American Journal of Science

*JULY 1946*

# MARINE EARLY PERMIAN OF THE CENTRAL ANDES AND ITS FUSULINE FAUNAS.

## Part II.

CARL O. DUNBAR and NORMAN D. NEWELL.

### Description of Species.

#### *Schwagerina prolongada* (Berry)

Plate 1, figs. 1-11.

? *Schellwienia convoluta* Meyer. Neues Jahrb. für Min., Geol., u. Pal., Beil. Bd., vol. 37, 1914, p. 598, pl. 14, fig. 1.

*Fusulina prolongada* Berry. Pan-American Geologist, vol. 49, 1933, p. 271, pl. 22, figs. 1, 5, 11.

*Description.*—A slender, subcylindrical species attaining a length of 10 to 12 mm. and a diameter of 1.9 to 2.0 with 7 to 8 closely coiled volutions. Young shells have a slender fusiform shape and a form ratio of 2:1 up to 4:1, but as they approach maturity they assume a subcylindrical shape with bluntly rounded poles and the form ratio rises to about 6:1. The antetheca is low except near the poles, and is strongly and regularly fluted along its basal margin while remaining nearly plane near the upper or outer edge.

The prolocula commonly range between 135 and 175 microns in diameter and are generally subspherical and thin walled. In the equatorial region the whorls are very low and the expansion gradual.

The spiral wall is rather thin, increasing gradually from 15 to 20 microns in the first volution to 80 or 90 microns in the sixth. Its structure is commonly obscure in the first 2 or 3 whorls but shows a distinct tectum and keriotheca in the outer volutions.

The septa are regularly folded from pole to pole but in axial sections the septal loops appear short because the folds are largely confined to the lower or proximal half of each septum.

Tangential slices (Fig. 4 of Plate 1) show well this peculiarity. The tunnel is wide, and in the first 4 or 5 volutions is bordered by very narrow, low chomata. A slender zone of axial filling follows the axis.

TABLE OF MEASUREMENTS.*

| whorls | Half length | | | | Radius vector | | | | Form ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 0 | .05 | .10 | .07 | .093 | .05 | .10 | .07 | .093 | 1.0 | ... | ... | ... |
| 1 | .25 | .35 | .23 | .29 | .12 | .15 | .13 | .14 | 2.0 | 2.3 | 1.7 | 2.0 |
| 2 | .45 | .70 | .50 | .50 | .18 | .21 | .19 | .19 | 2.5 | 3.3 | 2.6 | 2.6 |
| 3 | .70 | 1.08 | .90 | .75 | .25 | .28 | .26 | .26 | 2.8 | 4.0 | 3.5 | 2.9 |
| 4 | 1.00 | 1.70 | 1.25 | 1.00 | .33 | .40 | .37 | .36 | 3.0 | 4.2 | 3.3 | 2.8 |
| 5 | 1.70 | 2.50 | 2.00 | 1.80 | .45 | .59 | .49 | .50 | 3.5 | 4.2 | 4.1 | 3.6 |
| 6 | 2.70 | 4.20 | 3.90 | 3.00 | .60 | .77 | .70 | .64 | 4.5 | 5.5 | 5.6 | 4.7 |
| 7 | 4.30 | ... | 5.70 | 5.00 | .80 | ... | .94 | .86 | 5.4 | ... | 6.1 | 5.8 |
| 8 | 5.90 | ... | ... | ... | 1.00 | ... | ... | 1.08 | 5.9 | ... | ... | ... |

| | Tunnel angle | | | | Wall thickness | | | | Septal count | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #5 | 6 | 7 |
| 0 | ... | ... | ... | ... | ... | .020 | .015 | .015 | ... | ... | ... |
| 1 | ... | ... | ... | ... | ... | .015 | .020 | .015 | ... | ... | ... |
| 2 | ... | 40° | ... | 20° | ... | .020 | .020 | .025 | 17 | 16 | 12 |
| 3 | 27° | 48° | 36° | 28° | ... | .025 | .020 | .030 | 17 | 17 | 14 |
| 4 | 35° | 48° | 41° | 36° | ... | .035 | .025 | .036 | 18 | 19 | 16 |
| 5 | 38° | 48° | 50° | 45° | ... | .060 | .043 | .043 | 24 | 20 | ... |
| 6 | ... | 55° | 45° | 48° | ... | .070 | .070 | .070 | 25 | 29 | ... |
| 7 | 56° | ... | ... | 58° | ... | ... | ... | .070 | ... | ... | ... |

Specimens 1 to 6 are illustrated on Plate 1 as Figs. 1, 3, 8, 9, 10, and 11, respectively.

*Discussion.*—This species is very similar to *S. linearis* Dunbar and Skinner of the Wolfcamp strata of Texas, which it resembles in shape and size, in the form of its low septal folds, in the width of its tunnel, and in its secondary axial filling. Indeed, the distinction can hardly be more than varietal. In the Texas shells the prolocula are commonly much larger than in the South American form and have even thinner walls.

The original description and illustration of *Fusulina prolongada* Willard Berry would hardly permit recognition of the

* In this and following tables of measurements, data for several types are arranged for easy comparison. Specimens are numbered from left to right across each unit of the table and whorls are numbered from the top downward along the left side of the table, the proloculum being designated as zero.

species, but through the kindness of Professor Edward W. Berry we have been able to restudy the types. The axial section shown as figure 1 on Berry's plate is reproduced from a new photograph at the standard magnification of 10 diameters as Fig. 1 of our Plate 1. This we designate as the holotype specimen. It has been used along with some 50 other sections in drawing up the description given above.

This is probably the species described by Meyer as *Schellwienia convoluta* and we intended at first to use his specific name, but critical study of his description and illustration have persuaded us that such a course is not justified. Meyer stated that he had only a few individuals, that they were embedded in matrix, and that they were badly broken. He gave only a single figure which represents the inner whorls of an incomplete axial section. It is apparently a drawing rather crudely made and the magnification is not indicated. The significant part of his description may be translated freely as follows:

"The dimensions of the largest individual are 12 mm. in length by 2.8 mm. in diameter, the ratio being 6:1. This is a very high ratio. In the early volutions it is not so great, being only 2.6:1 in the third volution of the figured specimen. The form is still pointed at the ends in the early whorls, later becoming cylindrical. The diameter of the single observed proloculum is 0.15 mm.

"The coiling is extraordinarily close so that the four first volutions in the figured specimen attain a diameter of only 0.6 mm. The number of volutions runs up to 7. The thickness of the wall in the last volution is 0.055 mm."

This statement bears evidence of inexcusable carelessness and inaccuracy. If the length be 12 and the diameter 2.8 mm., then the ratio is not 6:1 but about 4.3:1. [The diameter probably was 1.8 instead of 2.8 mm.] Furthermore, the stated dimensions indicate that the diameter of the proloculum is exactly one fourth that of the fourth volution, whereas the figure shows it to be almost exactly one third. Since the actual scale of the figure is not indicated, the dimensions cannot be checked. On Meyer's plate there are figures of two other fusulines, and of brachiopods, a bryozoan, and a coral. At least five different magnifications are used on this plate and the scale is indicated for all but two of the figures, that of *Schellwienia convoluta* and one of another fusuline, *S.* aff. *vulgaris*. Two figures of another fusuline, *Schellwienia peruana*, are shown to be at 16 diameters. If we accept the stated dimensions of the proloculum, the figure of *S. convoluta* is enlarged to ±13.3 diameters; but if we accept the stated diameter of the fourth volution the enlargement is at ±11.3 diameters. On the assumption that the enlargement was to 16 diameters, we have reduced Meyer's figure to a X 10 enlargement and reproduced it as our Fig. 5 of Plate 1. Thus it corresponds rather closely in shape and dimensions with the inner volutions of *S. prolongada* Berry. On the contrary, detailed comparison of the shape of the septal loops and especially of the distribution of secondary filling, shows little resemblance. Actually, the strongest reason for suspecting that *Schellwienia convoluta* Meyer is the same as *Fusulina prolongada* Berry lies in the fact that Meyer's types came from Morochata, about 42 km. northwest of Cochabamba and that in our several collections from this general area *Schwagerina prolongada* (Berry) occurs abundantly and that it is the only species we have found with which *S. convoluta* could be compared.

*Distribution.*—Berry's types were stated to be from Chulpapampa and Yampupata, Bolivia. The species is abundant in Kozlowski's collections 8, 9, 12, 13, 15, and 16 about Apillapampa, Bolivia, and in Ahlfeld's collection 4 from the same section; it occurs also in Kozlowski's collection 3 at Yaurichambi and in Ahlfeld's collection 1 at Abra de Patapatani (between Achacachi and Chuchulaya) east of Lake Titicaca and in his collection 3 at Finca Chacapaya in the Cochabamba Basin. It is abundant in Newell's collection 139 near Tiquina; it is rare in Newell's collection 92 of the section at Muñani, Peru.

### *Schwagerina steinmanni* Dunbar and Newell, n. sp.

Plate 2, figs. 1-10.

*Description.*—An elongate fusiform species of 7 to 8 volutions, attaining at 8 volutions a length of 10.5 to 12.0 mm. and a diameter of 2.2—2.4 mm. The lateral slopes are gently convex and the poles bluntly rounded. The antetheca is lowest at the middle, increasing in height toward the poles, and is deeply and regularly folded throughout.

The prolocula are rather small, ranging between 120 and 200 microns in diameter. They are commonly subspherical but in occasional shells are irregular in shape. The first 3 or 4 volutions are closely coiled and have a very thin spiral wall scarcely exceeding 20 microns in thickness. The remaining volutions expand gradually and the wall thickens rapidly in the fourth volution and more slowly thereafter, commonly attaining a thickness of 65 to 75 microns in the outer whorl.

Folds are deep and regular on the lower (inner) margin of each septum but die out near the upper margin. Septa are moderately spaced, increasing from 11 or 12 in the first volution to 17 or 18 in the third and 18 to 25 in the fifth. Very slender chomata are present in the first 3 volutions only. The tunnel is moderately wide, and is difficult to measure in good thin sections except in the inner whorls. The tunnel angle measures 30° to 40° in the third volution and increases with acceleration in the outer whorls. A secondary filling is somewhat irregularly distributed along the axial region.

TABLE OF MEASUREMENTS.

| whorls | Half length | | | | Radius vector | | | | Form ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 0 | .09 | .09 | .06 | .10 | .09 | .07+ | .06 | .10 | ... | ... | ... | ... |
| 1 | .30 | .22 | .14 | .23 | .14 | .12 | .09 | .16 | 2.1 | 1.8 | 1.6 | 1.4 |
| 2 | .50 | .36 | .31 | .50 | .18 | .18 | .14 | .20 | 2.8 | 2.0 | 2.2 | 2.5 |
| 3 | .95 | .60 | .56 | .80 | .28 | .26 | .24 | .29 | 3.4 | 2.3 | 2.3 | 2.8 |
| 4 | 1.40 | .90 | .80 | 1.25 | .47 | .36 | .33 | .39 | 3.0 | 2.5 | 2.4 | 3.2 |
| 5 | 2.40 | 1.55 | 1.54 | 1.95 | .66 | .49 | .46 | .50 | 3.6 | 3.1 | 3.3 | 3.9 |
| 6 | 3.50 | 2.53 | 2.64 | 2.80 | .90 | .65 | .67 | .70 | 3.9 | 4.0 | 4.0 | 4.0 |
| 7 | 4.60 | 3.90 | 4.12 | 4.20 | 1.16 | .90 | .87 | .95 | 4.0 | 4.3 | 4.7 | 4.4 |
| 8 | ... | 5.05 | ... | 5.50 | ... | 1.10 | ... | 1.20 | ... | 4.6 | ... | 4.6 |

| whorls | Tunnel angle | | | | Wall thickness | | | | Septal count | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #5 | 6 | 7 |
| 0 | ... | ... | ... | ... | .018 | .020 | .015 | .025 | ... | ... | ... |
| 1 | 27° | 27° | 27° | ... | .018 | .020 | .020 | ... | 12 | 11 | 13 |
| 2 | 35° | 30° | 28° | ... | .020 | .020 | .020 | ... | 16 | 18 | 15 |
| 3 | 39° | 35° | 35° | 20° | .022 | .020 | .020 | .030 | 17 | 17 | 18 |
| 4 | 48° | 37° | 35° | 31° | .045 | .040 | .025 | .036 | 21 | 20 | 19 |
| 5 | ... | ... | 39° | 35° | ... | .035 | .055 | .045 | 24 | 22 | 19 |
| 6 | ... | ... | 42° | 41° | ... | .050 | .050 | .060 | 26 | 23 | ... |
| 7 | ... | ... | ... | 50° | .060 | .045 | .060 | .060 | 27 | ... | ... |
| 8 | ... | ... | ... | ... | .075 | .045 | .065 | .060 | ... | ... | ... |

Specimens 1-6 are illustrated on Plate 2 as Figs. 3, 2, 8, 10, 6, and 5, respectively.

*Discussion.*—This species most closely resembles *S. prolongada* (Berry) from which it differs in being thicker and evenly fusiform rather than cylindrical, in having a smaller form ratio, and in having rather higher septal folds. Oblique sections of *S. prolongada* appear foreshortened and are easily mistaken for our new species. With a few exceptions these species are not found together in the collections before us, and presumably each has a distinct stratigraphic (or perhaps ecological) distribution.

*Distribution.*—Found in great abundance in Kozlowski's collections 8 and 16 at Apillapampa, Bolivia. It occurs rarely with *S. prolongada* in Newell's collection 139 near Tiquina.

### *Schwagerina ahlfeldi* Dunbar and Newell, n. sp.

Plate 3, figs. 1-10.

*Description.*—A small, thickly fusiform species with broadly rounded middle and neatly pointed poles, commonly attaining a length of 5 to 6 mm. and a diameter of 2.5 to 3 mm., and having 7 to 8 rather closely coiled volutions.

The prolocula commonly range between 150 and 250 microns in diameter and are regularly subspherical. The initial whorls are very tightly coiled and later expansion is slow and gradual; the shape and form ratio of the shell change but little during growth. The spiral wall is very thin in the early whorls and thickens slowly in later volutions, having a thickness of 30 to 45 microns in the third volution and 50 to 70 in the fifth.

As shown in Figs. 5 and 6 of Plate 3, the septa are strongly and regularly folded throughout. The folds extend well up to the outer margin, hence septal loops appear high and narrow and closely spaced in axial sections. Septal pores are present but are commonly not conspicuous because the strong folding causes the septa to cross and recross the slices at high angles. The tunnel is low and narrow, the tunnel angle measuring about 25° to 30° in the third volution, and 25° to 35° in the fifth.

One of the most distinctive features of the species is the heavy secondary deposit which occupies an irregular conical area on each side of the tunnel. It varies considerably in development but in many shells solidly fills the chambers of all the inner whorls except near the tunnel, as shown by an axial section (Fig. 4 of Plate 3) or an excentric section (Fig. 10 of Plate 3).

TABLE OF MEASUREMENTS.

| whorls | Half length #1 | 2 | 3 | Radius vector #1 | 2 | 3 | Form ratio #1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .10 | .116 | .10 | .10 | .116 | .10 | ... | ... | ... |
| 1 | .28 | .46 | .28 | .17 | .20 | .16 | 1.6 | 2.3 | 1.8 |
| 2 | .50 | .71 | .50 | .28 | .33 | .29 | 1.8 | 2.1 | 1.7 |
| 3 | .65 | 1.08 | .93 | .43 | .51 | .49 | 1.5 | 2.0 | 1.8 |
| 4 | 1.00 | 1.60 | 1.30 | .57 | .73 | .73 | 1.7 | 2.2 | 1.8 |
| 5 | 1.20 | 2.30 | 1.95 | .74 | .97 | .96 | 1.6 | 2.4 | 2.0 |
| 6 | 1.60 | ... | 2.60 | .94 | ... | 1.24 | 1.7 | ... | 2.1 |
| 7 | 2.00 | ... | ... | 1.17 | ... | ... | 1.7 | ... | ... |
| 8 | 3.00 | ... | ... | 1.45 | ... | ... | 2.0 | ... | ... |

| whorls | Tunnel angle #1 | 2 | 3 | Wall thickness #1 | 2 | 3 | Septal count #4 | 5 |
|---|---|---|---|---|---|---|---|---|
| 0 | ... | ... | ... | .025 | .030 | .030 | ... | ... |
| 1 | ... | ... | ... | .030 | .030 | .030 | 13 | 12 |
| 2 | 21° | 25° | 35° | .030 | .030 | .030 | 22 | 23 |
| 3 | 24° | 30° | ... | .035 | .043 | .030 | 28 | 28 |
| 4 | 30° | 33° | 25° | .043 | .050 | .043 | 32 | 34 |
| 5 | ? | 34° | 25° | .057 | .070 | .050 | 42 | 38 |
| 6 | 22° | ... | 23° | .065 | ... | .057 | 48 | 40? |
| 7 | 20° | ... | ... | .070 | ... | ... | 53 | ... |
| 8 | 25° | ... | ... | ... | ... | ... | ... | ... |

Figures 1-5 are illustrated on Plate 3 as Figs. 4, 1, 2, 7, and 8, respectively.

