens of *Yabeina* sp.

Illustrations.—Plate 25, figures *7, 8*; Plate 26, figures *1-4*.——Pl. 25, fig. *7*. Axial section of holotype, ×10.——Pl. 25, fig. *8*. Axial section of paratype, ×10. [Both from collection WA-18.] ——Pl. 26, fig. *1*. Axial section of paratype, ×10. ——Pl. 26, fig. *2*. Sagittal section of paratype, ×10.——Pl. 26, fig. *3*. Part of specimen shown in Pl. 25, fig. 8, ×40.——Pl. 26, fig. *4*. Part of specimen shown in fig. 1, ×40. [All from collection WA-18.] [All figures are unretouched photographs.]

Genus PSEUDODOLIOLINA Yabe & Hanzawa, 1932

PSEUDODOLIOLINA CYLINDRICA Skinner & Wilde, n. sp.

Shell small, cylindrical, with bluntly rounded, slightly umbilicate poles. Mature specimens have 10.5 to 12.5 volutions, and measure 4.50 to 5.20 mm. in length and 1.85 to 2.30 mm. in diameter. Form ratio varies from 2.26 to 2.43.

Very thin spirotheca usually appears to consist of single dense layer but exceptionally is seen to be composed of very thin, dense tectum and slightly thicker, less dense, structureless inner layer. In 10th volution its thickness measures only 14 to 22 μ. Septa not fluted, although their basal margins commonly curve sharply forward (Pl. 28, fig. 2). They number 5 in 1st whorl, 8 to 10 in 2nd, 6 to 10 in 3rd, 6 to 9 in 4th, 7 to 9 in 5th, 8 to 11 in 6th, 9 to 14 in 7th, 10 to 16 in 8th, 15 to 19 in 9th, 14 in 10th, 14 in 11th, and 17 in 12th. Slow increase in number of septa in successive whorls results from progressive increase in width of chambers and consequent wider spacing of septa. Tops of chambers tend to be flat or even slightly concave, rather than arched as in most fusulinids (Pl. 28, figs. 2, 3).

Proloculus small and tending to be flattened at right angles to axis, producing bean-shaped outline, particularly in sagittal sections (Pl. 28, figs. 2, 3). Outside diameters of proloculi in figured types are 101 by 122 μ, 137 by 158 μ, 102 by 107 μ, 89 by 141 μ, 98 by 133 μ, and 91 by 135 μ. First chamber outside proloculus commonly larger than proloculus itself (Pl. 28, fig. 3). Initial aperture placed within indentation in proloculus wall with margin produced as tube with flaring terminus that projects into proloculus. Row of small, rounded foramina present along basal margin of each septum from pole to pole. Adjacent foramina separated by high, narrow parachomata which are continuous from chamber to chamber. Although each parachoma increases slightly in height at its intersections with septa, highest portion is near center of each chamber, midway between adjacent septa, where it commonly reaches to top of chamber (Pl. 28, figs. 2, 3). Axial sections which cut these high humps on parachomata present false appearance of having transverse septula (Pl. 27, figs. 2-4). In tangential sections cut near tops of chambers humps appear as row of dots between adjacent septa (Pl. 27, fig. 5). [All described species of *Pseudodoliolina* may be placed in one or other of two groups on the basis of their parachomata, one characterized by parachomata similar to those of *P. cylindrica* SKINNER & WILDE, n. sp., and the other typified by *P. ozawai* YABE & HANZAWA, type species of the genus. In the latter group the highest points on a parachoma are at its intersections with the septa, and it never reaches the top of the chamber even there. As a result, axial sections never present an appearance of having transverse septula (Pl. 28, fig. 4). It is not known whether this grouping has any stratigraphic significance.] In *P. cylindrica* the parachomata appear to be absent in the 1st volution. They number 2 to 4 in 2nd whorl, 6 to 7 in 3rd, 8 to 12 in 4th, 13 to 15 in 5th, 16 to 19 in 6th, 21 to 22 in 7th, 23 to 28 in 8th, 27 to 30 in 9th, 29 to 35 in 10th, 34 to 38 in 11th, and 38 to 40 in 12th.

Discussion.—Pseudodoliolina cylindrica can be distinguished from *P. oliviformis* THOMPSON, WHEELER & DANNER, the only other described American species, by its slightly larger size, more numerous parachomata, somewhat smaller proloculus, more cylindrical shape, and slightly larger form ratio.

Occurrence.—We have found this species in collections WA-6A, WA-8, WA-9, WA-12, and WA-14. In the first 4 it is associated with *Boultonia cascadensis* THOMPSON, WHEELER & DANNER, *Chusenella leei* SKINNER & WILDE, n. sp.,

C. referta SKINNER & WILDE, n. sp., and *C. cheni* SKINNER & WILDE, n. sp. In WA-14 it is associated with *Pseudodoliolina oliviformis* and with *Neoschwagerina pusilla* SKINNER & WILDE, n. sp. It is particularly abundant in collection WA-8, where it nearly fills the rock.

Illustrations.—Plate 27, figs. *1-7*; Pl. 28, figs. *1-3*.——Pl. 27, figs. *1, 2*. Axial section of holotype, ×10, ×20.——Pl. 27, figs. *3, 4*. Axial sections of paratypes, ×20.——Pl. 27, fig. *5*. Tangential section of paratype, ×20.——Pl. 27, figs. *6, 7*. Sagittal sections of paratypes, ×20. [All from collection WA-8.]——Pl. 28, fig. *1*. Sagittal section of paratype, ×20.——Pl. 28, figs. *2, 3*. Specimens shown in Pl. 27, figs. *6* and *7*, respectively, ×40. [Note that many parachomata reach tops of chambers midway between adjacent septa. This character produces a false appearance of transverse septula in axial sections, as in Pl. 27, figs. *2, 3,* and *4*. Also note large first chamber outside of proloculus. In many specimens, as in *3*, this chamber is larger than proloculus.] [All from collection WA-8.] [All figures are unretouched photographs.]

Illustrations for comparison.—Plate 28, figures *4, 5*.——Pl. 28, fig. *4*. *Pseudodoliolina ozawai* YABE & HANZAWA. Axial section of topotype of type species, ×20. [In this species, unlike *P. cylindrica,* parachomata do not reach tops of chambers.] [From Kosamé Limestone (OZAWA's zone 7), Samé quarry, Akasaka, Gifu Prefecture, Japan.] [Unretouched photograph.]——Pl. 28, fig. *5*. *P. oliviformis* THOMPSON, WHEELER & DANNER. Axial section of topotype, ×20. [From collection WA-14.] [Unretouched photograph.]

Genus CANCELLINA Hayden, 1909

For many years this genus has been poorly understood, largely due to a widespread impression, particularly among American workers, that it completely lacks axial septula while having well-developed transverse septula. It is difficult to visualize how this misunderstanding started since HAYDEN, in describing the type species, stated (p. 249), ". . . they appear to have been similar to *N. craticulifera* SCHWAGER, from which this species differs by the absence of well-marked auxiliary septa. In some instances, however, I have observed transverse sections with such septa, but they are quite rudimentary and are found only in the outermost whorls."

The terms "auxiliary septa" and "transverse section," as used by HAYDEN, correspond to "axial septula" and "sagittal section," respectively, of modern terminology.

HAYDEN originally proposed *Cancellina* as a subgenus of *Neoschwagerina*, but it has since been raised to generic status. The species in question, *Cancellina primigena* HAYDEN, was described from a remote locality in Afghanistan, and it has never been certainly identified from any other place. Moreover, FURON (1927) made a diligent search for HAYDEN's locality but was unable to find it. Since HAYDEN's collections appear to be lost, it is at present impossible to study typical specimens of *C. primigena*, and HAYDEN's photographs are too poor to permit a definite conclusion as to the presence or absence of incipient axial septula.

Probably the conclusion that *Cancellina* is totally devoid of axial septula resulted from too hurried reading of HAYDEN's description. Since his publication was limited in circulation, few workers had access to it. Consequently, such an erroneous interpretation, once in print, would be perpetuated by repetition.

OZAWA (1927) described a species from Akasaka, Japan, as *Cancellina nipponica*. Because it possesses rudimentary axial septula in the outer whorls, most subsequent workers regarded it as belonging in the genus *Neoschwagerina*. Subsequently, a number of species, mostly from Japan, have been assigned to *Cancellina*. All have poorly developed axial septula, at least in the outer whorls.

THOMPSON (1948), assuming that *Cancellina* has no axial septula and operating on the theory that evolution in the neoschwagerinids progressed invariably from forms with a thick spirotheca to those with a thin spirotheca, diagnosed the genus as possessing a thick spirotheca and no axial septula. In so doing he removed from the genus all but the type species and OZAWA's *C. simplex*, which OZAWA originally described, probably correctly, as a species of *Neoschwagerina*. In this same publication (pl. 18, figs. 6-9), THOMPSON figured as *C. primigena?* two sections, one axial and one sagittal, from Persia. It is quite possible that these two specimens are not conspecific, since one has a large proloculus and the other a minute one. The sagittal section has no axial septula. The axial section is of a form having well-de-

veloped parachomata, but only incipient transverse septula, which in places appear not to be developed at all. Both specimens have a rather thick spirotheca. In any event, THOMPSON's specimens cannot be conspecific with *C. primigena*, which has a relatively thin spirotheca and well-developed transverse septula. We should be inclined to regard the axial section figured by THOMPSON as transitional between *Misellina* and *Neoschwagerina*, and the sagittal section may well belong to a species of *Misellina*.

Since that time several Japanese specialists, notably KANMERA (1957), have made an intensive study of the genus. KANMERA pointed out that the general course of evolution among the neoschwagerinids progressed from simple forms with a thick spirotheca and a few thick septula to advanced types with a thin spirotheca and numerous thin septula. Thus, primitive species of *Neoschwagerina* have a relatively thick wall, rather thick primary transverse septula, and thick axial septula. Advanced species tend to have thinner walls, thinner and more numerous primary axial septula, and secondary axial septula. In the next stage, *Yabeina*, the spirotheca is still thinner, the axial septula are thinner and more numerous, and secondary transverse septula are added. In addition, the tips of the septula tend to be consolidated into an opaque mass, apparently by the plugging of the constituent alveoli with secondary material. The most advanced stage appears in *Lepidolina* in which the spirotheca is very thin and the septula are still thinner, more numerous, and consolidated throughout most of their length.

This succession does not include the highly specialized genera *Afghanella* and *Sumatrina*. The first of these is fusiform to ellipsoidal in shape and has a very thin spirotheca and completely consolidated septula, which are markedly thicker at their tips than at their points of connection with the spirotheca. *Sumatrina* differs from *Afghanella* in having a subcylindrical shape and a spirotheca so thin that only in exceptionally well-preserved specimens can a keriotheca be detected. In fact, for many years the spirotheca of *Sumatrina* was thought to be composed of the tectum alone. These two genera have usually been regarded as specialized offshoots of *Neoschwagerina*.

KANMERA noted that the primitive neoschwagerinids, with only a few poorly developed axial septula, can be divided into two general groups. One includes species with a relatively thin spirotheca and thin septula, while the other is made up of species with a thick spirotheca and thick septula. The two groups are contemporaneous, and, so far as development of septula is concerned, about equally advanced. Since *Cancellina primigena* has a comparatively thin spirotheca, KANMERA regarded the thin-walled group as *Cancellina*. The thick-walled group he considered to be primitive species of *Neoschwagerina*. He pointed out that the generally accepted idea that the latter genus was descended from the former would entail a reversal of the evolutionary trend from thick to thin spirotheca. To KANMERA this seemed improbable.

He postulated that *Cancellina* and *Neoschwagerina* represented two divergent lines, probably derived from a common ancestral form, and that *Cancellina* evolved through *Afghanella* to *Sumatrina*, while *Neoschwagerina* evolved through *Yabeina* to *Lepidolina*. Thus, each line would progress from thicker to thinner spirotheca and from few to numerous septula, and no anomaly would be involved. The fact that the type species of *Cancellina*, contrary to general belief, does possess rudimentary axial septula tends to strengthen KANMERA's argument. For the present, at least, we are following his classification.

CANCELLINA DANNERI Skinner & Wilde, n. sp.

Shell small, subcylindrical to slender ellipsoidal, with bluntly pointed poles. Mature specimens have 8 or 9, exceptionally 10.5, volutions. Such individuals measure 3.50 to 5.60 mm. in length and 1.40 to 2.50 mm. in diameter. Form ratio varies from 2.24 to 2.61.

Thin spirotheca composed of tectum and finely alveolar keriotheca, its thickness in 8th whorl 16 to 26 μ. Septa essentially plane and rather widely spaced. They number 6 to 8 in 1st volution, 7 to 10 in 2nd, 9 to 10 in 3rd, 9 to 11 in 4th, 9 to 11 in 5th, 9 to 10 in 6th, 11 to 12 in 7th, 11 to 14 in 8th, 13 in 9th, and 17 in 10th. Some short, rudimentary axial septula first appear in 2nd volution, becoming more common in outer whorls. We have not observed more than one per chamber, even in outermost volutions, and many chambers have none.

Proloculus small, its outside diameter varying from 75 to 114 μ. Row of low, elliptical foramina, wider than high, present along basal margin of

each septum from pole to pole. Parachomata separating adjacent foramina are most distinctive feature of this species. Ordinarily, they appear as narrow, solid ridges of secondary material, running along floor of chambers parallel to sagittal plane, but in this new species parachomata in outer 3 or 4 volutions are hollow, appearing in axial sections, which cut them at right angles, as open loops rising from floor of volution (Pl. 29, figs. 2, 3, 9). [This feature has been observed in every specimen examined, regardless of the stage of growth at which the individual died. Thus, the outer whorls of juvenile specimens of only 4 or 5 volutions display this character, while in the corresponding whorls of mature specimens the parachomata are solid. From this we conclude that the parachomata were hollow, when formed, at all stages of growth, but later became filled with secondary deposits. This plugging apparently lagged several whorls behind the growth of the shell.] Parachomata number 1 to 2 in 1st volution, 2 to 5 in 2nd, 5 to 7 in 3rd, 6 to 10 in 4th, 10 to 16 in 5th, 11 to 16 in 6th, 14 to 19 in 7th, 16 to 21 in 8th, 19 to 26 in 9th, and about 27 in 10th.

Primary transverse septulum consisting of ribbon-like prolongation of keriothecal elements pendent from ceiling of whorl occurs immediately above each parachoma. Septula cross septa at right angles with their basal margins joined to tops of parachomata to form partitions which divide long meridional chambers into rectangular chamberlets. Immediately behind and in front of each septum are small, rounded lateral foramina which pierce the transverse septula at their junctions with the parachomata (Pl. 29, fig. 6), thus providing communication from end to end of the shell. No secondary transverse septula present.

Discussion.—The hollow parachomata of *Cancellina danneri* serve to distinguish it from any other known species of the genus. At first we believed that this was a generic character and that we were dealing with a new genus. Later, however, we observed some similar hollow parachomata in the outermost whorls of several species of *Neoschwagerina.* Still later, Morikawa & Suzuki (1961) described *N. akasakensis* from Akasaka, Japan, which has hollow parachomata throughout much of the shell. We have been forced to conclude that the parachomata of many, if not all, of the neoschwagerinids were formed in this manner. The difference lies in the fact that in most species the plugging of the parachomata with secondary deposits followed closely upon growth of the shell. As a result, perhaps only in the chamber immediately behind the antetheca at any growth stage will the parachomata be found still unfilled. If this is true, the probability of any particular axial section cutting the hollow portion would be very small, thus accounting for the infrequency with which the phenomenon is observed. This species is named for Dr. W. R. Danner.

Occurrence.—We have found this unusual species in collections WA-6, WA-7, and WA-17, where it is associated with *Schwagerina pinguis* Skinner & Wilde, n. sp., *Neoschwagerina brevis* Thompson, Wheeler & Danner, and *N. peculiaris* Skinner & Wilde, n. sp.

Illustrations.—Plate 29, figures *1-9.*——Figs. *1, 2.* Axial section of holotype, an unusually large specimen, ×10, ×20. [Note hollow parachomata in outer whorls.]——Figs. *3, 4.* Axial sections of paratypes, ×20.——Figs. *5-7.* Sagittal sections of paratypes, ×20.——Fig. *8.* Oblique tangential section of paratype, ×20. [Note that where section cuts near floor of volutions parachoma appears as 2 roughly parallel lines.]——Fig. *9.* Part of tangential section of paratype showing hollow parachomata of outer whorls, ×40. [All from collection WA-6.] [All figures are unretouched photographs.]

Genus NEOSCHWAGERINA Yabe, 1903

NEOSCHWAGERINA PECULIARIS Skinner & Wilde, n. sp.

Shell small, inflated fusiform to subglobular, with convex lateral slopes and bluntly rounded poles. Mature specimens have 14 to 17.5 volutions and measure 4.25 to 5.40 mm. in length and 3.40 to 4.15 mm. in diameter. Form ratio varies from 1.15 to 1.39. [We have a single axial section of a microspheric individual which has 12.5 whorls and measures 3.60 mm. in length and 2.55 in diameter. The first 1.5 volutions of this specimen are discoidal in shape and coiled askew to the later whorls.]

Spirotheca composed of tectum and finely alveolar keriotheca, its thickness in 13th whorl measuring 29 to 30 μ. Septa plane and rather thick, keriotheca extending part way down an-

terior and posterior faces. They number about 6 in 1st volution, 7 in 2nd, 7 to 8 in 3rd, 9 in 4th, 8 to 10 in 5th, 8 to 10 in 6th, 10 in 7th, 10 to 12 in 8th, 11 to 15 in 9th, 12 to 19 in 10th, and 13 in 11th. One axial septulum per chamber first appears in 3rd whorl, with 2nd added in 4th. As many as 3 axial septula per chamber may occur from 7th volution outward, 4 from 10th, and 5 from 11th. These are maximum numbers, and some chambers may have only 2 to 3, even in outermost whorls.

Proloculus small, its outside diameter measuring 94 to 105 μ. [In the microspheric specimen the outside diameter of the proloculus is only 45 μ.] Row of low, rounded foramina present along basal margin of each septum from pole to pole. Adjacent foramina separated by low, narrow parachomata which first appear in 2nd volution. Parachomata number 2 to 3 in 2nd whorl, 3 to 5 in 3rd, 5 to 8 in 4th, 7 to 10 in 5th, 10 to 13 in 6th, 11 to 16 in 7th, 13 to 18 in 8th, 16 to 23 in 9th, 19 to 25 in 10th, 20 to 27 in 11th, 20 to 28 in 12th, 23 to 31 in 13th, 26 to 28 in 14th, 33 to 34 in 15th, 36 to 38 in 16th, and about 37 in 17th. [A peculiar character of this species is the presence of thin, dense partitions, somewhat resembling the phrenothecae which are present in some schwagerinids. These partitions are irregular, sporadic in their occurrence, and usually horizontal or convex upward. They extend from one septum or septulum to another and tend to partition off the upper part of the chambers (Pl. 31, figs. 1-3). They are evident to a greater or lesser degree in all sections of this species which we have seen, but we have never encountered them in any other neoschwagerinid species.]

Primary transverse septulum positioned immediately above each parachoma with basal margins of septula joined to tops of parachomata to form partitions which subdivide meridional chambers into rectangular chamberlets. Small, rounded lateral foramina perforate transverse septula at their junctions with parachomata, providing communication from end to end of shell. These foramina located immediately behind and in front of each septum. Secondary transverse septula absent.

Discussion.—*Neoschwagerina peculiaris* is similar in size and shape to *N. brevis* Thompson, Wheeler & Danner, with which it occurs. It differs from the latter in its slightly smaller size, thinner spirotheca, somewhat larger proloculus, less numerous parachomata, more numerous axial septula, and, above all, in the presence of the phrenotheca-like structures which serve to distinguish it from all other known species of the genus.

Occurrence.—This species is fairly common in collections WA-6, WA-7, and WA-17, where it is associated with *Schwagerina pinguis* Skinner & Wilde, n. sp., *Cancellina danneri* Skinner & Wilde, n. sp., and *Neoschwagerina brevis* Thompson, Wheeler & Danner.

Illustrations.—Plate 30, figures *1-9*; Plate 31, figures *1-4*.——Pl. 30, figs. *1, 9*. Axial section of holotype, $\times 10$, $\times 20$.——Pl. 30, figs. *2, 3*. Axial sections of paratypes, $\times 10$.——Pl. 30, fig. *4*. Axial section of microspheric paratype, $\times 10$.——Pl. 30, figs. *5, 6*. Sagittal sections of paratypes, $\times 10$.——Pl. 30, figs. *7, 8*. Tangential sections of paratypes, $\times 10$. [*1, 2, 5, 6, 9* from collection WA-6; *3* from collection WA-17; *4, 7, 8* from collection WA-7.]——Pl. 31, figs. *1, 4*. Specimen shown in Pl. 30, fig. *4*, $\times 20$, $\times 40$.——Pl. 31, fig. *2*. Specimen shown in Pl. 30, fig. *5*, $\times 20$.——Pl. 31, fig. *3*. Specimen shown in Pl. 30, fig. 7, $\times 20$. [These individuals display exceptionally well the peculiar phrenotheca-like partitions that characterize this species.] [*1, 3, 4* from collection WA-7; *2* from collection WA-6.] [All figures are unretouched photographs.]

NEOSCHWAGERINA PUSILLA Skinner & Wilde, n. sp.

Shell small, ellipsoidal to inflated fusiform, with convex lateral slopes and bluntly rounded poles. Mature specimens have 10.5 to 13 volutions and measure 3.40 to 4.20 mm. in length and 2.20 to 2.60 mm. in diameter. Form ratio varies from 1.41 to 1.91, being most commonly about 1.50.

Unusually thin spirotheca composed of tectum and finely alveolar keriotheca, its thickness in 11th whorl measuring only 19 to 26 μ. Septa plane and number 3 to 5 in 1st volution, 7 to 9 in 2nd, 8 to 9 in 3rd, 8 to 9 in 4th, 9 to 12 in 5th, 9 to 14 in 6th, 11 to 15 in 7th, 13 to 14 in 8th, and about 13 in 9th. Axial septula first appear in 3rd whorl with maximum of 1 per chamber in 3rd volution, 2 in 4th and 5th, 3 in 6th, and 4 from 7th outward.

Proloculus minute, its outside diameter varying from 58 to 81 μ. Row of low, rounded foramina present from pole to pole along base of each

septum. Adjacent foramina separated by narrow, rather high parachomata which first appear in 2nd whorl. Parachomata number 2 to 3 in 2nd volution, 3 to 7 in 3rd, 5 to 9 in 4th, 10 to 13 in 5th, 11 to 16 in 6th, 15 to 20 in 7th, 15 to 23 in 8th, 20 to 27 in 9th, 22 to 30 in 10th, 27 to 30 in 11th, and about 30 in 12th.

Primary transverse septulum present immediately above each parachoma with basal margins of septula joined to tops of parachomata to form partitions which divide meridional chambers into rectangular chamberlets. Lateral communication is provided by lateral foramina which pierce these partitions at junctions of septula and parachomata. They are located immediately behind and in front of each septum. Rare rudimentary secondary transverse septula appear in outermost volutions, indicating that this is a highly advanced species in spite of its small size.

Discussion.—Neoschwagerina pusilla is the smallest known American member of the genus. It can be distinguished from *N. brevis* THOMPSON, WHEELER & DANNER by its smaller size, thinner spirotheca, the earlier appearance of parachomata, the earlier appearance of more than one axial septulum per chamber, and the presence of sporadically occurring secondary transverse septula in the outer volutions.

Occurrence.—We have found this species only in collections WA-3 and WA-14, where it is associated with *Pseudodoliolina cylindrica* SKINNER & WILDE, n. sp., and *P. oliviformis* THOMPSON, WHEELER & DANNER.

Illustrations.—Plate 32, figures *1-6.*——Figs. *1, 2.* Axial section of holotype, ×10, ×20.——Figs. *3, 4.* Axial sections of paratypes, ×20.——Figs. *5, 6.* Sagittal sections of paratypes, ×20. [All from collection WA-14.] [All figures are unretouched photographs.]

NEOSCHWAGERINA INSULARIS Skinner & Wilde, n. sp.

Neoschwagerina morcropensis THOMPSON, WHEELER, & DANNER, 1950 *(partim)*, Cushman Found. Foram. Research. Contr., v. 1, p. 59, 60, pl. 6, figs. 7, 8 (*not* pl. 6, figs. 9-11).

Shell rather large, inflated fusiform to ellipsoidal, with convex lateral slopes and bluntly rounded poles. Mature specimens have 17 to 18.5 volutions and measure 9.00 to 10.40 mm. in length and 5.90 to 6.90 mm. in diameter. Form ratio varies from 1.51 to 1.70.

Spirotheca composed of tectum and finely alveolar keriotheca, its thickness in 16th whorl measuring 43 to 61 μ. Septa plane and thin. They number 6 to 7 in 1st volution, 11 to 12 in 2nd, 11 to 13 in 3rd, 13 in 4th, 11 to 13 in 5th, 12 to 15 in 6th, 11 to 15 in 7th, 12 to 14 in 8th, 13 to 15 in 9th, 16 to 19 in 10th, 17 to 18 in 11th, 19 to 22 in 12th, 20 to 23 in 13th, 22 to 24 in 14th, 21 to 26 in 15th, about 28 in 16th, and 30 in 17th. Axial septula first appear in 3rd volution with maximum of 1 per chamber in 3rd, 4th, and 5th whorls, 2 per chamber in 6th, 3 in 7th, 8th, and 9th, 4 in 10th, 11th, 12th, and 13th, and 5, or rarely 6, from 14th whorl outward.

Proloculus small, its outside diameter varying from 72 to 163 μ. Row of small, elliptical foramina present along basal margin of each septum from pole to pole, adjacent foramina being separated by narrow, rather high parachomata which may be slightly thickened at top. Parachomata number 2 to 3 in 1st volution, 5 to 6 in 2nd, 7 to 8 in 3rd, 10 in 4th, 12 to 14 in 5th, 14 to 16 in 6th, 19 to 22 in 7th, 22 to 25 in 8th, 25 to 27 in 9th, 30 to 32 in 10th, 35 to 37 in 11th, 36 to 48 in 12th, 45 to 53 in 13th, 50 to 54 in 14th, and 53 to 65 in 15th.

Thin primary transverse septulum positioned directly above each parachoma, basal margins of septula being joined to tops of parachomata so as to produce partitions which divide meridional chambers into rectangular chamberlets. Each septulum pierced by small, rounded lateral foramina near its junction with underlying parachoma, providing lateral communication within shell, such foramina being located immediately behind and in front of each septum, commonly with 2 per chamber perforating each primary septulum. In some specimens 3rd foramen may be present near middle of chamber in outer whorls and outermost whorls of fully mature specimens may have rather well-developed secondary transverse septula, but their occurrence is sporadic.

Discussion.—THOMPSON, WHEELER & DANNER originally included specimens of this species in their *Neoschwagerina morcropensis.* A comparison of specimens from Morcrop quarry, the type locality of *N. morcropensis*, shows that several rather marked differences serve to distinguish the two species. *N. insularis* differs from *N. morcropensis* in its smaller size and form ratio, more numerous parachomata and axial septula per

chamber, and fewer volutions. In addition, *N. morcropensis* has no trace of secondary transverse septula. *N. insularis* is the most highly advanced American member of the genus known at present.

Occurrence.—This species is abundant in collections WA-21 and WA-30, from the Cowell quarry on San Juan Island.

Illustrations.—Plate 32, figure 7; Plate 33, figures *1-5.*——Pl. 32, fig. 7. Axial section of holotype, ×10. [From collection WA-21.]——Pl. 33, figs. *1, 2.* Axial sections of paratypes, ×10. ——Pl. 33, figs. *3, 4.* Sagittal sections of paratypes, ×10.——Pl. 33, fig. *5.* Part of specimen shown in *2,* ×20. [*1* from collection WA-30; all others from collection WA-21.] [All figures are unretouched photographs.]

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PART 6

PERMIAN FUSULINIDS FROM BLACK MOUNTAIN AREA, NORTHWESTERN WASHINGTON

ABSTRACT

Four species of fusulinids, belonging to three genera, are described from a limestone in the Permian Chilliwack Series exposed on and near Black Mountain, Whatcom County, Washington. The fauna suggests a probable early Leonardian age for the limestone.

INTRODUCTION

On the north side of Black Mountain, in northern Whatcom County, Washington, and just south of the Canadian border, Dr. W. R. Danner found a limestone in the Permian Chilliwack Series containing a profusion of well-preserved fusulinids (Fig. 8). Concerning the exposure he said (personal communication), "I do not know the exact thickness of the fusulinid

Fig. 8. Index map showing location of Black Mountain area, northwestern Washington.

limestone on Black Mountain, but it is probably at least 200 feet." In a later letter he wrote, "The fusulinid limestone is underlain by a cobble conglomerate. The cobbles are mostly volcanic rocks. Under the cobble conglomerate comes another limestone which contains some large brachiopods tentatively identified as *Gigantoproductus* by paleontologists of the U.S.G.S. This same lower limestone also contains corals from the *Schwagerina* zone of southern Asia such as *Iranophyllum*. The corals were also identified by the U.S.G.S. Thus, some say the bed is lower Permian and some say it is Mississippian."

DANNER sent us several thin sections of the lower limestone, and we were able to identify the fusulinid genera *Ozawainella* and *Eostaffella*, as well as a number of endothyrids. It seems probable that this limestone is of about the same age as the Coffee Creek Formation of the Suplee area, east-central Oregon, and we are inclined to regard it as Morrowan or early Derryan in age.

In addition to the fusulinid limestone which DANNER sent us, we have three collections made by Dr. L. R. LAUDON in the same area, but apparently from a slightly different locality. LAUDON's collections evidently came from the same zone as DANNER's, for the lithology and fauna are identical. *Pseudofusulinella*, *Schwagerina*, and a rather primitive species of *Parafusulina* are present, suggesting an early Leonardian age for these rocks.

We wish to express our thanks to Dr. DANNER and Dr. LAUDON for supplying us with this material and information as to its occurrence, and to the Humble Oil & Refining Company for permission to publish this paper. All figured specimens are deposited in the files of the Humble Oil & Refining Company at Midland, Texas.

FUSULINID COLLECTIONS

WA-19.—Limestone in Permian Chilliwack Series on the north side of Black Mountain, just south of the Canadian border. S½ sec. 4, T. 40 N., R. 6 E., Whatcom County, Washington. Colleceted by W. R. DANNER.

WA-25.—Limestone in Permian Chilliwack Series. Same zone and locality as WA-19. Collected by W. R. Danner.

WA-37.—Limestone in Permian Chilliwack Series. Road just below old quarry in Black Mountain-Maple Falls area. Sec. 9, T. 40 N., R. 6 E., Whatcom County, Washington. Collected by L. R. LAUDON.

WA-38.—Limestone in Permian Chilliwack Series. Same locality as WA-37. Collected by L. R. LAUDON.

WA-39.—Limestone in Permian Chilliwack Series. Same locality as WA-37. Collected by L. R. LAUDON.

SYSTEMATIC PALEONTOLOGY

Genus PSEUDOFUSULINELLA Thompson, 1951

PSEUDOFUSULINELLA DANNERI Skinner & Wilde, n. sp.

Shell small, thickly fusiform, with straight to slightly concave lateral slopes and moderately pointed poles. Mature specimens have 8 to 9 volutions and measure 5.60 to 6.10 mm. in length and 2.90 to 3.00 mm. in diameter. Form ratio varies from 1.87 to 2.03.