*Discussion.*—In shape, septal evolution, and axial filling this species resembles *S. compacta* (White) of the Wolfcamp formation of Texas, but it is distinctly smaller, relatively shorter, and has much larger prolocula.

In size and shape it is extremely like *S. gümbeli* Dunbar and Skinner of the lower Leonard group of Texas, but its whorls are somewhat more closely coiled, especially the early ones, and its axial deposits are more massive and its prolocula generally smaller than in the Texas shells. As shown in a tangential slice of the outer whorls (Fig. 5 of Plate 3), the septal evolution is so far advanced as to foreshadow the development of cuniculi. In this respect also it resembles *S. gümbeli.* Judged by this feature, its age should be late Wolfcamp or possibly early Leonard.

*Schwagerina gruperaensis* Thompson and Miller, from southernmost Mexico, is also similar to our species, but is much larger, has larger prolocula, and more open coiling.

*Distribution.*—This species characterizes the upper half of unit 3 of Newell's section on Tiquina Strait. This limestone, about 655 feet thick, extends from about 820 to 1475 feet above the Permian-Devonian contact. Fusulines were collected from six different zones, ranging from near the base to near the top of this limestone. In the upper three, *S. ahlfeldi* occurs in abundance. No other fusulines were found with it in the two upper zones (Collections 145 and 147), but in Collection 143 from a little above the middle of this limestone it is associated with *S.* cf. *S. emaciata* (Beede).

Its absence from the richly fossiliferous beds about Apillapampa and Cochabamba would suggest that unit 3 at San Pedro is a zone not represented in our collections farther south. Nor has it been found in the long section near Muñani or the one near Cerro Pirhuate.

### *Schwagerina* (?) *patens* Dunbar and Newell, n. sp.

Plate 4, figs. 1-8; Plate 8, figs. 11, 12.

*Schwagerina* aff. *laxissima* Thompson. Jour. Paleont., vol. 17, p. 204, pl. 33.

*Description.*—An elongate, meloniform species, commonly attaining a length of 11 to 12 mm. and a diameter of 3.2 to 3.5 mm. At this size the shell consists of 6 to 7 very rapidly

---

PLATE 1.

*Schwagerina prolongada* (Berry).

Fig. 1. Holotype, axial section (x 10) from Chulpapampa, Bolivia. This is the specimen illustrated as figure 1 of plate 22 by Berry. It is in the collections of Johns Hopkins University.

Fig. 2. Specimens in the rock (x 1) from Ahlfeld's collection 4 at Apillapampa, Bolivia. Y. P. M. 17382.

Fig. 3. Axial section (x 10) from Ahlfeld's collection 3 at Finca Chacapaya near Sipespie Ceste, Cochabamba Basin, Bolivia. Y. P. M. 17383.

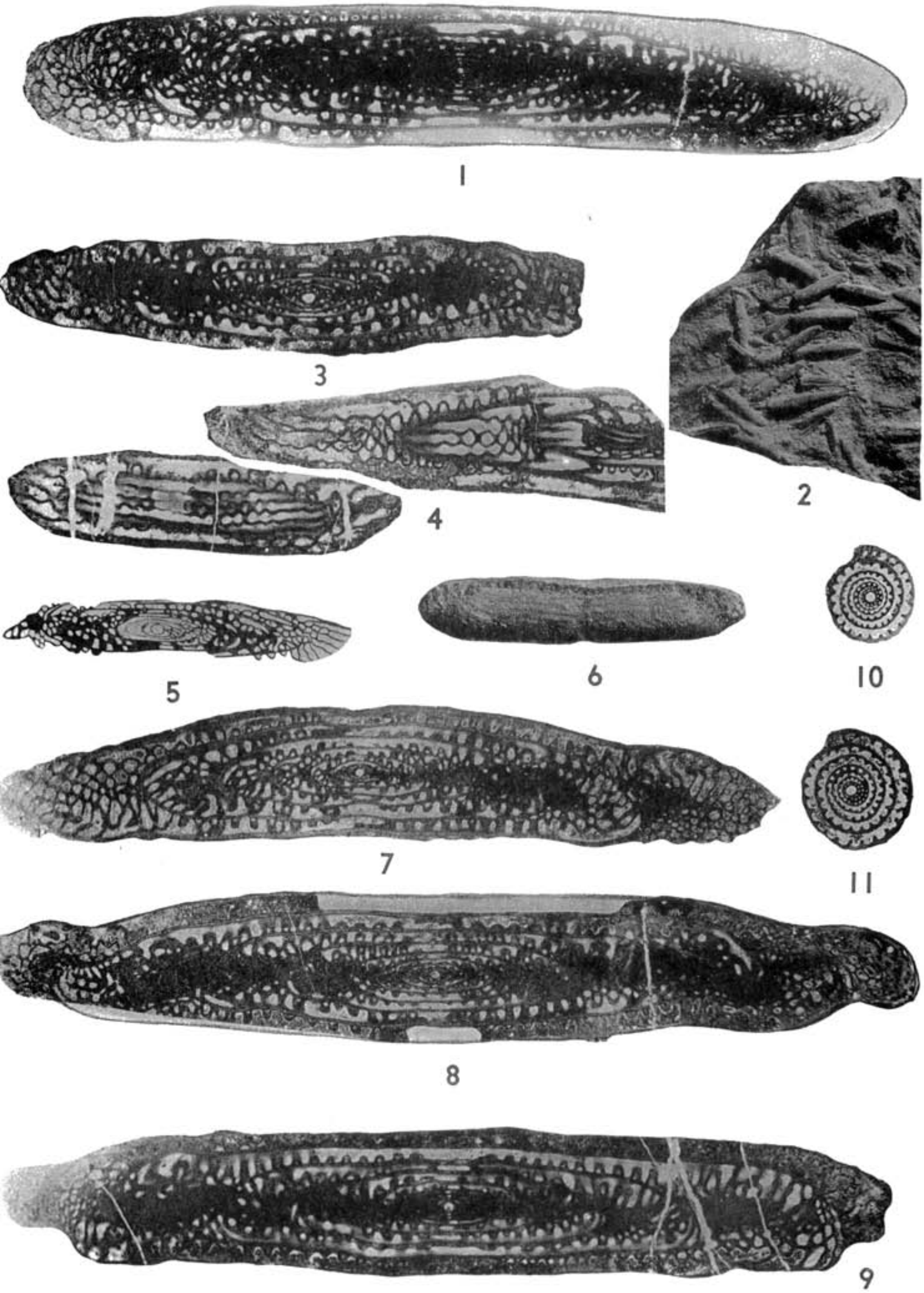
Fig. 4. Tangential slices (x 10) from Kozlowski's collection 15 at Apillapampa, Bolivia.

Fig. 5. Copy of Meyer's figure of *Schellwienia convoluta,* reduced to 10/16 of the original.

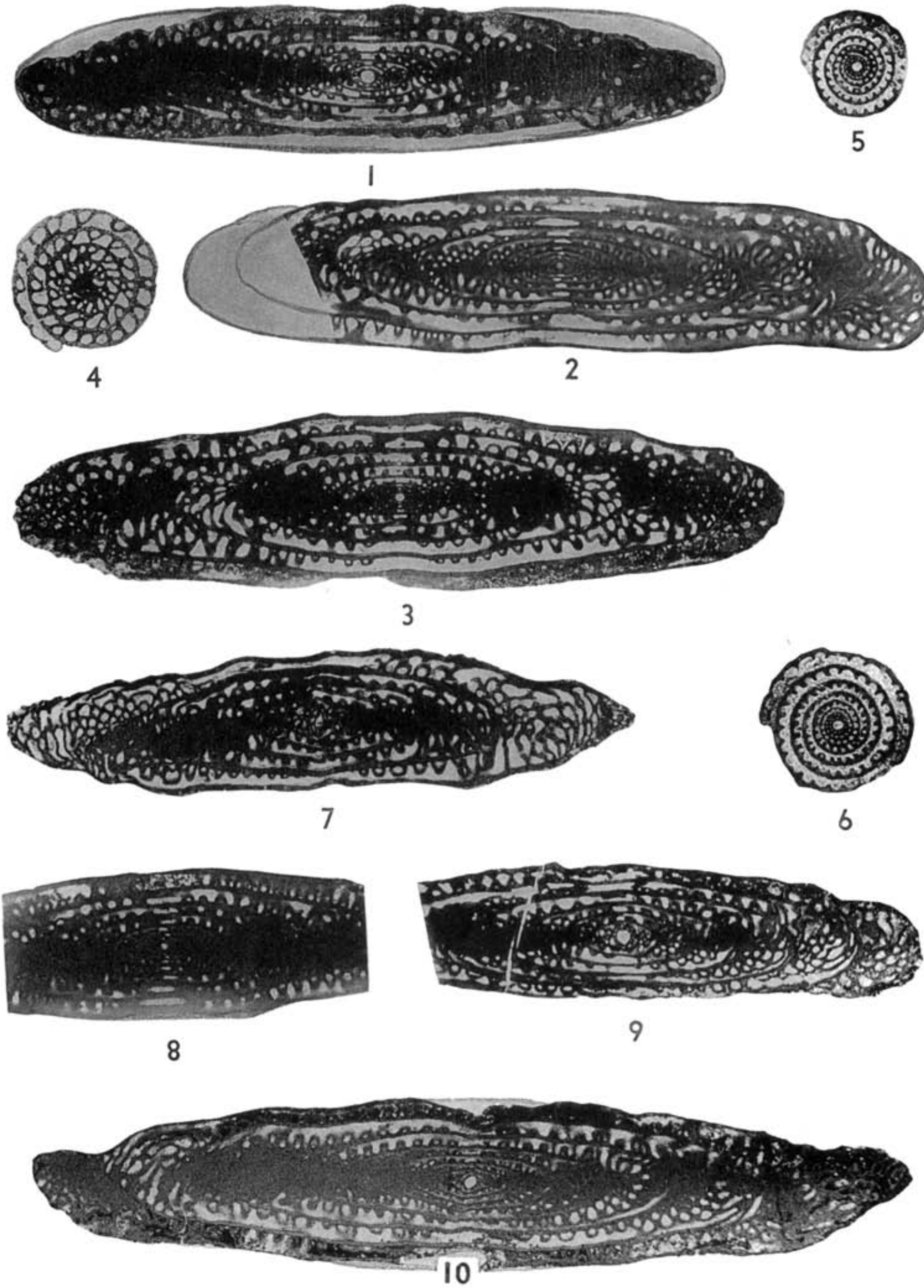
Fig. 6. Paratype immature shell (x 5) from Chulpapampa, Bolivia. This is the specimen represented by figure 11 of Berry's plate 22. It is in the collections of Johns Hopkins University.

Figs. 7, 8. Axial sections (x 10) from Ahlfeld's collection 4 at Apillapampa, Bolivia. Y. P. M. 17384, 17385.

Figs. 9-11. Axial and two sagittal sections (x 10) from Kozlowski's collection 15 at Apillapampa, Bolivia.




*Schwagerina prolongada*
*(Berry)*




*Schwagerina steinmanni*

expanding volutions. The ends of the shell are commonly unsymmetrical and the axis not straight.

The prolocula show a range in size from less than 200 to nearly 400 microns in diameter but commonly measure between 250 and 300 microns.

The ontogeny of this shell is distinctive. The innermost whorls are short and thick and rather tightly coiled, and have a relatively thick wall and well developed chomata and considerable epithecal deposit. But the rate of expansion is exceptionally high and the outer volutions appear high and loosely coiled. Chomata disappear in the third or fourth volution; the wall increases slowly in thickness in the outer whorls. The net result is that the early whorls appear as a thick-walled and closely coiled nucleus in the middle of a large, loosely coiled shell. In either axial or sagittal section they appear at first glance to have the characters of an elongate *Pseudoschwagerina.* But critical examination of the sagittal sections shows that the dense central nucleus owes its appearance largely to the thick chomata and other epithecal deposit—the radial expansion is gradual although somewhat irregular. The septa are rather strongly folded but in the high outer volutions the folds are large and in axial sections the loops appear rounded and very irregular. Septal pores are abundant but unusually small.

The tunnel is low and uncommonly variable in width. In the first 3 or 4 volutions it is clearly defined by the bordering chomata, but in the outer whorls it is difficult to observe in good thin sections.

Specimens 2-7 are illustrated on Plate 4 as Figs. 1, 7, 8, 6, 4, and 5, respectively.

*Discussion.*—This species is very similar to *Schwagerina* (?) *laxissima* Dunbar and Skinner of the Wolfcamp series in Texas,

---

PLATE 2.

*Schwagerina steinmanni* Dunbar and Newell, n. sp.

Fig. 1. Axial section (x 10) from Ahlfeld's collection 3 at Finca Chacapaya near Sipespie Ceste of Cochabamba Basin, Bolivia. Y. P. M. 17386.

Figs. 2, 3, 8. Axial sections (x 10) from Kozlowski's collection 16 at Apillapampa, Bolivia. Figure 3 shows the holotype.

Figs. 4-6. Excentric and two sagittal sections (x 10) from same locality.

Figs. 7, 9. Axial sections (x 10) from Newell's collection 139 near Tiquina Strait. Y. P. M. 17426, 17427.

Fig. 10. Axial section (x 10) from bed 3 of Newell's section at Tiquina. Newell collection 146. Y. P. M. 17428.

TABLE OF MEASUREMENTS.

| whorls | Half length | | | | Radius vector | | | | Form ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 0 | .13 | .14 | .21 | .10 | .12 | .14 | .18 | .10 | 1.0 | 1.0 | 1.1 | 1.0 |
| 1 | .31 | .30 | .47 | .24 | .16 | .23 | .33 | .17 | 1.3 | 1.3 | 1.4 | 1.4 |
| 2 | .70 | .74 | .93 | .47 | .33 | .33 | .49 | .30 | 2.1 | 2.2 | 1.8 | 1.5 |
| 3 | 1.57 | 1.33 | 2.28 | 1.20 | .61 | .47 | .74 | .47 | 2.5 | 2.8 | 3.0 | 2.5 |
| 4 | 3.29 | 2.28 | 3.00 | 2.20 | .94 | .70 | 1.17 | .61 | 3.5 | 3.2 | 2.5 | 3.3 |
| 5 | ... | 3.00 | 3.57 | 4.10 | ... | 1.16 | 1.71 | 1.03 | ... | 2.5 | 2.0 | 4.0 |
| 6 | ... | 4.00 | ... | 5.60 | ... | 1.43 | ... | 1.45 | ... | 2.7 | ... | 3.8 |

| whorls | Tunnel angle | | | | Wall thickness | | | | Septal count | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #5 | 6 | 7 |
| 0 | ... | ... | ... | ... | .025 | .035 | .035 | .020 | ... | ... | ... |
| 1 | 20° | 20° | 22° | 16° | .022 | .030 | .045 | .020 | 15 | 18 | 15 |
| 2 | 31° | 20° | 40° | 20° | .033 | .040 | .035 | .035 | 25 | 28 | 32 |
| 3 | 42° | 33° | 55° | 24° | .050 | .050 | .050 | .045 | 32 | 35 | 30 |
| 4 | ... | ... | ... | 24° | .045 | .075 | .055 | .040 | 32 | 30 | 32 |
| 5 | ... | ... | ... | ... | ... | .070 | .075 | .050 | 36 | ... | 35 |
| 6 | ... | ... | ... | ... | ... | .080 | ... | .090 | ... | ... | ... |

of which it may prove to be only a geographical subspecies. The South American form has a thinner wall and tends to develop chomata in one more volution than the Texas form.

The correct generic assignment of both these species is problematical. Obviously they are descended from *Triticites*, and during their youth could not be distinguished from that genus. But their adult volutions have the characters of *Schwagerina* in that their septa are strongly folded and chomata are obsolete. In their high outer volutions they mimic *Pseudoschwagerina* and strikingly resemble species such as *P. d'orbignyi* and *P. texana*. But they fail to show the sudden inflation at the end of the juvenile stage which is characteristic of *Pseudoschwagerina*, and their walls are notably thicker than is normal for that genus.

The specimen illustrated in Figs. 11 and 12 on Plate 8 shows a unique and puzzling biologic feature. Near one end of the penultimate volution the shell has incorporated the shell of a juvenile individual of the same species. The young shell consisted of a proloculum and approximately one volution. Well defined chomata adhering to the surface of the proloculum define the tunnel and clearly indicate the orientation of the young shell which is approximately at right angles to that of the large one.

There is no possibility that this small shell was introduced as a foreign object after the large shell was empty. Preservation is exceptionally perfect and no matrix had entered the large shell. Moreover, it is evident that the small shell is enveloped in a tangle of septal folds and was actually overgrown by the large one.

Occasional shells of many species of fusulines are found with a double proloculum which appears to indicate that two young individuals had fused completely; but in such cases the individuals were at almost identically the same growth stage when fusion occurred, and it appears possible that it may represent some kind of sex phenomenon akin to the conjugation that is common among the Ciliophora. But the fusion of a very young with a nearly mature individual is an enigma. Is it possible that the adult devoured a young individual and then, instead of rejecting the shell of the latter, grew around and invested it?

*Distribution.*—This species occurs in abundance in Kozlowski's collection 1 and in Newell's collection 138 at Yaurichambi, Bolivia. In the latter it is associated with rare specimens of *Triticites boliviensis*, n. sp.

This is the species which Thompson (1943, p. 204) described as *Schwagerina* aff. *laxissima* Dunbar and Skinner from a deep well in the Agua Caliente oil field in the Department of Loreto northeast of Tarma.

### *Schwagerina muñaniensis* Dunbar and Newell, n. sp.

Plate 11, figs. 7-13.

*Description.*—A small, thickly fusiform species with inflated middle and neatly pointed poles, commonly attaining a length of 5 to 6 mm. and a diameter of 2.5 to 2.6 mm. Shells of this size have about 6 volutions.

The prolocula are small, thin walled, and spheroidal. The first whorl is closely coiled about the small proloculum but the expansion is rapid and the outer volutions are relatively high. The spiral wall is thin, having a thickness of 25 to 30 microns in the second whorl and rarely exceeding 70 microns in the outer whorls.

The septa are strongly folded throughout. The tunnel is narrow but is difficult to measure in thin sections because of the septal folding and the lack of chomata. In the first 2 or 3 whorls there are very low, slender chomata but they are obsolete in the remaining volutions.

TABLE OF MEASUREMENTS.

| whorls | Half length | | | | Radius vector | | | | Form ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 0 | .045 | ... | .09 | .096 | .045 | .086 | .08 | .096 | ... | ... | ... | ... |
| 1 | .14 | ... | .30 | .30 | .12 | .14 | .12 | .16 | 1.2 | 2.5 | 2.5 | 1.9 |
| 2 | .30 | .40 | .60 | .60 | .17 | .23 | .21 | .23 | 1.8 | 2.0 | 2.9 | 2.6 |
| 3 | .60 | .80 | 1.00 | .90 | .30 | .36 | .40 | .36 | 2.0 | 2.0 | 2.5 | 2.5 |
| 4 | 1.20 | 1.40 | 1.70 | 1.30 | .51 | .60 | .70 | .67 | 2.3 | 2.0 | 2.4 | 2.0 |
| 5 | 1.90 | 2.10 | 2.60 | 2.20 | .93 | 1.00 | 1.16 | 1.00 | 2.0 | 1.9 | 2.2 | 2.2 |
| 6 | 2.60 | 2.85 | ... | 3.20 | 1.43 | 1.40 | ... | 1.36 | 1.8 | 2.0 | ... | 2.3 |

| whorls | Tunnel angle | | | | Wall thickness | | | |
|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 2 | ... | 25° | 20° | 26° | .025 | .029 | .029 | .029 |
| 3 | 19° | 35° | 29° | 26° | .030 | .030 | .036 | .043 |
| 4 | 27° | 43° | 29° | 33° | .050 | .060 | .050 | .070 |
| 5 | ... | 34° | 27° | 31° | .070 | .070 | .080 | .070 |
| 6 | ... | ... | ... | 28° | ... | .070 | ... | .070 |

Specimens 1-4 are illustrated on Plate 11 as Figs. 8, 9, 10, and 13, respectively.

*Discussion.*—In its thin wall, loose coiling and strong septal folding, this species resembles *S. nelsoni* Dunbar and Skinner of the Wolfcamp series in Texas, but is only about half as large in corresponding volutions and scarcely attains half the size of the Texas shell. Also it has a much smaller proloculum.

In size and proportions, it resembles *S. bellula* of the Wolfcamp series in Texas. That species also has very small prolocula and high, strong septal folds, but its wall is thicker and it tends to develop epithecal filling along the axis.

*Distribution.*—This species is fairly common in Newell's collection 92 from the Cretaceous conglomerate that rests on the Permian section near Muñani, Peru. The specimen shown as Fig. 7 on Plate 11 was found in Kozlowski's collection 2 at Yaurichambi, where it is associated with *Pseudoschwagerina kozlowskii.*

### *Schwagerina* sp. A

Plate 3, fig. 11.

Associated with *Schwagerina ahlfeldi* in collection N145 from the Tiquina section is an axial section of a shell that resembles that species in general shape and size and in the intensity of its high septal folds. But this shell has a large proloculum (260 microns in diameter) and its inner whorls are few and loosely coiled. Moreover, it has almost no axial filling.

This shell is well outside the range of variation shown by a large number of sections of *S. ahlfeldi*, but whether it represents an individual aberration or a variety or a distinct species cannot be determined until more shells of this type are found.

### *Schwagerina* cf. *S. emaciata* (Beede)

Plate 3, figs. 12, 13.

In Kozlowski's collection from Yaurichambi we find two axial sections of a small slender *Schwagerina* distinctly different from any other species seen in our Andean collections but remarkably similar to *S. emaciata* of the Wolfcamp series in the United States.

One consists of 6½ volutions and has a length of 4.6 mm. and a diameter of 1.6 mm.; the other includes 7½ volutions and has a length (restored) of about 5.7 mm. and a diameter of 1.85 mm. The prolocula are very small, that of the first specimen having a diameter of 100 microns and that of the second only 95 microns. The wall reaches a maximum thickness of about 70 microns in the outer whorl and is rather coarsely alveolar. The septal folds are strong and septal loops high and narrow. A trace of slender chomata can be seen in the first 2 or 3 volutions. The tunnel angle is narrow, rising to about 30° in the fifth and sixth whorls.

Comparison with the illustrations and measurements of *S. emaciata* (Beede) as given by Dunbar and Skinner in 1937 (p. 633 and pl. 56) will show that all the data cited above fall within the limits of the Beede species. Direct comparison of superposed thin sections confirms the identity and we only hesitate to apply the name of the Wolfcamp species to the South American form without additional sections.

*Occurrence.*—Two specimens, only, were found in Kozlowski's collection 7 at Yaurichambi where they are associated with *Pseudoschwagerina d'orbignyi, Triticites patulus, T. titicaca-*

*ensis*, and *T. opimus*. Several specimens apparently belonging to this species were found also in Newell's collection 92-C in bed 3 of the section near Muñani where it has approximately the same associations.

*Pseudoschwagerina kozlowskii* Dunbar and Newell, n. sp.
Plate 5, figs. 1-7.

*Description.*—A thickly fusiform species with evenly elliptical axial profile and subacutely pointed poles. It commonly has about 5 volutions and attains a length of 8 to 9 mm. and a diameter of 4 to 5 mm., the form ratio varying from 1.7 to 2.2.

The proloculum shows a considerable range in size, being only 140 microns in diameter in measured specimen no. 5 but 230 microns in specimen no. 6 and 400 microns in another specimen, but it is commonly between 175 and 250 microns in diameter and is subspherical.

The juvenarium commonly includes about 2½ volutions but if the proloculum is small it may amount to 3½ volutions and if the proloculum is large the juvenarium may be reduced to 2 volutions. In this portion of the shell the whorls are low and the tunnel is bordered by rather slender but well defined chomata. Following the juvenarium the whorl rapidly increases in height, commonly reaching a maximum within half a volution and then declining again in the last whorl as well shown in Figs. 6 and 7 of Plate 5. Chomata are usually completely lacking in the inflated whorls.

The spiral wall is alveolar, showing well defined tectum and keriotheca and increasing gradually in thickness from 20 to 30 microns in the first whorl to about 50 microns in the third and commonly near 100 microns in the fifth.

The septa are gently folded but since they are widely spaced in the inflated whorls the septal loops appear sparse and extremely irregular in axial sections. The true extent of folding is better shown in the juvenile whorls where the septa are more closely spaced and invariably lie near the plane of the section. As shown in Fig. 7 of Plate 5, the septa appear short and thick in the juvenile whorls and very long and much thinner in the inflated whorls. Septal pores are abundant in the inflated whorls.

The tunnel is rather narrow in the juvenile whorls where it is bounded by narrow chomata; but in the inflated whorls it can seldom be measured in thin sections because the septa are so spaced that only rarely does one coincide with the slice. Commonly the septal folds increase in depth in the outer volution.

Statistical measurements tabulated below show large discrepancies between individual shells as is common in this genus. This springs partly from the large variation in the size of the prolocula and the fact that the number of volutions in the juvenarium varies inversely with its size. Thus, for example, the third volution of specimen no. 1 is in the inflated part and in specimen no. 2 it is in the juvenarium. Furthermore, in shells that expand so rapidly, apparent discrepancies are notable if the slices do not fall precisely in the plane coincident with the ends of complete volutions. That is, if one shell is measured exactly at the ends of volutions 1, 2, 3, and 4, and another at 3/4, 1 3/4, 2 3/4 and 3 3/4 volutions, the former will appear to be considerably larger even though the shells are equal in size and shape.

TABLE OF MEASUREMENTS.

| whorls | Half length | | | | Radius vector | | | | Form ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 0 | .12 | .09 | .12 | .14 | .12 | .09 | .12 | .14 | 1.0 | 1.0 | 1.0 | 1.0 |
| 1 | .45 | .27 | .43 | .46 | .25 | .20 | .20 | .29 | 1.8 | 1.4 | 2.1 | 1.5 |
| 2 | .90 | .60 | .90 | 1.10 | .50 | .34 | .40 | .51 | 1.8 | 1.8 | 2.2 | 2.1 |
| 3 | 1.80 | .90 | 1.80 | 2.17 | 1.10 | .50 | .80 | 1.20 | 1.7 | 1.8 | 2.2 | 1.8 |
| 4 | 3.10 | 2.20 | 3.00 | 3.30 | 1.85 | 1.00 | 1.60 | 1.95 | 1.7 | 2.2 | 1.9 | 1.7 |
| 5 | 4.40 | 3.40 | ... | ... | 2.25 | 1.70 | 2.10 | ... | 1.9 | 2.0 | ... | ... |

| whorls | Tunnel angle | | | | Wall thickness | | | | Septal count | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #5 | 6 | 7 |
| 0 | ... | ... | ... | ... | .020 | ... | .020 | ... | ... | ... | ... |
| 1 | 35° | 32° | 28° | 27° | .027 | .020 | .030 | .030 | 10 | 11 | 10 |
| 2 | 38° | 34° | 34° | 37° | .034 | .030 | .050 | .050 | 13 | 17 | 18 |
| 3 | ? | 36° | 22° | 20° | .050 | .050 | .050 | .060 | 17 | 15? | 17 |
| 4 | 33° | ? | ... | ... | .060 | .060 | .070 | .080 | 20 | 26? | ? |
| 5 | ... | ... | ... | ... | .090 | .070 | .110 | ... | 16 | ... | ... |
| 6 | ... | ... | ... | ... | ... | ... | ... | ... | 25? | ... | ... |

Specimens 1, 2, 3, and 5 are illustrated as Figs. 4, 2, 3, and 7, respectively, on Plate 5.

*Discussion.*—This species is intermediate in shape between *P. uddeni* and *P. texana* of the United States. It is less inflated than the former and its volutions never attain as great height;

and it is not so slender and elongate as *P. texana* and its septa are less strongly folded. It is very similar in size and shape to *P. beedei* Dunbar and Skinner from the basal Wolfcamp in the Hueco Mountains, but it appears to be constantly somewhat more slender in the juvenile whorls.

*Occurrence.*—This is a common species in Kozlowski's collections, being present in collection 5 from Yaurichambi, in collections 9, 11, 12, 13, 14, and 18 from Apillapampa, and in collections 19, 20, and 21 from Carpacayma. It is abundant in Newell's collection 92C from unit 3 of his section near Muñani, Peru, which is about 1000 feet above the base of the Permian at that locality. It is also common in Newell's lot 92 which was collected from boulders in the base of the Cretaceous where it rests upon the Permian.

At several localities it is associated with *Pseudoschwagerina d'orbignyi* and with *Schwagerina prolongada* and *Triticites boliviensis.*

### *Pseudoschwagerina d'orbignyi* Dunbar and Newell, n. sp.

Plate 6, figs. 1-9.

*Description.*—A slender species for this genus with bluntly rounded poles and without an equatorial bulge, the axial profile

---

PLATE 3.

*Schwagerina ahlfeldi* Dunbar and Newell, n. sp.

Figs. 1, 2. Paratype axial sections (x 10) from near the top of unit 3 of Newell's section at San Pedro, Strait of Tiquina, Copacabana Peninsula, Bolivia. Newell's collection 145. Y. P. M. 17429.

Figs. 3, 4. Paratype and holotype axial sections (x 10) from a loose block on the outcrop at the same locality. Newell's collection 140. Y. P. M. 17431, 17432.

Figs. 5, 6. Slightly tangential section and tangential slice (x 10) from same rock specimen as the last. Newell's collection 140. Y. P. M. 17433, 17432.

Figs. 7, 8. Paratype sagittal sections (x 10) from same locality as the last. Newell's collection 140. Y. P. M. 17434, 17435.

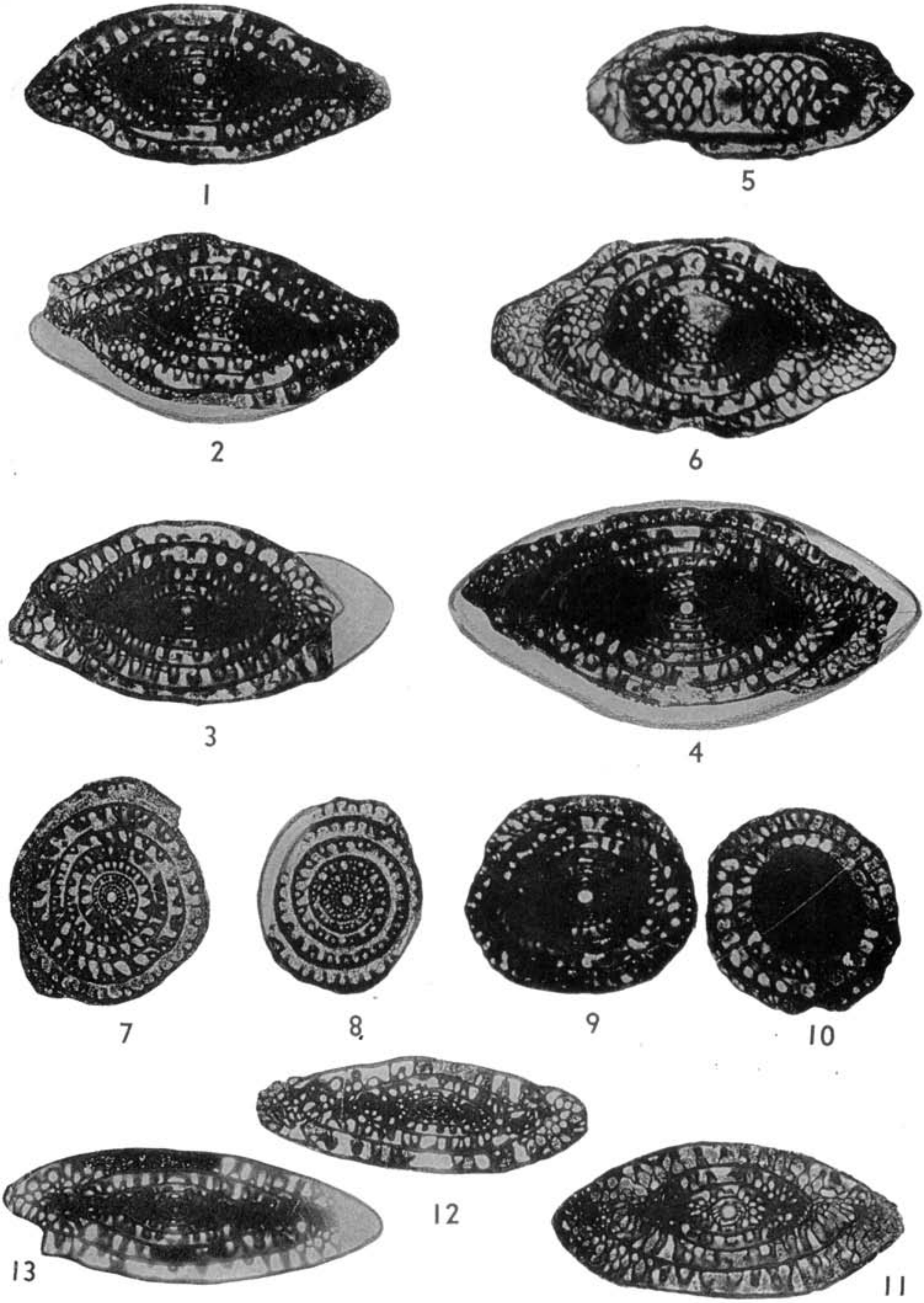
Figs. 9, 10. Slightly oblique sagittal section and excentric section (x 10) showing the heavy axial filling. Same locality as the last. Newell's collection 145. Y. P. M. 17436.