Spirotheca composed of tectum and diaphanotheca, 7th whorl measuring 67 to 87 μ in thickness. In some specimens fine mural pores can be seen traversing the wall. Septa are gently wavy across the middle of the shell, becoming rather strongly fluted toward the poles. They number 7 to 10 in 1st whorl, 11 to 15 in 2nd, 14 to 15 in 3rd, 17 to 20 in 4th, 18 to 22 in 5th, 21 to 29 in 6th, 28 to 33 in 7th, and about 33 in 8th. Septal pores abundant, usually appearing as dark spots because of later plugging with epithecal material.

Proloculus unusually large for members of this genus, its outside diameter varying from 141 to 248 μ. Tunnel narrow and about half as high as chambers. Tunnel angle 20 to 24 degrees in 8th volution. Chomata rather narrow but high, commonly reaching nearly to tops of chambers.

Discussion.—Because of its relatively large size and large proloculus *Pseudofusulinella danneri* does not closely resemble any other known member of the genus. It is named for Dr. W. R. DANNER.

Occurrence.—This species is abundant in our collections WA-19, WA-25, WA-37, WA-38, and WA-39.

Illustrations.—Plate 34, figures *1-5*.——Fig. *1* Axial section of holotype, ×10.——Figs. *2, 3*. Axial sections of paratypes, ×10.——Figs. *4, 5*. Sagittal sections of paratypes, ×10. [*1, 3* from

collection WA-25; *2* from collection WA-37; *4, 5* from collection WA-19.] [All figures are unretouched photographs.]

Genus SCHWAGERINA von Möller, 1877

SCHWAGERINA CASCADENSIS Skinner & Wilde, n. sp.

Shell large, elongate fusiform, with convex lateral slopes and bluntly pointed poles. Adult specimens have about 7 volutions and measure 13.00 to 16.20 mm. in length and 4.00 to 4.80 mm. in diameter. Form ratio varies from 3.25 to 3.45.

Spirotheca, composed of tectum and coarsely alveolar keriotheca, measures 107 to 141 μ in thickness in 6th whorl. Phrenothecae present but not conspicuous. Septa intensely and regularly fluted from pole to pole. They number 11 to 17 in 1st volution, 19 to 26 in 2nd, 28 to 38 in 3rd, 27 to 38 in 4th, 29 to 38 in 5th, 36 in 6th, and about 37 in 7th. Septal folds narrow and high, extending to tops of septa. Secondary deposits massive but somewhat variable in distribution, usually nearly filling shell outside of tunnel area in first 4 or 5 volutions.

Proloculus very large, its outside diameter varying from 463 to 631 μ, averaging about 550 μ. Tunnel low and not very wide. Tunnel angle measures 31 to 40 degrees in 6th volution. Weak chomata present only on proloculus.

Discussion.—Schwagerina cascadensis is similar to *S. chilliwackensis* Skinner & Wilde, n. sp., with which it occurs. The latter, however, has a larger form ratio, a slightly wider tunnel, and less massive secondary deposits.

Occurrence.—This large species occurs abundantly in collections WA-19, WA-25, WA-37, and WA-38.

Illustrations.—Plate 34, figures *6-9*; Plate 35, figure *1*.——Pl. 34, fig. *6*. Axial section of holotype, ×10.——Pl. 34, fig. *7*. Axial section of paratype, ×10.——Pl. 34, figs. *8, 9*. Sagittal sections of paratypes, ×10. [*6, 8* from collection WA-19; *7* from collection WA-37; *9* from collection WA-25.]——Pl. 35, fig. *1*. Axial section of paratype, ×10. [From collection WA-19.] [All figures are unretouched photographs.]

SCHWAGERINA CHILLIWACKENSIS Skinner & Wilde, n. sp.

Shell large, elongate fusiform, with convex lateral slopes and bluntly pointed poles. Mature individuals have 6 to 7 volutions and measure 13.10 to 15.60 mm. in length and 3.40 to 3.80 mm. in diameter. Form ratio varies from 3.44 to 4.35.

Spirotheca, composed of tectum and coarsely alveolar keriotheca, measures 94 to 121 μ in thickness in 5th whorl. Phrenothecae present but not conspicuous. Septa strongly fluted throughout shell. They number 15 to 16 in 1st volution, 25 to 28 in 2nd, 29 to 36 in 3rd, 29 to 41 in 4th, and about 33 in 5th. Septal folds high, reaching to tops of septa. Axial filling present but not massive, except in first 2 whorls.

Proloculus very large, its outside diameter varying from 490 to 638 μ, averaging about 575 μ. Tunnel low and moderately wide. Tunnel angle measures 41 to 43 degrees in 5th volution, and 41 to 52 degrees in 6th. Very weak chomata sometimes observed on proloculus.

Discussion.—Schwagerina chilliwackensis is similar to *S. cascadensis* Skinner & Wilde, n. sp., with which it occurs. It differs from that species in its larger form ratio, wider tunnel, and less massive secondary deposits.

Occurrence.—This species is abundant in collections WA-25, WA-37, and WA-38.

Illustrations.—Plate 35, figures *2-5*; Plate 36, figure *1*.——Pl. 35, fig. *2*. Axial section of holotype, ×10.——Pl. 35, fig. *3*. Axial section of paratype, ×10.——Pl. 35, figs. *4, 5*. Sagittal sections of paratypes, ×10. [All from collection WA-25.]——Pl. 36, fig. *1*. Axial section of paratype, ×10. [From collection WA-25.] [All figures are unretouched photographs.]

Genus PARAFUSULINA Dunbar & Skinner, 1931

PARAFUSULINA LAUDONI Skinner & Wilde, n. sp.

Shell large, elongate subcylindrical, with bluntly pointed poles. Mature specimens have 6 to 6.5 volutions and measure 13.40 to 16.30 mm. in length and 3.30 to 3.60 mm. in diameter. Form ratio varies from 4.06 to 4.53.

Spirotheca, composed of tectum and coarsely alveolar keriotheca, measures 101 to 107 μ in thickness in 5th whorl. Phrenothecae present but not conspicuous. Septa strongly and regularly fluted from pole to pole. Septal count for our only sagittal section is 15, 23, 32, 31, 35 for 1st to 5th volutions, respectively. Septal folds high, usually reaching tops of septa. Septal pores common, particularly in outer whorls. Light, discontinuous secondary deposits present along axis.

Low, narrow cuniculi developed, at least in outer volutions (Pl. 36, fig. 5).

Proloculus large, its outside diameter ranging from 396 to 658 μ, averaging about 485 μ. Tunnel low and wide. Tunnel angle measures 58 to 62 degrees in 6th volution. No chomata have been observed.

Discussion.—Parafusulina laudoni is a rather primitive representative of the genus, and does not closely resemble any other known species. It is named for Dr. L. R. LAUDON.

Occurrence.—We have found only a few specimens of this species in collection WA-19. It is included here because of its stratigraphic implications.

Illustrations.—Plate 36, figures *2-5.*——Fig. *2.* Axial section of holotype, $\times$10.——Fig. *3.* Axial section of paratype, $\times$10.——Fig. *4.* Sagittal section of paratype, $\times$10.——Fig. *5.* Tangential section of paratype showing cuniculi, $\times$10. [All from collection WA-19.] [All unretouched photographs.]

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PART 7

PERMIAN FUSULINIDS FROM MARBLE CANYON LIMESTONE, BRITISH COLUMBIA

ABSTRACT

One species each of *Schwagerina* and *Chusenella,* and nine species of *Yabeina* are described from the Marble Canyon Limestone of southern British Columbia. All are new except two species of *Yabeina.* Three other species of *Schwagerina,* one of which was originally described from northwestern Washington, are also present in the Marble Canyon Limestone.

INTRODUCTION

About 55 miles west-northwest of Kamloops, and 12 miles west of Cache Creek, British Columbia, Marble Canyon joins Hat Creek Canyon from the northwest (Fig. 9). At this point Hat Creek flows northeast, and the two canyons join nearly at a right angle. Marble Canyon cuts diagonally through a great ridge of limestone which trends north-northwest and extends across country for many miles. Near the middle of the canyon, which is about 12 miles long, is a drainage divide. The northwestern part of the canyon drains northwest into the Fraser River, while the southeastern part drains southeast into Hat Creek. The canyon is narrow and the walls are precipitous. Within the canyon are three lakes, the northwestern one being much larger than the other two. In some earlier reports these have been referred to as the "three Pavilion lakes," but on the map which accompanies the report of DUFFELL & MCTAGGART (1952) the largest lake is shown as Pavilion Lake, while the two smaller ones are referred to as the Crown Lakes.

The locality may be reached by turning off the Cariboo Road at about 7.3 miles north-northwest of Cache Creek, and following a dirt road that goes first west and then southwest up Hat Creek drainage. At a point 12.0 miles by road from the Cariboo Road the Marble Canyon Limestone is well exposed in the northwest wall of Hat Creek Canyon. The limestone is thick-bedded and varies in color from light gray to nearly black. It rests upon siliceous shale and is overlain unconformably by Tertiary conglomerate. At this point the limestone appears to dip slightly south of west at about 45 degrees, but as one proceeds southwestward up Hat Creek Canyon the dip steadily increases until at mileage 12.8, where Marble Canyon enters Hat Creek Canyon from the northwest, the beds are nearly vertical. At this point the road divides, one branch continuing up Hat Creek, while the other turns sharply to the right and enters Marble Canyon. Immediately inside Marble Canyon the bedding becomes obscure and much of the limestone is marbleized.

Fusulinids were first described from this locality by Dawson (1879) who mistook them for the Tertiary genus *Loftusia* and named them *L. columbiana*. Dunbar (1932) restudied Dawson's

Fig. 9. Index map showing location of Marble Canyon area, British Columbia.

thin sections, none of which was centered, and referred the species to *Neoschwagerina* and compared it to the oriental species *N. margaritae* DEPRAT.

THOMPSON & WHEELER (1942), working with material collected by WHEELER, pointed out that DAWSON's species actually is a member of the genus *Yabeina*. In the same paper they described a smaller species of *Yabeina* as *Y. minuta* THOMPSON & WHEELER, and added descriptions of two schwagerinids under the names *Schwagerina pavilionensis* THOMPSON & WHEELER and *S. pavilionensis* var. *acris* THOMPSON & WHEELER, respectively.

It should be noted that all specimens described up to this point were derived from cobbles collected from the talus along the foot of the northeast wall of Marble Canyon. THOMPSON, WHEELER & DANNER (1950) redescribed *Yabeina columbiana, Y. minuta,* and *Schwagerina acris,* elevating the last to specific rank, and illustrated them with specimens collected *in situ* along the northwest wall of Hat Creek Canyon. They also described a minute species as *Codonofusiella duffelli* THOMPSON, WHEELER & DANNER, and figured a specimen which they referred with question to *Schwagerina royandersoni* THOMPSON, WHEELER & DANNER. The type specimens of this last species were obtained from the Canyon Creek quarry in northwestern Washington.

We have part of WHEELER's collection, sent to us many years ago by the late Dr. H. G. SCHENCK, as well as collections made by SKINNER in 1949 from the northwest wall of Hat Creek Canyon. These collections have been supplemented by material collected in 1957 by Dr. L. R. LAUDON, both from Marble Canyon and Hat Creek Canyon.

In addition to the species described in the present paper, we have found *Schwagerina royandersoni* THOMPSON, WHEELER & DANNER, *S. pavilionensis* THOMPSON & WHEELER, and *S. acris* THOMPSON & WHEELER in our Marble Canyon material. *S. royandersoni* was originally described from the limestone exposed in Canyon Creek quarry in northwestern Washington.

We wish to express our thanks to Dr. L. R. LAUDON for supplying us with material, and to the Humble Oil & Refining Company for permission to publish this study. All figured specimens are deposited in the files of the Humble Oil & Refining Company at Midland, Texas.

FUSULINID COLLECTIONS

BC-1.—Marble Canyon Limestone. Cobbles collected from the talus along the northeast shore of the middle lake in Marble Canyon. Collected by H. E. WHEELER and donated by H. G. SCHENCK.

BC-3.—Marble Canyon Limestone. Northwest wall of Hat Creek Canyon, beside road at a point 12.0 miles by road southwest of the junction of the Hat Creek road with the Cariboo Road. This is 0.8 mile northeast of the confluence of Marble and Hat Creek canyons, and about 40 feet above the base of the limestone exposed here. Collected by J. W. SKINNER.

BC-4.—Marble Canyon Limestone. Northwest wall of Hat Creek Canyon, just southwest of BC-3 and about 260 feet stratigraphically higher. Collected by J. W. SKINNER.

BC-5.—Marble Canyon Limestone. Northwest wall of Hat Creek Canyon, southwest of BC-4 and about 250 feet stratigraphically higher. Collected by J. W. SKINNER.

BC-10.—Marble Canyon Limestone. Cobbles collected along the northeast shore of the southeasternmost lake in Marble Canyon. Collected by L. R. LAUDON.

BC-11.—Marble Canyon Limestone. Northwest wall of Hat Creek Canyon just northeast of the mouth of Marble Canyon. L. R. LAUDON's collection KB-4.

BC-12.—Marble Canyon Limestone. Same locality as BC-11. L. R. LAUDON's collection KC-3.

BC-13.—Marble Canyon Limestone. East of road opposite southeast end of southeasternmost lake in Marble Canyon. L. R. LAUDON's collection KD-9.

SYSTEMATIC PALEONTOLOGY

Genus SCHWAGERINA von Möller, 1877

SCHWAGERINA CANADENSIS Skinner & Wilde, n. sp.

Shell moderately large, fusiform, with convex lateral slopes and sharply pointed poles. Mature individuals have about 9 volutions and measure 8.00 to 8.60 mm. in length and 3.30 to 3.70 mm. in diameter. Form ratio varies from 2.32 to 2.42.

Spirotheca, composed of tectum and coarsely alveolar keriotheca, measures 87 to 114 μ in thickness in 6th volution. Septa strongly and regularly fluted from pole to pole. They number 11 to 15 in 1st whorl, 12 to 20 in 2nd, 14 to 24 in 3rd, 20 to 24 in 4th, 22 to 27 in 5th, 26 to 35 in

6th, and about 30 in 7th. Septal folds high, reaching to tops of chambers. Heavy secondary deposit nearly fills chambers in axial zone.

Proloculus rather large, its outside diameter measuring 255 to 382 μ. Tunnel low and rather narrow, tunnel angle measuring 24 to 30 degrees in 6th whorl and about 33 degrees in 7th. Weak chomata present only in first 2 volutions.

Discussion.—Schwagerina canadensis does not closely resemble any previously described species. It differs from *S. pavilionensis* THOMPSON & WHEELER, which also occurs in the Marble Canyon Limestone, in its smaller size, smaller proloculus, and less massive secondary deposits.

Occurrence.—We have found this species only in collection BC-3, where it is associated with *Schwagerina royandersoni* THOMPSON, WHEELER & DANNER, *Chusenella spicata* SKINNER & WILDE, n. sp., *Yabeina dawsoni* SKINNER & WILDE, n. sp., *Y. gracilis* SKINNER & WILDE, n. sp., *Y. cylindrica* SKINNER & WILDE, n. sp., *Y. ampla* SKINNER & WILDE, n. sp., and *Y. parvula* SKINNER & WILDE, n. sp.

Illustrations.—Plate 37, figures *1-5.*——Fig. *1.* Axial section of holotype, ×10.——Fig. *2, 3.* Axial sections of paratypes, ×10.——Figs. *4, 5.* Sagittal sections of paratypes, ×10. [All from collection BC-3.] [All figures are unretouched photographs.]

Genus CHUSENELLA Hsu, 1942

[*emend.* CHEN, 1956]

CHUSENELLA SPICATA Skinner & Wilde, n. sp.

Shell moderately large, fusiform, with inflated equatorial portion, concave lateral slopes, and extended, sharply pointed poles. Mature specimens have 6.5 to 7.5 whorls, of which the first 3.5 to 4 are tightly coiled, followed by more loosely coiled later volutions. Such individuals measure 7.30 to 8.70 mm. in length, and 2.40 to 3.10 mm. in diameter. Form ratio varies from 2.92 to 3.62.

Spirotheca composed of tectum and moderately coarse keriotheca with thickness in sixth whorl measuring 80 μ. Septa nearly plane in tightly coiled volutions, but becoming strongly fluted from pole to pole in outer whorls. They number 8 to 9 in 1st whorl, 11 to 13 in 2nd, 15 to 16 in 3rd, 16 to 18 in 4th, 18 to 20 in 5th, and 22 to 27 in 6th. Septal folds in outer volutions high, commonly reaching to tops of chambers. Narrow band of secondary material present along axis.

Proloculus small, its outside diameter measuring 121 to 154 μ. Tunnel low and rather narrow, tunnel angle varying from 21 to 27 degrees in 6th whorl. Weak chomata present only in first 3 to 4 volutions.

Discussion.—Chusenella spicata is similar to *C. cheni* SKINNER & WILDE in general appearance. It may be distinguished from that species by its greater length, somewhat larger form ratio, slightly narrower tunnel, and smaller proloculus.

Occurrence.—This species occurs sparingly in collections BC-3 and BC-10, where it is associated with *Schwagerina royandersoni* THOMPSON, WHEELER & DANNER, *S. canadensis* SKINNER & WILDE, n. sp., *Yabeina minuta* THOMPSON & WHEELER, *Y. obesa* SKINNER & WILDE, n. sp., *Y. dawsoni* SKINNER & WILDE, n. sp., *Y. gracilis* SKINNER & WILDE, n. sp., *Y. cylindrica* SKINNER & WILDE, n sp., *Y. ampla* SKINNER & WILDE, n. sp., and *Y. parvula* SKINNER & WILDE, n. sp.

Illustrations.—Plate 37, figures *6-10.*——Fig. *6.* Axial section of holotype, ×10.——Figs. *7, 8.* Axial sections of paratypes, ×10.——Figs. *9, 10.* Sagittal sections of paratypes, ×10. [All from collection BC-10.] [All figures are unretouched photographs.]

Genus YABEINA Deprat, 1914

YABEINA COLUMBIANA (Dawson)

Loftusia columbiana DAWSON, 1879, Quart. Jour. Geol. Soc. London, v. 35, p. 69-75, pl. 6, figs. 1-7.

Neoschwagerina cf. *craticulifera* VON STAFF, 1912, Palaeontographica, v. 59, p. 161.

Neoschwagerina columbiana DUNBAR, 1932, Roy. Soc. Canada Proc. and Trans., 3d ser., v. 26, sec. 4, p. 45-49, pl. 1, figs. 1-4.

Yabeina columbiana THOMPSON & WHEELER, 1942 (*partim*), Jour. Paleontology, v. 16, p. 708-710, pl. 106, fig. 5; pl. 107, fig. 5; pl. 109, figs. 1-4 (*not* pl. 108, fig. 1).

Yabeina columbiana THOMPSON, WHEELER, & DANNER, 1950, Cushman Found. Foram. Research, Contrib., v. 1, pl. 61, pl. 8, figs. 1-3.

Shell moderate in size, inflated fusiform to ellipsoidal, with convex lateral slopes and bluntly rounded poles. Mature specimens possess 17 to 18.5 volutions and measure 7.40 to 8.30 mm. in length and 4.30 to 4.80 mm. in diameter. Form ratio varies from 1.54 to 1.93.

Very thin spirotheca composed of tectum and finely alveolar keriotheca. In 16th volution its thickness measures only 16 to 22 μ. Septa thin and essentially plane, although their distal margins are usually bent rather sharply forward.

They number 7 to 8 in 1st whorl, 12 to 13 in 2nd, 13 to 14 in 3rd, 13 to 15 in 4th, 15 to 16 in 5th, 14 to 15 in 6th, 16 to 18 in 7th, 17 in 8th, 17 to 20 in 9th, 19 to 20 in 10th, 20 to 23 in 11th, 19 to 22 in 12th, 23 to 25 in 13th, 27 to 28 in 14th, 28 to 29 in 15th, and about 34 in 16th. Axial septula first appear in 3rd volution, with maximum of 1 per chamber in 3rd whorl, 2 in 4th to 6th whorls, 3 in 7th, 4 in 8th, 5 in 9th and 10, and 6 from 11th whorl outward. Septula thin, with their tips consolidated and nearly opaque. In outer whorls many septa have thin, dense lamella which extends upward from anteriorly directed distal margin to point high on anterior face of septum, cutting across arc produced by anterior concavity of septum. In tangential sections such lamella appears as thin, dark line just in front of and parallel to septum.

Proloculus small, its outside diameter measuring 71 to 161 μ. Row of low, rounded foramina present along base of each septum from pole to pole. Adjacent foramina separated by thin, high parachomata which number 1 to 2 in 1st whorl, 3 to 4 in 2nd, 5 to 8 in 3rd, 9 to 12 in 4th, 12 to 16 in 5th, 15 to 18 in 6th, 18 to 21 in 7th, 21 to 26 in 8th, 26 to 31 in 9th, 31 to 32 in 10th, 32 to 37 in 11th, 31 to 42 in 12th, 40 to 48 in 13th, 45 to 50 in 14th, 47 to 56 in 15th, 52 to 57 in 16th, and about 56 in 17th.

Thin primary transverse septulum located directly above each parachoma, and distal margins of septula joined to tops of parachomata to form partitions which subdivide meridional chambers into rectangular chamberlets. Lateral communication within shell provided by rounded lateral foramina which pierce these partitions at junctions of septula with parachomata. Such foramina are located immediately behind and in front of each septum. Secondary transverse septula first appear in 7th volution. They are thin and their distal margins are commonly slightly thickened. From 7th to 14th whorls only single secondary septulum occurs between each pair of primary septula; thereafter, 2 are commonly present.

Discussion.—Dawson originally described this species under the name of the Eocene genus *Loftusia,* and for this reason it escaped attention for many years. Later, von Staff (1912) referred to the presence of *Neoschwagerina* in British Columbia, but gave no description or specific locality. In 1932 Dunbar was able to borrow Dawson's thin sections, and redescribed the species as *Neoschwagerina columbiana.* Finally, in 1942, Thompson & Wheeler, working with material collected by Wheeler, pointed out that Dawson's species actually belongs in *Yabeina* rather than in *Neoschwagerina. Y. columbiana* (Dawson) more nearly resembles *Y. minuta* Thompson & Wheeler than any other known species. It may be distinguished from the latter by its larger size, slightly more inflated shape, slightly smaller form ratio, more numerous volutions, and the later appearance of a second secondary transverse septulum between pairs of primary septula.

Occurrence.—This species is abundant in collection BC-1, and questionably present in collections BC-5 and BC-10.

Illustrations.—Plate 38, figures *1-6.*——Figs. *1-3.* Axial sections of topotypes, ×10.——Figs. *4, 5.* Sagittal sections of topotypes, ×10.——Fig. *6.* Part of specimen shown in *1,* ×20. [All from collection BC-1.] [All figures are unretouched photographs.]

YABEINA MINUTA Thompson & Wheeler

Yabeina minuta Thompson & Wheeler, 1942 *(partim),* Jour. Paleontology, v. 16, p. 707, 708, pl. 106, figs. 6-8 (*not* pl. 106, figs. 9, 10).

Shell rather small, inflated fusiform, with straight to slightly convex lateral slopes and bluntly pointed to rounded poles. Mature specimens have 13 to 15 volutions and measure 6.50 to 7.50 mm. in length and 3.30 to 3.70 mm. in diameter. Form ratio varies from 1.85 to 2.18.

Thin spirotheca composed of tectum and finely alveolar keriotheca, in 13th volution its thickness measuring only 12 to 16 μ. Septa thin and nearly plane, although their distal margins are usually curved gently forward, causing anterior faces to be slightly concave. They number about 9 in 1st volution, 15 in 2nd, 13 in 3rd, 15 in 4th, 17 in 5th, 15 in 6th, 17 in 7th, 16 in 8th, 16 in 9th, 16 in 10th, and 16 in 11th. In outer whorls some septa have very thin, dense lamella which extends upward from distal margin of septum to point high on anterior face, cutting across arc produced by anterior concavity of septum. Axial septula first appear in 3rd volution, with maximum of 1 per chamber in 3rd and 4th whorls, 2 in 5th, 3 in 6th, 4 in 7th, 5 in 8th and 9th, 6 in 10th, and 7 from 11th whorl outward.

Proloculus small, its outside diameter varying from 104 to 141 μ. Row of low, rounded foramina present along basal margin of each septum from

pole to pole alternating with high, thin parachomata which number 1 to 3 in 1st volution, 3 to 5 in 2nd, 4 to 8 in 3rd, 7 to 12 in 4th, 10 to 17 in 5th, 11 to 19 in 6th, 14 to 21 in 7th, 15 to 24 in 8th, 23 to 31 in 9th, 29 to 35 in 10th, 32 to 38 in 11th, 33 to 42 in 12th, 39 to 46 in 13th, and 46 to 47 in 14th.

Thin primary transverse septulum positioned directly above each parachoma, and distal margins of septula joined to tops of parachomata to produce partitions which subdivide meridional chambers into rectangular chamberlets. Small, rounded lateral foramina pierce each partition to provide lateral communication within shell. Such foramina are located immediately behind and in front of each septum. Secondary transverse septula first appear in 7th volution. From 7th through 11th whorl is 1 secondary septulum between each pair of primary septula, after which there are usually 2.

Discussion.—Thompson & Wheeler figured 5 specimens, one with question, as *Yabeina minuta*. The first 3, upon which their description of the species appears to have been based, differ rather markedly from the other 2. Since they did not designate a holotype, we are restricting the species to the form shown in their plate 106, figures 6-8, and designating the specimen figured as plate 106, figure 7, as the holotype. These 3 specimens agree closely with their description and with the specimens which we are figuring in this report. Their other 2 photographs show a species with a more slender shape and a much larger proloculus. We describe it below as *Yabeina dawsoni* Skinner & Wilde, n. sp. In 1950, Thompson, Wheeler & Danner figured 3 specimens of still another species as *Y. minuta*. It has a still more slender shape, fewer volutions, and a large proloculus. We are describing it as *Y. gracilis* Skinner & Wilde, n. sp.

Yabeina minuta Thompson & Wheeler is similar to *Y. columbiana* (Dawson). It differs in its smaller size, fewer volutions, slightly less inflated shape, and the earlier appearance of 2 secondary transverse septula between pairs of primary septula.

Occurrence.—We have found this species in collections BC-1, BC-5, BC-10, and BC-13.

Illustrations.—Plate 39, figures *1-7*.——Figs. *1-3*. Axial sections of topotypes, ×10.——Fig. *4*. Sagittal section of topotype, ×10——Fig. 5. Sagittal section of specimen from another locality, ×10. Fig. *6*. Part of specimen shown in *2*, ×20.——Fig. *7*. Specimen shown in *5*, ×20. [*1-4*, 6 from collection BC-1; *5*, *7* from collection BC-13.] [All figures are unretouched photographs.]

YABEINA OBESA Skinner & Wilde, n. sp.

Shell moderate in size, highly inflated fusiform to subglobular, with convex lateral slopes and bluntly rounded poles. Mature specimens have 16 to 18.5 volutions, and measure 5.20 to 7.00 mm. in length, and 3.90 to 5.20 mm. in diameter. Form ratio varies from 1.27 to 1.46.

Thin spirotheca composed of tectum and finely alveolar keriotheca, in 15th whorl thickness measuring 17 to 20 μ. Septa thin and plane. They number 9 in 1st volution, 15 to 18 in 2nd, 15 to 16 in 3rd, 15 to 17 in 4th, 16 in 5th, 15 in 6th, 16 to 17 in 7th, 17 to 20 in 8th, 18 to 19 in 9th, 16 to 20 in 10th, 18 to 22 in 11th, 18 in 12th, and 22 in 13th. Axial septula first appear in 3rd whorl with maximum of 1 septulum per chamber in 3rd and 4th volutions, 2 in 5th, 3 in 6th, 4 in 7th to 9th, 6 in 10th and 11th, and 7 from 12th whorl outward. Axial septula are thin, but consolidation of their distal margins not conspicuous.

Proloculus small, its outside diameter varying from 151 to 190 μ. Row of low, elliptical foramina present along distal margin of each septum from pole to pole. Adjacent foramina separated by high, very narrow parachomata which number 1 or 2 in 1st volution, 3 to 5 in 2nd, 5 to 9 in 3rd, 9 to 11 in 4th, 11 to 17 in 5th, 16 to 18 in 6th, 19 to 23 in 7th, 23 to 25 in 8th, 26 to 27 in 9th, 30 to 32 in 10th, 35 to 40 in 11th, 41 to 42 in 12th, 44 to 47 in 13th, 47 to 49 in 14th, 51 to 54 in 15th, 57 in 16th, and 60 in 17th.

Primary transverse septulum located directly above each parachoma, and distal margins of septula joined to tops of parachomata to form partitions subdividing meridional chambers into rectangular chamberlets. Small, rounded lateral foramina pierce these partitions to provide communication from end to end of shell. Such foramina are located immediately behind and in front of each septum. Secondary transverse septula first appear in 5th volution, but do not become common until 9th. Until 11th whorl is reached there is never more than 1 secondary septulum between pairs of primary septula. From 11th volution outward there may be 1 or 2 secondary septula between adjacent primary septula. Both primary and secondary septula are very thin.

Discussion.—*Yabeina obesa* differs from *Y. columbiana* (DAWSON) in its more inflated shape, smaller form ratio, somewhat larger proloculus, and thinner septula. Both axial and transverse septula are very thin, in this respect approaching the genus *Lepidolina*. This appears to be one of the most advanced American species known at present.

Occurrence.—This species is common in collections BC-1, BC-5, and BC-10.

Illustrations.—Plate 40, figures *1-7*.——Fig. *1*. Axial section of holotype, ×10.——Figs. *2, 3*. Axial sections of paratypes, ×10.——Figs. *4, 5*. Sagittal sections of paratypes, ×10.——Fig. *6*. Part of holotype, ×20.——Fig. *7*. Specimen shown in *4*, ×20. [All from collection BC-1.] [All figures are unretouched photographs.]

YABEINA DAWSONI Skinner & Wilde, n. sp.

Yabeina minuta THOMPSON & WHEELER, 1942 (*partim*), Jour. Paleontology, p. 707, 708, pl. 106, figs. 9, 10 (*not* pl. 106, figs. 6-8).

Shell moderate in size, fusiform, with slightly convex lateral slopes and bluntly pointed to rounded poles. Mature specimens have 14.5 to 17 volutions and measure 6.00 to 8.20 mm. in length and 3.00 to 4.20 mm. in diameter. Form ratio varies from 1.88 to 2.16.

Thin spirotheca composed of tectum and finely alveolar keriotheca, in 13th volution thickness varying from 17 to 22 μ. Septa thin and number 11 to 12 in 1st whorl, 14 to 15 in 2nd, 16 to 17 in 3rd, 17 in 4th, 18 in 5th, 15 to 20 in 6th, 18 to 20 in 7th, 18 to 22 in 8th, 19 to 21 in 9th, 18 to 20 in 10th, 18 to 20 in 11th, 19 to 20 in 12th, and about 20 in 13th. Axial septula first appear in 3rd volution with maximum of 1 septulum per chamber in 3rd and 4th whorls, 2 in 5th and 6th, 3 in 7th and 8th, 4 in 9th and 10th, 5 in 11th and 12, and 6 from 13th whorl outward. Distal margins of septula commonly consolidated.

Proloculus rather large for members of this genus, its outside diameter measuring 164 to 256 μ. Row of low, rounded to elliptical foramina present along distal margin of each septum from pole to pole. These alternate with high, narrow parachomata which number 2 to 3 in 1st whorl, 5 to 7 in 2nd, 8 to 10 in 3rd, 11 to 12 in 4th, 15 to 18 in 5th, 17 to 21 in 6th, 21 to 24 in 7th, 25 to 26 in 8th, 32 to 34 in 9th, 33 to 36 in 10th, 34 to 38 in 11th, 38 to 40 in 12th, 42 to 44 in 13th, 46 to 47 in 14th, 50 to 51 in 15th, and about 56 in 16th.

Thin primary transverse septulum positioned directly above each parachoma, and distal margins of septula joined to tops of parachomata to form partitions which divide meridional chambers into rectangular chamberlets. Small, rounded lateral foramina pierce these partitions to provide lateral communication within shell. These foramina are located just behind and in front of each septum. Short secondary transverse septula first appear in 3rd volution, but do not become common until 6th. Only one secondary septulum is present between adjacent primary septula until 11th volution is reached, after which there are commonly 2.

Discussion.—Two specimens of *Yabeina dawsoni* were illustrated by THOMPSON & WHEELER as *Y. minuta*. *Y. dawsoni* differs from *Y. minuta* in its larger proloculus and the earlier appearance of the secondary transverse septula. This species is named in honor of G. M. DAWSON.

Occurrence.—This species is common in collections BC-1, BC-3, BC-5, BC-10, and BC-13.

Illustrations.—Plate 41, figures *1-7*.——Fig. *1*. Axial section of holotype, ×10.——Figs. *2, 3*. Axial sections of paratypes, ×10.——Figs. *4, 5*. Sagittal sections of paratypes, ×10.——Fig. *6*. Part of specimen shown in *3*, to show nature of transverse septula, ×40.——Fig. *7*. Specimen shown in *5*, × 20. [*1, 3, 4, 6* from collection BC-1; *2* from collection BC-5; 5, 7 from collection BC-3.] [All figures are unretouched photographs.]

YABEINA GRACILIS Skinner & Wilde, n. sp.

Yabeina minuta THOMPSON, WHEELER, & DANNER, 1950, Cushman Found. Foram. Research, Contrib., v. 1, p. 62, pl. 8, figs. 4-7.

Shell rather small, slender fusiform to subcylindrical, with straight to slightly convex lateral slopes and bluntly pointed poles. Mature individuals have 11.5 to 13.5 volutions and measure 6.00 to 6.80 mm. in length, and 2.20 to 2.70 mm. in diameter. Form ratio varies from 2.52 to 2.73.

Spirotheca composed of tectum and finely alveolar keriotheca, in 11th whorl its thickness measuring 16 to 22 μ. Septa essentially plane and number 8 to 10 in 1st volution, 13 to 15 in 2nd, 15 in 3rd, 13 to 16 in 4th, 15 to 16 in 5th, 15 to 16 in 6th, 16 to 18 in 7th, 18 to 19 in 8th, and about 19 in 9th. Few axial septula appear as early

as 1st volution in some specimens, with maximum of 1 septulum per chamber in first 2 whorls, 2 in 3rd and 4th, 3 in 5th, and 4 from 6th whorl outward. Distal margins of axial septula are usually consolidated, with secondary deposits in ends of alveoli.

Proloculus rather large for members of this genus, its outside diameter measuring 109 to 242 μ. Row of small, rounded foramina present along distal margin of each septum from end to end of shell. Foramina alternate with moderately high, narrow parachomata which number 2 or 3 in 1st volution, 5 or 6 in 2nd, 7 to 9 in 3rd, 10 to 13 in 4th, 16 to 18 in 5th, 19 to 21 in 6th, 23 to 26 in 7th, 25 to 31 in 8th, 32 to 33 in 9th, 36 to 38 in 10th, 38 to 43 in 11th, 44 in 12th, and 45 in 13th.

Thin primary transverse septulum is positioned directly above each parachoma, and distal margins of septula joined to tops of parachomata to form partitions which subdivide meridional chambers into rectangular chamberlets. Small, rounded lateral foramina pierce these partitions to provide lateral communication within shell. These foramina are located immediately behind and in front of each septum. Very short secondary transverse septula first appear in 8th volution, usually with only 1 between adjacent primary septula, but from 11th whorl outward 2 may occur.

We have a single microspheric specimen (Pl. 42, figs. 6, 9) which apparently belongs to this species. It has 12.5 volutions and measures about 7.20 mm. in length and 2.30 mm. in diameter. Its proloculus has an outside diameter of only 50 microns, and first 2 whorls are discoidal and coiled askew to later ones.

Discussion.—Thompson, Wheeler & Danner figured 4 specimens of *Yabeina gracilis* Skinner & Wilde, n. sp., as *Y. minuta* Thompson & Wheeler, but its larger form ratio and larger proloculus readily distinguish it from that species. *Y. gracilis* is similar to *Y. cylindrica* Skinner & Wilde, n. sp., but it differs from the latter in its smaller size, smaller form ratio, and fewer volutions.

Occurrence.—We have found this species in collections BC-1, BC-3, BC-5, BC-10, and BC-13.

Illustrations.—Plate 42, figures *1-9*.——Fig. *1*. Axial section of holotype, ×10.——Figs. *2, 3*. Axial sections of paratypes, ×10.——Figs. *4, 5*. Sagittal sections of paratypes, ×10.——Fig. *6*. Axial section of microspheric paratype, ×10. ——Fig. *7*. Specimen shown in *2*, ×20.——Fig. *8*. Specimen shown in *5*, ×20.——Fig. *9*. Specimen shown in *6*, ×20. [*1, 2, 4, 7* from collection BC-1; *3* from collection BC-13; *5, 8* from collection BC-3; *6, 9* from collection BC-5.] [All figures are unretouched photographs.]

YABEINA DUNBARI Skinner & Wilde, n. sp.

Yabeina? n. sp., Thompson, Wheeler, & Danner, 1950, Cushman Found. Foram. Res., Contrib., v. 1, p. 62, pl. 8, figs. 8-10.

Shell moderate in size, inflated fusiform, with slightly concave to slightly convex lateral slopes and bluntly pointed poles. Mature specimens have 13 to 15 volutions and measure 6.60 to 8.50 mm. in length and 5.00 to 5.90 mm. in diameter. Form ratio varies from 1.29 to 1.57.

Spirotheca composed of tectum and finely alveolar keriotheca, in 12th whorl its thickness measuring 16 to 23 μ. Septa thin and essentially plane. They number about 8 in 1st whorl, 10 in 2nd, 13 in 3rd, 16 in 4th, 15 in 5th, 17 in 6th, 18 in 7th, 19 in 8, 19 in 9th, 20 in 10th, 23 in 11th, 28 in 12th, 27 in 13th, 27 in 14th, and 28 in 15th. Axial septula present in 1st volution with maximum of 1 septulum per chamber in 1st whorl, 2 in 2nd and 3rd, 3 in 4th, 4 in 5th to 8th, 5 in 9th, and as many as 6 in outermost whorls. Tips of septula are usually consolidated, with secondary material plugging ends of alveoli.

Proloculus very large for members of this genus, its outside diameter varying from 220 to 422 μ, averaging about 322 μ. Row of low, rounded foramina present along distal margin of each septum from pole to pole. Foramina alternate with high, narrow parachomata which number 4 to 5 in 1st whorl, 8 to 9 in 2nd, 10 to 13 in 3rd, 16 to 19 in 4th, 19 to 24 in 5th, 24 to 26 in 6th, 28 to 29 in 7th, 31 in 8th, 34 to 37 in 9th, 36 to 39 in 10th, 43 to 46 in 11th, 46 to 49 in 12th, and about 51 in 13th.

Thin primary transverse septulum positioned directly above each parachoma, and distal margins of septula joined to tops of parachomata to form partitions which subdivide meridional chambers into rectangular chamberlets. Lateral communication within shell provided by small, rounded lateral foramina which pierce each such partition immediately behind and in front of each septum. Short secondary transverse septula first

appear in 6th volution. Only 1 secondary septulum between adjacent primary septula until 9th whorl is reached, after which there are commonly 2.

Discussion.—THOMPSON, WHEELER & DANNER figured 3 specimens of *Yabeina dunbari* SKINNER & WILDE, n. sp., as *Yabeina?* n. sp. It does not closely resemble any other known American species, its shape and large proloculus distinguishing it from all others. This species is named in honor of Dr. CARL O. DUNBAR.

Occurrence.—*Yabeina dunbari* is common in collections BC-1 and BC-5, and it occurs questionably in collection BC-10.

Illustrations.—Plate 43, figures *1-6.*——Fig. *1.* Axial section of holotype, ×10.——Figs. *2, 3.* Axial sections of paratypes, ×10.——Figs. *4, 5.* Sagittal sections of paratypes, ×10.——Fig. *6.* Part of axial section of paratype showing nature of transverse septula, ×40. [All from collection BC-1.] [All figures are unretouched photographs.]

YABEINA CYLINDRICA Skinner & Wilde, n. sp.

Shell moderately large, subcylindrical, with slightly convex lateral slopes and bluntly pointed poles. Mature specimens have 13 to 15 volutions and measure 9.20 to 10.40 mm. in length and 2.30 to 3.50 mm. in diameter. Form ratio varies from 2.97 to 3.28.

Thin spirotheca composed of tectum and finely alveolar keriotheca, in 12 volution its thickness measuring 14 to 20 μ. Septa thin and essentially plane. They number about 11 in 1st whorl, 17 in 2nd, 16 in 3rd, 15 in 4th, 18 in 5th, 16 in 6th, 19 in 7th, and 23 in 8th. Axial septula first appear in 2nd volution, with maximum of 1 septulum per chamber in 2nd and 3rd whorls, 2 in 4th, 3 in 5th, 4 in 6th, and 5 from 7th whorl outward. They are thin and their distal margins are usually consolidated.

Proloculus large for members of this genus, its outside diameter varying from 206 to 366 μ. Row of low, rounded foramina present along distal margin of each septum from pole to pole. Foramina alternate with high, narrow parachomata which number 2 to 4 in 1st whorl, 6 to 8 in 2nd, 10 to 12 in 3rd, 13 to 18 in 4th, 17 to 23 in 5th, 22 to 25 in 6th, 25 to 31 in 7th, 29 to 32 in 8th, 30 to 37 in 9th, 35 to 43 in 10th, 40 to 48 in 11th, 44 to 51 in 12th, 54 in 13th, 55 to 57 in 14th, and 62 in 15th.

Thin primary transverse septulum positioned directly above each parachoma, and distal margins of septula joined to tops of parachomata to form partitions which subdivide meridional chambers into rectangular chamberlets. Small, rounded lateral foramina pierce these partitions to provide lateral communication within shell. Foramina located immediately behind and in front of each septum. Short secondary transverse septula first appear in 5th whorl. Only 1 secondary septulum is present between adjacent primary septula until 9th whorl is reached, after which 2 are present in some specimens.

Discussion.—*Yabeina cylindrica* SKINNER & WILDE, n. sp., is similar to *Y. gracilis* SKINNER & WILDE, n. sp., but it differs from the latter in its larger size, larger form ratio, and more numerous volutions. It also resembles *Lepidolina toriyamai* KANMERA from Japan in general appearance, but it is much less advanced in its development than that species.

Occurrence.—We have found this species in collections BC-3, BC-5, and BC-10.

Illustrations.—Plate 44, figures *1-7.*——Fig. *1.* Axial section of holotype, ×10.——Figs. *2, 3.* Axial sections of paratypes, ×10.——Figs. *4, 5.* Sagittal sections of paratypes, ×10.——Fig. *6.* Specimen shown in *3*, ×20.——Fig. *7.* Specimen shown in *5*, ×20. [*1, 4* from collection BC-10; *2, 3, 6* from collection BC-5; *5, 7* from collection BC-3.] [All figures are unretouched photographs.]

YABEINA AMPLA Skinner & Wilde, n. sp.

Yabeina columbiana THOMPSON & WHEELER, *(partim)*, Jour. Paleontology, v. 16, p. 708-710, pl. 108, fig. 1 (*not* pl. 106, fig. 5; pl. 107, fig. 5; pl. 109, figs. 1-4).

Shell large, inflated fusiform, with convex lateral slopes and bluntly rounded poles. Mature specimens have 19.5 to 22 volutions and measure 10.40 to 12.70 mm. in length and 6.35 to 7.40 mm. in diameter. Form ratio varies from 1.55 to 1.79.

Thin spirotheca consisting of tectum and finely alveolar keriotheca, in 18th volution its thickness varying from 19 to 25 μ. Septa thin and essentially plane. Septal count for 1st to 18th whorls of typical specimen is 9, 13, 15, 15, 12, 13,

13, 14, 15, 16, 17, 18, 19, 21, 23, 25, 25, 23. Axial septula first appear in 3rd volution with maximum of 1 axial septulum per chamber in 3rd and 4th whorls, 2 in 5th and 6th, 3 in 7th, 4 in 8th, 5 in 9th, 6 in 10th, 7 in 11th and 12th, 8 in 13th and 14th, 9 in 15th, and 10 from 16th whorl outward. Distal margins of septula are consolidated, with secondary material plugging ends of alveoli.

Proloculus small, its outside diameter measuring 56 to 198 μ, averaging about 117 μ. Row of low, elliptical foramina present along distal margin of each septum from pole to pole. Alternating with foramina are thin, high parachomata which first appear in 2nd volution. They number about 2 in 2nd whorl, 4 in 3rd, 8 in 4th, 11 in 5th, 14 in 6th, 16 in 7th, 18 in 8th, 24 in 9th, 29 in 10th, 37 in 11th, 43 in 12th, 43 in 13th, 49 in 14th, 57 in 15th, 55 in 16th, 60 in 17th, and 66 in 18th.

Thin primary transverse septulum positioned directly above each parachoma, and distal margins of septula are joined to tops of parachomata to form partitions which divide meridional chambers into rectangular chamberlets. Lateral communication within shell is provided by small, rounded lateral foramina which pierce these partions immediately behind and in front of each septum. Secondary transverse septula first appear in 6th volution. There is only 1 secondary septulum between adjacent primary septula until 11th whorl is reached, after which there are commonly 2.

Discussion.—Thompson & Wheeler included 1 axial section of this species in their illustrations of *Yabeina columbiana* (Dawson). It differs from that species in its larger size, more numerous volutions, and the more numerous axial septula per chamber from 10th volution outward.

Occurrence.—*Yabeina ampla* occurs sparingly in collections BC-1, BC-3, and BC-5, and questionably in collection BC-10.

Illustrations.—Plate 45, figures *1-4*; Plate 46, figure *1*.——Pl. 45, fig. *1*. Axial section of holotype, ×10.——Pl. 45, figs. *2, 3*. Axial sections of paratypes, ×10.——Pl. 45, fig. *4*. Part of specimen shown in *2*, ×20. [*1* from collection BC-1; *2, 4* from collection BC-5; *3* from collection BC-3.]——Pl. 46, fig. *1*. Sagittal section of paratype, ×10. [From collection BC-3.] [All figures are unretouched photographs.]

YABEINA PARVULA Skinner & Wilde, n. sp.

The specimens included here fall into 2 groups which we believe represent megalospheric and microspheric forms, respectively, of a single species. The megalospheric form has, at maturity, 14 to 14.5 volutions and measures 4.80 to 5.20 mm. in length and 3.50 to 4.30 mm. in diameter. Form ratio varies from 1.21 to 1.37. The microspheric forms commonly have about 14.5 volutions, although exceptional specimens may have as many as 19. They measure 4.30 to 6.00 mm. in length and 3.80 to 4.90 mm. in diameter with form ratio varying from 1.13 to 1.22. First 2 to 2.5 whorls are discoidal and coiled askew to later ones. Both forms are highly inflated fusiform to subglobular in shape, with convex lateral slopes and bluntly pointed poles.

Spirotheca composed of tectum and finely alveolar keriotheca, in 10th whorl its thickness varying form 19 to 29 μ. Septa thin and essentially plane. Septal count for 1st to 10th whorls of typical specimen is 8, 14, 12, 13, 15, 18, 18, 18, 19, 18. Axial septula first appear in 3rd volution, with maximum of 1 axial septulum per chamber in 3rd and 4th whorls, 2 in 5th and 6th, 3 in 7th and 8th, 4 in 9th and 10th, and 5 from 11th whorl outward. The distal margins of the septula are usually consolidated, with secondary deposits plugging ends of alveoli.

Proloculus small in megalospheric form, its outside diameter measuring 121 to 193 μ. Outside diameter of proloculus in microspheric form varying from 36 to 72 μ. Row of low, rounded foramina present along distal margin of each septum from pole to pole. Foramina alternate with high, thin parachomata which number 3 to 4 in 1st volution, 6 to 7 in 2nd, 10 in 3rd, 11 to 13 in 4th, 14 in 5th, 17 in 6th, 21 in 7th, 23 to 25 in 8th, 28 to 31 in 9th, 30 to 34 in 10th, 32 to 37 in 11th, 36 in 12th, and 40 in 13th. This count is for the megalospheric form. Parachomata first appear in 2nd volution in microspheric form. Parachomata count for 2nd to 13th whorls of a typical microspheric specimen is 2, 5, 8, 11, 14, 19, 21, 22, 26, 28, 31, 31.

Primary transverse septulum positioned directly above each parachoma and distal margins of septula joined to tops of parachomata to form partitions which divide meridional chambers into rectangular chamberlets. Lateral communication within shell is provided by small, rounded lateral

foramina which pierce these partitions immediately behind and in front of each septum. Short secondary transverse septula first appear in 6th volution. There is only 1 secondary septulum between adjacent primary septula until 10th whorl is reached, after which there are commonly 2.

Discussion.—*Yabeina parvula* is similar to *Y. minuta* THOMPSON & WHEELER; it differs from the latter in its more inflated shape, smaller form ratio, thicker septula, less numerous axial septula per chamber outward from 6th whorl, and somewhat thicker spirotheca. In general, *Y. parvula* is a more primitive species than *Y. minuta*.

Occurrence.—This species is abundant in collections BC-3 and BC-5.

Illustrations.—Plate 46, figures *2-11*; Plate 47, figures *1, 2*.——Pl. 46, fig. *2*. Axial section of holotype, ×10.——Pl. 46, figs. *3, 4*. Axial sections of megalospheric paratypes, ×10.——Pl. 46, figs. *5-7*. Axial sections of microspheric paratypes, ×10.——Pl. 46, figs. *8, 9*. Sagittal sections of megalospheric paratypes, ×10.——Pl. 46, figs. *10, 11*. Sagittal sections of microspheric paratypes, ×10. [All from collection BC-3.]——Pl. 47, fig. *1*. Axial section of holotype, shown in plate 46, figure 2, ×20.——Pl. 47, fig. *2*. Specimen shown in Pl. 46, fig. *5*, ×20. These are regarded as megalospheric and microspheric forms, respectively, of a single species. [Both from collection BC-3.] [All figures are unretouched photographs.]

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PART 8

ALASKANELLA, NEW PERMIAN FUSUILINID GENUS

ABSTRACT

Alaskanella, a new fusulinid genus from the lower Permian of Alaska, is described. A second species is described from extreme western Yukon.

INTRODUCTION

During the summers of 1958 and 1959 Dr. L. R. LAUDON examined the lower Permian sections exposed on the north side of the north fork of the Tatonduk River, about three miles east of the Alaska-Yukon boundary northwest of Dawson, and along the lower reaches of the Nation River northwest of Eagle, Alaska (Fig. 10). Numerous fusulinid collections were made from the Tatonduk section, and a single fusulinid collection was obtained from the Nation River exposure.

According to LAUDON (personal communication) the fossiliferous rocks in the Tatonduk exposure represent the upper part of the Nation River Formation of older reports, overlain by the Tahkandit Limestone. He stated, "The lower part of the Nation River contains several thousand feet of relatively unfossiliferous conglomerates, grits, silts, and shales. A massive chert conglomerate is present in the middle part all through the area, and this fauna begins immediately above this conglomerate. The fossils are distributed abundantly through some 1,700 feet of strata."

Fusulinid-bearing samples from this section were submitted to us for identification. They proved to be undescribed species of *Schwagerina* whose evolutionary development strongly suggests a Wolfcampian (Early Permian) age. The section from which they were obtained consists largely of clastic rocks with intercalated limestone lenses. Many of these limestones are limonitic or glauconitic, and all of them are more or less clastic. Fragments of bryozoans and crinoid columnals are abundant in most of them.

This section is overlain, probably unconformably, by the Tahkandit Limestone. Concerning the latter LAUDON stated, "The Tahkandit Limestone, some 900 feet in thickness here, is predominantly chert. I estimate that more than 60 percent of the rock on the surface exposures is chert. It may be largely secondary, but at least it is chert now. The rest is brown dolomite and various types of dolomitic limestone. We found no fusulines."

From a gravel bar in the bed of the north fork of the Tatonduk River at the foot of this exposed section LAUDON collected a number of fusulinid-bearing cobbles. Most of them can be matched with collections made in place from the section between the "massive chert conglomerate" and the Tahkandit limestone, but one, which is literally filled with *Alaskanella yukonensis* SKINNER & WILDE, n. sp., has not been found *in situ*. There can be little doubt, however, that it came from the section below the Tahkandit Limestone.

The Nation River collection came from a cobble which was picked up on the west bank of the Nation River just upstream from the confluence of Hardluck Creek and the river, and about 100 feet downstream from an outcrop of the Tahkandit Limestone. According to LAUDON "It very obviously came from one of the Tahkandit limestone beds that are exposed in that area. The Tahkandit Limestone exposed in the creek bed was directly and abruptly overlain by black, calcareous Triassic shales containing *Daonella*." The material is a brown calcareous siltstone which is literally filled with well-preserved specimens of *Alaskanella laudoni* SKINNER & WILDE, n. sp. From this it appears that *A. laudoni* is slightly younger than *A. yukonensis*.

We wish to express our thanks to Dr. LOWELL R. LAUDON for supplying us with this interesting material and for giving us permission to quote some of his remarks regarding its occurrence. We also wish to thank the Humble Oil & Refining

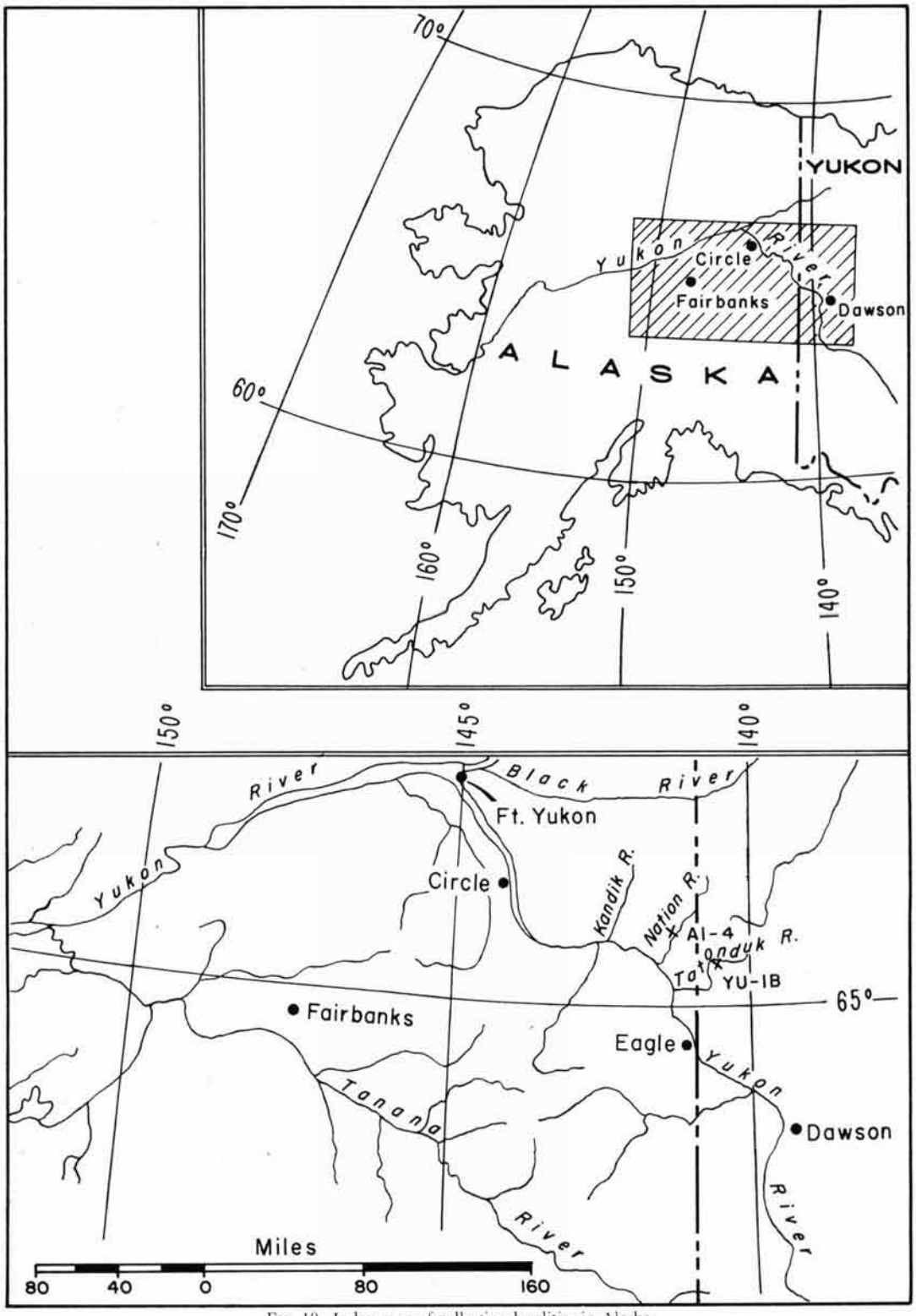

FIG. 10. Index map of collection localities in Alaska.

Company for permission to publish this paper. All figured specimens are deposited in the collections of the Humble Oil & Refining Company at Midland, Texas.

SYSTEMATIC PALEONTOLOGY

Genus ALASKANELLA Skinner & Wilde, n. gen.

Type species.—Alaskanella laudoni SKINNER & WILDE, n. sp.

Diagnosis.—Shell of medium size, slender, cylindrical to subcylindrical, with bluntly rounded poles. Mature individuals usually possess 5 to 8 volutions and are bilaterally symmetrical at all stages of growth. Proloculus of moderate size, its outside diameter ranging from 154 to 248 μ in specimens studied. Spirotheca thin and composed of tectum and moderately coarse keriotheca. Coiling tight and uniform throughout growth. Lower half of each septum strongly and regularly fluted from pole to pole, in axial sections producing uniformly semicircular septal loops which seldom exceed half height of chambers. Upper half of each septum essentially plane. Although opposed folds of adjacent septa meet and divide lower part of each chamber into rounded chamberlets, cuniculi have not been observed. Secondary deposits thicken septa near poles of outer volutions, producing narrow band of axial filling as seen in axial sections, but apparently are absent in inner whorls. Phrenothecae not observed. Tunnel about one-half as high as chambers, and in specimens studied tunnel angle varies from 49 to 67 degrees. Weak chomata present in early volutions, but replaced by pseudochomata in later ones.

Discussion.—Alaskanella more nearly resembles *Monodiexodina* SOSNINA than any other genus, differing from the latter principally in the absence of cuniculi and the much weaker development of axial filling. It differs from *Schwagerina* VON MÖLLER in its uniformly slender cylindrical shape, very regular but low septal fluting, and very thin spirotheca. It is distinguished from *Eoparafusulina* COOGAN by the absence of cuniculi.

Occurrence.—Lower Permian.

ALASKANELLA LAUDONI Skinner & Wilde, n. gen., n. sp.

Shell moderate in size, slender, cylindrical, with bluntly rounded poles. Mature individuals have 6 to 7.5 rather tightly and uniformly coiled volutions. Such specimens measure 7.81 to 8.40 mm. in length and 1.64 to 1.89 mm. in diameter. Form ratio varies from 4.46 to 5.33, averaging about 4.90.

Spirotheca thin and composed of tectum and moderately coarse keriotheca, with thickness in 6th whorl only 39 to 46 μ. Septa strongly and regularly fluted from pole to pole, but fluting affects only lower half of each septum, in axial sections producing semicircular septal loops about one-half as high as chambers. Septa number 9 to 10 in 1st volution, 12 to 13 in 2nd, 14 to 15 in 3rd, 15 to 17 in 4th, 18 to 21 in 5th, 20 to 22 in 6th, and about 22 in 7th. Phrenothecae not observed, but septal pores are abundant, particularly near poles. Although opposed folds of adjacent septa meet and divide lower part of each chamber into rounded chamberlets, cuniculi were not developed. Septa thickened by coating of secondary material near poles of outer volutions, as seen in axial sections producing narrow band of axial filling. These epithecal deposits are either absent or quite thin in early whorls.

Proloculus of moderate size, with outside diameter varying from 154 to 215 μ. Tunnel about one-half as high as chambers and tunnel angle measures 57 to 67 degrees in 6th volution. Weak chomata present in early whorls, but replaced by pseudochomata in later ones.

Discussion.—Alaskanella laudoni resembles *A. yukonensis* SKINNER & WILDE, n. sp., but differs from the latter in its larger size, more nearly cylindrical shape, and somewhat wider tunnel. We know of no other species with which it might be confused. It is named for Dr. LOWELL R. LAUDON, who collected the material.

Occurrence.—This species is very abundant in a piece of Tahkandit Limestone picked up from the west bank of the Nation River just upstream from the confluence of Hardluck Creek and the river, and about 100 feet downstream from an outcrop of the Tahkandit Limestone. This is our collection Al-4.

Illustrations.—Plate 48, figures *1-13*; Plate 49, figures *1-3*.——Pl. 48, fig. *1*. Axial section of holotype, ×10.——Pl. 48, figs. *2-5*. Axial sections of paratypes, ×10.——Pl. 48, figs. *6-8*. Sagittal sections of paratypes, ×10.——Pl. 48, figs. *9-11*. Tangential sections of paratypes, ×10.——Pl. 48, fig. *12*. Part of specimen shown in *5* showing wall structure and septal pores in polar region of shell, ×40.——Pl. 48, fig. *13*. Part of paratype, ×40.——Pl. 49, fig. *1*. Part of specimen shown in Pl. 48, fig. *10*, ×100. [In lower part of figure crushing has turned spirotheca so that alveoli are shown end on.]——Pl. 49, figs. *2, 3*. Parts of paratypes, ×100. [In fig. *3* alveoli are seen end on, showing honeycomb-like structure of keriotheca.] [All from collection Al-4.] [All figures are unretouched photographs.]

ALASKANELLA YUKONENSIS Skinner & Wilde, n. sp.

Shell rather small, slender, subcylindrical, tapering slightly from middle to bluntly rounded poles. Mature specimens have 5.5 to 6.5 tightly and uniformly coiled volutions. Such individuals measure 5.17 to 6.76 mm. in length and 1.20 to 1.31 mm. in diameter. Form ratio varies from 4.30 to 5.17, averaging about 5.00.

Thin spirotheca composed of tectum and moderately coarse keriotheca, with thickness of 36 to 45 μ in 5th whorl. Lower half of each septum strongly and regularly fluted from pole to pole, but upper part of septum essentially plane, in axial sections producing semicircular septal loops about one-half as high as chambers. Septa number 8 to 10 in 1st volution, 14 to 15 in 2nd, 14 to 15 in 3rd, 17 to 18 in 4th, and 19 to 21 in 5th. Phrenothecae absent, and septal pores, although present, small and inconspicuous. Opposed folds of adjacent septa touch near their lower margins, dividing lower part of each chamber into rounded chamberlets. Cuniculi, however, have not been observed. Rather heavy coating of secondary material thickens septa in polar regions of outer whorls, producing band of axial filling when seen in axial sections.