*Schwagerina* sp. A.

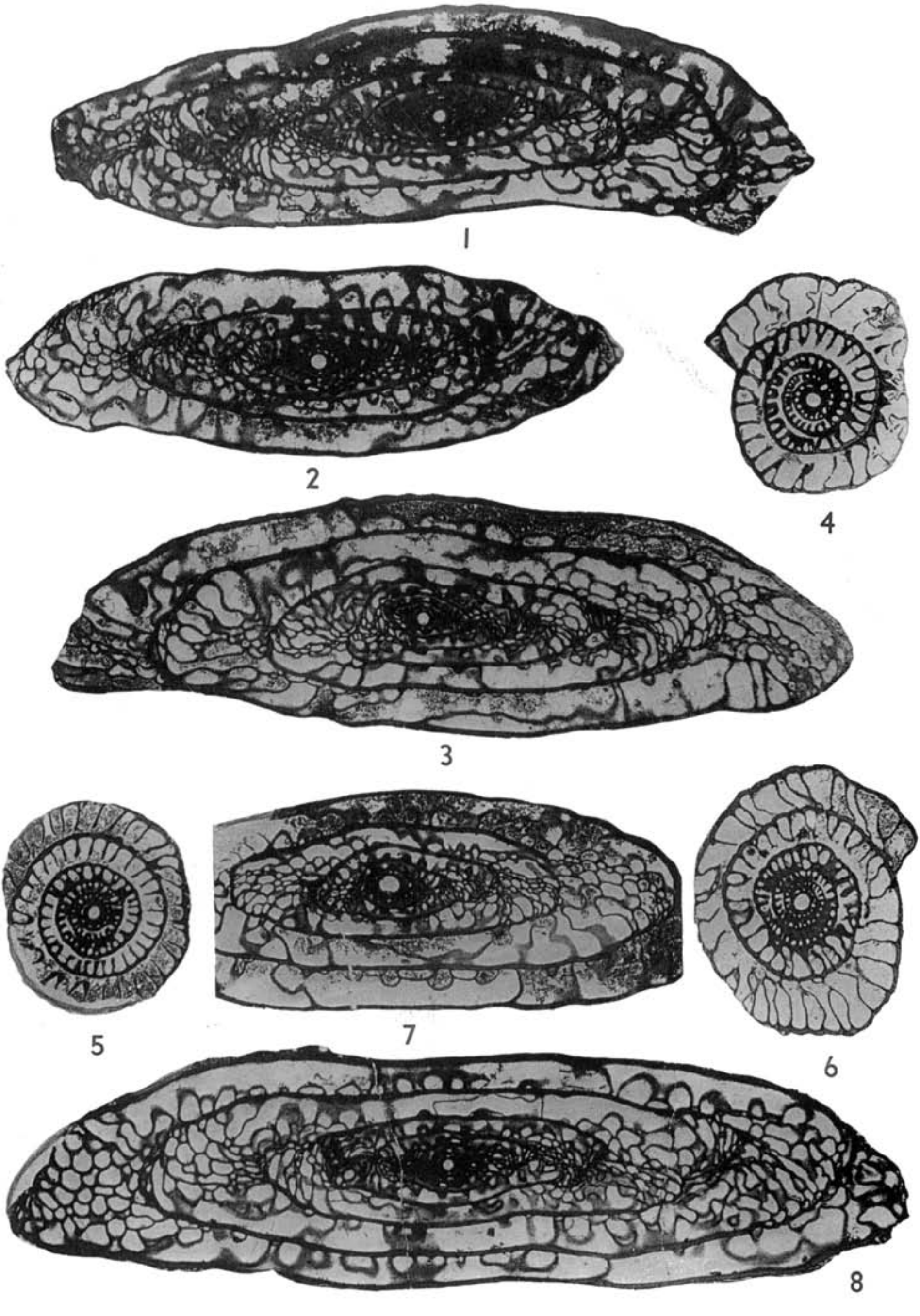
Fig. 11. Axial section (x 10) from same bed as figures 1 and 2. Newell's collection 145. Y P. M. 17437.

*Schwagerina* cf. *S. emaciata* (Beede)

Figs. 12, 13. Axial sections (x 10) from Kozlowski's collection 7 at Yaurichambi.




*Schwagerina ahlfeldi*




*Schwagerina patens*

being an elongate ellipse with a form ratio commonly about 2.5. The shell has about 5 volutions and reaches a length of 5.5 to 6.5 mm. and a diameter of 2.0 to 3.0 mm.

The prolocula range from less than 150 to about 340 microns in diameter and the juvenarium includes from 1½ to 3½ volutions, the number varying inversely with the size of the proloculum. Accordingly, the statistical measurements as tabulated below appear rather widely discordant since the second or third volution in one shell may represent the tightly coiled juvenarium and in another the inflated part of the shell. For example, specimen no. 1 with a smaller proloculum and 5 volutions corresponds very closely in adult size and shape with specimen no. 4 which has a larger proloculum and only 4 volutions.

In the juvenarium there are well defined but slender chomata that disappear in the first of the inflated whorls. The inflation is not quite so rapid as in *P. kozlowskii*, the whorls do not reach so great a height, and the poles are more bluntly rounded.

The spiral wall is like that of *P. kozlowskii* in structure and thickness.

The septa are widely spaced, as is usual in this genus, and are gently folded so that in axial sections the septal loops appear sparse and very irregular. There is a tendency for the lower margin of the septa to be more deeply folded in the outer whorl. The final volution commonly decreases in height, as shown in Figs. 8 and 9 of Plate 6, and the septa are more closely spaced. In some shells these last chambers show a rather close tangle of septal loops. Septal pores are abundant in the inflated whorls.

The tunnel is rather wide, increasing from 20° or 30° in the first volution to 50° or 60° in the fourth. It is clearly defined by the chomata in the juvenile whorls but is commonly not well

---

PLATE 4.

*Schwagerina* (?) *Patens* Dunbar and Newell, n. sp.

Figs. 1, 4, 6. Paratype axial section and two sagittal sections (x 10), from Kozlowski's collection 1 at Yaurichambi.

Figs. 2, 3, 5. Paratype axial sections and a sagittal section (x 10) from Newell's collection 138 at Yaurichambi, Bolivia. Y. P. M. 17438-17440.

Fig. 7. Axial section (x 10) from Kozlowski's collection 1 at Yaurichambi.

Fig. 8. Holotype axial section from Newell's collection 138 at Yaurichambi, Bolivia. Y. P. M. 17441.

shown in good thin sections of the outer whorls where it can be studied best in thick sections or polished surfaces.

Specimens 1, 2, 3, 4, 5, and 6 are illustrated as Figs. 2, 4, 5, 6, 8, and 9, respectively, of Plate 6.

*Discussion.*—This species is distinguished from *P. kozlowskii* by its shape and form ratio. Its proportions resemble those of

TABLE OF MEASUREMENTS.

| whorls | Half length #1 | 2 | 3 | 4 | Radius vector #1 | 2 | 3 | 4 | Form ratio #1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .09 | .17 | .08 | .10 | .09 | .14 | .08 | .10 | 1.0 | ... | 1.0 | 1.0 |
| 1 | .35 | .70 | .50 | .60 | .16 | .35 | .12 | .19 | 2.2 | 2.0 | 4.0 | 3.0 |
| 2 | .70 | 1.50 | 1.10 | 1.50 | .28 | .65 | .40 | .32 | 2.5 | 2.3 | 2.7 | 4.7 |
| 3 | 1.50 | 2.40 | 2.10 | 2.75 | .50 | 1.20 | .90 | .50 | 3.0 | 2.0 | 2.3 | 5.5 |
| 4 | 2.70 | 4.10 | 3.90 | 4.20 | 1.00 | 1.60 | 1.55 | 1.20 | 2.7 | 2.6 | 2.5 | 3.5 |
| 5 | ... | ... | 4.90 | ... | ... | ... | 1.80 | 1.60 | ... | ... | 2.7 | ... |

| whorls | Tunnel angle #1 | 2 | 3 | 4 | Wall thickness #1 | 2 | 3 | 4 | Septal count #5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | ... | ... | ... | ... | .020 | .030 | .015 | .030 | ... | ... | ... |
| 1 | 20° | 28° | ? | 30° | .015 | ? | .015 | ? | 10 | 9 | 10 |
| 2 | 31° | 38° | 39° | 35° | .020 | .050 | .020 | .030 | 15 | 16 | 14 |
| 3 | 37° | 36° | 39° | 43° | .040 | .085 | .050 | .045 | 18 | 16 | 16 |
| 4 | 61° | ? | 50° | 50° | .060 | .085 | .070 | .065 | 23 | 18 | 17 |
| 5 | ... | ... | ... | ... | .090 | ? | .085 | ? | 23 | 18 | ? |
| 6 | ... | ... | ... | ... | ... | ... | ... | ... | 30 | 28 | ? |

*P. texana* of the United States but its ends are thicker and more bluntly rounded and its axial profile elliptical rather than fusiform. It is also considerably smaller than *P. texana*.

---

## PLATE 5.

*Pseudoschwagerina kozlowskii* Dunbar and Newell, n. sp.

Fig. 1. Specimens in the stone (x 1) from Kozlowski's collection 20 at Carpacayma, Bolivia. The more slender specimens belong to the species *P. d'orbignyi*, n. sp.

Fig. 2. Paratype axial section (x 10) from Kozlowski's collection 9 at Apillapampa, Bolivia.

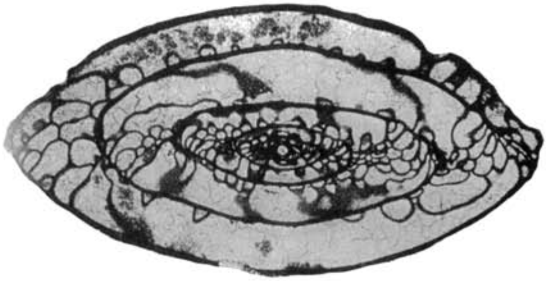
Fig. 3. Paratype axial section (x 10) from Kozlowski's collection 18 at Apillapampa.

Fig. 4. Holotype axial section (x 10) from Kozlowski's collection 11 at Apillapampa.

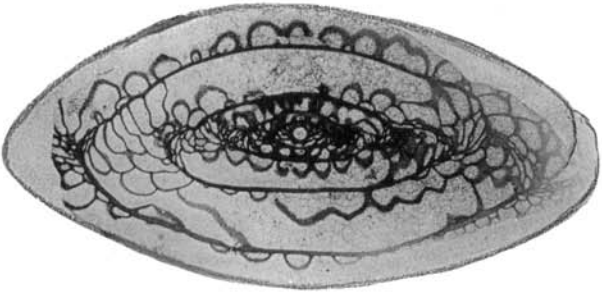
Fig. 5. Paratype axial section (x 10) from Newell's collection 92 at the top of the Permian section near Muñani, Peru. Y. P. M. 17442.

Figs. 6, 7. Paratype sagittal sections (x 10) from Kozlowski's collection 9 at Apillapampa.

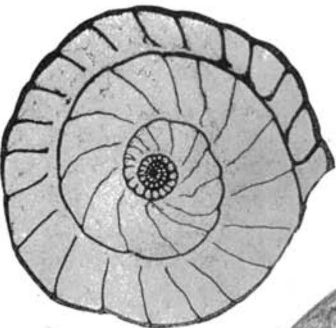
1



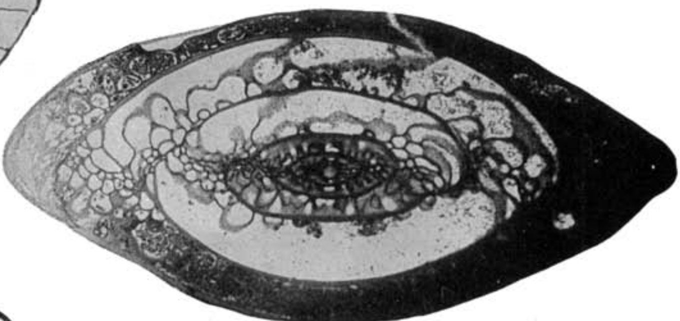
2



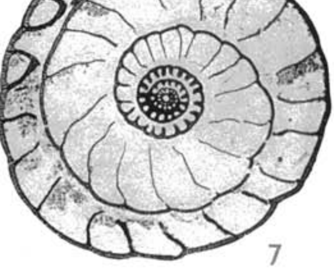
3



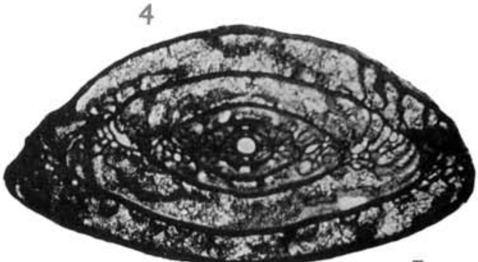
6



4

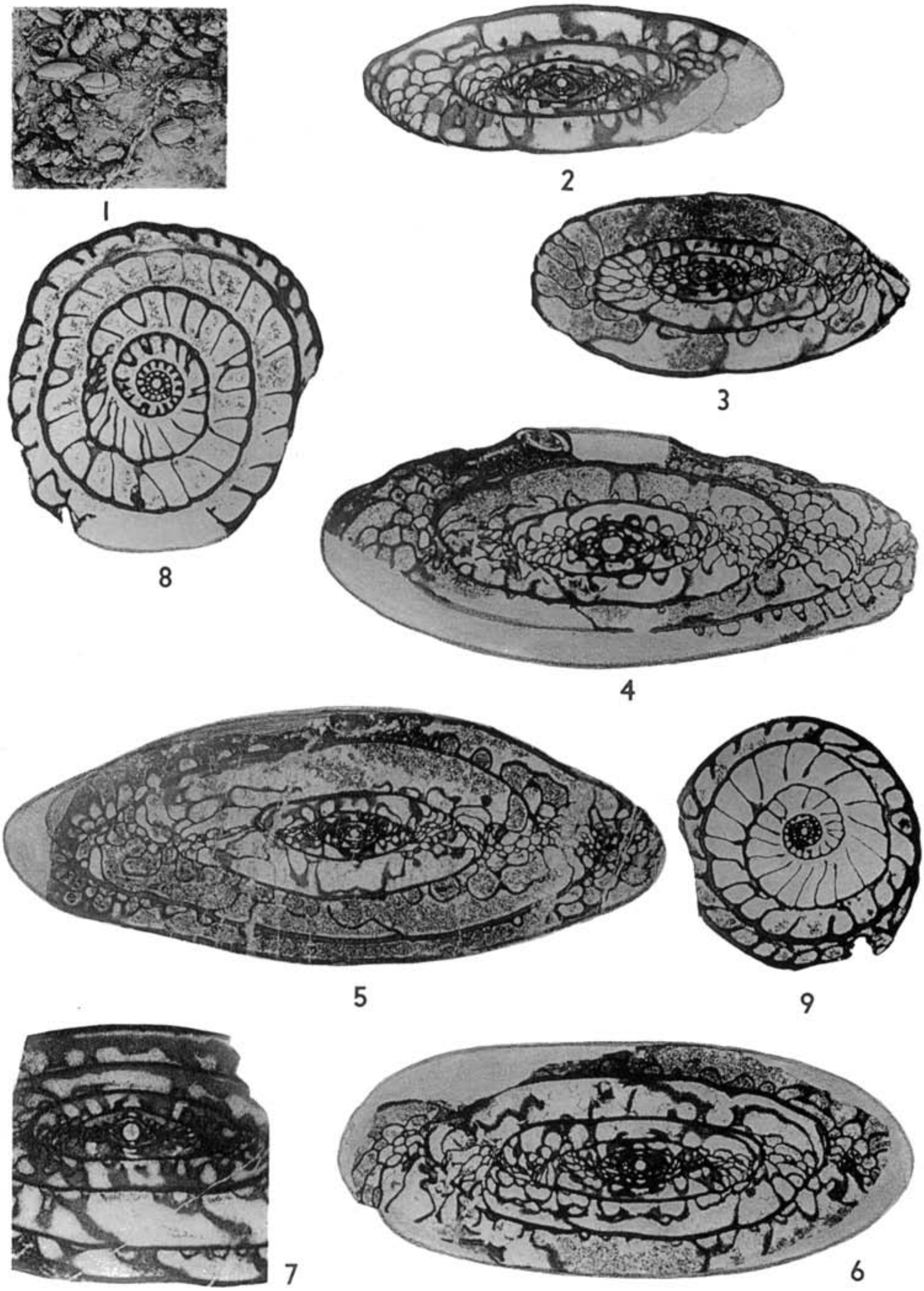


7



5

*Pseudoschwagerina kozlowskii*



*Pseudoschwagerina d'orbignyi*

*Occurrence.*—This species has been found in Kozlowski's collection 5 at Yaurichambi; in collections 11, 14, and 18 at Apillapampa; and in collection 19 at Carpacayma. In each of these it is associated with *P. kozlowskii* and in the last two lots with *Schwagerina prolongada.*

### *Pseudoschwagerina uddeni* (Beede and Kniker)

Plate 7, figs. 1-5; Plate 12, fig. 8.