Proloculus moderate in size, with outside diameter ranging from 168 to 248 μ. Tunnel about one-half as high as chambers, and tunnel angle measures 49 to 55 degrees in 5th volution. Weak chomata present in early whorls replaced by pseudochomata in later ones.

Discussion.—*Alaskanella yukonensis* is similar to *A. laudoni* Skinner & Wilde, n. sp., but differs from the latter in its smaller size, more tapering shape, and narrower tunnel. It does not closely resemble any other described species.

Occurrence.—The specimens on which this species is based are very abundant in a cobble collected from a gravel bar in the bed of the north fork of the Tahtonduk River at the foot of a thick section of interbedded clastic rocks and limestones. According to Dr. L. R. Laudon, who collected the material, this clastic section corresponds to the upper part of the Nation River Formation of older reports. This is our collection Yu-1B.

Illustrations.—Plate 49, figures *4-9*.——Fig. *4*. Axial section of holotype, ×10.——Figs. *5, 6*. Axial sections of paratypes, ×10.——Figs. *7, 8*. Sagittal sections of paratypes, ×10.——Fig. *9*. Tangential section of paratype, ×10. [All from collection Yu-1B.] [All figures are unretouched photographs.]

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1-4. Yabeina ampla SKINNER & WILDE, n. sp. (p. 52).

PLATE 46

1. Yabeina ampla SKINNER & WILDE, n. sp. (p. 52).—*2-11. Y. parvula* SKINNER & WILDE, n sp. (p. 53).

PLATE 47

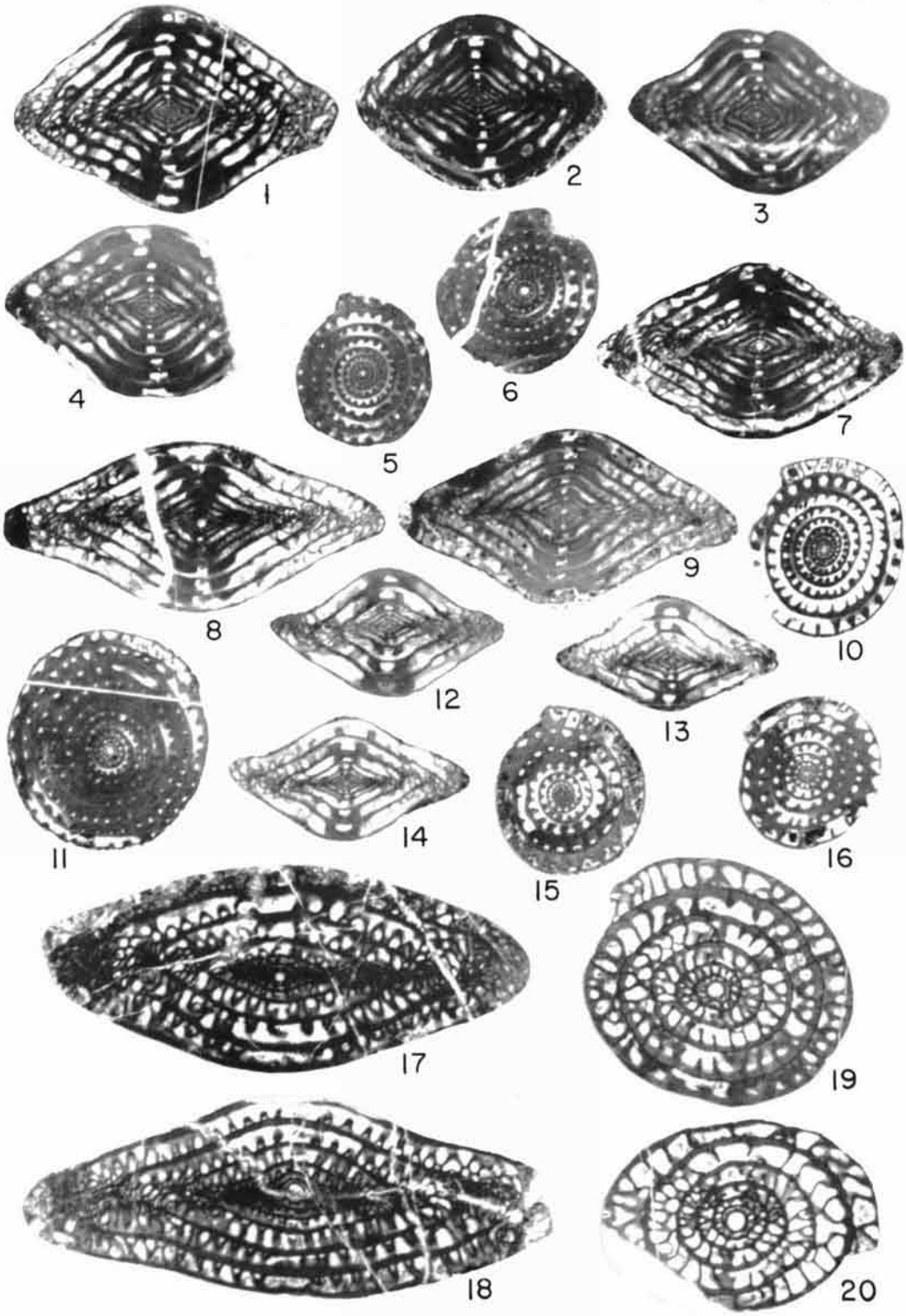
1, 2. Yabeina parvula SKINNER & WILDE, n. sp. (p. 53).

PLATE 48

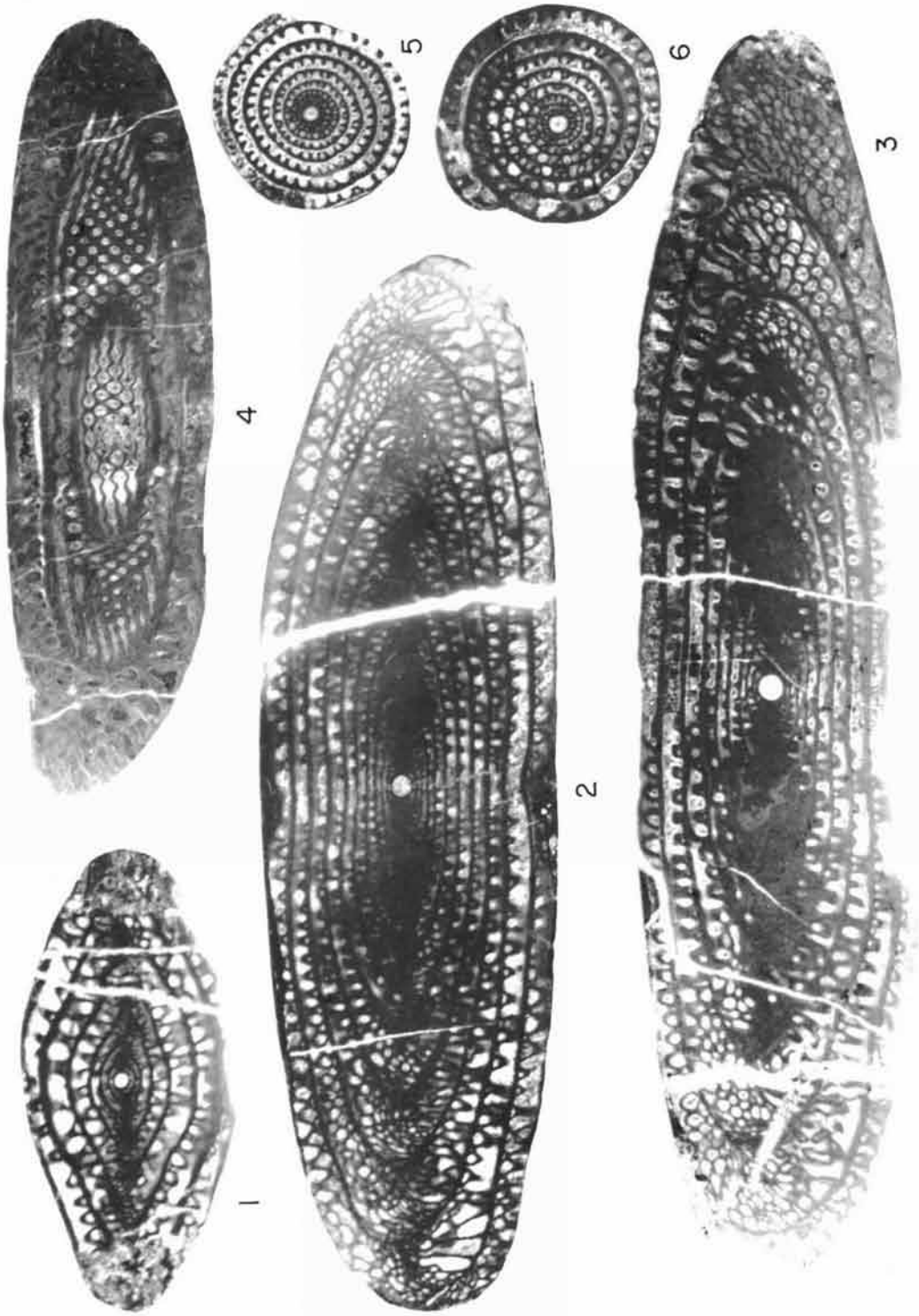
1-13. Alaskanella laudoni SKINNER & WILDE, n. gen., n. sp. (p. 57).

PLATE 49

1-3. Alaskanella laudoni SKINNER & WILDE, n. gen., n. sp. (p. 57).—*4-9. A. yukonensis* SKINNER & WILDE, n. gen., n. sp. (p. 58).

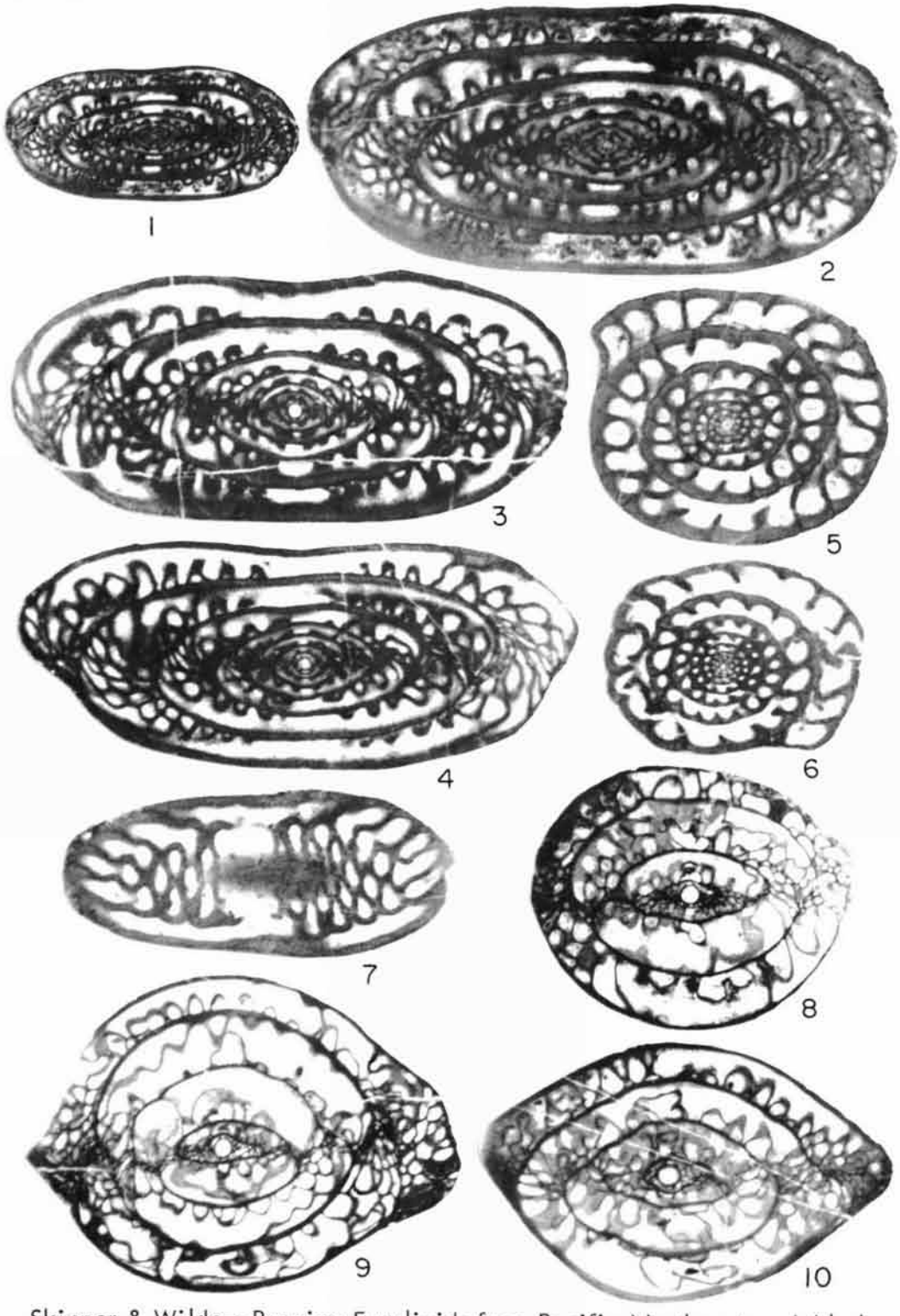


Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 1. Northwestern Nevada (Pseudofusulinella, 1-16; Schwagerina, 17-20)

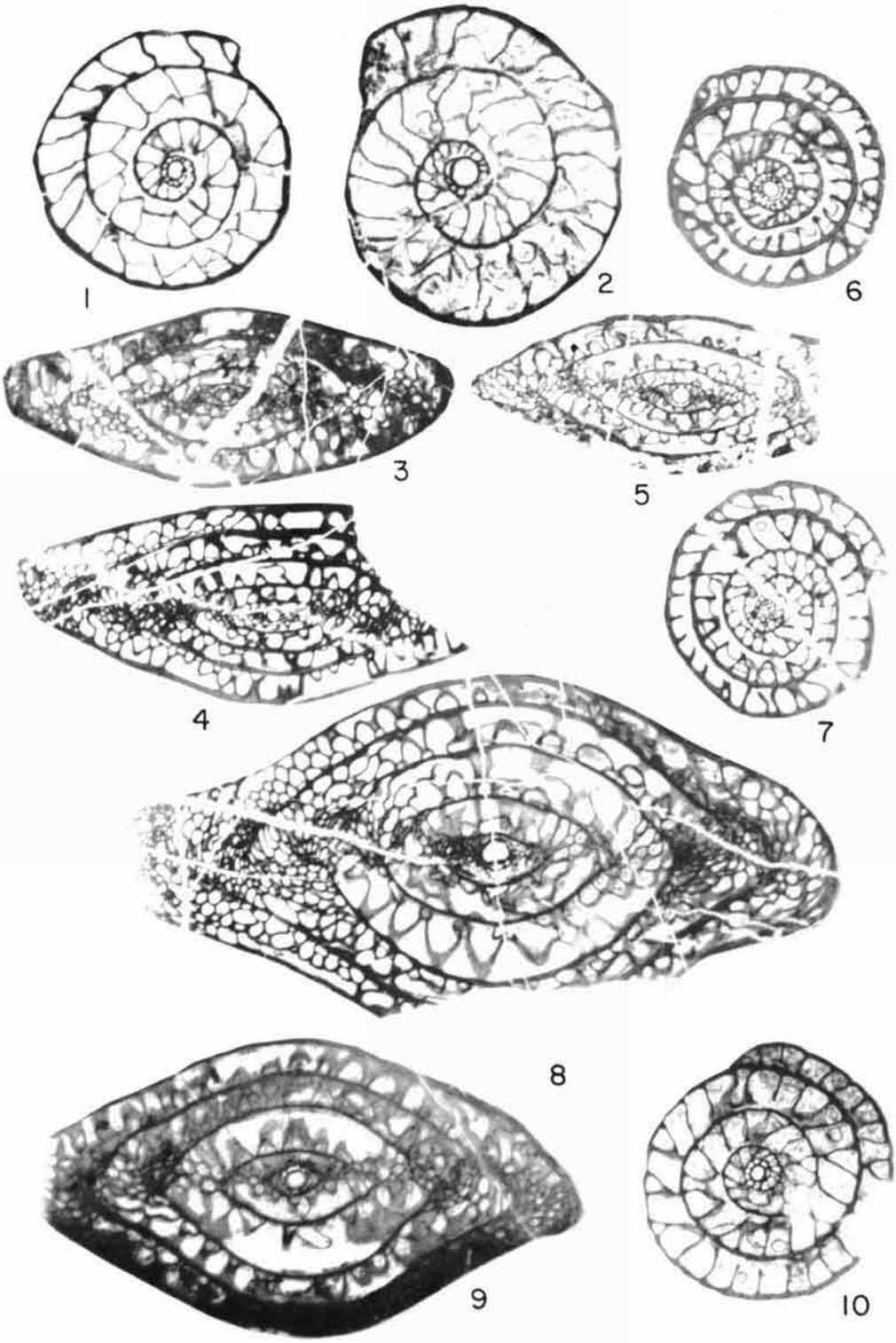


Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 1. Northwestern Nevada (Schwagerina, 1-6)

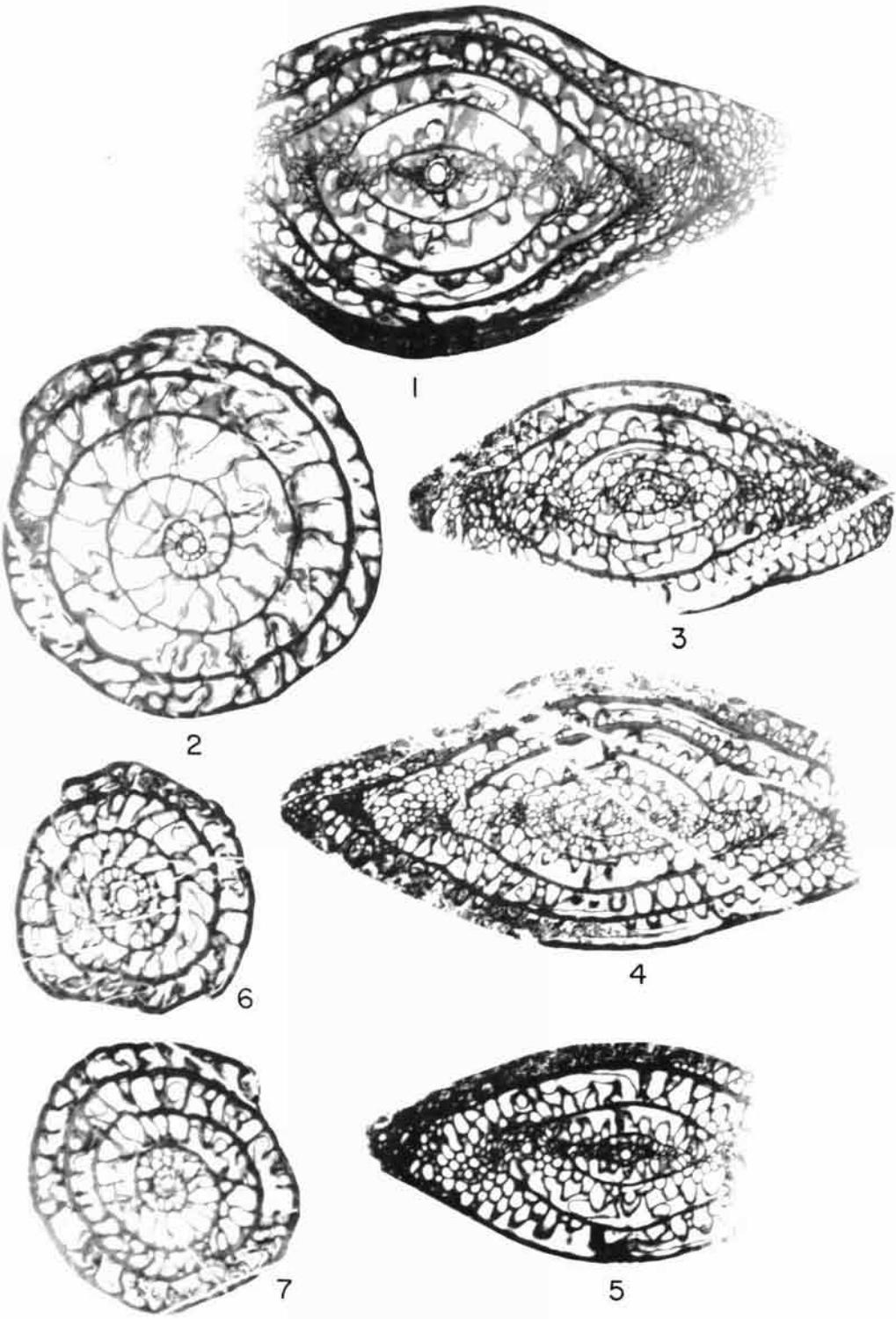
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 1. Northwestern Nevada (Schwagerina, 1; Eoparafusulina, 2-8)



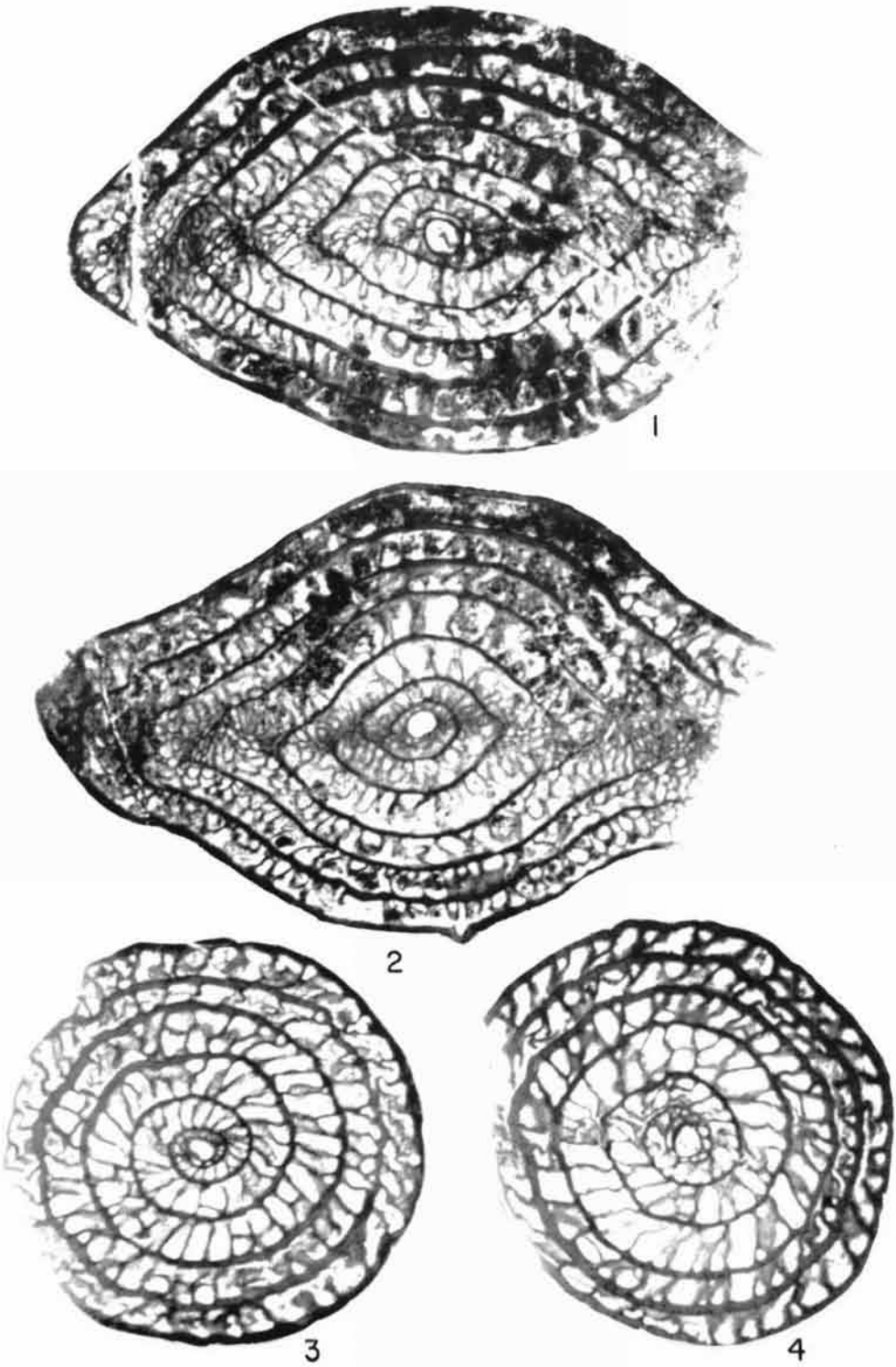
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 1. Northwestern Nevada (Eoparafusulina, 1-7; Chalaroschwagerina, 8-10)



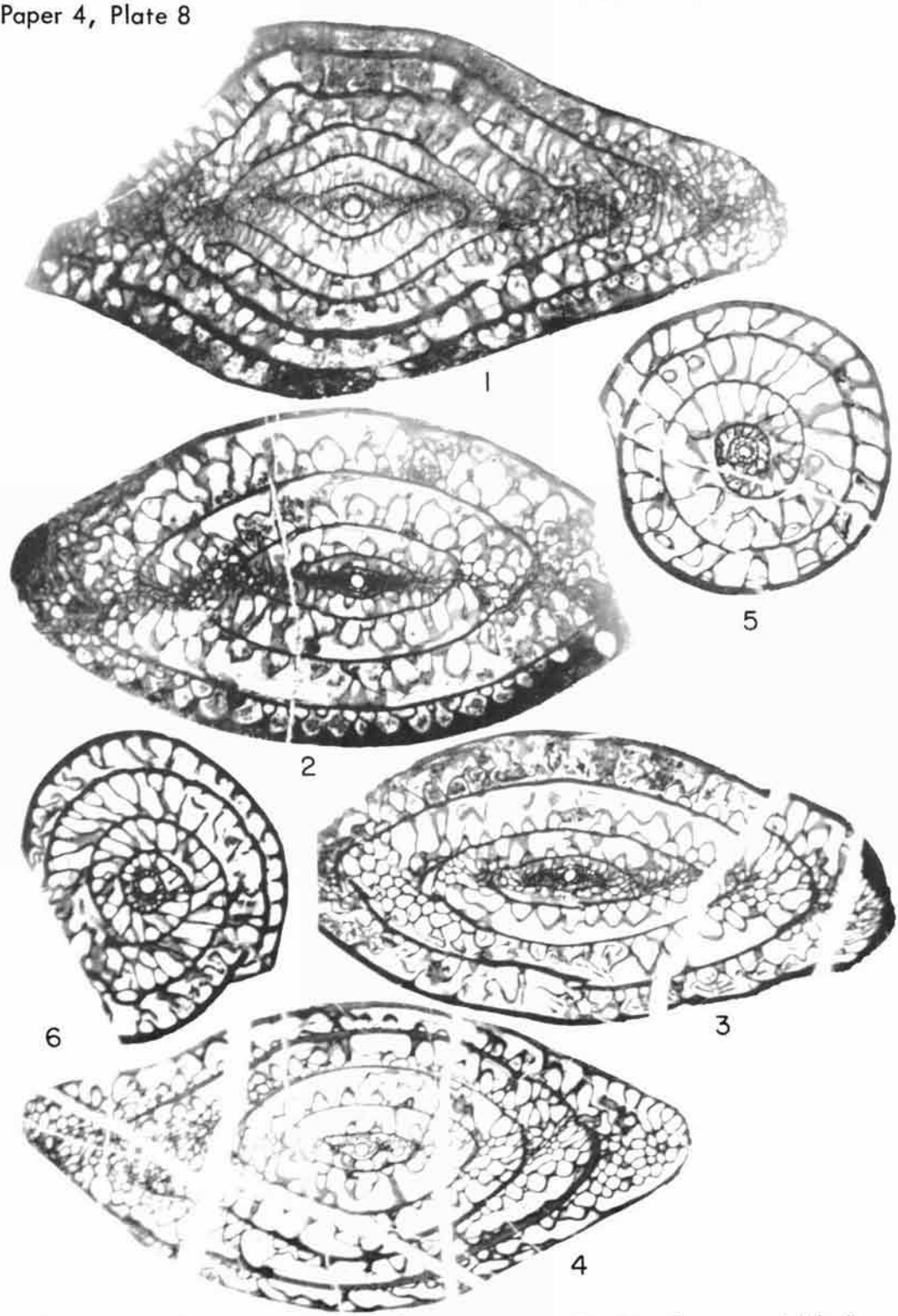
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 1. Northwestern Nevada (Chalaroschwagerina, 1-10)



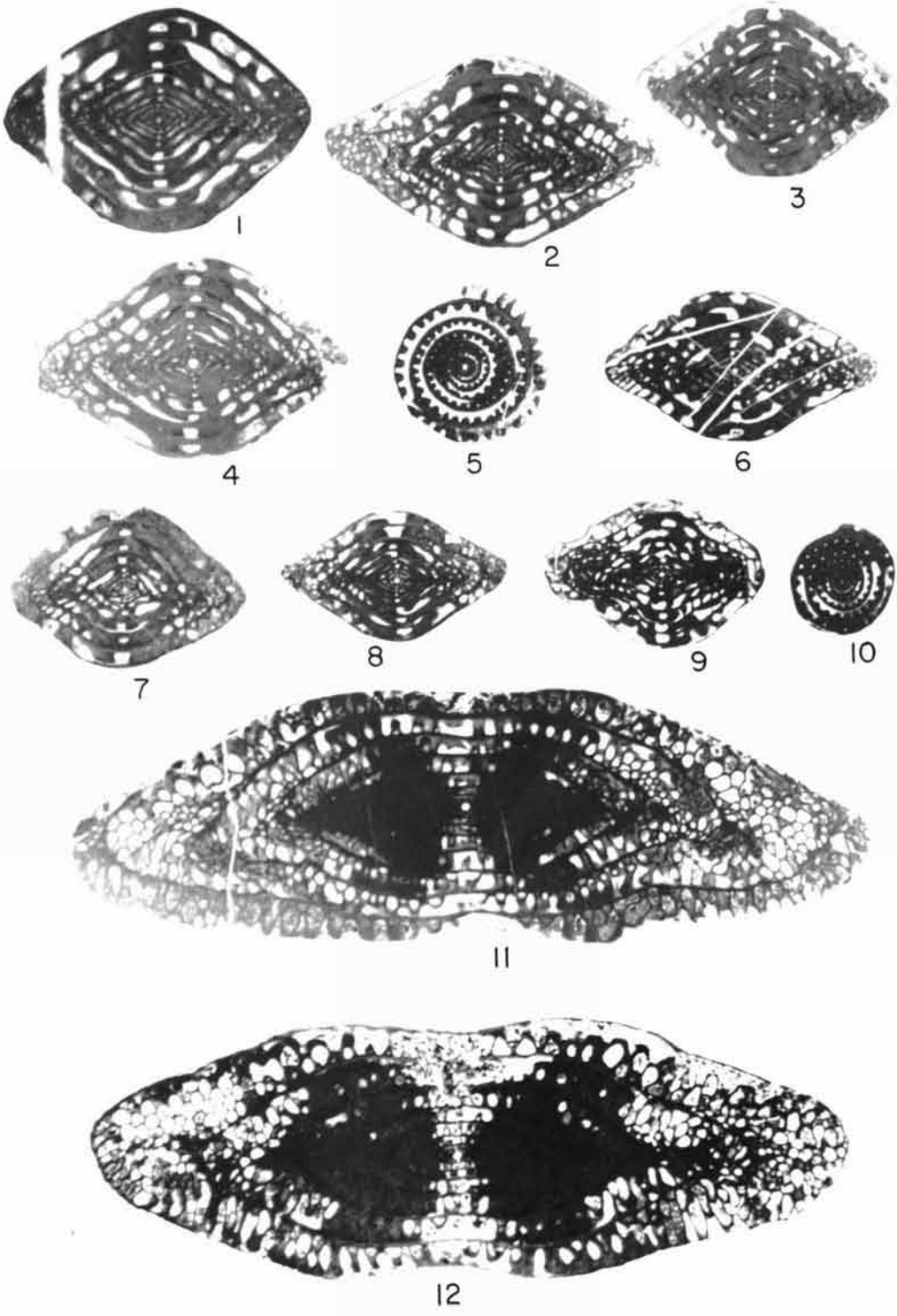
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 1. Northwestern Nevada (Chalaroschwagerina, 1-7)



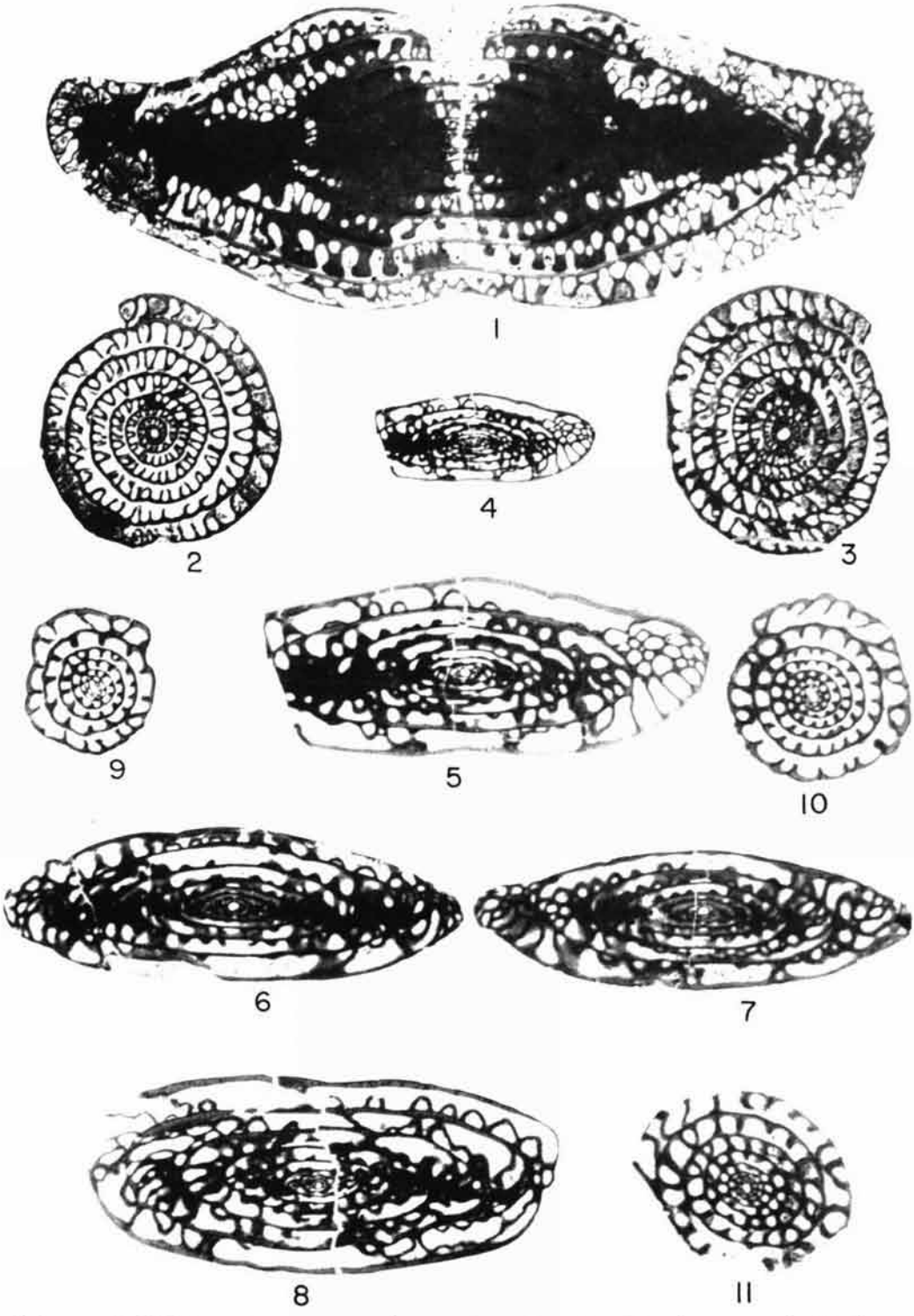
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 1. Northwestern Nevada (Chalaroschwagerina, 1-4)



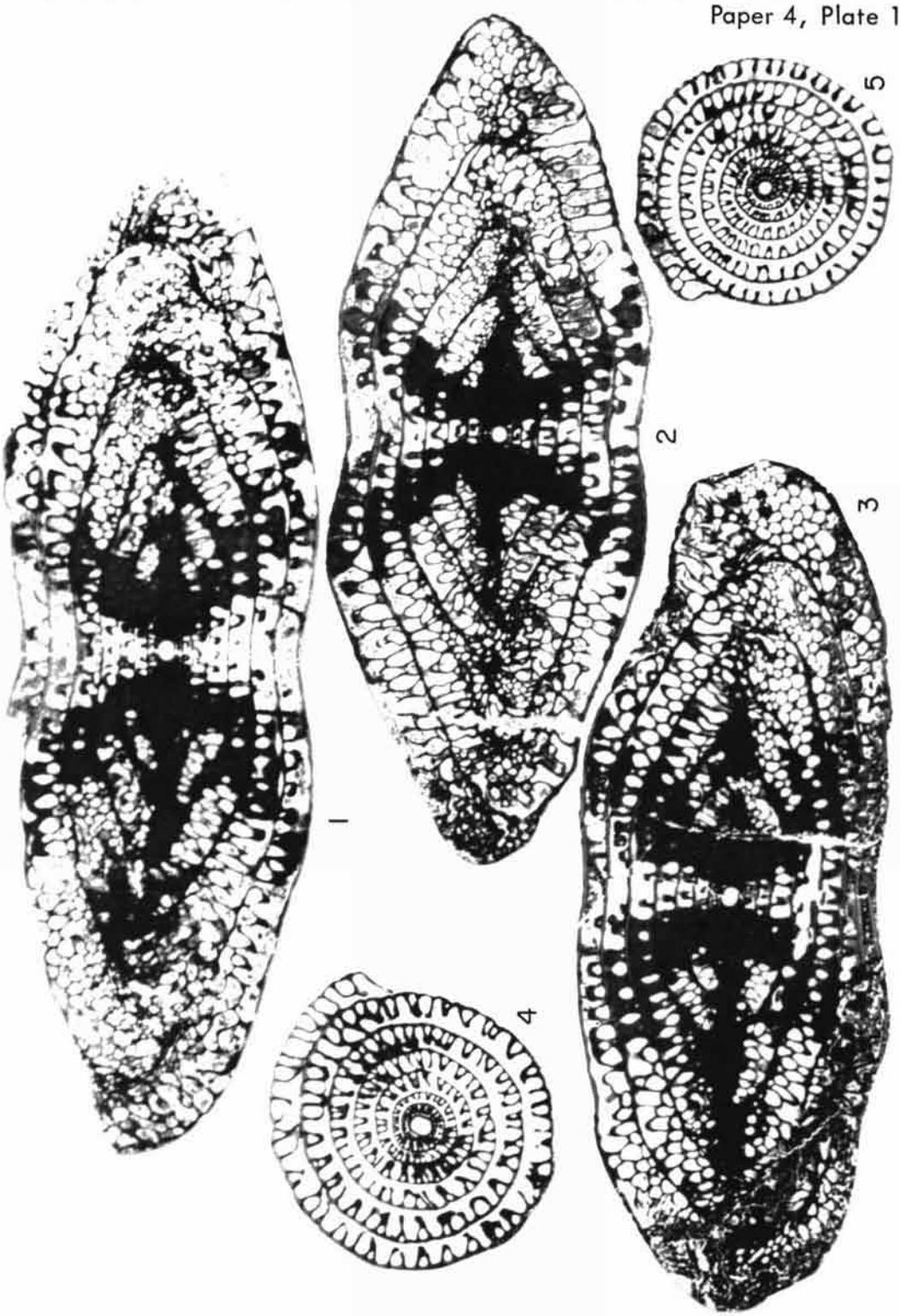
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 1. Northwestern Nevada (Chalaroschwagerina, 1-6)



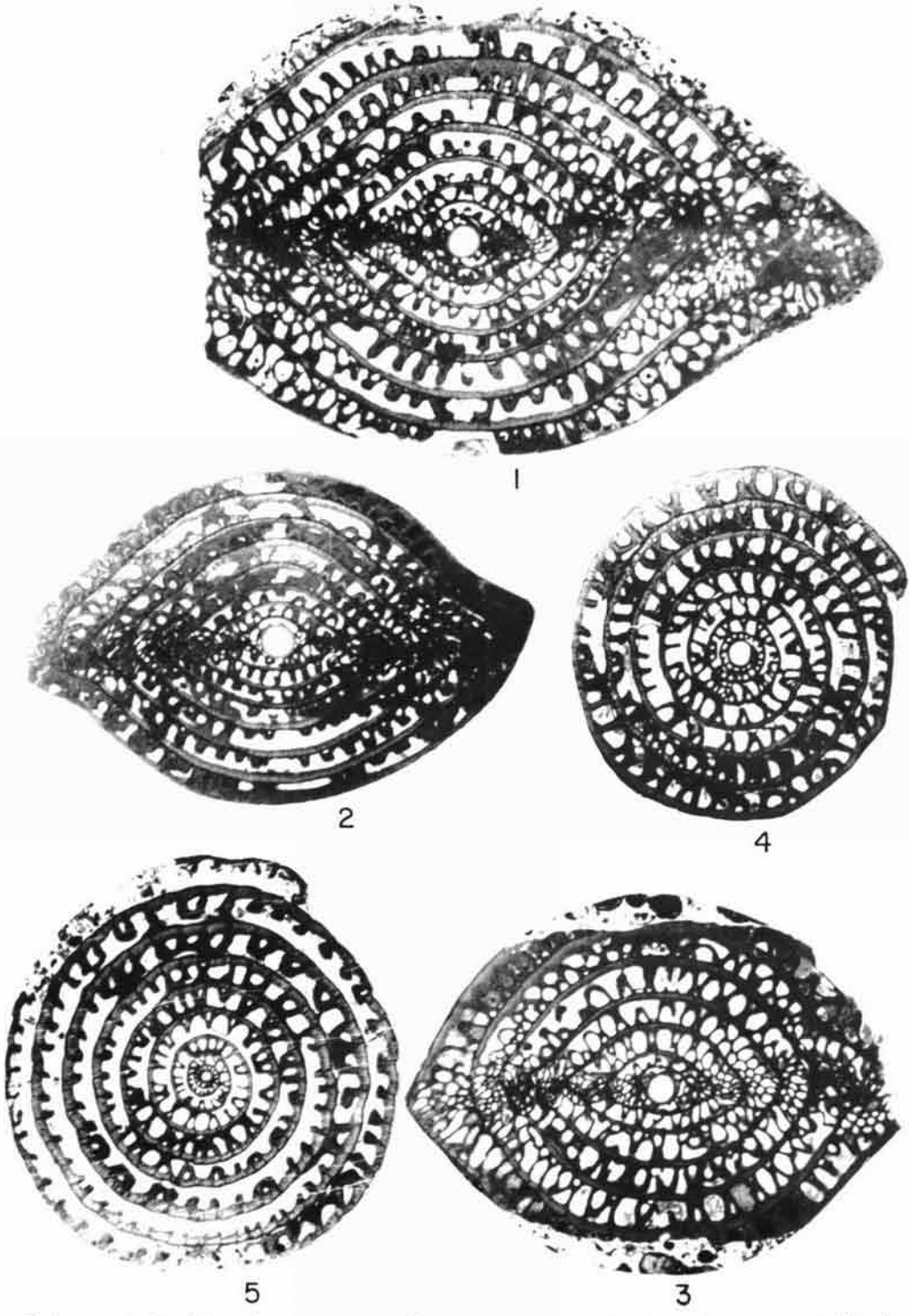
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 2. East-central Oregon (Pseudofusulinella, 1-10; Schwagerina, 11, 12)



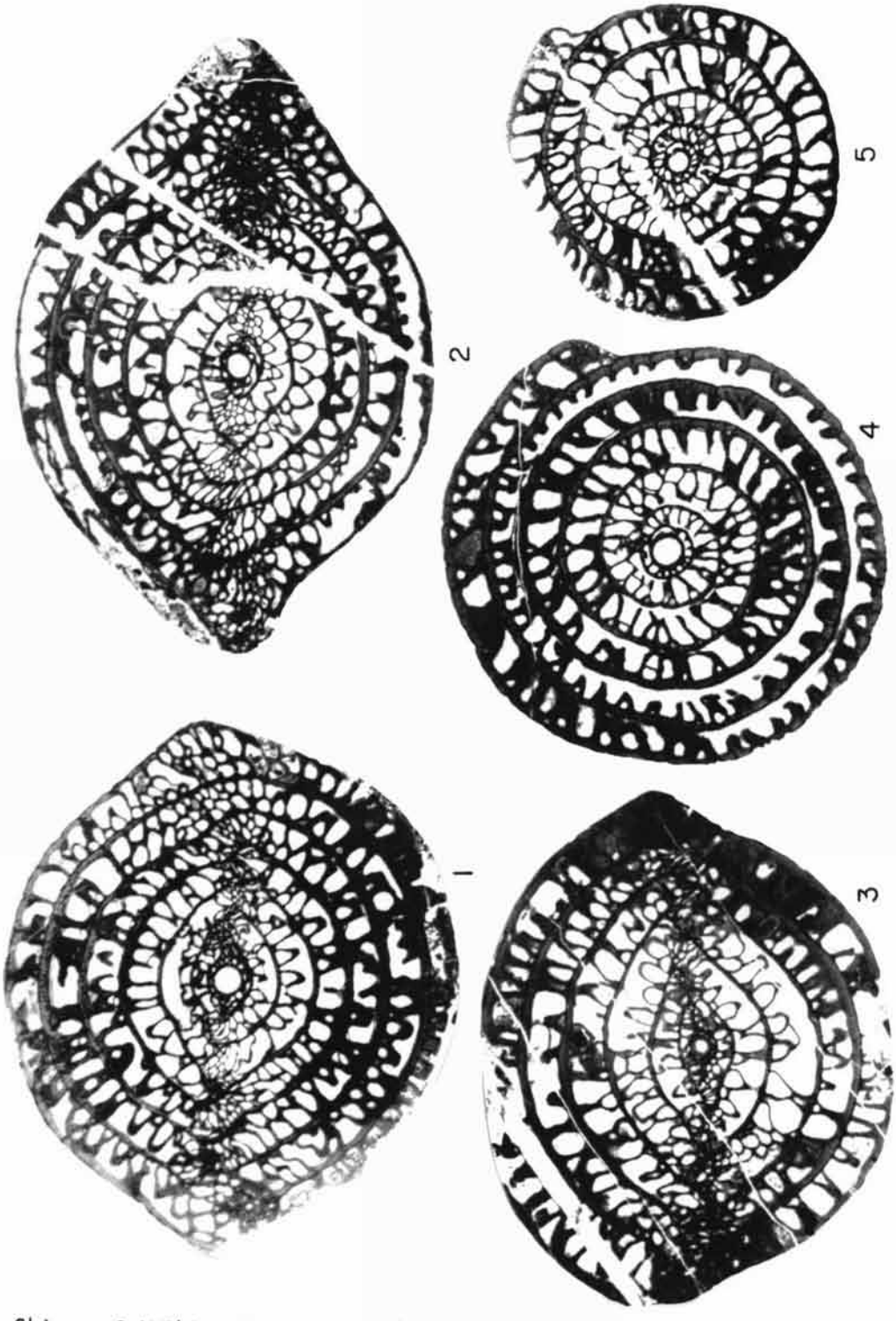
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 2. East-central Oregon (Schwagerina, 1-11)



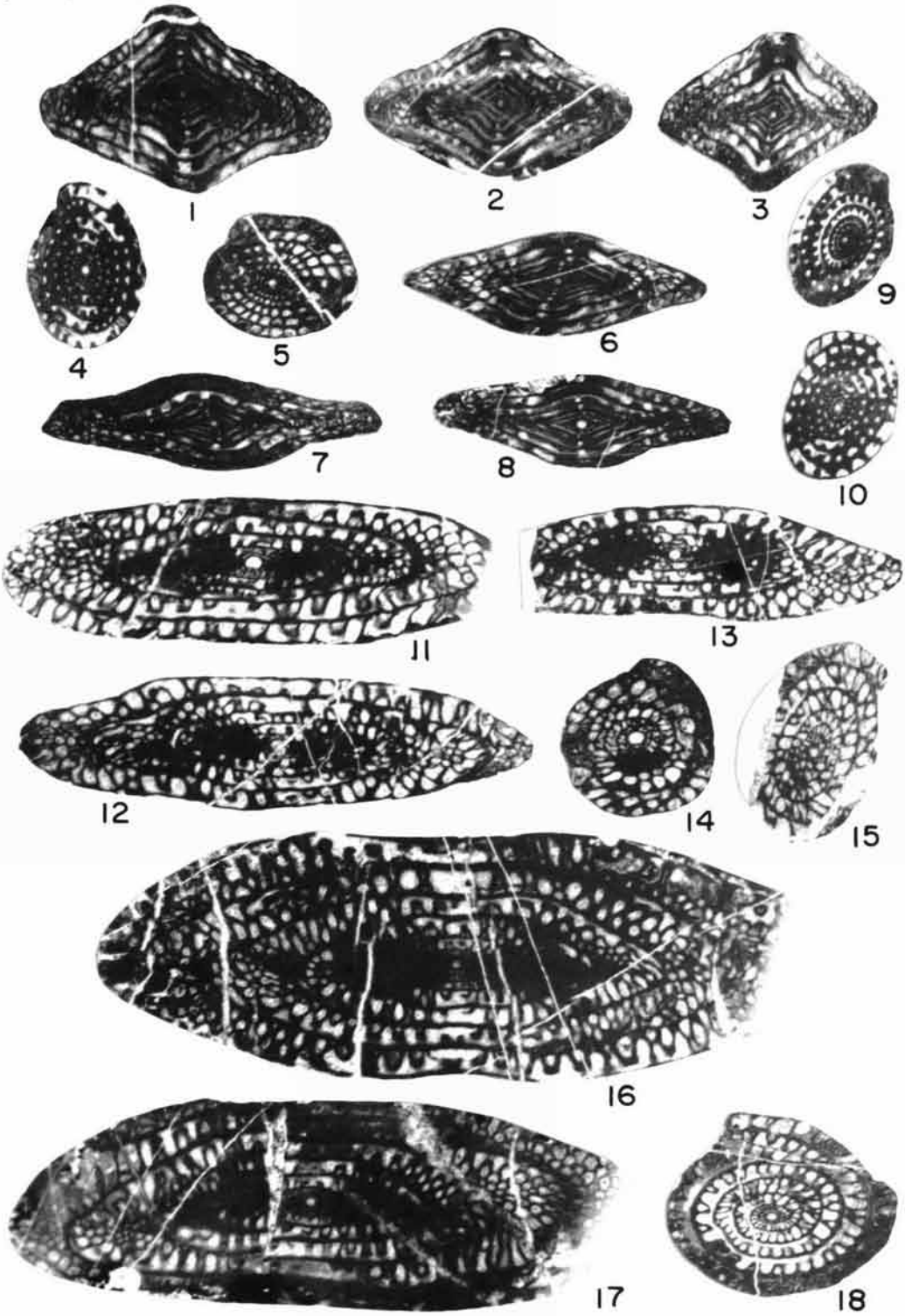
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 2. East-central Oregon (Schwagerina, 1-5)



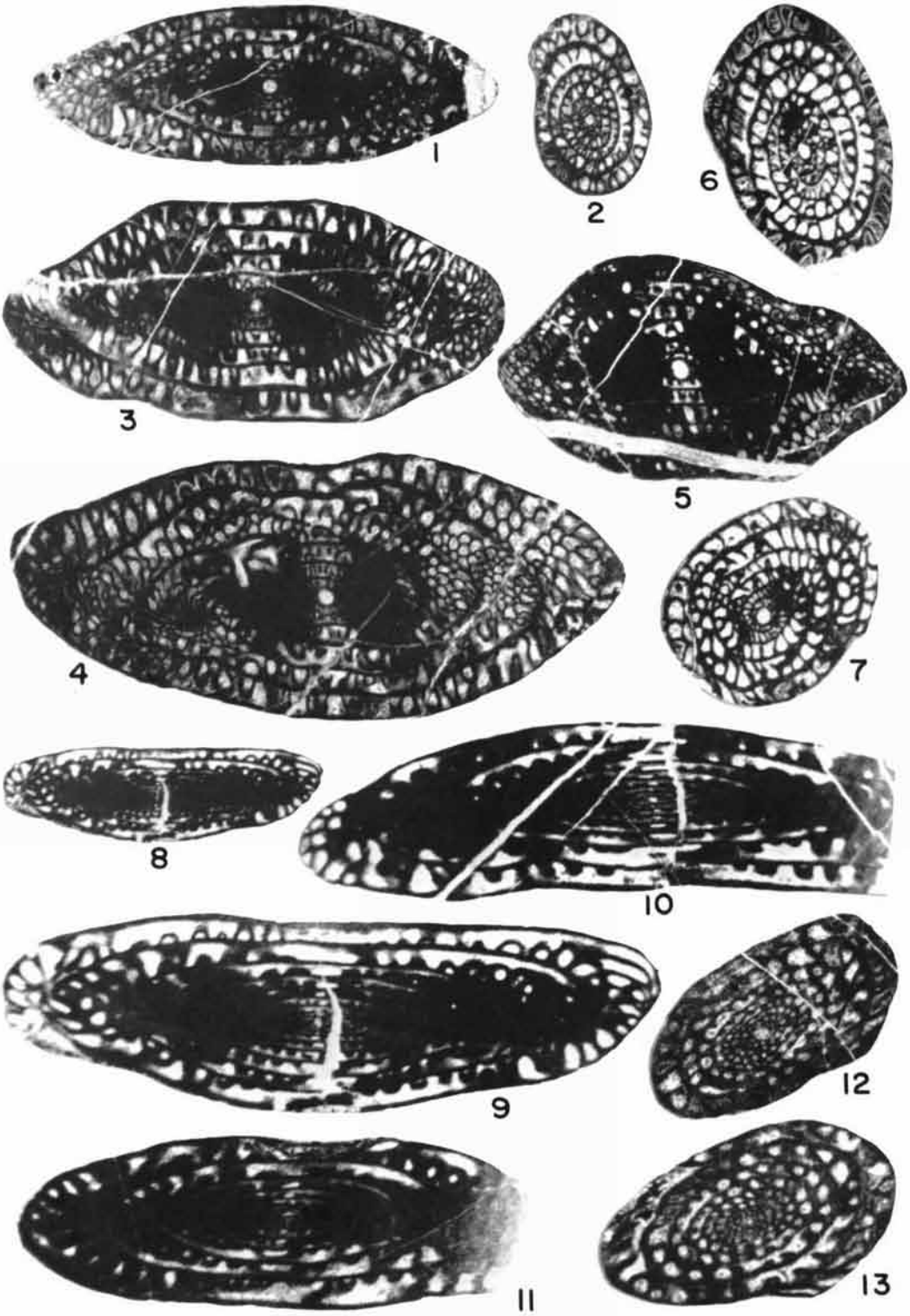
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 2. East-central Oregon (Schwagerina, 1-5)



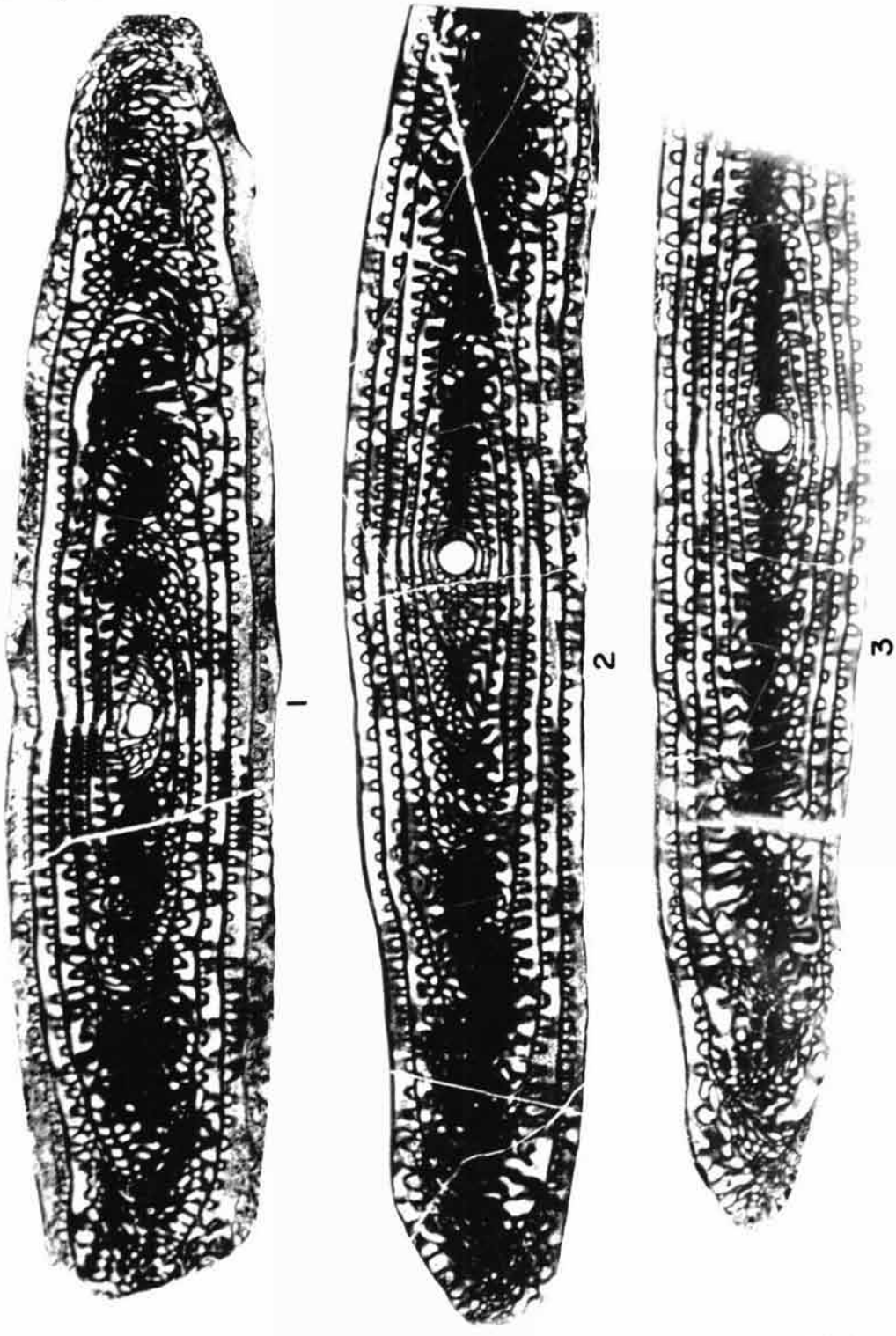
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 2. East-central Oregon (Chalaroschwagerina, 1-5)



Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 3. Northeastern Washington (Pseudofusulinella, 1-10; Schwagerina, 11-18)



Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 3. Northeastern Washington (Schwagerina, 1-13)



Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 3. Northeastern Washington (Parafusulina, 1-3)

1

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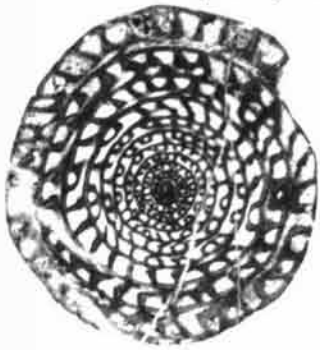

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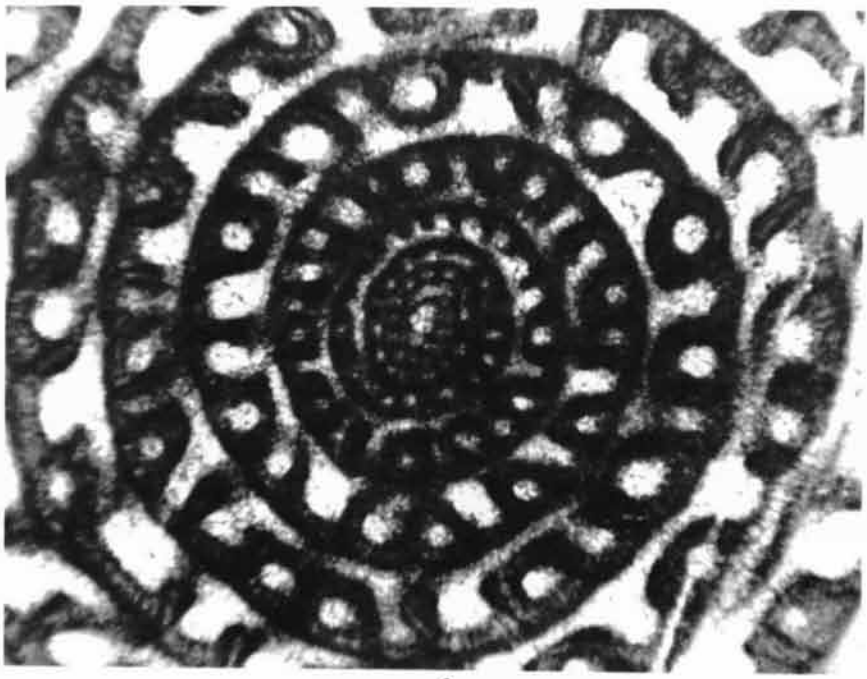