*Discussion.*—It was a matter of great surprise to find this well known Texan species in South America, and we were predisposed to describe it as new; but after careful comparison with numerous sections from Texas we are unable to find any characters that would justify a distinction. Among our sections is a sagittal slice of a specimen having the remarkable diameter of 10 mm. (Pl. 12, Fig. 8). Its penultimate whorl reaches a height of .22 mm. This is the specimen to which we referred in a preliminary note (Amer. Jour. Sci., vol. 243, p. 218) as "the largest species of *Pseudoschwagerina* yet known." It is, apparently, the largest specimen yet known, but after cutting many sections from this lot we are inclined to believe that it is only an abnormally large individual of *P. uddeni.*

*Distribution.*—This is the well known species so widely distributed in the Wolfcamp strata of southwestern United States. Its only occurrence in the collections before us from South America is in unit 7 of Newell's section at Cerro Pirhuate, Peru, where it is extremely abundant. In the same unit, but not in the same layer, we find *Schwagerina prolongada, S.* (?) *patens, Pseudoschwagerina kozlowskii,* and *Triticites patulus.*

---

PLATE 6.

*Pseudoschwagerina d'orbignyi* Dunbar and Newell, n. sp.

Fig. 1. Specimens in the rock (x 1) from Kozlowski's collection 19 at Carpacayma, Bolivia.

Fig. 2. Juvenile axial section (x 10) from Kozlowski's collection 18 at Apillapampa, Bolivia.

Figs. 3, 5, 6, 9. Two paratypes, the holotype axial section, and a paratype sagittal section (x 10) from Kozlowski's collection 11 at Apillapampa. Figure 6 shows the holotype.

Fig. 4. Paratype axial section (x 10) from Kozlowski's collection 14 at Apillapampa.

Figs. 7, 8. Incomplete axial and sagittal section from Kozlowski's collection 19 at Carpacayma.

## *Triticites berryi* (Willard Berry)

Plate 8, figs. 1-10.

*Schellwienia berryi* Jones mss.
*Fusulina berryi* Berry. Pan-American Geologist, vol. 59, 1933, p. 270, pl. 22, figs. 6 and 7 [not 10].

*Description.*—A small species of 7 to 8 volutions attaining a length of 7.0 to 8.0 mm. and a diameter of 2.0 to 2.5 mm. The shape is evenly fusiform with gently convex lateral slopes tapering to rounded poles.

The prolocula commonly range between 120 and 150 microns in diameter. The early whorls are relatively short and the form ratio increases steadily with growth from about 2.0 in the second whorl to 3.5 or 4.0 at maturity.

The wall is of moderate thickness, increasing gradually from about 40 microns in the third whorl to a maximum of 65 to 80 microns in the sixth. It has the typical structure for *Triticites*, the keriotheca being well developed.

The septa are rather widely spaced for a shell of such small size and the number increases but slowly in successive whorls, scarcely exceeding 20 in the outer volution. However, they are rather strongly folded for this genus. Septal pores are

TABLE OF MEASUREMENTS.

| whorls | Half length #1 | 2 | 3 | 4 | Radius vector #1 | 2 | 3 | 4 | Form ratio #1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .07 | .07 | .06 | .06 | .07 | .057 | .06 | .06 | ... | ... | ... | ... |
| 1 | .23 | .20 | .23 | .17 | .14 | .10 | .12 | .10 | 1.6 | 2.0 | 2.0 | 1.7 |
| 2 | .37 | .44 | .40 | .33 | .21 | .16 | .20 | .16 | 1.8 | 2.8 | 2.0 | 2.0 |
| 3 | .74 | .61 | .71 | .61 | .33 | .26 | .29 | .24 | 2.2 | 2.3 | 2.4 | 2.5 |
| 4 | 1.33 | .94 | 1.23 | 1.06 | .50 | .36 | .43 | .36 | 2.6+ | 2.6 | 3.0 | 2.9 |
| 5 | 2.14 | 1.45 | 2.03 | 1.55 | .73 | .53 | .64 | .56 | 3.0 | 2.7 | 3.0 | 2.8 |
| 6 | 3.46 | 2.45 | 2.86 | 2.45 | 1.01 | .74 | .89 | .71 | 3.4 | 3.3 | 3.1 | 3.4 |
| 7 | 4.30+ | ... | ... | 3.76 | 1.21 | .91 | 1.14 | .97 | 3.5+ | ... | ... | 4.0 |

| whorls | Tunnel angle #1 | 2 | 3 | 4 | Wall thickness #1 | 2 | 3 | 4 | Septal count #5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ... | ... | ... | ... | ... | ... | ... | ... | 12 | 13 |
| 2 | ... | 20° | 28° | ... | ... | ... | ... | ... | 17 | 15 |
| 3 | 27° | 27° | 33° | 31° | ... | .040 | ... | ... | 17 | 16 |
| 4 | 28° | 26° | 36° | 41° | ... | .043 | ... | .045 | 14 | 18 |
| 5 | 40° | 39° | 41° | 40° | .065 | .050 | ... | .065 | 19 | 19 |
| 6 | 45° | 39° | 57° | 49° | .070 | .078 | ... | ... | 18 | 21 |
| 7 | 49° | 50° | ... | 56° | ... | ... | ... | .065 | 19 | ... |

plentiful in the outer whorls, especially in the end zones. Chomata are well developed but not massive. The tunnel tends to widen progressively, its angle being near 30° in the third volution and near 50° in the seventh.

Specimen 1 is the holotype. Specimen 1, 2, 5, and 6 are illustrated on Plate 8, as Figs. 7, 4, 10, and 9, respectively.

*Discussion.*—The original illustrations included 3 figures, an axial and a sagittal section, and an external view of a specimen with one end missing. The latter shows the antetheca which is very regularly and strongly folded, even across the middle of the shell. We are convinced, however, that this unsectioned specimen belongs to a different species, *Schwagerina prolongada.* Accordingly, the axial section figured by Doctor Berry (our Plate 6, Fig. 7) is here designated the holotype of the species. Fortunately, the original lot from which the types were selected includes abundant specimens and of these we have cut 9 axial and 3 sagittal sections. These agree closely and are undoubtedly conspecific with the holotype section. But associated with them is another specimen which externally agrees closely with the one used by Berry to illustrate the exterior of this species (his plate 22, figure 10). Berry's original has been kept intact but its mate was photographed and then cut down to the axis. It was then discovered to have a well marked axial filling and all the other characters of *Schwagerina prolongada.* There can be little doubt that the specimen shown by Berry's plate 22, figure 10, has the same characters. In the original lot studied by Doctor Berry there are, however, several specimens showing the characteristic shape of *T. berryi* which he had cut down to the axial plane and which can be definitely identified with the thin sections. We have introduced figures of these (Plate 8, Figs. 4, 5, 6, 9, 10).

The holotype axial section is much thicker than the usual thin sections and for this reason the septa appear denser and the septal loops more abundant than they do in the other thin sections, but, if cut thinner, part of these would disappear.

*Occurrence.*—The types are from Chulpapampa, Bolivia, but the species was identified by Berry from Yampupata, also. The types are preserved at Johns Hopkins University.

The species occurs in Kozlowski's collection 6 from Yaurichambi, and in his collection 10, 11, and 16 from Apillapampa, Bolivia.

## *Triticites patulus* Dunbar and Newell, n. sp.

Plate 10, figs. 1-10.

*Fusulina peruana* Willard Berry [non Meyer]. Pan-American Geologist, vol. 59, 1933, p. 269, pl. 22, figs. 4, 8, 9, 12.

*Description.*—Shell thickly fusiform (or elliptical in axial profile) with bluntly rounded poles; attaining a length of 5 to 6 mm. and a diameter of 2.5 to 3.0 mm., and at this size consisting of 6 to 7 volutions. The majority of the shells seen are somewhat smaller and are probably immature, having 5 to 6 volutions.

The prolocula range between 125 and 250 microns in diameter with the mean around 200 microns. The inner volutions are rather closely coiled, but the expansion is rapidly accelerated so that the outer volutions are exceptionally high. This is a distinctive feature of the species and gives the shell considerable resemblance to *Pseudoschwagerina* from which, however, it is distinguished by its gradual inflation, its heavier chomata and its thicker wall.

The spiral wall is rather thick, ranging from 25 to 30 microns in the first volution up to 90 microns in the sixth. It is distinctly alveolar with a well differentiated tectum and keriotheca. The tunnel is high and narrow and the chomata are rather massive in the first 3 or 4 volutions but become obsolete in the highly inflated outer whorls.

The septa are rather strongly folded for this genus. Septal pores are abundant but rather small, and are easily overlooked as a result of the strong folding which causes the septa to cross thin sections at a high angle.

Table of measurements.

| whorls | Half length | | | | Radius vector | | | | Form ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 0 | .065 | .085 | .086 | .057 | .065 | .085 | .086 | .057 | ... | ... | ... | ... |
| 1 | .15 | .25 | .20 | .12 | .12 | .15 | .14 | .10 | 1.2 | 1.7 | 1.4 | 1.2 |
| 2 | .30 | .50 | .57 | .21 | .21 | .26 | .24 | .18 | 1.4 | 1.9 | 2.3 | 1.1 |
| 3 | .60 | 1.00 | 1.00 | .46 | .35 | .43 | .41 | .30 | 1.7 | 2.3 | 2.4 | 1.5 |
| 4 | 1.15 | 1.55 | 1.70 | .87 | .57 | .64 | .64 | .49 | 2.0 | 2.4 | 2.0 | 1.7 |
| 5 | 1.55 | 2.50 | 2.43 | 1.71 | .93 | 1.00 | 1.00 | .79 | 1.6 | 2.5 | 2.4 | 2.1 |
| 6 | 2.20 | 3.60 | ... | ... | 1.26 | 1.43 | ... | ... | 1.7 | 2.5 | ... | ... |

| | Tunnel angle | | | | Wall thickness | | | | Septal count | |
|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #5 | 6 |
| 0 | ... | ... | ... | ... | .012 | .030 | .025 | .025 | ... | ... |
| 1 | ... | ... | 25° | 20° | .015 | .030 | .030 | .020 | 14 | 14 |
| 2 | 18° | 10° | 28° | 19° | ... | .030 | .035 | .025 | 19 | 17 |
| 3 | 27° | 18° | 33° | 27° | .050 | .050 | .040 | .030 | 19 | 19 |
| 4 | 28° | 24° | 42° | 29° | .060 | .060 | .060 | .050 | 20 | 19 |
| 5 | ... | 29° | ... | ... | .080 | .100 | .090 | .060 | ... | 24 |
| 6 | 24° | 39° | ... | ... | .080 | .100 | ... | ... | ... | ... |

Specimens 1, 2, 3, 5, and 6 are shown on Plate 10 as Figs. 7, 8, 6, 9, and 10, respectively.

*Discussion.*—We have cut about 50 sections of this common species. Its distinctive features are its thickly ellipsoidal shape and its accelerated expansion and high outer volutions.

Berry identified this shell with *Schellwienia peruana* Meyer, the types of which were found at Tarma, Peru; but, as shown on page 486, that form is not only specifically but even generically distinct from the Bolivian shells. *Schellwienia* is a straight synonym of *Fusulina*, and *peruana* of Berry is therefore a homonym of *peruana* Meyer. Figures 1 and 2 of our Plate 10 show exterior views of the two immature shells figured by Berry and figures 4, 5, 9, and 10 show axial and sagittal sections cut by Dunbar from cotypes selected by Berry.

There is no other American species of *Triticites* which approaches this one in its rapid and accelerated expansion.

*Distribution.*—This is a very common species in Kozlowski's collections 2, 4, 5, and 7 at Yaurichambi and in his collections 13 and 16 at Apillapampa, Bolivia.

### *Triticites titicacaensis* Dunbar and Newell, n. sp.

Plate 11, figs. 1-6.

*Description.*—A small, thickly ventricose species with regularly curved lateral slopes and neatly pointed poles, commonly 4.5 to 5.0 mm. in length and slightly over 2 mm. in diameter. Shells of this size have about 7 rather tightly coiled volutions.

The prolocula range in diameter from about 100 to 200 microns and are normally subspherical and have a wall thicker than that of the first volution. The spiral wall is rather thin, commonly measuring only 20 to 25 microns in thickness in the third volution and rarely exceeding 60 microns in the outer whorls.

Septa are rather strongly folded for this genus and septal loops are abundant even across the middle of axial sections. The tunnel is very narrow, commonly measuring between 15° and 25° in the third whorl and scarcely more in the outer volutions. It is bordered by massive chomata that are uncommonly heavy for a shell of this genus. In addition to the chomata, there is considerable epithecal material spread as a film on the wall and septa, all of which tends to give the shell a compact, dense appearance in thin section.

TABLE OF MEASUREMENTS.

| whorls | Half length | | | | Radius vector | | | | Form ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 0 | .101 | .042 | .086 | .064 | .101 | .042 | .071 | .064 | 1.0 | 1.0 | 1.2 | 1.0 |
| 1 | .17 | .10 | .21 | .14 | .14 | .07 | .14 | .10 | 1.2 | 1.4 | 1.5 | 1.4 |
| 2 | .34 | .18 | .43 | .29 | .21 | .13 | .24 | .17 | 1.6 | 1.3 | 1.7 | 1.7 |
| 3 | .50 | .34 | .67 | .46 | .30 | .18 | .41 | .29 | 1.6 | 1.8 | 1.6 | 1.5 |
| 4 | .76 | .57 | 1.23 | .77 | .44 | .31 | .66 | .43 | 1.7 | 1.8 | 1.8 | 1.7 |
| 5 | 1.15 | .86 | ... | 1.20 | .60 | .47 | .96 | .63 | 1.9 | 1.8 | ... | 1.9 |
| 6 | 1.57 | 1.23 | ... | 1.57 | .79 | .64 | ... | .84 | 1.9 | 1.9 | ... | 1.8 |
| 7 | 2.00 | 1.71 | ... | 2.28 | 1.03 | .93 | ... | ... | 1.9 | 1.8 | ... | ... |

| whorls | Tunnel angle | | | | Wall thickness | | | | Septal count |
|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #5 |
| 0 | ... | ... | ... | ... | .025 | .025 | .020 | .025 | ... |
| 1 | 14° | 17° | 19° | 13° | .020 | .015 | .025 | .018 | 14 |
| 2 | 10° | 13° | 9° | 17° | .023 | .015 | .030 | .020 | 14 |
| 3 | 16° | 22° | 29° | 16° | .025 | .020 | .040 | .024 | 18 |
| 4 | 14° | 18° | 21° | 22° | .030 | .025 | .055 | .020 | 20 |
| 5 | 17° | 21° | ... | 32° | .030 | .028 | .063 | .033 | 17 |
| 6 | 21° | 26° | ... | ... | .055 | .030 | ... | .045 | 21 |
| 7 | ... | ... | ... | ... | .075 | .037 | ... | ... | ... |

Specimens 1, 3, 4, and 5 are illustrated on Plate 11 as Figs. 1, 4, 5, and 6, respectively.

## PLATE 7.

*Pseudoschwagerina uddeni* (Beede and Kniker)

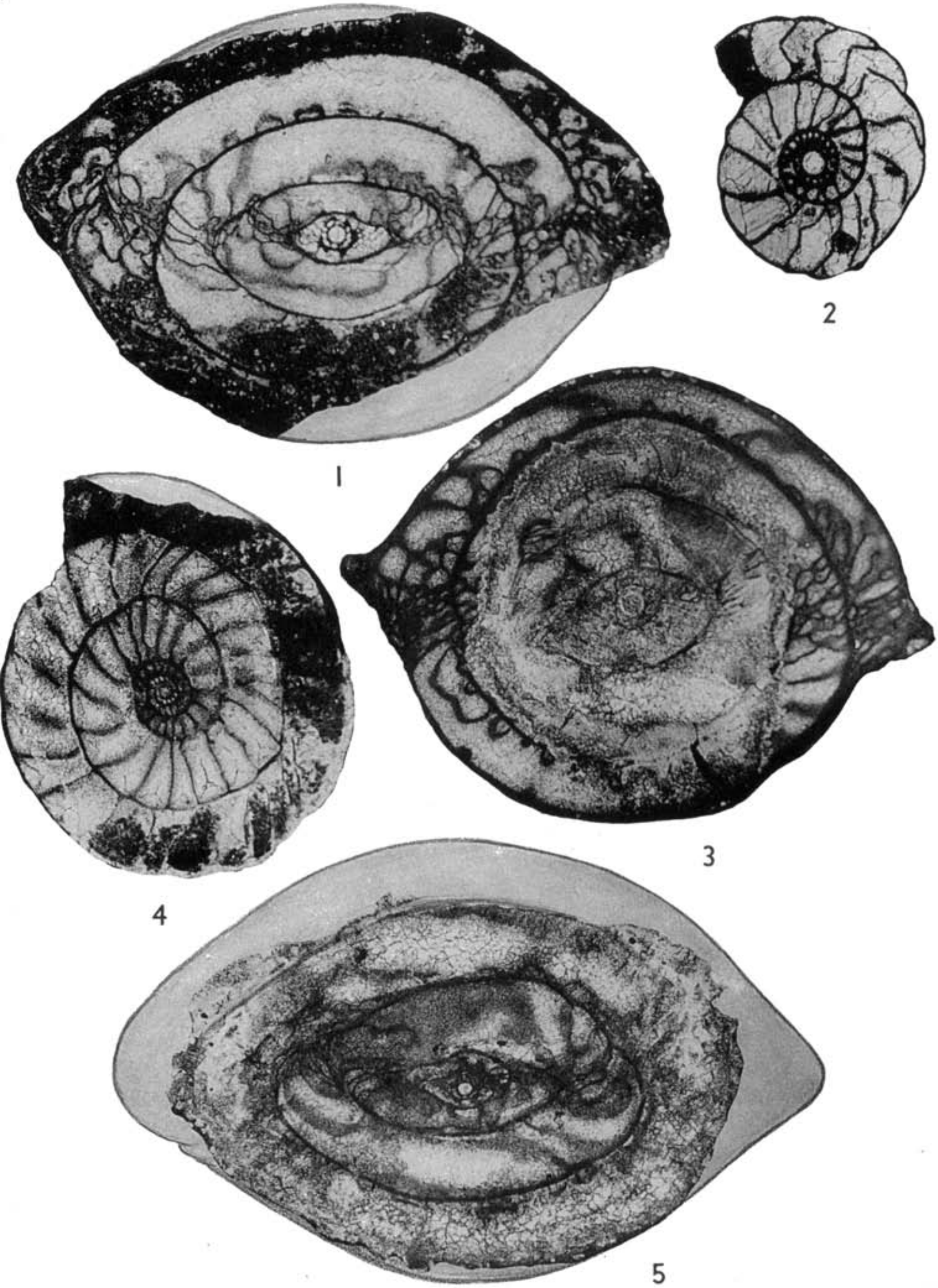
Fig. 1. Axial section (x 10). Y. P. M. 17443.

Fig. 3. Slightly oblique axial section (x 10) which foreshortens the axial length. Y. P. M. 17444.

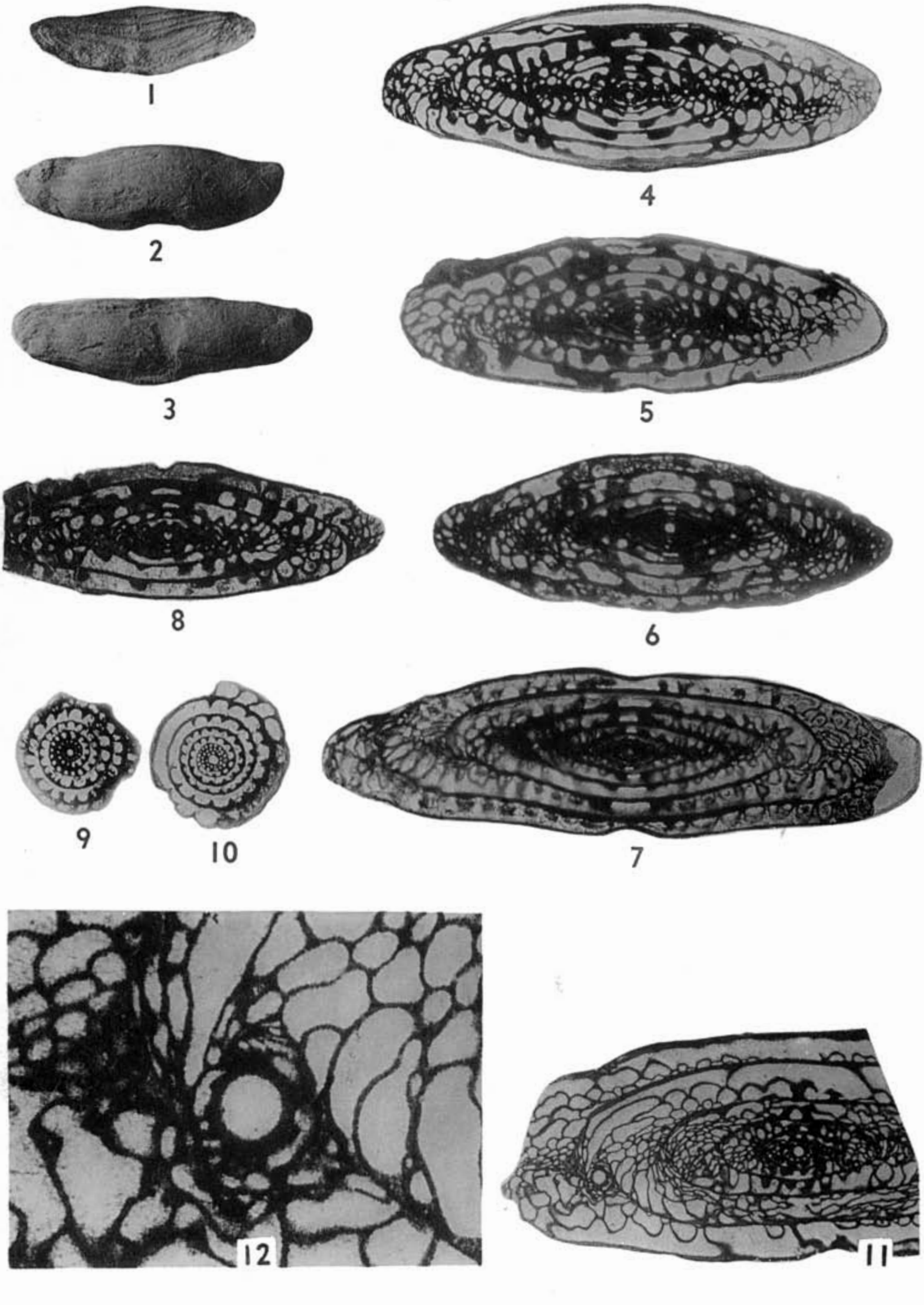
Fig. 5. Axial section (x 10) with restored outer margin. Y. P. M. 17445.

Figs. 2, 4. Incomplete sagittal sections (x 10). Y. P. M. 17446, 17447.

All from Newell's collection 69-7 in bed 7 of the section at Cerro Pirhuate, Peru. This is about 2100 feet above the base of the Upper Paleozoic.




*Pseudoschwagerina uddeni*




*Triticites berryi*

*Discussion.*—This species is distinguished by its close coiling, strong septal folding, heavy chomata, narrow tunnel, and the epithecal deposit especially in the juvenile whorls.

*Distribution.*—This species was found in Kozlowski's collections 2, 5, and 7 from Yaurichambi, and in his collection 16 from Apillapampa, Bolivia.

### *Triticites boliviensis* Dunbar and Newell, n. sp.

Plate 9, figs. 1-11.

*Description.*—This is a slender species of medium-small size. The middle of the shell is subcylindrical or but slightly fusiform and the poles are rather bluntly rounded. It commonly attains a length of 7 to 8 mm. and a diameter of 1.6 to 2.0 mm., and at this size has 6 to 7 volutions. The shell shown by Fig. 8 on Plate 9 has 8 volutions and is larger than any other specimen seen which we would refer to this species.

The proloculum is small, commonly between 125 and 200 microns in diameter, and subspherical. The equatorial expansion is slow and gradual and the whorls low. The wall is thin, increasing gradually from about 20 microns thickness in the first volution to 30 microns in the third and 45 microns in the fifth. It shows distinctly an alveolar structure of rather fine texture.

---

## PLATE 8.

### *Triticites berryi* (Willard Berry)

Figs. 1-3. Paratypes (x 5) from Chulpapampa, Bolivia, in the collections of Johns Hopkins University.

Figs. 4-6. Paratype axial sections (x 10) from the same collection.

Fig. 7. Holotype axial section. This is the specimen figured by Berry as figure 6 of his plate 22.

Fig. 8. Axial section from Kozlowski's collection 7 at Yaurichambi, Bolivia.

Figs. 9, 10. Paratype sagittal sections (x 10) from the same lot as figures 4 to 6.

### *Schwagerina* (?) *patens* Dunbar and Newell, n. sp.

Fig. 11. Axial section (x 10) showing at the left end of the penultimate whorl a young shell of the same species incorporated in the large shell. From Kozlowski's collection 1 at Yaurichambi, Bolivia.

Fig. 12. Enlarged detail (x 50) of the area about the young shell in figure 11.

The septa are nearly plane across the middle of the shell but are thrown into relatively loose, irregular folds near the poles, as indicated in Fig. 3 of Plate 9. Septal pores are common but very fine. The tunnel is low and rather wide, the tunnel angle increasing from about 40° to 50° in the third volution up to 55° or 60° in the fifth. Chomata are well developed in all but the outer whorl, but are rather slender.

TABLE OF MEASUREMENTS.

| whorls | Half length | | | | Radius vector | | | | Form ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 |
| 0 | .086 | .05 | .071 | .071 | .071 | .05 | .071 | .057 | 1.2 | 1.0 | 1.0 | 1.2 |
| 1 | .23 | .20 | .24 | .27 | .12 | .10 | .15 | .15 | 1.9 | 2.0 | 1.6 | 1.8 |
| 2 | .36 | .45 | .46 | .44 | .18 | .18 | .23 | .23 | 2.0 | 2.5 | 2.0 | 1.9 |
| 3 | .57 | .90 | .84 | .91 | .26 | .28 | .36 | .36 | 2.1 | 3.2 | 2.3 | 2.5 |
| 4 | 1.07 | 1.50 | 1.57 | 1.71 | .30 | .45 | .54 | .51 | 3.5 | 3.3 | 2.9 | 3.3 |
| 5 | 1.85 | 2.25 | ... | 2.43 | .57 | .65 | ... | .77 | 3.2 | 3.5 | ... | 3.1 |
| 6 | 2.43 | 3.40 | ... | ... | .76 | .90 | ... | ... | 3.1 | 3.7 | ... | ... |

| | Tunnel angle | | | | Wall thickness | | | | Septal count | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | 2 | 3 | 4 | #1 | 2 | 3 | 4 | #5 | 6 | 7 |
| 0 | ... | ... | ... | ... | .025 | .020 | .013 | .019 | ... | ... | ... |
| 1 | 35° | ... | 28° | 22° | .020 | .015 | .021 | .020 | 12 | 11 | 11 |
| 2 | 37° | 25° | 36° | 45° | .025 | .015 | .020 | .030 | 15 | 12 | 13 |
| 3 | 40° | 35° | 44° | 49° | .029 | .025 | .030 | .030 | 16 | 16 | 13 |
| 4 | 48° | 50° | ... | 53° | .027 | .030 | .033 | .040 | 17 | 19 | 17 |
| 5 | 56° | 51° | ... | ... | .059 | .043 | ... | .045 | 15 | 21 | 22 |
| 6 | ... | ... | ... | ... | .040 | .065 | ... | .045 | ... | ... | ... |

Specimens 1 to 7 are illustrated on Plate 9 as Figs. 3, 7, 1, 4, 11, 9, and 10.

*Discussion.*—This small slender triticite is a conservative form and might be compared with Pennsylvanian rather than Permian species. There is considerable resemblance, for example, to *T. venustus* Dunbar and Henbest of Illinois and to *T. acutus* Dunbar and Condra from the Virgil series in Nebraska and Kansas. It is difficult to draw useful distinctions between such simple and conservative forms. But since the one before us is associated with Permian faunas and is from a distant continent, it seems wise not to apply to it the name of our Pennsylvanian species.

*Distribution.*—The types of this species are mostly from Kozlowski's collection 14 at Apillapampa, Bolivia, and there it is associated with *Pseudoschwagerina kozlowskii* and *P. d'orbignyi.* It is also associated with these species in Kozlowski's collections 10, 11, and 12 from the same locality and is present in his collection 1 at Yaurichambi where it is associated with *Schwagerina patens.*

### *Triticites nitens* Dunbar and Newell, n. sp.

Plate 9, figs. 12-16.

*Description.*—A minute species of 5 to 6 volutions which only attains a length of about 2.5 to 3.0 mm. and a thickness of 1 to 1.2 mm. Its shape is meloniform with convex lateral slopes and bluntly rounded poles.

The proloculum is minute, commonly between 100 and 150 microns in diameter. The spiral wall is thin and the volutions are closely coiled.

The septa are very gently folded except near the poles, and the tunnel is bordered by well-developed chomata.

TABLE OF MEASUREMENTS.

| whorls | Half length #1 | 2 | 3 | 4 | Radius vector #1 | 2 | 3 | 4 | Form ratio #1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .071 | .071 | .071 | .071 | .071 | .057 | .071 | .057 | 1.0 | 1.2 | 1.0 | 1.2 |
| 1 | .16 | .23 | .17 | .20 | .10 | .11 | .11 | .10 | 1.6 | 2.0 | 1.5 | 2.0 |
| 2 | .26 | .36 | .26 | .37 | .14 | .17 | .17 | .16 | 1.8 | 2.1 | 1.5 | 2.3 |
| 3 | .51 | .53 | .43 | .58 | .20 | .23 | .27 | .31 | 2.5 | 2.3 | 1.5 | 1.8 |
| 4 | .71 | .79 | .67 | .96 | .33 | .36 | .41 | .37 | 2.1 | 2.1 | 1.6 | 2.5 |
| 5 | 1.11 | 1.13 | 1.08 | ... | .43 | .44 | .57 | ... | 2.5 | 2.5 | 1.8 | ... |

| whorls | Tunnel angle #1 | 2 | 3 | 4 | Wall thickness #1 | 2 | 3 | 4 | Septal count #5 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | ... | ... | ... | ... | .013 | .019 | .025 | .015 | 10 |
| 1 | 14° | 16° | 24° | 17° | .014 | .015 | .015 | .019 | 15 |
| 2 | 22° | 20° | 21° | 30° | .025 | .019 | .020 | .020 | 19 |
| 3 | 24° | 26° | 28° | 31° | .035 | .020 | .030 | .025 | 20 |
| 4 | 30° | 32° | ... | ... | .025 | .030 | .030 | .027 | 22 |
| 5 | ... | ... | ... | ... | ... | .040 | .033 | ... | ... |
| 6 | ... | ... | ... | ... | ... | .034 | ... | ... | ... |

Specimens 1, 2, 3, and 5 are illustrated on Plate 9 as Figs. 14, 13, 16, and 15, respectively.

*Discussion.*—One might suspect that these minute shells are merely juvenile individuals of one of the larger species. The small size of its prolocula and early volutions would rule out most of the associated species. We have compared them closely with the inner whorls of *Triticites boliviensis* and the resemblance is close through the third volution, but in the fourth and fifth whorls *T. boliviensis* rapidly expands and by the end of the fifth is nearly twice as long as *T. nitens*. After careful study we are forced to conclude that this is a minute species. It was found sparingly in several collections but is not abundant in any of the material studied.

*Occurrence.*—This species is most common in Kozlowski's collection 16 from Apillapampa, Bolivia, and has also been found in collections 13 and 14 from the same locality. In collection 16 it is associated with *Schwagerina prolongada*, *S. steinmanni*, *Triticites berryi*, *T. patulus*, and *T. titicacaensis*; and in collections 13 and 14 it is associated with *Pseudoschwagerina kozlowskii* and *P. d'orbignyi*.

---

PLATE 9.

*Triticites boliviensis* Dunbar and Newell, n. sp.

Fig. 1. Axial section (x 10) of juvenile shell from Kozlowski's collection 10 at Apillapampa, Bolivia.

Fig. 2. Axial section (x 10) from Newell's collection 138 at Yaurichambi, Bolivia. Y. P. M. 17448.

Fig. 3. Axial and tangential slices (x 10) of specimens in the rock from Kozlowski's collection 14 at Apillapampa.

Figs. 4-7. Four typical axial sections (x 10) from the same collection as the last. Figure 4 represents the holotype.

Fig. 8. Axial section (x 10) of a specimen tentatively referred to this species, though it has more volutions and a greater size than the types. The course of the septa indicates that at the left end the shell is curving away and that end of the section is therefore somewhat foreshortened. From Kozlowski's collection 1 at Yaurichambi, Bolivia.

Figs. 9, 10. Sagittal sections (x 10) from Kozlowski's collection 13 at Apillapampa, Bolivia.

Fig. 11. Sagittal section (x 10) from Kozlowski's collection 10 at Apillapampa.