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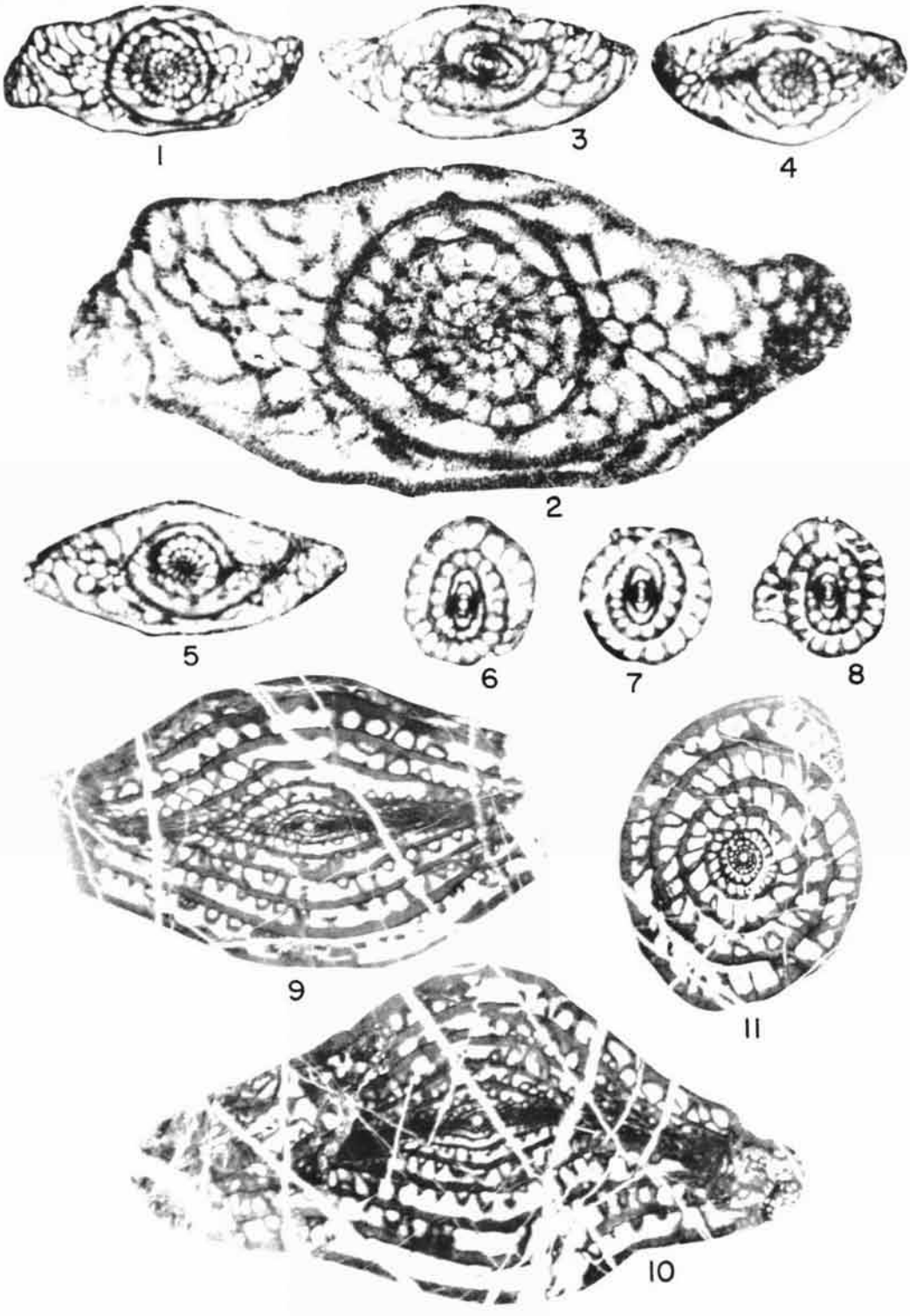
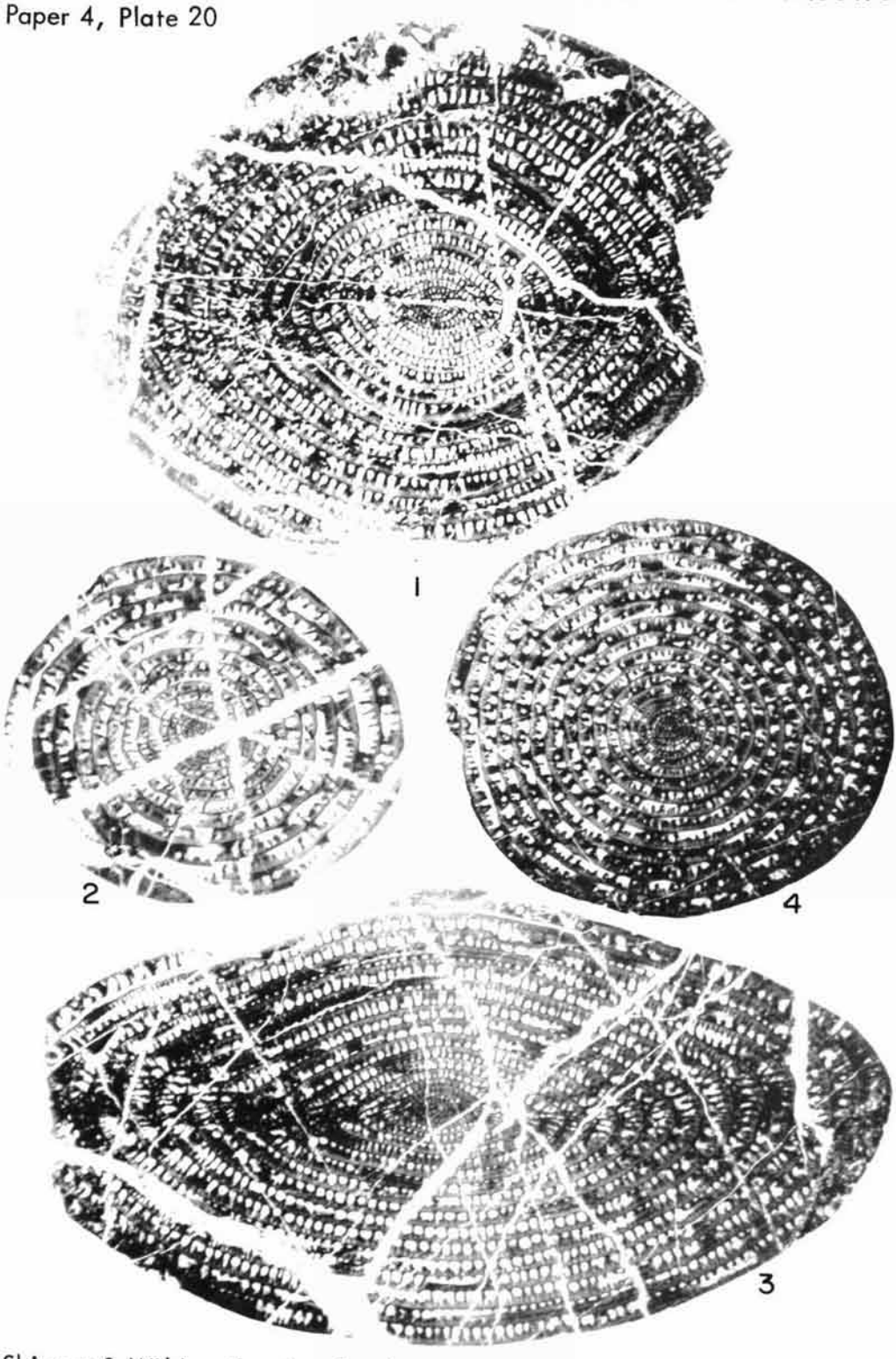
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 3. Northeastern Washington (Parafusulina, 1-5)

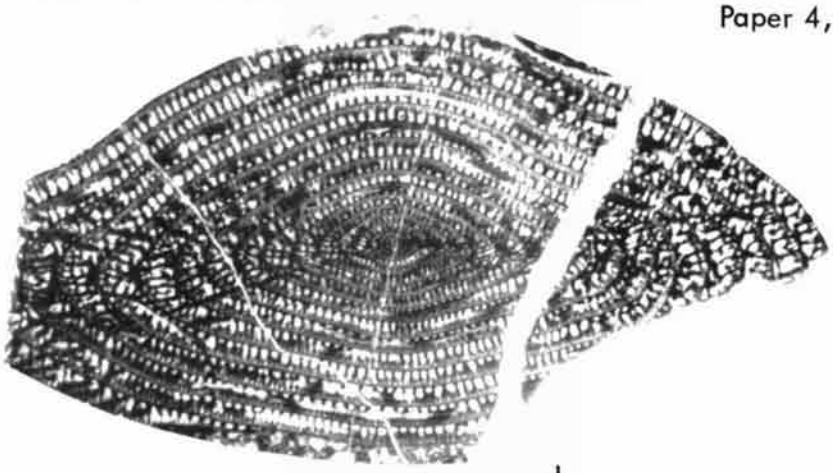


Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 4. Northwestern Washington (Dunbarula, 1-8; Schwagerina, 9-11)

Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 4. Northwestern Washington (Schwagerina, 1, 2; Yabeina, 3-5)



Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 4. Northwestern Washington (Yabeina, 1-4)



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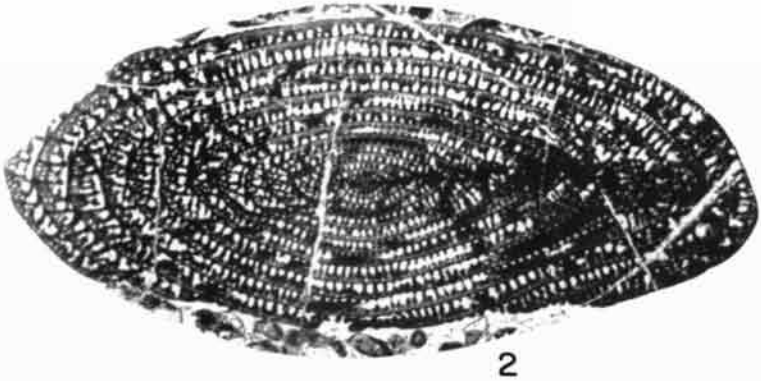

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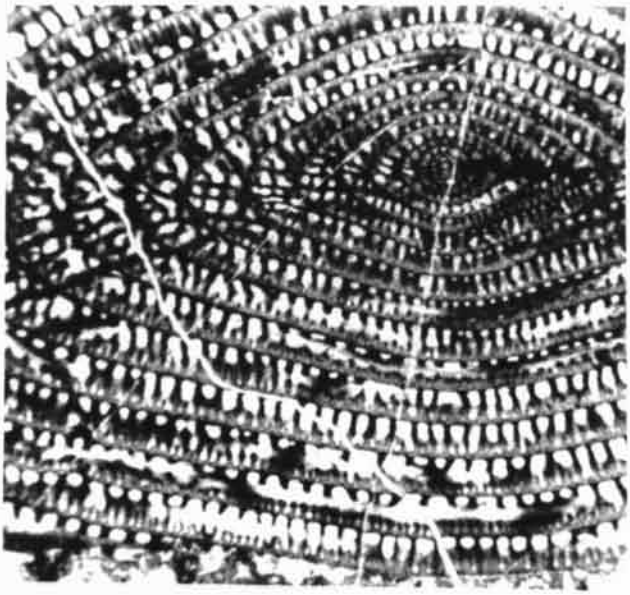

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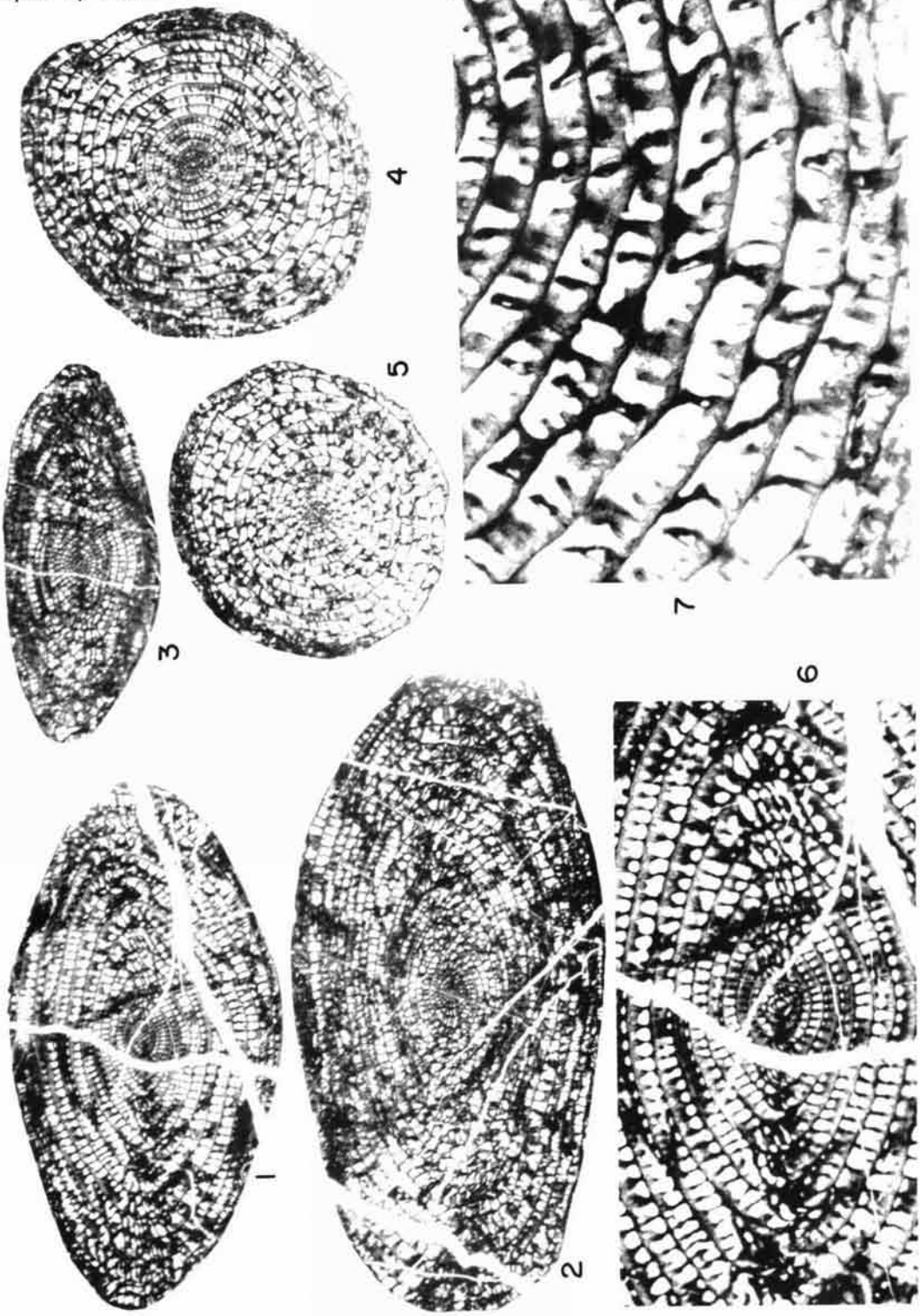
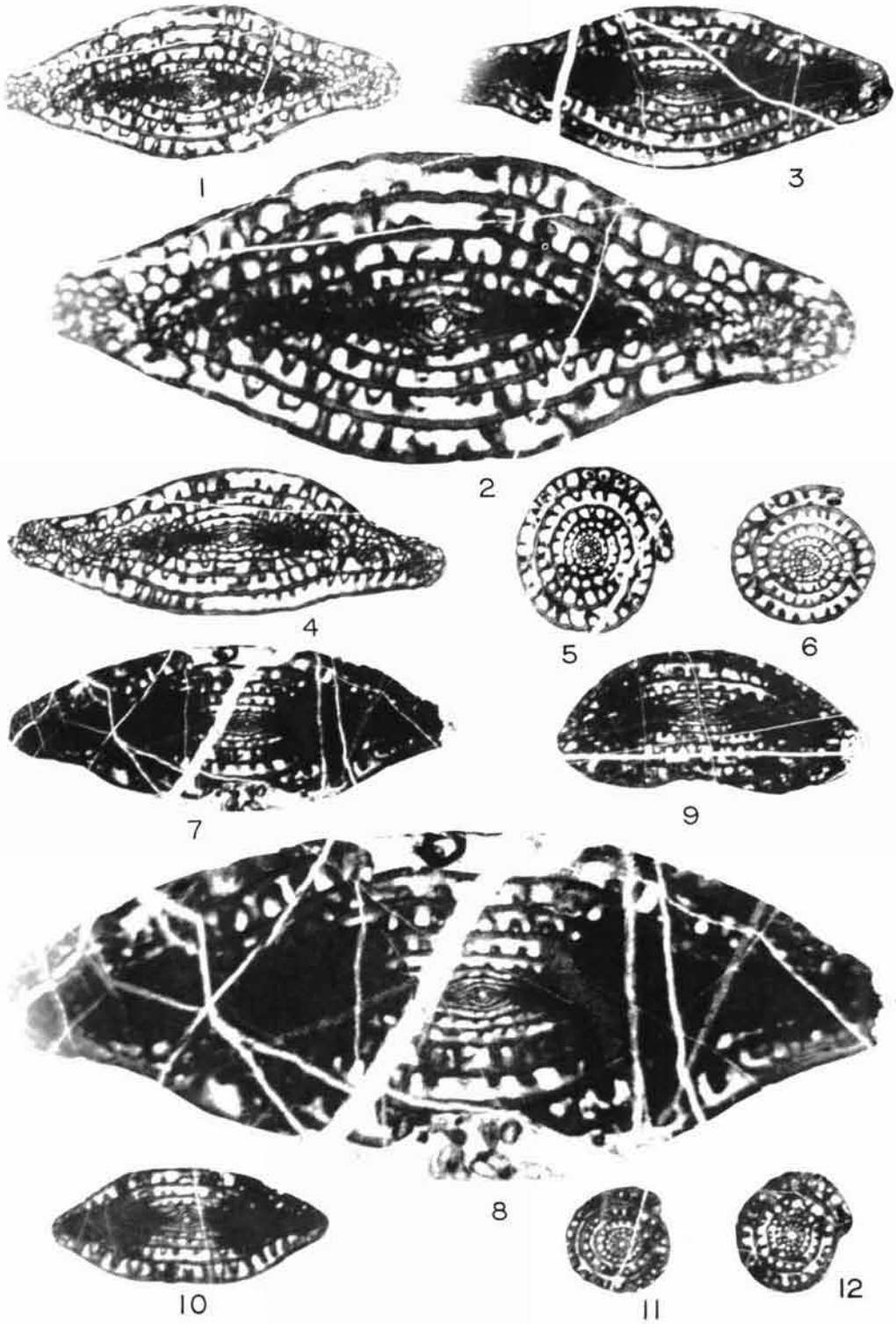
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 4. Northwestern Washington (Yabeina, 1-4)

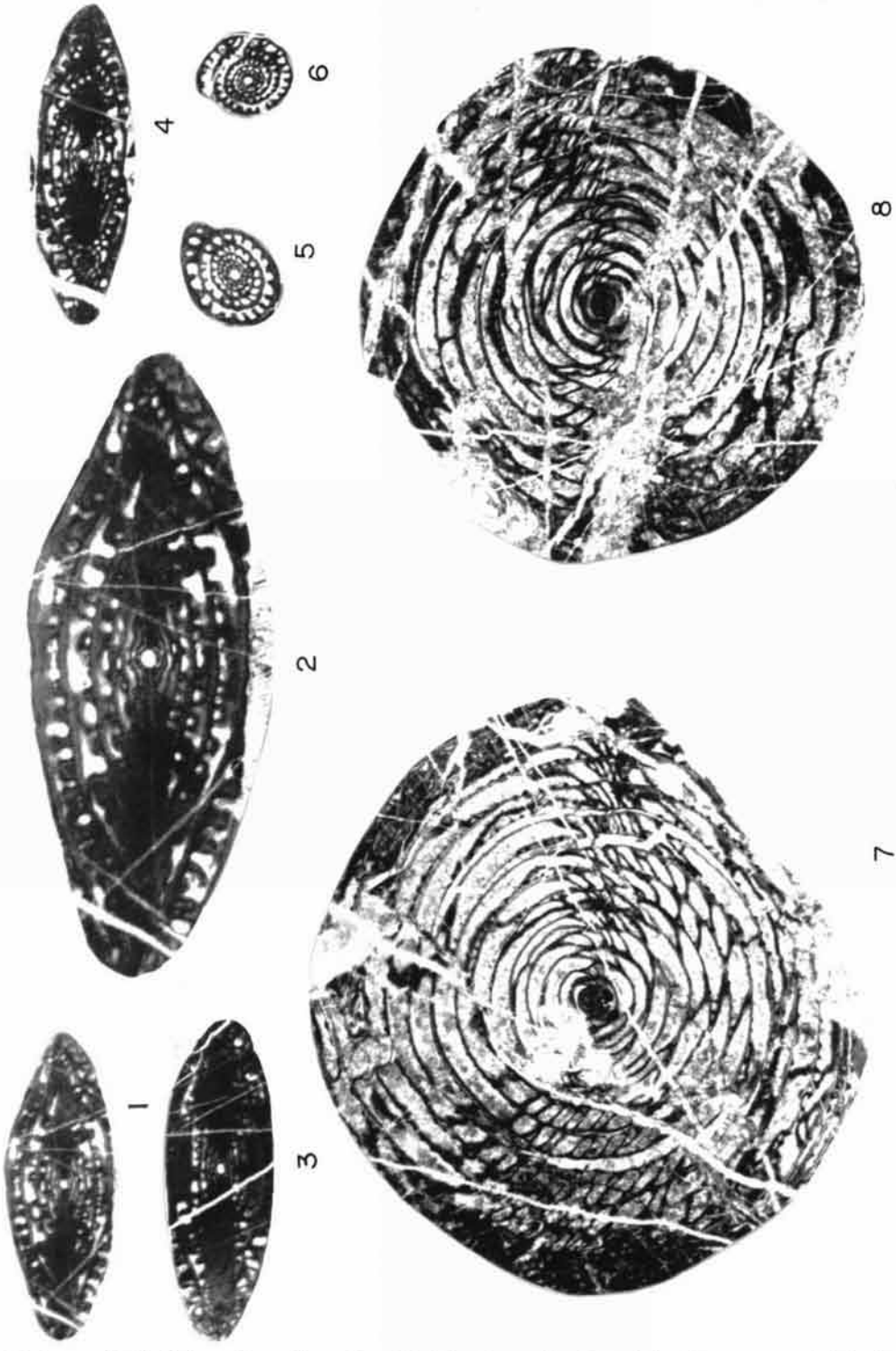


Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 4. Northwestern Washington (Yabeina, 1-7)

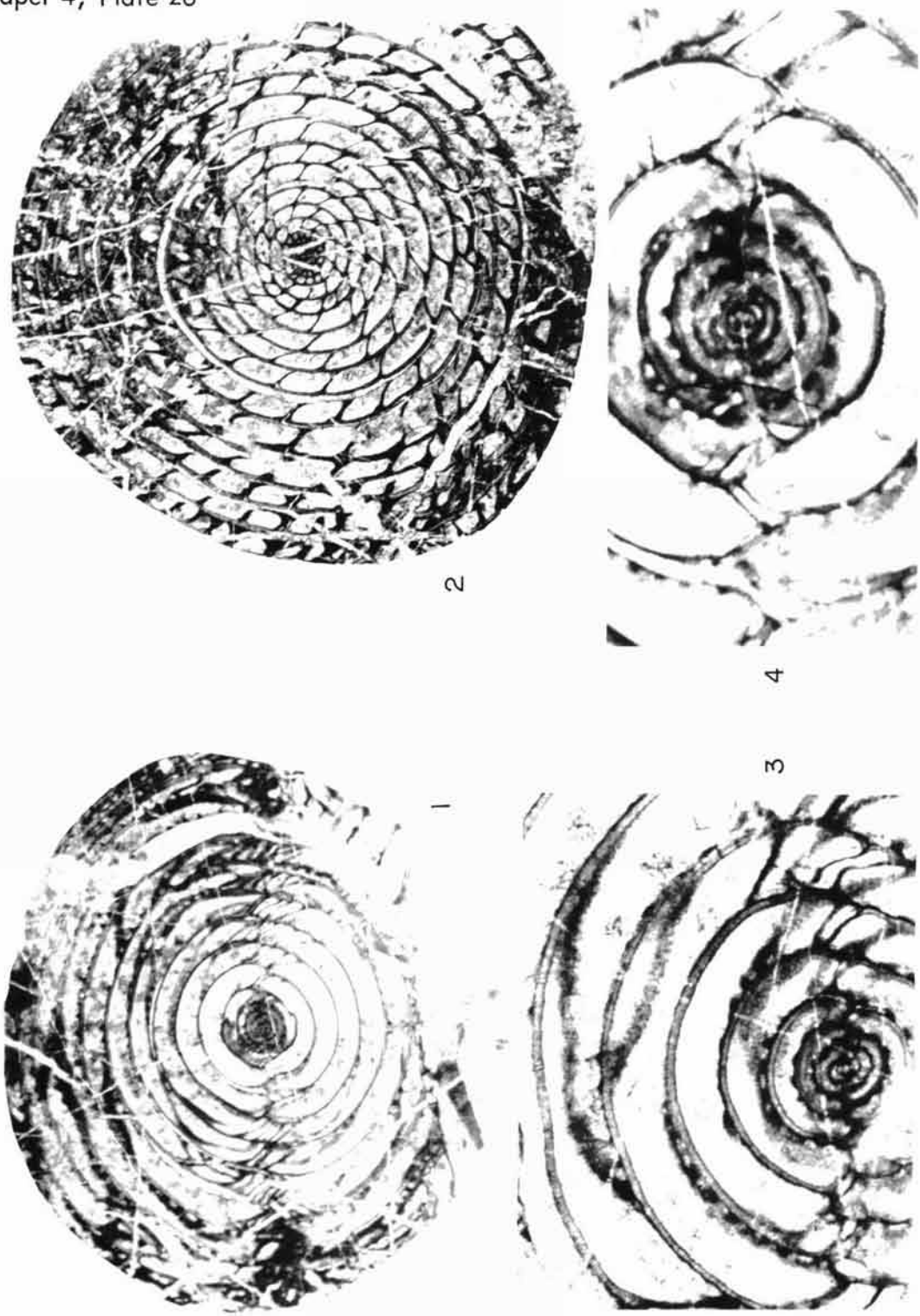
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Schwagerina, 1-5)



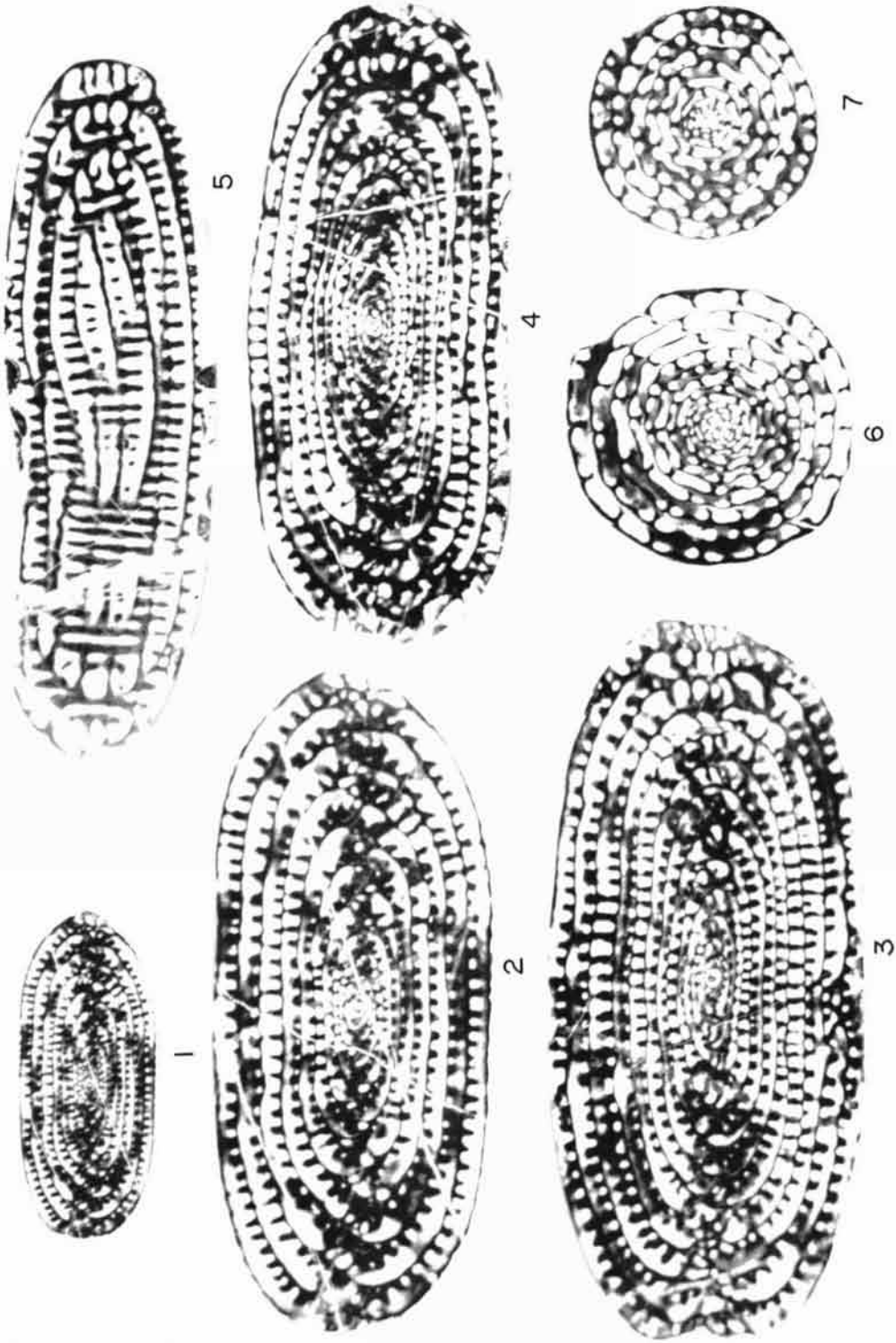
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Chusenella, 1-12)



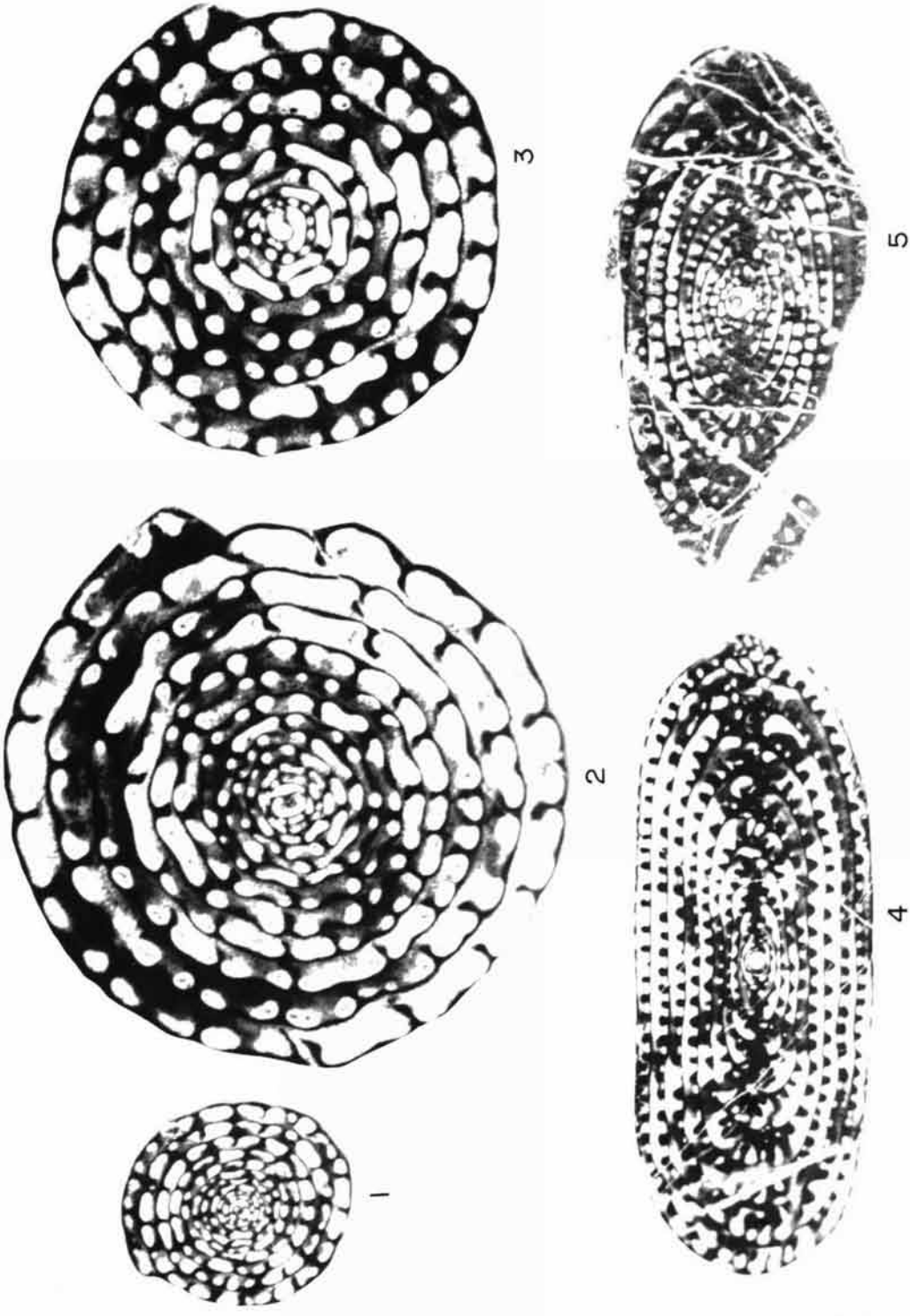
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Chusenella, 1-6; Verbeekina, 7, 8)