*Triticites nitens* Dunbar and Newell, n. sp.

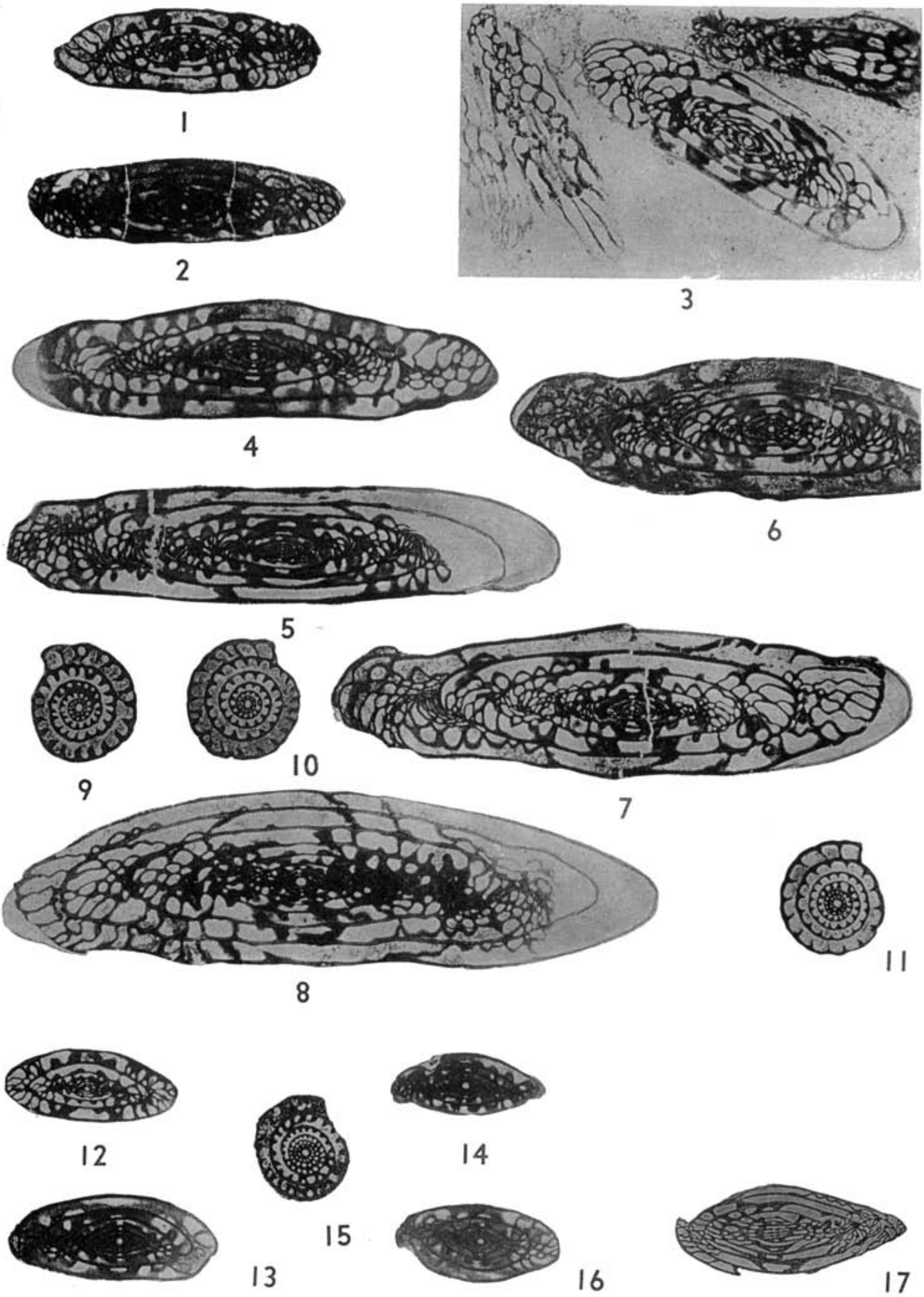
Fig. 12. Paratype axial section (x 10) from Kozlowski's collection 13 at Apillapampa, Bolivia.

Figs. 13, 14, 16. Holotype and two paratype axial sections (x 10) from collection 16 at the same locality.

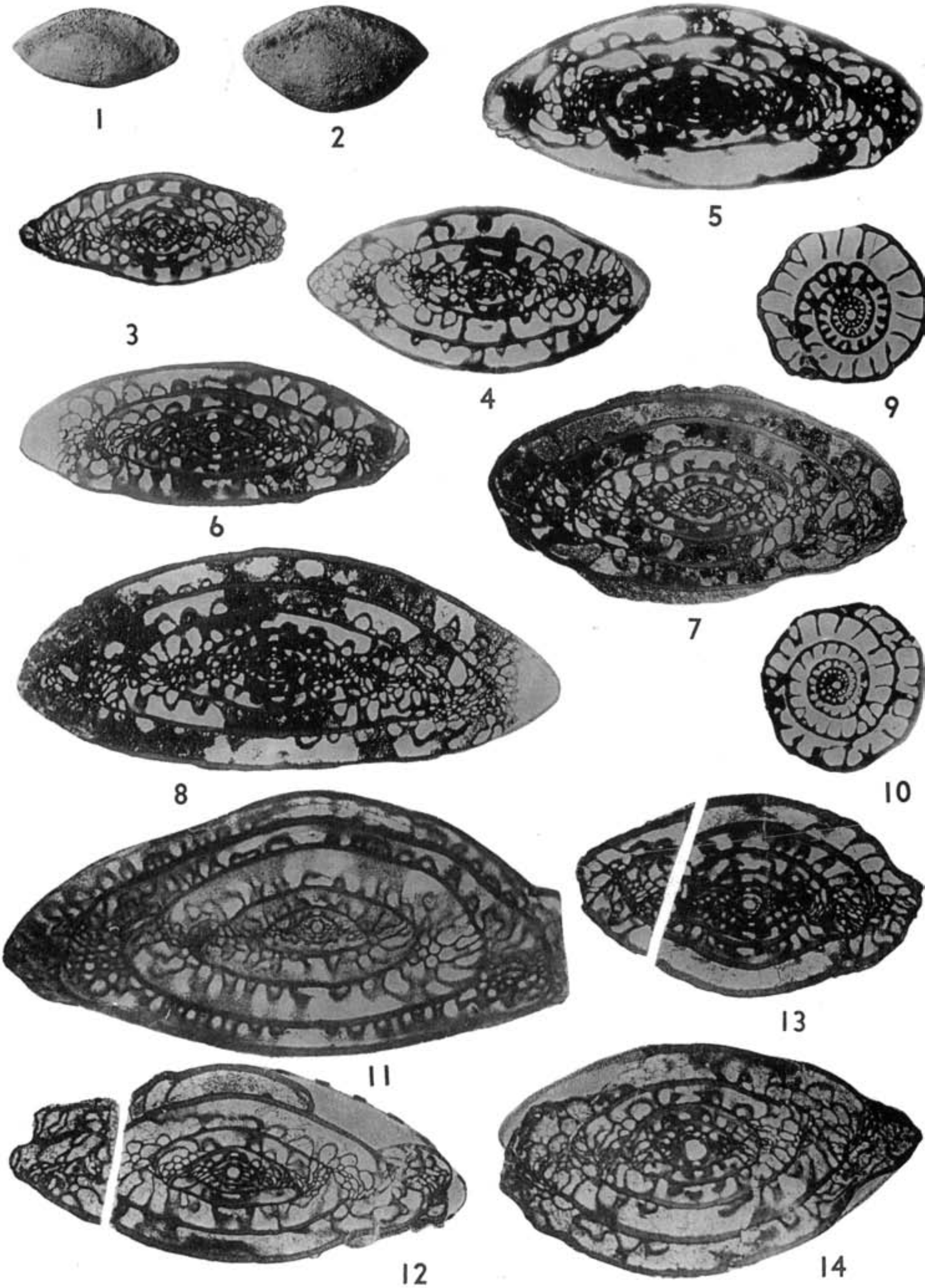
Fig. 15. Paratype sagittal section from collection 16 at the same locality.

*Fusulinella peruana* (Meyer)

Fig. 17. Reproduction of Meyer's original figure reduced to a magnification of 10 diameters.




*Triticites boliviensis*




*Triticites patulus*
*Triticites opimus*

### *Triticites opimus* Dunbar and Newell, n. sp.

Plate 10, figs. 11-14.

*Description.*—A rather large, thickly fusiform species of 5 to 6 volutions attaining a length of 5 to 8 mm. and a diameter of 3 to 3.6 mm. The lateral slopes are convex and the poles obtusely rounded. There appears to be an unusual amount of irregularity in the shape near the poles.

The prolocula are rather large and show wide range in size with diameters ranging from about 200 to some 400 microns. The shell expands rapidly during growth and the volutions are uncommonly high. The spiral wall is thick and distinctly alveolar.

The tunnel is rather narrow and variable in width, with a tendency for the tunnel angle to reach its maximum in the fourth volution and decrease in the fifth. Chomata are present but are rather slender and are proportionately more massive in the first 2 or 3 volutions than in later ones.

The septa are rather widely spaced and are somewhat strongly folded for this genus. The holotype (Fig. 11 of Plate 10) shows uneven folds along the inner margin of the septa which are relatively strong and high in the last 1½ volutions but are weaker and lower in the inner whorls. This is a thick section and the septal loops appear more abundant than they do in normal thin slices.

---

PLATE 10.

*Triticites patulus* Dunbar and Newell, n. sp.

Figs. 1, 2. Exterior views of two immature shells (x 5) from Chulpapampa, Bolivia. These were figured by Berry as *Fusulina peruana* Meyer and are in the collections of Johns Hopkins University.

Fig. 3. Axial section of young shell (x 10) from Kozlowski's collection 2 at Yaurichambi, Bolivia.

Figs. 4, 5, 9, 10. Two axial and two sagittal sections (x 10) from Chulpapampa in the collections of Johns Hopkins University. These sections were cut by Dunbar from Berry's lot labelled "*Fusulina peruana* Meyer."

Figs. 6, 7, 8. Axial sections showing shells of different growth stages (x 10) from Kozlowski's collection 7 at Yaurichambi. The specimen represented as figure 7 is designated as the holotype.

*Triticites opimus* Dunbar and Newell, n. sp.

Fig. 11. Holotype (x 10) from Newell's collection 92-C from bed 3 of the section near Muñani, Peru. Y. P. M. 17454.

Figs. 12-14. Paratype axial sections from Newell's collection 92 in bed 51 of the section near Muñani. Y. P. M. 17455-17457.

TABLE OF MEASUREMENTS.

| whorls | Half length #1 | 2 | 3 | 4 | Radius vector #1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|
| 0 | .10 | .20 | .14 | .12 | .10 | .18 | .12 | .12 |
| 1 | .34 | .54 | .30 | .43 | .20 | .43 | .19 | .23 |
| 2 | .87 | .93 | .80 | .86 | .43 | .66 | .31 | .31 |
| 3 | 1.78 | 1.50 | 1.60 | 1.16 | .80 | .97 | .50 | .57 |
| 4 | 2.75 | 2.57 | 2.40 | 1.95 | 1.20 | 1.45 | .89 | .87 |
| 5 | 3.70 | ... | 3.20 | 2.86 | 1.75 | ... | 1.27 | 1.43 |
| 6 | ... | ... | ... | 3.71 | ... | ... | ... | ... |

| whorls | Tunnel angle #1 | 2 | 3 | 4 | Wall thickness #1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|
| 0 | ... | ... | ... | ... | .030 | .040 | .040 | .035 |
| 1 | ... | 23° | 31° | 22° | .045 | .070 | .030 | .045 |
| 2 | 34° | 18° | 34° | 28° | .070 | .060 | .030 | .060 |
| 3 | 34° | 30° | 44° | 40° | .070 | .085 | .050 | .070 |
| 4 | 34° | 59° | 55° | 38° | .108 | .108 | .070 | .100 |
| 5 | 22° | ... | 45° | ? | .130 | ... | .100 | .130 |
| 6 | ... | ... | ... | ? | ... | ... | ... | .140 |

Specimens 1-3 are illustrated on Plate 10 as Figs. 11, 14, and 12, respectively.

*Discussion.*—In size and shape, and in its high volutions, this species resembles *Pseudoschwagerina kozlowskii*, with which it is associated, but it expands gradually and has well developed chomata and a relatively thick wall. It is unquestionably to be referred to *Triticites*.

It also resembles *T. patulus* in its rapid expansion, but differs notably from that species in its ontogeny, having a much larger proloculum, fewer and more loosely coiled early whorls, weaker chomata, and a smaller number of volutions at maturity.

*Occurrence.*—Found in the section near Muñani where it is rather common in bed 3 (Newell's collection 92-C). Also present in Kozlowski's collection 7 from Yaurichambi.

### *Fusulinella peruana* (Meyer)

Plate 9, fig. 17; Plate 12, figs. 1-7.

*Schellwienia peruana* Meyer. Neues Jahrb. für Min., Geol. und Pal., Beil.-Bd. 37, 1914, p. 623, pl. 14, figs. 3a and b. (Not *Fusulina peruana* Berry, 1933.)

*Original description* (free translation).—"The shells are strongly inflated, 2.5 to 3.7 mm. long and 1.5 to 1.8 mm. thick.

The number of volutions appears to reach 6 at maximum, but commonly only 5 are present. The whorls are tightly coiled and the height of the volutions increases gradually from the inner to the outer. The wall is very thin, reaching only 30 microns in the outer whorl. The twice measured proloculum has a diameter of 60 microns. The septa are thick and but very slightly folded. The folding appears strongest in the axial region. A rather narrow tunnel is always clearly displayed, being bounded by strong chomata. The septal count in the single measured specimen is 15, 18, 21, 24 for the first 4 volutions, respectively. The increase in the number is so gradual that the septal curve is a straight line. Nothing could be seen of keriotheca."

Meyer's description was clearly based on inadequate material. He figured only one sagittal and one longitudinal section and the latter is somewhat oblique and does not cut the proloculum (our Pl. 9, Fig. 17). He stated that he counted the septa in only one specimen and measured the proloculum in only two.

Fortunately he located the source of his types in the section at Tarma and it is almost certainly bed 22 of Newell's section (page 387). The abundant fusulines collected from that bed by Newell are in all probability, therefore, topotypes of Meyer's species. On the basis of this material it is redescribed as follows:

*Description.*—A rather thickly fusiform species of 7 to 8 volutions commonly attaining a length of about 4.8 and a thickness of about 2.3 mm. The middle of the shell is very slightly inflated and the poles are rather bluntly rounded.

The proloculum is commonly between 100 and 150 microns in diameter and is spheroidal. The volutions of the shell expand gradually and rather slowly. The first whorl is almost spheroidal with a form ratio of only 1.2 to 1.3 and the shape changes gradually during ontogeny until the length is about twice the diameter at maturity.

The septa are nearly plane except near the poles where they are irregularly folded. Septal pores are abundant, at least in the outer whorls, but are rather obscure. The tunnel is moderately high and of moderate width, as shown in the table of measurements.

The wall has the structure typical of *Fusulinella*, the diaphanotheca appearing as an almost clear layer between the

TABLE OF MEASUREMENTS.

| whorls | Half length #1 | 2 | 3 | 4 | Radius vector #1 | 2 | 3 | 4 | Form ratio #1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .07 | .05 | ? | .07 | .07 | .05 | ? | .07 | 1.0 | 1.0 | ... | 1.0 |
| 1 | .14 | .09 | .12 | .17 | .12 | .10 | .09 | .14 | 1.2 | ... | 1.3 | 1.2 |
| 2 | .26 | .21 | .24 | .30 | .17 | .16 | .14 | .20 | 1.5 | 1.3 | 1.7 | 1.5 |
| 3 | .43 | .36 | .36 | .47 | .27 | .26 | .21 | .29 | 1.6 | 1.4 | 1.7 | 1.6 |
| 4 | .79 | .63 | .46 | .73 | .40 | .39 | .33 | .41 | 2.0 | 1.6 | 1.4 | 1.8 |
| 5 | 1.30 | .99 | .79 | 1.01 | .59 | .59 | .47 | .57 | 2.2 | 1.7 | 1.7 | 1.8 |
| 6 | 1.55 | 1.47 | 1.13 | 1.37 | .77 | .77 | .63 | .73 | 2.0 | 1.9 | 1.8 | 1.9 |
| 7 | 2.00 | 2.10 | 1.57 | 1.85 | 1.04 | 1.04 | .86 | .95 | 2.0 | 2.0 | 1.8 | 2.0 |
| 8 | ... | ... | 2.15 | ... | ... | ... | 1.10 | ... | ... | ... | 2.0 | ... |

| whorls | Tunnel angle #1 | 2 | 3 | 4 | Wall thickness #1 | 2 | 3 | 4 | Septal count #5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | ... | ... | ... | ... | .020 | ... | ... | .015 | ... | ... |
| 1 | ... | ... | ... | ... | ... | .015 | .015 | .015 | 11 | 13 |
| 2 | 16° | 24° | 22° | 21° | .020 | .015 | .020 | .030 | 15 | 18 |
| 3 | 13° | 20° | 21° | 15° | ... | .043 | .030 | .035 | 17 | 23 |
| 4 | 24° | 16° | 23° | 17° | .043 | .030 | .030 | .035 | 21 | 25 |
| 5 | 24° | 21° | 25° | 26° | ... | .043 | .043 | .050 | 22 | 27 |
| 6 | 30° | 27° | 25° | 25° | .043 | .070 | .070 | .070 | 26 | 32 |
| 7 | 37° | 34° | 32° | 17° | .060 | ... | .060 | .043 | ... | ... |
| 8 | ... | ... | 38° | ... | ... | ... | .036 | ... | ... | ... |

tectoria, as shown on Fig. 5, Plate 12. The inner tectorium is thinner than the diaphanotheca but the outer tectorium comprises fully half the thickness of the wall and is not clearly delimited from the chomata which are thick and wide.

## PLATE 11.

### *Triticites titicacaensis* Dunbar and Newell, n. sp.

Figs. 1, 2. Holotype axial section (x 10 and x 20) from Kozlowski's collection 7 at Yaurichambi, Bolivia.

Figs. 3, 6. Paratype axial and sagittal sections (x 10) from Kozlowski's collection 16 at Apillapampa, Bolivia.

Figs. 4, 5. Paratype axial sections (x 10) from Kozlowski's collection 2 at Yaurichambi, Bolivia.

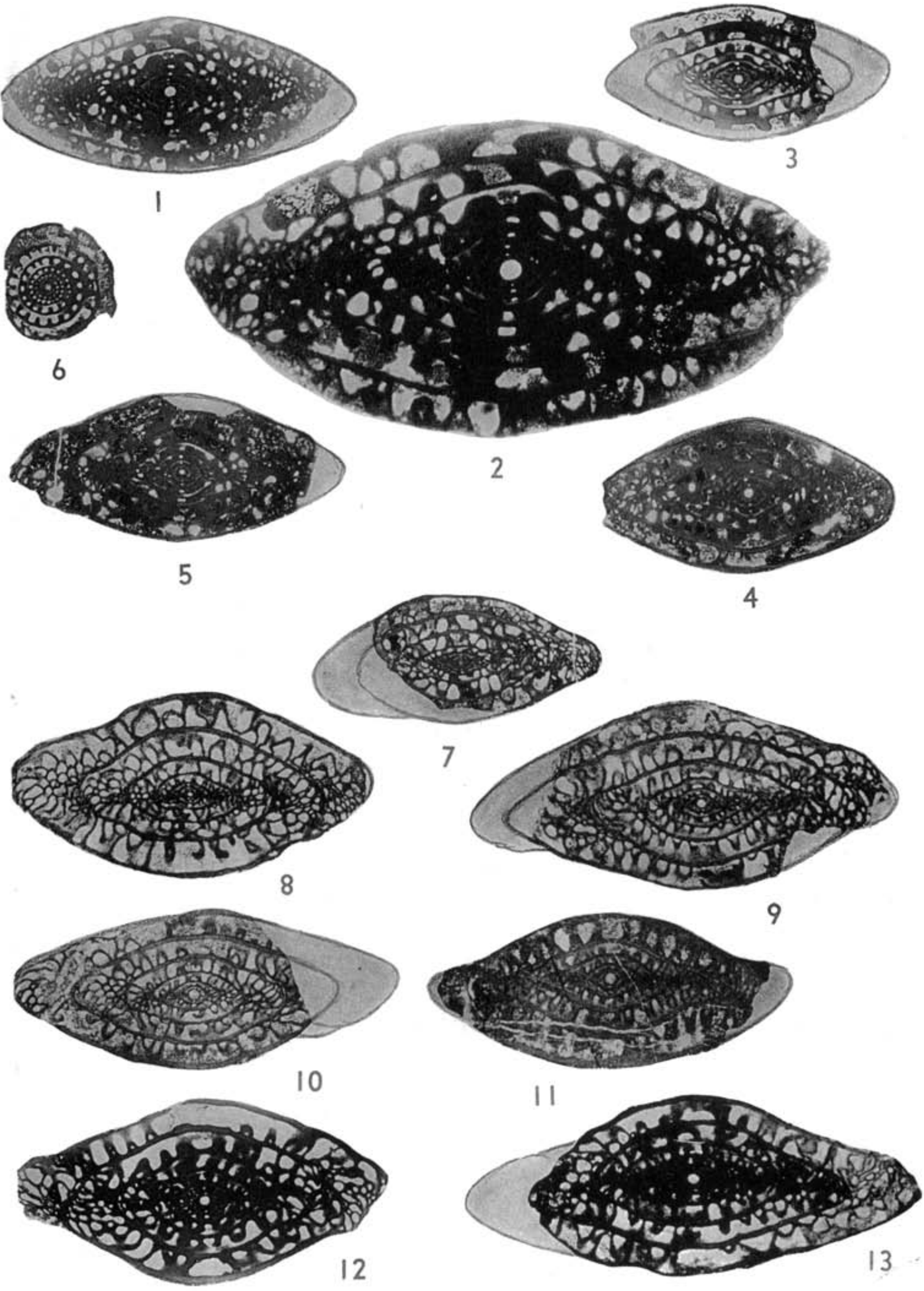
### *Schwagerina muñaniensis* Dunbar and Newell, n. sp.

Fig. 7. Paratype axial section (x 10) from Kozlowski's collection 2 at Yaurichambi, Bolivia.

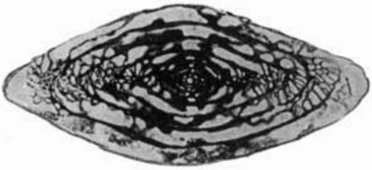
Fig. 8. Holotype axial section (x 10) from Newell's collection 92 at the summit of the Permian section near Muñani, Peru. Y. P. M. 17449.

Figs. 9-11, 13. Paratype axial sections (x 10) from the same collection as figure 8. Y. P. M. 17450-17453.

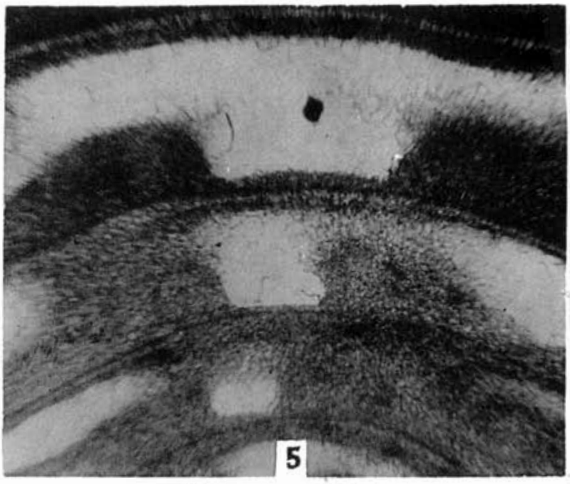
Fig. 12. Axial section (x 10) from Kozlowski's collection 7 at Yaurichambi, Bolivia.




*Triticites titicacaensis*
*Schwagerina muñaniensis*



1

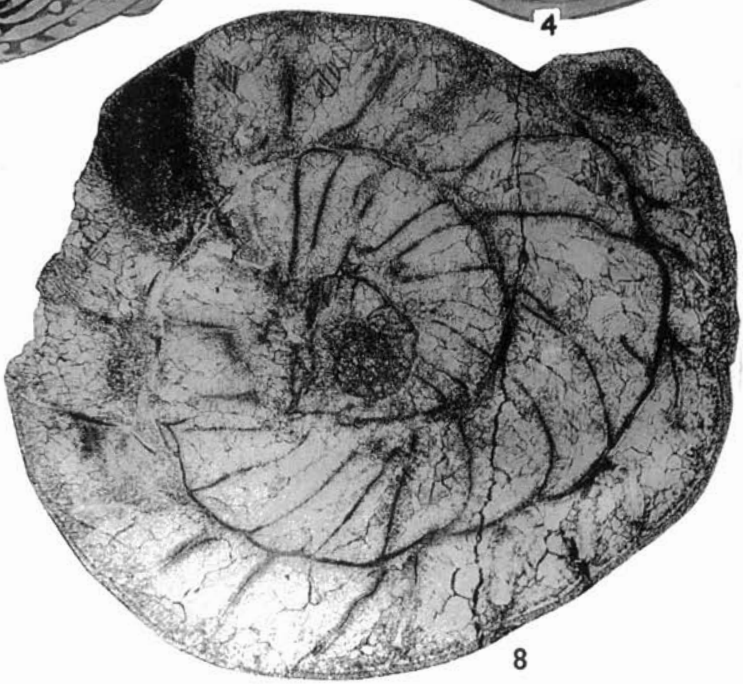


5

2

4

3



6

7

8

*Fusulinella peruana*
*Pseudoschwagerina*

Specimens numbered 1 to 6 are illustrated by Figs. 1-4, 6, and 7 on Plate 12.

*Discussion.*—If our shells are topotypes, Meyer must have based his species upon immature individuals, since he observed only 5 or 6 volutions and indicated a maximum length of 3.7 mm., whereas ours commonly attain 7 to 8 volutions and have a length of 4.8 mm. Support for this inference may be seen in the fact that in the fifth and sixth volutions our shells agree closely with the dimensions given by Meyer. Our measurements of the prolocula appear to differ from those of Meyer who found the diameter to be only 60 microns in the two specimens examined. But his illustration (his figure 3b) clearly shows a larger size. When allowance is made for the fact that this figure is enlarged 16 diameters, it indicates a proloculum having an inside diameter of about 68 microns and an outside diameter of about 115 microns. If we assume that Meyer measured the inside dimensions, as some students have done, then the discrepancy disappears. Meyer also indicated a thinner wall than we have observed, but if he was dealing with immature shells this difference also is explained.

This is an uncommonly large species for the genus *Fusulinella* and its wall attains an exceptional thickness due to the massive inner tectorium.

The form which Willard Berry described under the name of "*Fusulina peruana* (Meyer)," from the Lake Titicaca region, is both generically and specifically distinct and is redescribed in this study as *Triticites patulus*, n. sp.

*Occurrence.*—Found near the top of the Tarma group (=Des Moines series) in the section at Tarma, central Peru (bed 22 of Newell's section).

---

PLATE 12.

*Fusulinella peruana* Meyer.

Figs. 1-4. Axial sections (x 10) of topotypes from bed 22 of Newell's section of the Tarma group at Tarma, Peru. Y. P. M. 17459, 17460.

Fig. 5. Enlargement (x 150) of a part of the section shown in figure 4. This can be identified with an area in the second to fifth volutions in the upper half of that figure.

Figs. 6, 7. Sagittal sections (x 10) from the same lot. Y. P. M. 17461.

*Pseudoschwagerina* cfr. *P. uddeni* (Beede and Kniker).

Fig. 8. Sagittal section (x 10) of a specimen from collection 69-7 in bed 7 of Newell's section at Cerro Pirhuate, Peru. Y. P. M. 17458.

REFERENCES.

Berry, E. W.: 1928. An ammonoid from the Carboniferous of Peru. Amer. Jour. Sci. (5), **15**, 151-153.

Berry, Willard: 1933. Fusulina from Peru and Bolivia. Pan-Amer. Geologist, **59**, 269-272, pl. 22.

Bowman, Isaiah: 1916. The Andes of southern Peru. Amer. Geogr. Soc., New York, 1-336, 204 figs. (Spanish translation by Carlos Nicholson, Arequipa, Peru, 1938.)

Cabrera la Rosa, Augusto, and Petersen, George: 1936. Reconocimiento geológico de los yacimientos petroliferos del Departamento de Puno. Bol. Cuerpo Ing. Minas del Perú; Departamento de Petroleo, no. 115, 1-100, 1 fig., 15 pls.

Derby, O. A.: 1876. Notes on the Paleozoic fossils (in "Exploration of Lake Titicaca," by A. Agassiz). Bull. Mus. Comp. Zool., **3**, 279-286.

D'Orbigny, Alcide: 1842. Voyage dans l'Amérique méridionale de 1826-1833, **3**, pt. 4, Paleontologie.

Douglas, J. A.: 1915. Geological sections through the Andes of Peru and Bolivia. I, From the coast at Arica in the north of Chile to La Paz and the Bolivian "Yungas." Quart. Jour. Geol. Soc. London, **70**, 1-53.

————: 1920. Ibid., II, From the Port of Mollendo to the Inambari River. Quart. Jour. Geol. Soc. London, **76**, 1-61, pls. 1-6.

Forbes, D.: 1861. Report on the geology of South America, Part I, Bolivia and southern Peru; with notes on the fossils by Huxley, Salter, and Jones. Quart. Jour. Geol. Soc. London, **17**, 7-62.

Gabb, W. M.: 1877. Description of a collection of fossils made by Dr. A. Raimondi in Peru. Jour. Acad. Nat. Sci., Philadelphia, (2), **8**.

Gerth, H.: 1915. Geol. und morphologischen Beobachtungen in den Kordilleren Südperus. Geol. Rundschau, **6**, 129-153, pls. 2-7.

Gregory, H. E.: 1913. Geologic sketch of Titicaca Island and adjoining areas. Amer. Jour. Sci. (4), **36**, 187-213.

————: 1916. A geological reconnaissance of the Cuzco Valley, Peru. Amer. Jour. Sci. (4), **41**, 1-100, 2 pls.

Harrison, J. V.: 1913. Geología de los Andes Centrales en parte del Departamento de Junín, Perú. Bol. Soc. Geol. Peru, **16**, 1-97. (In Spanish and English.)

Keidel, Juan, and Harrington, H. J.: 1938. On the discovery of Lower Carboniferous tillites in the Precordillera of San Juan, Western Argentina. Geol. Mag., **75**, 103-129.

King, Robert E.: 1930. Geology of the Glass Mountains, Texas. Pt. II, Faunal summary and correlation of the Permian formations with description of Brachiopoda. Univ. of Texas Bull. 3042, 1-245, 5 figs., 44 pls.

Kozlowski, Roman: 1914. Les brachiopodes du Carbonifére supérieur de Bolivie. Ann. de Paleontologie, **9**, 1-100, 24 figs., 11 pls.

Lisson, Carlos I., and Boit, Bernardo: 1942. Edad de los Fósiles Peruanos y distribución de sus depósitos, 4th ed., Lima.

Maldonado, E.: 1918. Contribución al estudio de la geología de Sicuani. Revista Universitaria, Año 13, **2** (Lima).

McLaughlin, Donald H.: 1924. Geology and physiography of the Peruvian Cordillera, Departments of Junín and Lima. Bull. Geol. Soc. Amer., **35**, 591-632.

Meyer, Hermann L. F.: 1914. Carbonfaunen aus Bolivia und Perú. Neues Jahrb. für Min., Geol. und Pal., Beil.-Bd. **37**, 590-652, pls. 13 and 14.

Miller, A. K.: 1934. *Pseudoparalegoceras,* a new genus of Carboniferous ammonoid. Jour. Paleont., **8**, 18-20, pl. 2.

Newell, N. D.: 1946. Geological investigations around Lake Titicaca. Amer. Jour. Sci., **244**, 357-366.

Read, Charles B.: 1941. Plantas fósseis do Neo-Paleozoico do Paraná e Santa Caterina, Brazil. Div. Geol. e Miner., Mon. 12, 1-102.

Singewald, J. T., and Berry, E. W.: 1922. The geology of the Corocoro Copper-District of Bolivia. Johns Hopkins Univ. Studies in Geol., no. 1, 1-117, pls. 1-7.

Steinmann, G.: 1929. Geologie von Peru, 1-448, pls. 1-9, Heidelberg. (Spanish edition, Geología del Perú, Heidelberg, 1930.)

Thomas, H. D.: 1928 and 1930. An Upper Carboniferous fauna from the Amotape Mountains, northwestern Peru. Geol. Mag., **65**, 146-152, pl. 5, 215-234, pls. 6-8, 289-301, pls. 10-12; **67**, 394-408, pl. 24.

Thompson, M. L.: 1943. Permian fusulinid from Peru. Jour. Paleont., **17**, 203-205, pl. 33.

Toula, F.: 1869. Ueber einige Fossilien des Kohlenkalkes von Bolivia. Akad. der Wiss., Wien.

Weaver, Charles E.: 1942. A general summary of the Mesozoic of South America and Central America. Proc. Eighth Amer. Sci. Congress, **4**, 149-193, 1 fig., 2 pls.

CARL O. DUNBAR,
PEABODY MUSEUM,
YALE UNIVERSITY,
NEW HAVEN, CONN.

NORMAN D. NEWELL,
THE AMERICAN MUSEUM OF NATURAL HISTORY,
AND COLUMBIA UNIVERSITY,
NEW YORK CITY.