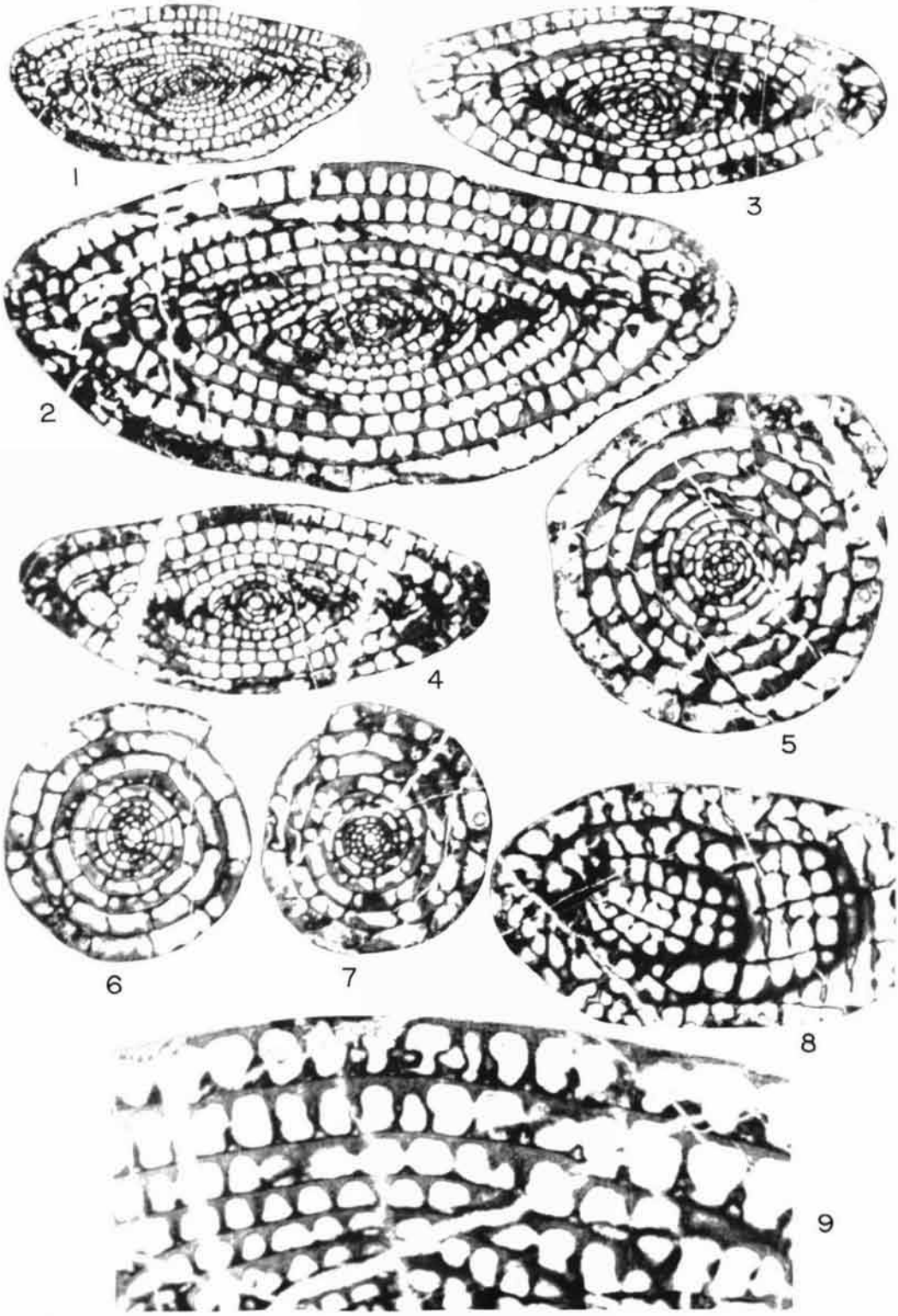
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Verbeekina, 1-4)



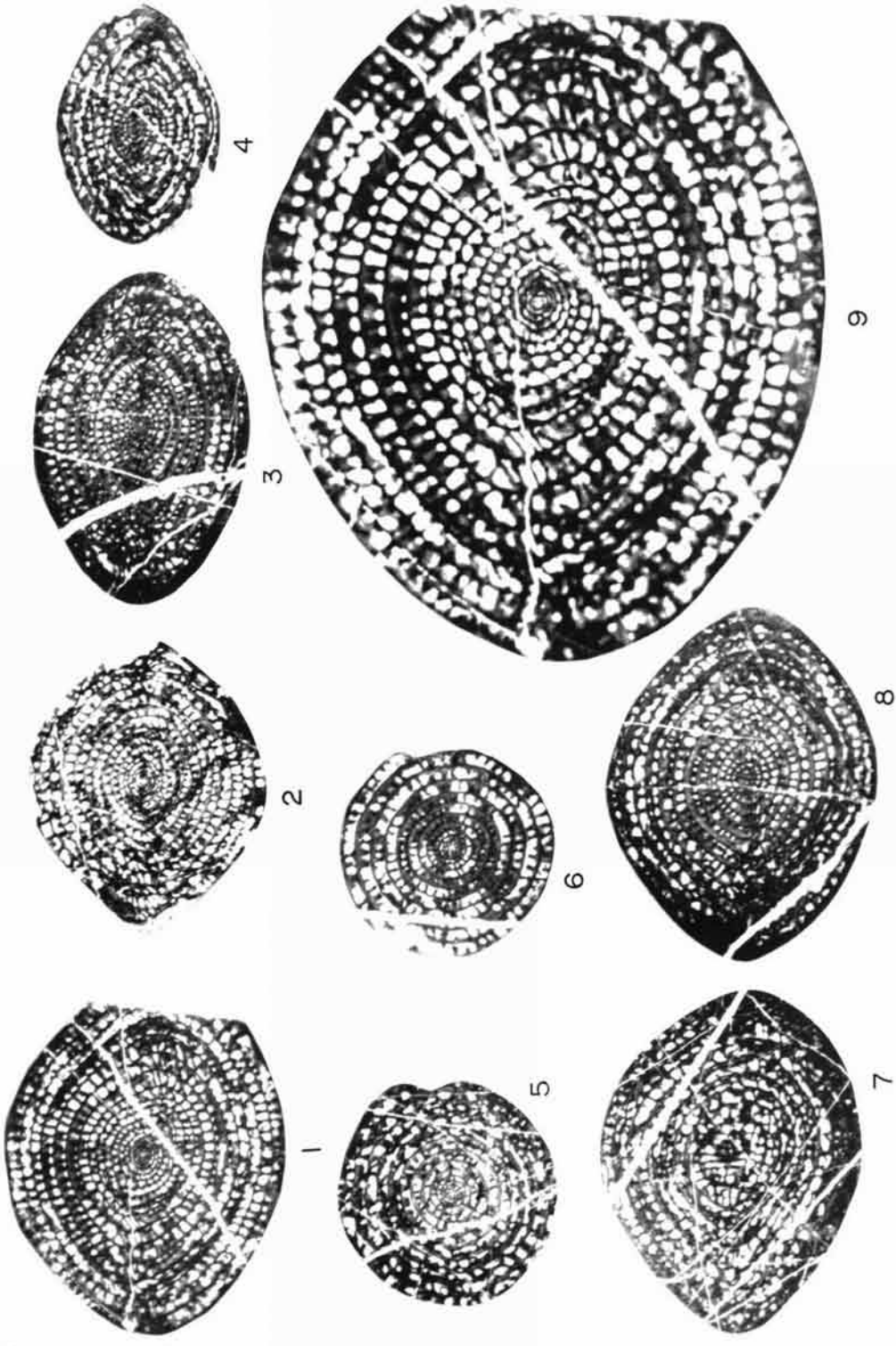
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Pseudodoliolina, 1-7)



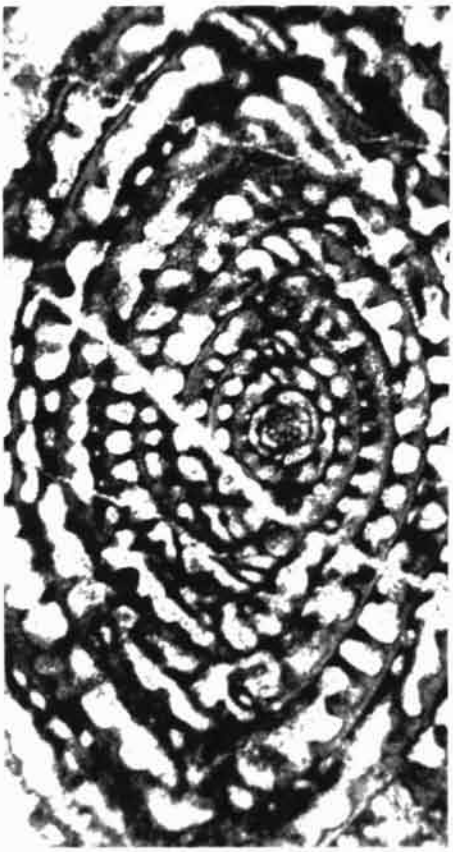
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Pseudodoliolina, 1-5)

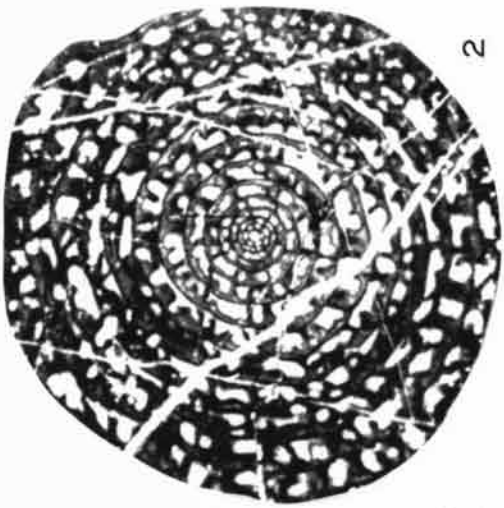


Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Cancellina, 1-9)

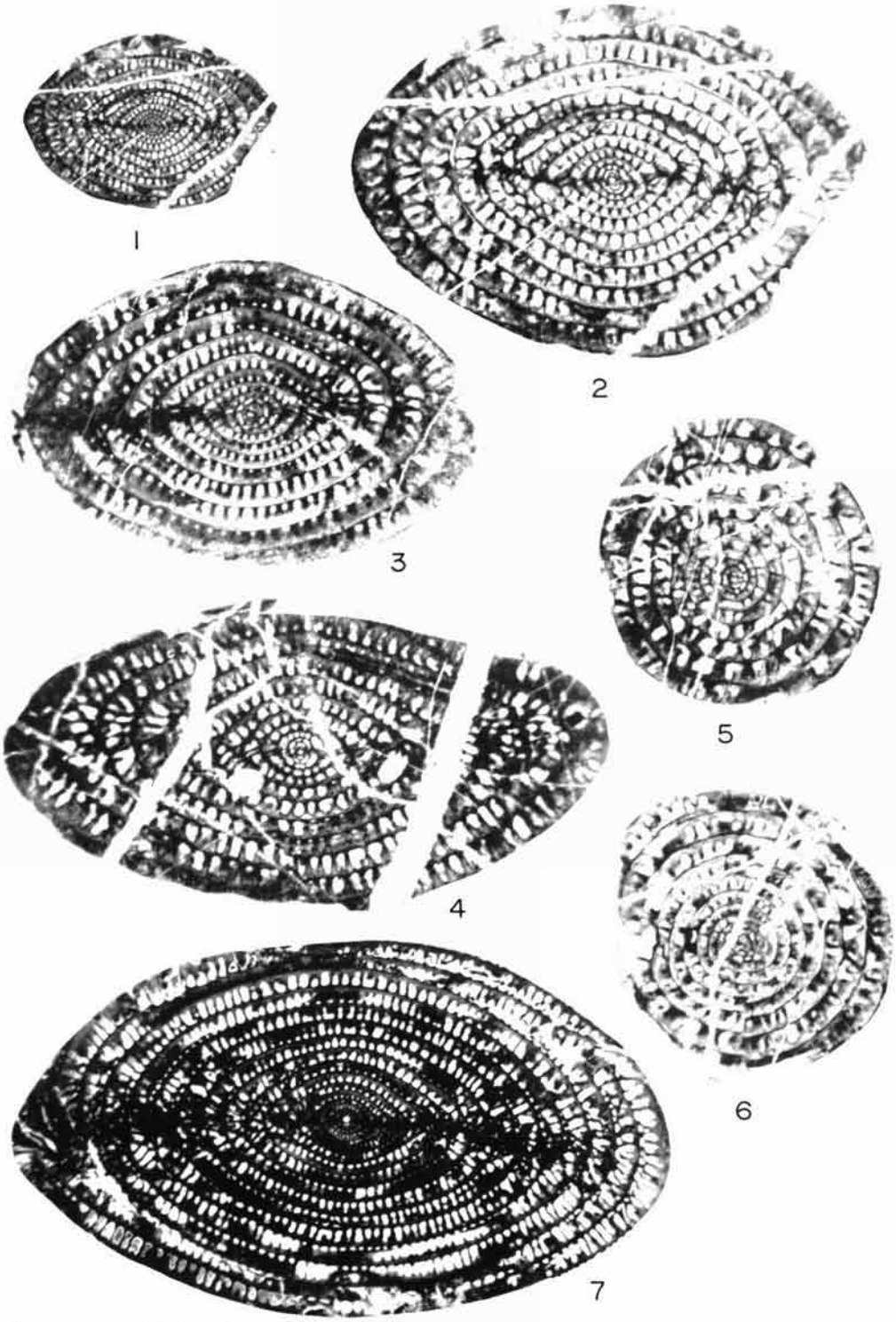


Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Neoschwagerina, 1-9)

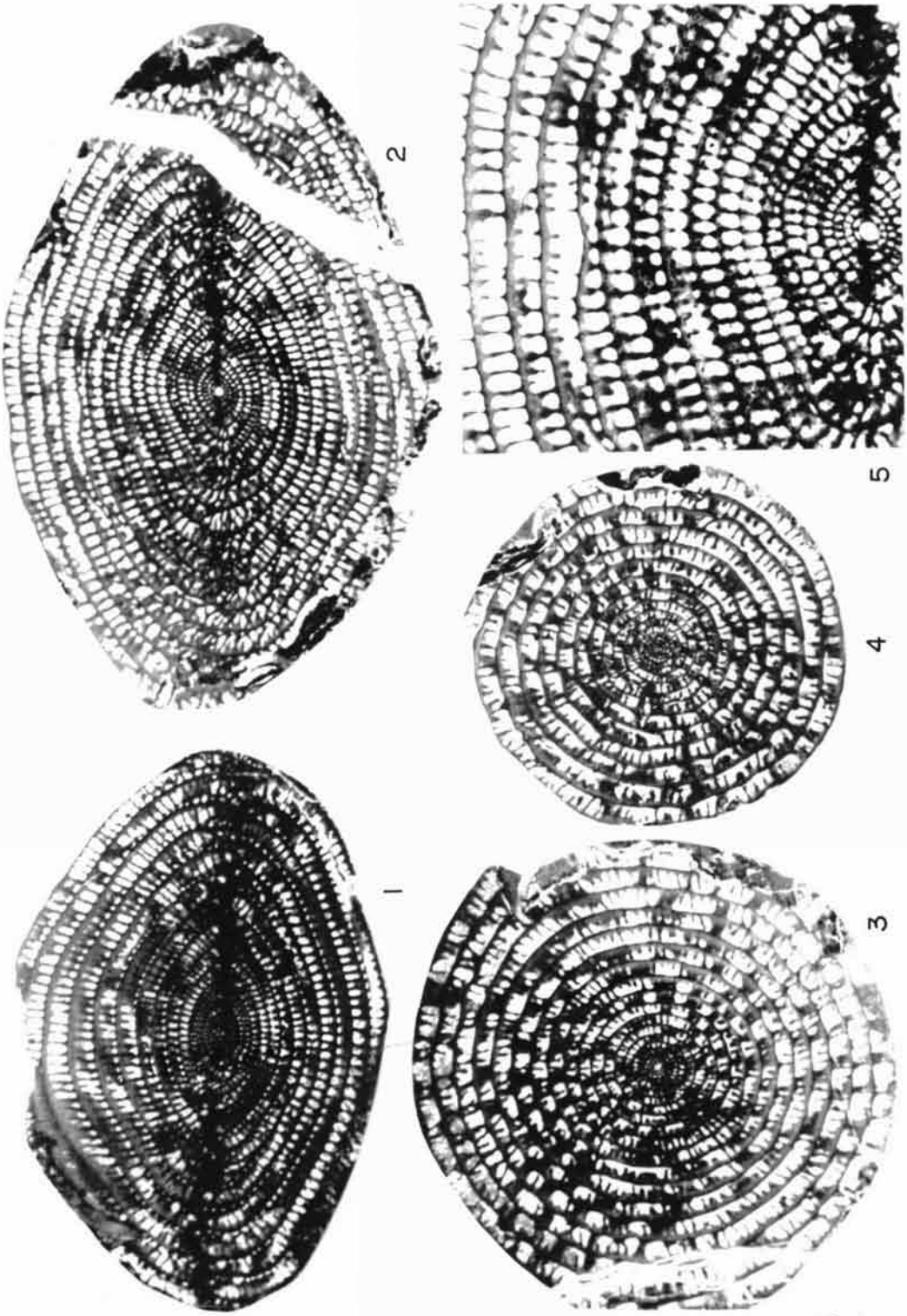




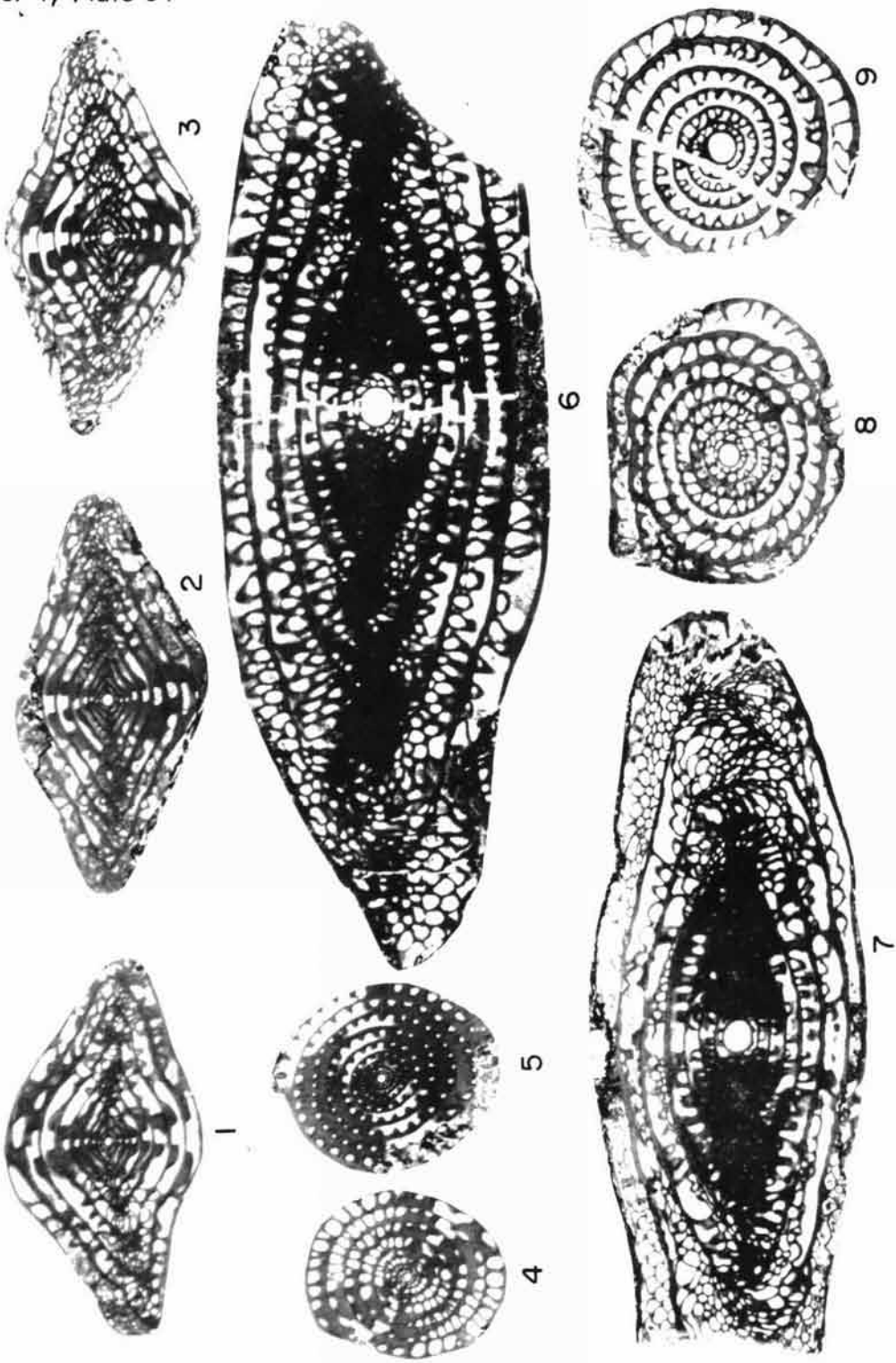
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Neoschwagerina, 1-4)



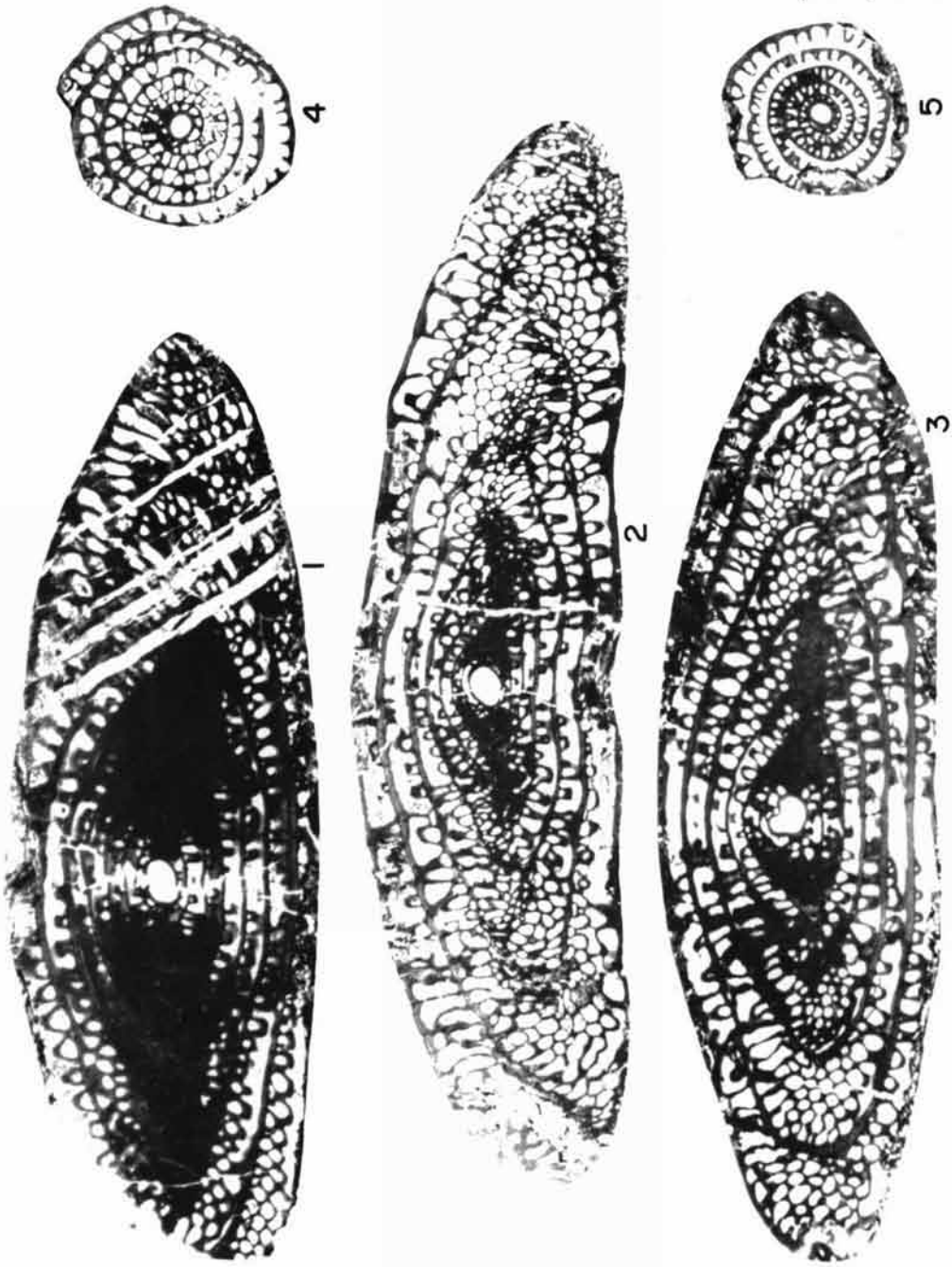
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Neoschwagerina, 1-7)



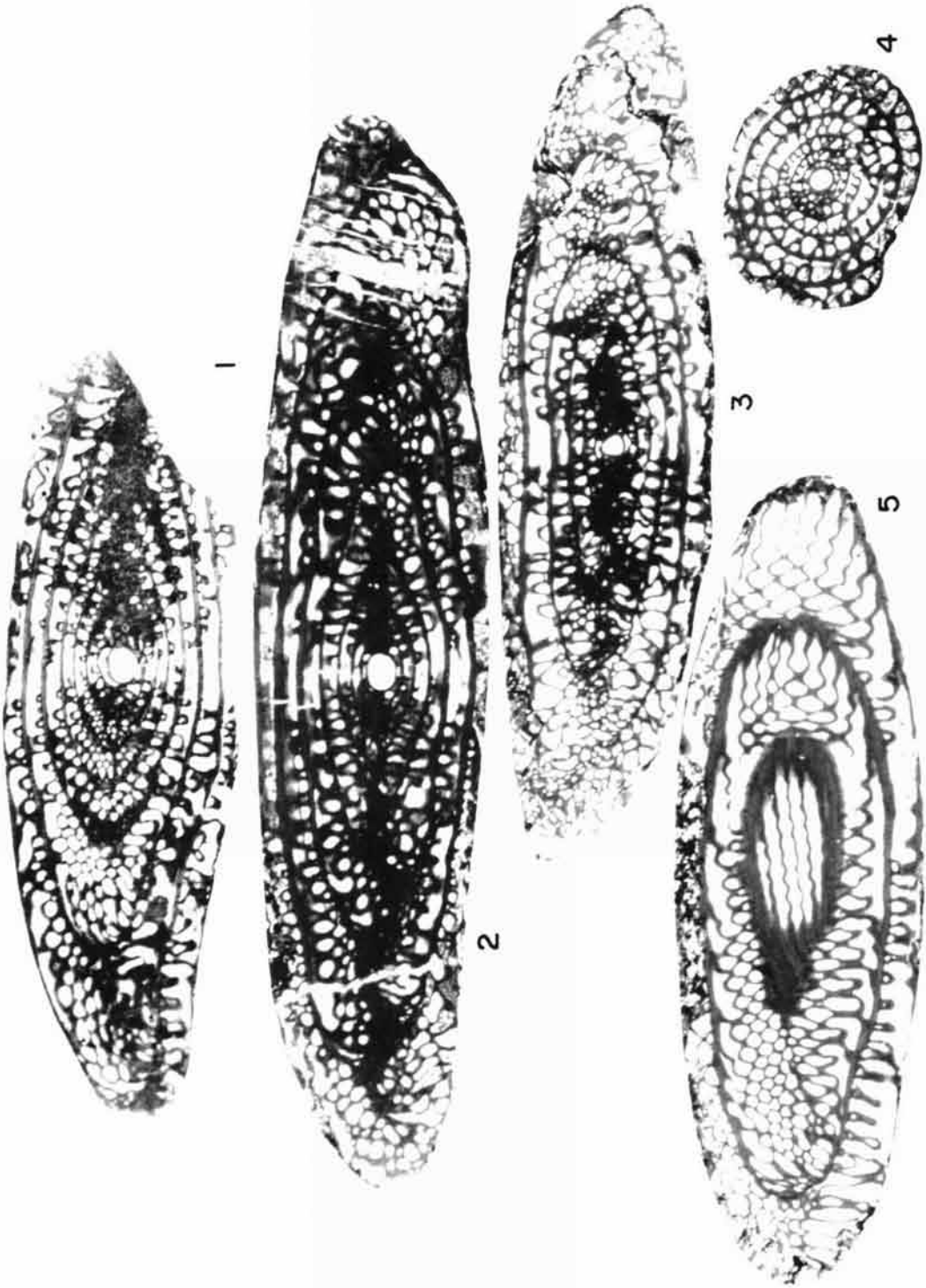
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 5. Northwestern Washington (Neoschwagerina, 1-5)



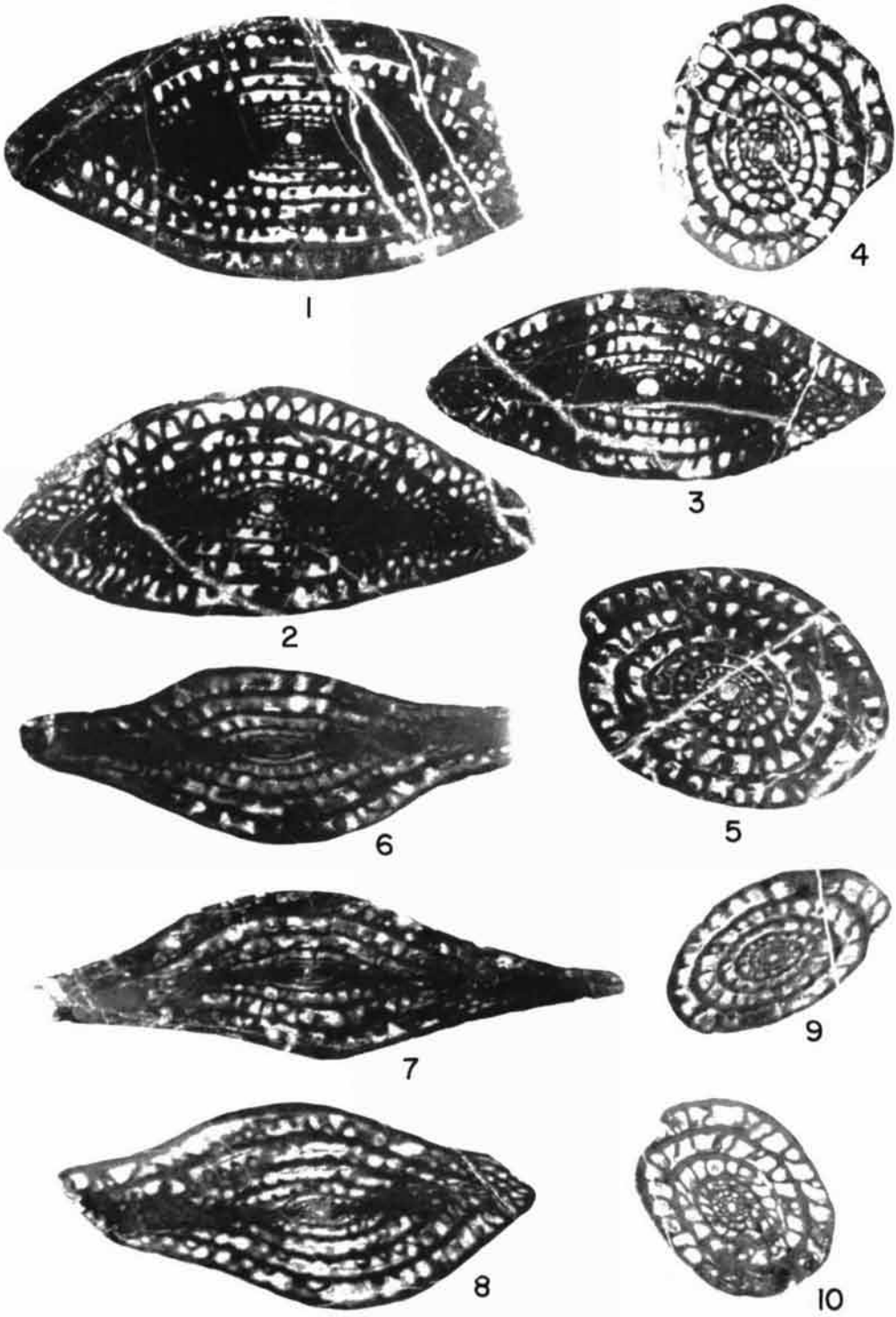
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 6. Northwestern Washington (Pseudofusulinella, 1-5; Schwagerina, 6-9)



Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 6. Northwestern Washington (Schwagerina, 1-5)



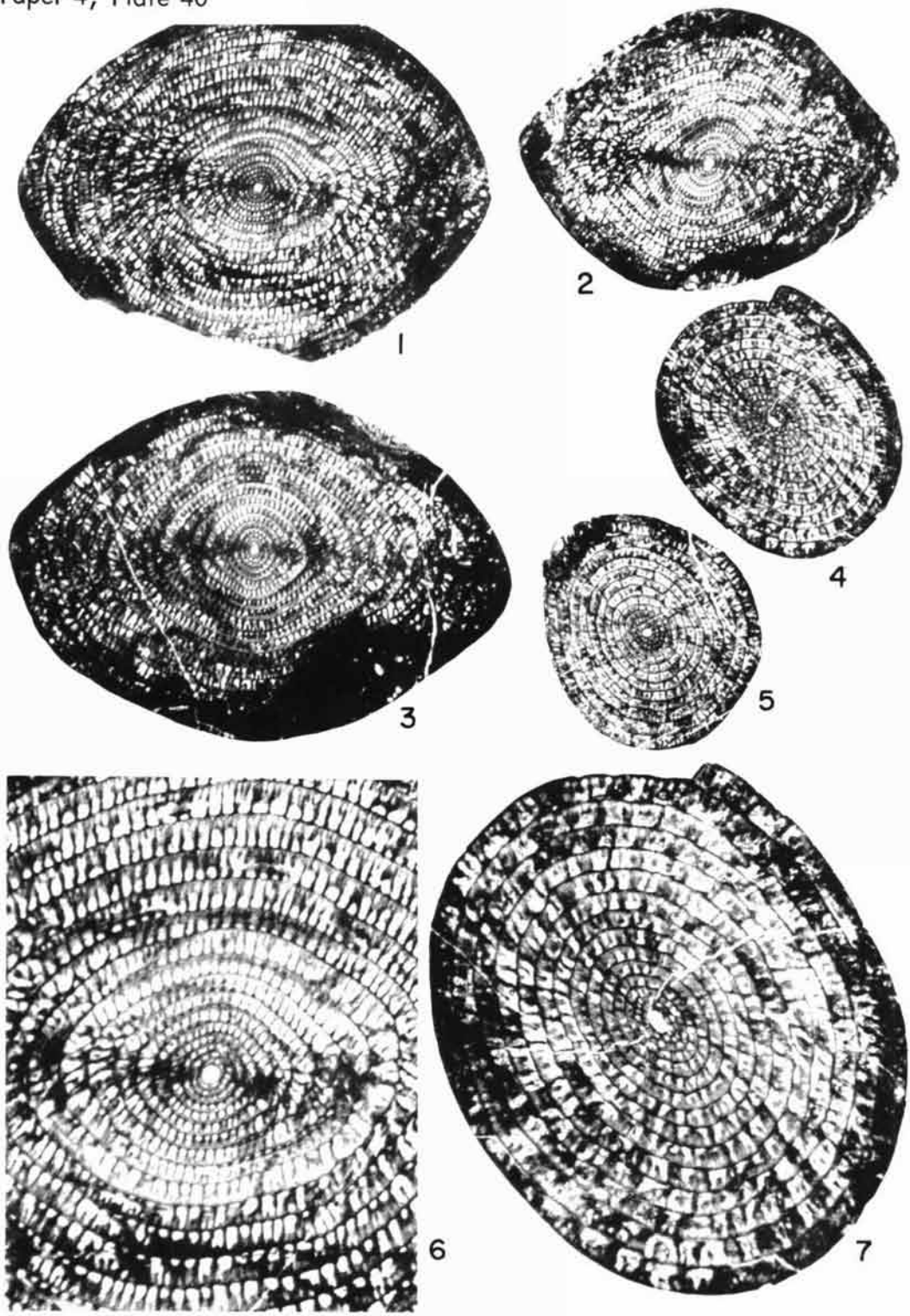
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 6. Northwestern Washington (Schwagerina, 1; Parafusulina, 2-5)



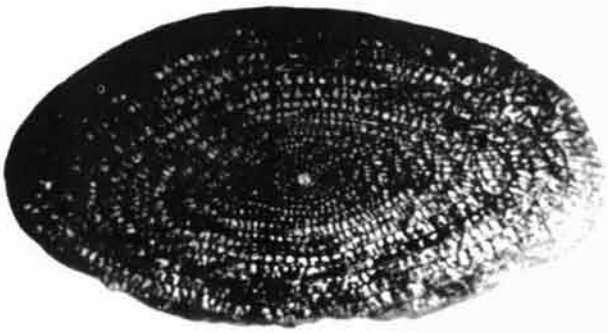
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Schwagerina, 1-5; Chusenella, 6-10)

Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-6)

Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-7)



Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-7)



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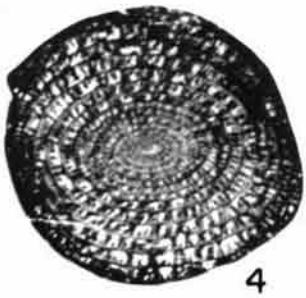

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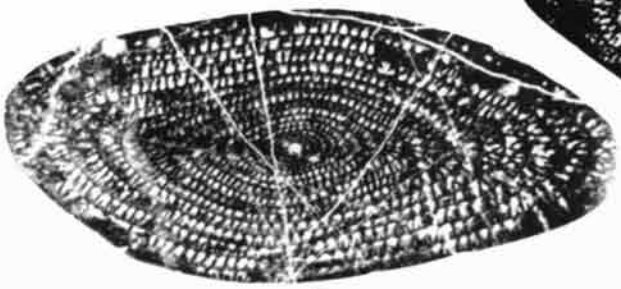

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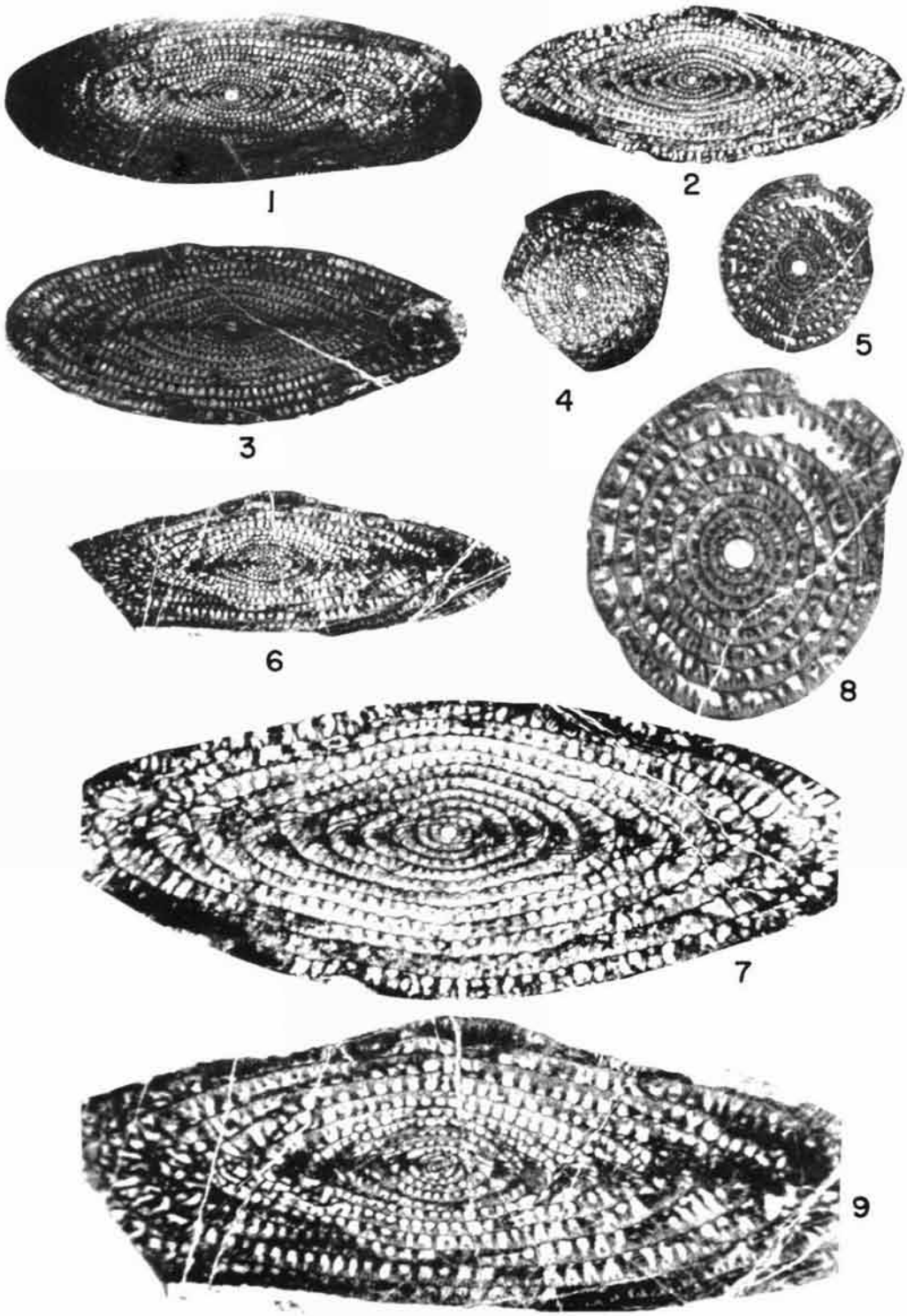
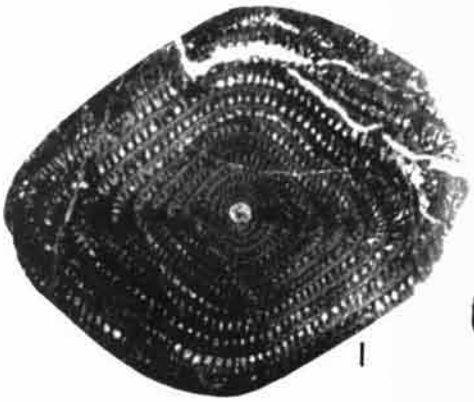
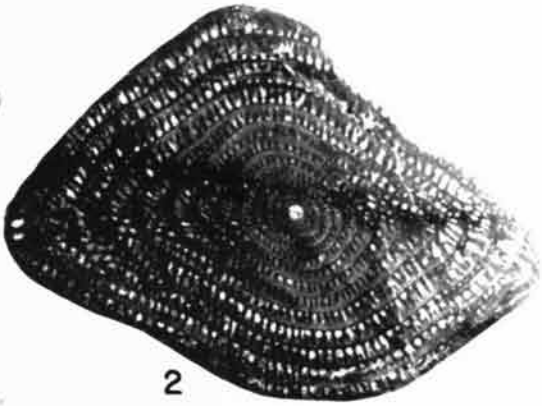
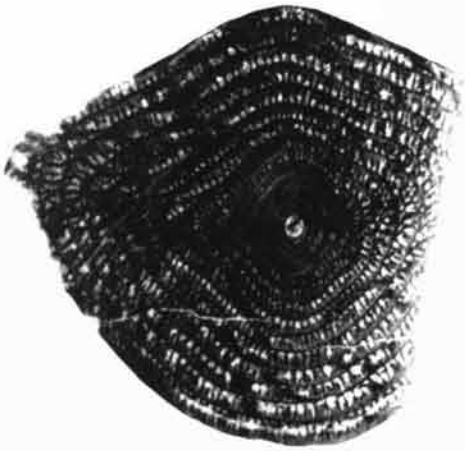
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-7)

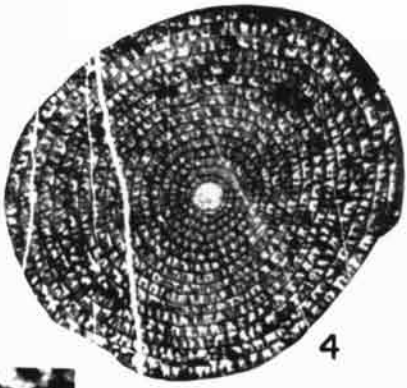


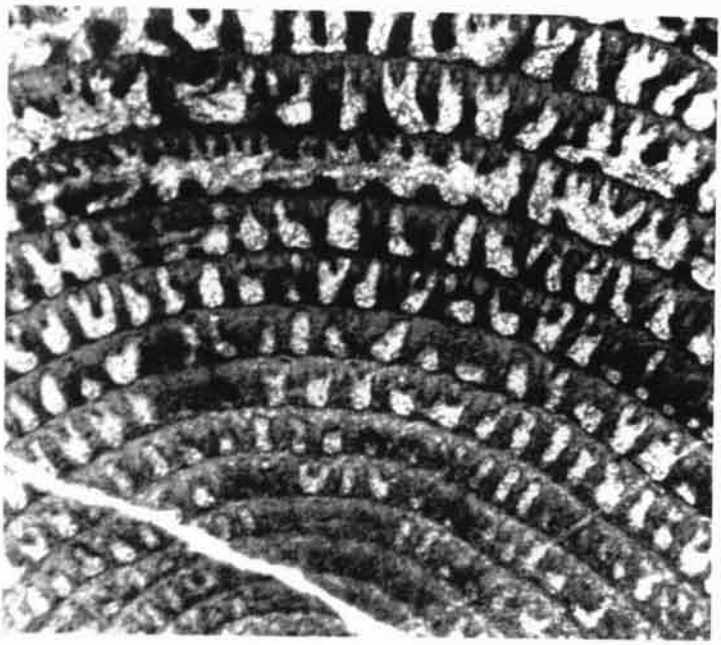
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-9)

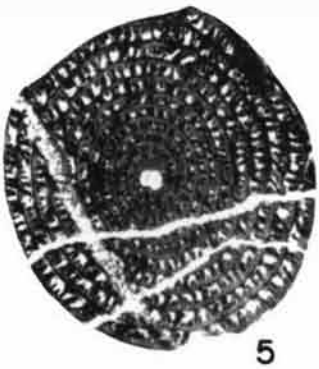




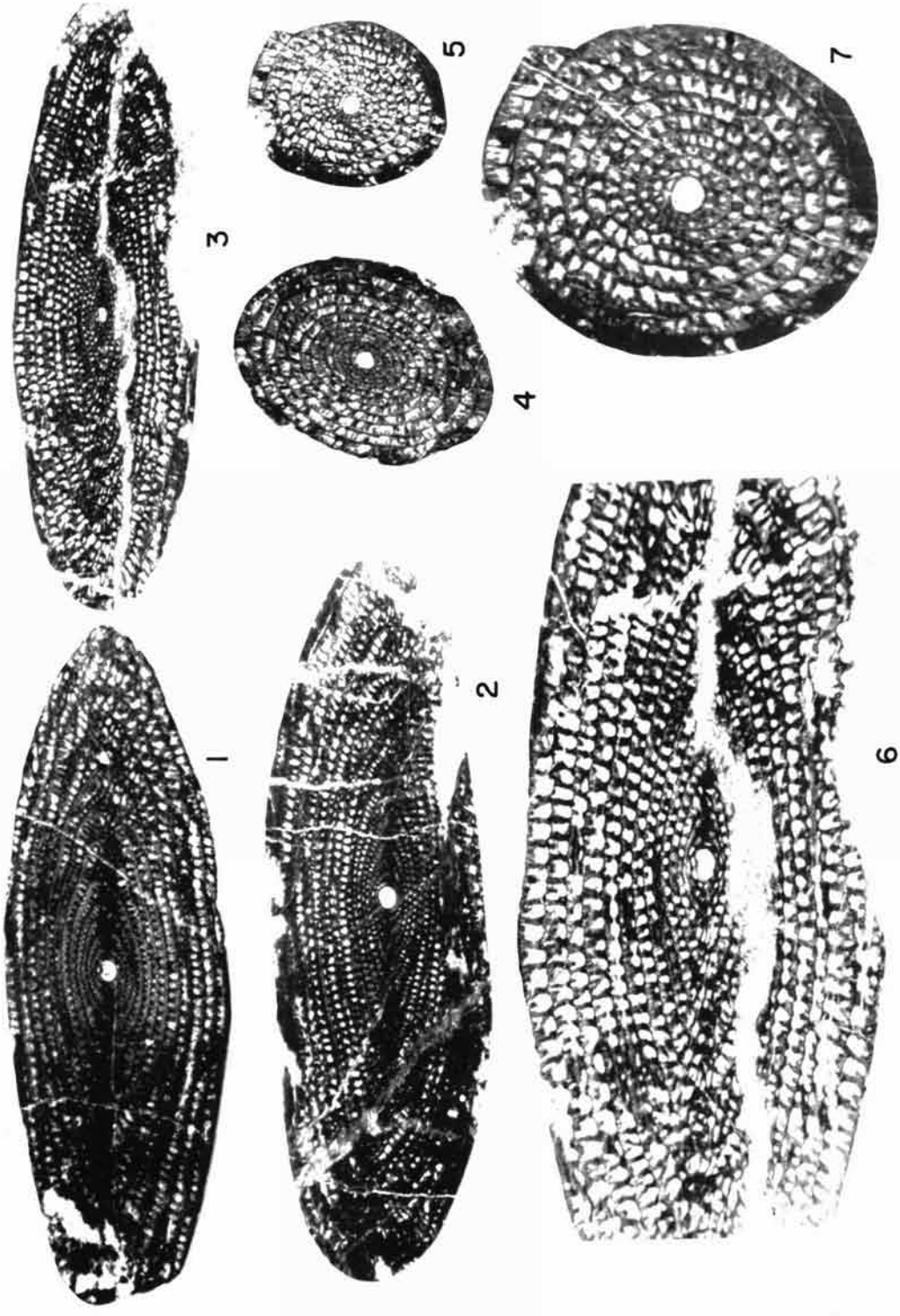






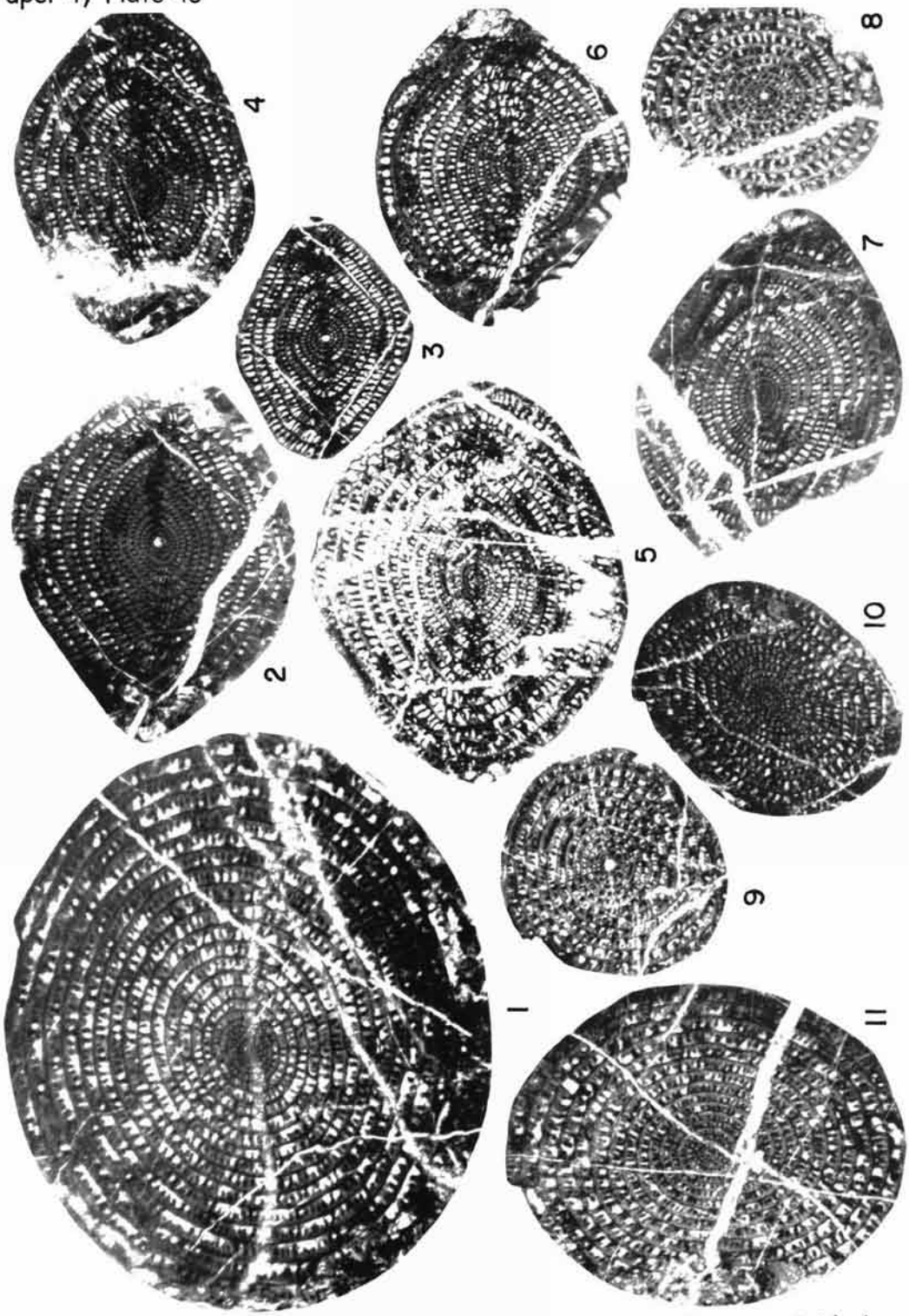


Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-6)



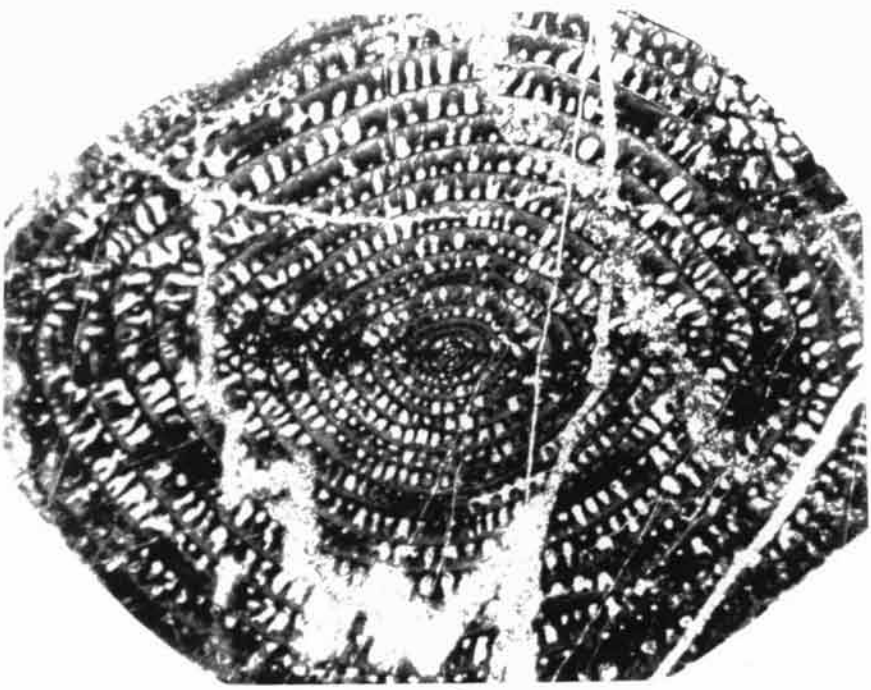
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-7)

Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-4)



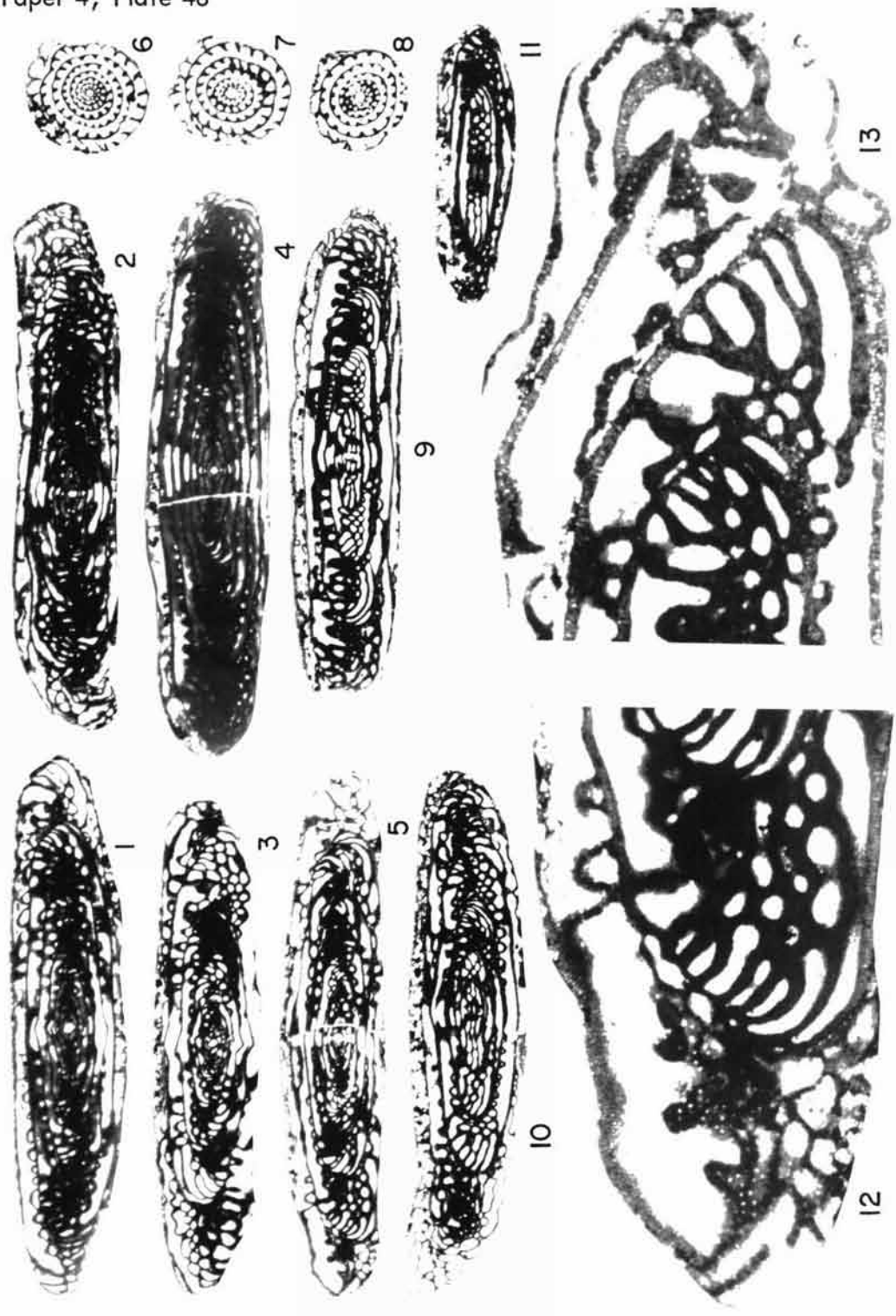
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1-11)

1



2

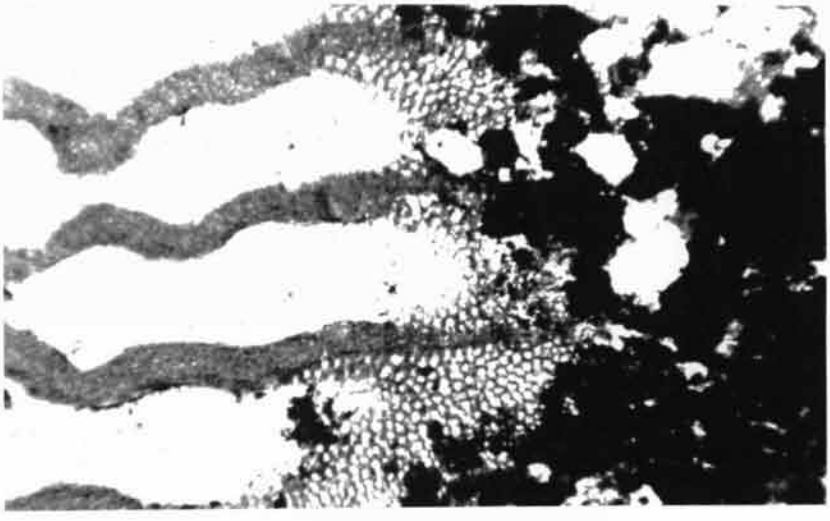
Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 7. British Columbia (Yabeina, 1, 2)



Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 8. Alaska (Alaskanella, 1-13)


1


2


3


4


5


6


7


8


9

Skinner & Wilde--Permian Fusulinids from Pacific Northwest and Alaska
Part 8. Alaska (Alaskanella, 1-9)