THE TRANSITIONAL PERMIAN AMMONOID FAUNA OF TEXAS.

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An ammonoid fauna transitional from Coal Measures to Permian has long been needed. It was formerly thought that the Artinsk fauna of Russia filled this gap, but later studies have shown that even the Artinsk fossils do not extend down to the bottom of the Permian, and that the basal beds are barren. There is a great gap between the ammonoids as we last see them in the upper Uralian and when we next meet them in the Artinsk. Highly specialized *Propinacoceras, Artinskia*, and *Medlicottia* do not come into being all at once and there is nothing in the Uralian even remotely approaching them. *Pronorites* of the Coal Measures is certainly the radicle, but separated from its descendants by at least one generic step.

It was formerly assumed that the development from the ammonoids of the Coal Measures to those of the Permian must have taken place in the waters of the ancient Mediterranean or its direct connections. That was because the faunas of that region were the only ones well known. But the center of gravity has shifted, and we now have an upper Coal Measures ammonoid fauna, in the southwestern states of the Union, of twenty-six species and eight genera, as contrasted with three species and three genera in the Uralian. Also Dr. Emil Boese[1] has described from western Texas the "Wolfcamp" ammonoids from beds at least 2,000 feet below the equivalent of the Artinsk horizon. This fauna Boese rightly assigns to the lowest Permian, but older and more primitive than any Permian previously known, and distinctly younger and more specialized than any known Coal Measures (Uralian) fauna.

The University of Texas has sent the writer, for study, all of Boese's original specimens, including the types; and more recently the writer has also received from Prof. I. A. Keyte,[2] of Colorado Springs, Colorado, a collection from the

[1] The Permo-Carboniferous ammonoids of the Glass Mountains, West Texas, and their stratigraphical significance. Univ. Texas Bull. 1762, 1917.

[2] The writer wishes to acknowledge his indebtedness to the cordial assistance of Prof. I. A. Keyte, and of Dr. J. A. Udden, Dr. J. W. Beede, and Dr. C. L. Baker, in sending collections of Permian fossils and furnishing data concerning their occurrence and association.

Wolfcamp formation, zone of *Uddenites,* in which nearly all of Boese's Wolfcamp species are present, with some additions, including a new species of *Parapronorites* and one of *Prothalassoceras,* both being Lower Permian genera and new to America. Professor Keyte[3] has recently published a preliminary account of this fauna, stating that the zone of *Uddenites* is in the "upper Gaptank," and not in the Wolfcamp formation, as Boese had thought. Keyte is also of the opinion that the fauna is the equivalent of the Cisco, and thus belongs to Upper Pennsylvanian instead of to Lower Permian. These conclusions are not borne out by the present studies.

The Upper Pennsylvanian ammonoid fauna is now quite well known, and has increased greatly since the publication of the writer[4] twenty-five years ago, thanks to the work of G. H. Girty, J. W. Beede, and Emil Boese. It now includes twenty-six species: *Gastrioceras* 12, *Schistoceras* 4, *Shumardites* 1, *Agathiceras* 1, *Marathonites* 1, *Gonioloboceras* 3, *Neodimorphoceras* 3, *Daraelites* ? 1. These are listed in the table beyond, but the list is incomplete, for the writer has several undescribed Upper Pennsylvanian species. (Note the omission of *Schuchertites grahami* from the list. This species is probably the young of *Engonoceras* Hyatt, of the Cretaceous; and being preserved in brownish red oxide of iron like the Cisco species of Graham, was probably mixed with them by A. B. Gant.)

The Upper Pennsylvanian fauna gives one of the best interregional correlation zones in the whole Carboniferous. It is like the upper Uralian, only much richer, and has been called by Schmidt[5] the "zones of *Schistoceras,*" which name is hardly appropriate, since *Schistoceras* is quite as common in the lowest Permian as in the Upper Pennsylvanian. In the same paper, Schmidt assigns the Wolfcamp fauna to the upper Uralian, because of the lack of *Parapronorites* and *Medlicottia.* This argument is no longer effective, since it is shown here that *Parapronorites* is present, and that *Uddenites* is a primitive Medlicottoid, quite as specialized as could be expected at the base of the Permian.

The Wolfcamp ammonoid fauna, as now known, consists

[3] Keyte, I. A., Blanchard, W. G., Jr., and Baldwin, H. L., Jr., Gaptank-Wolfcamp problem of the Glass Mountains, Texas. Jour. Pal., 1, No. 2, 175-178, 1927.

[4] Smith, J. P., The Carboniferous ammonoids of America. U. S. Geol. Survey, Mon. 42, 1903.

[5] Schmidt, H., Die carbonischen Goniatiten Deutschlands. Jahrb. preuss. geol. Landesanstalt, 45, 513, 1924.

of ten genera and seventeen species, distributed as follows: *Gastrioceras* 2, *Paralegoceras* 1, *Schistoceras* 4, *Shumardites* 2, *Marathonites* 3, *Agathiceras* 1, *Daraelites* 1, *Uddenites* 1, *Parapronorites* 1, *Prothalassoceras* 1.

This fauna includes *Schistoceras hyatti, S. hildrethi, S. fultonense,* and *Gastrioceras subcavum,* which range up unchanged from the Upper Pennsylvanian. It also includes other Coal Measures genera: *Shumardites, Marathonites, Paralegoceras, Agathiceras,* and *Daraelites,* which range up from the Pennsylvanian, but with specific change and increasing complication. It likewise has *Parapronorites* and *Prothalassoceras,* widely distributed in the Permian, and as yet unknown below the Permian. Included also is *Uddenites,* the most primitive Medlicottoid known, but clearly related to, and probably ancestral to, the Medlicottiinae that mark the Permian everywhere.

The Wolfcamp fauna lacks: *Gonioloboceras* and *Neodimorphoceras* of the Upper Pennsylvanian, and *Paragastrioceras, Propinacoceras, Artinskia,* and *Medlicottia* of the Artinsk horizon. It is thus more specialized than the Cisco or any other Uralian assemblage, and less so than the Artinsk.

Boese[6] cites the occurrence of *Lyttonia* and *Richthofenia* from a higher level of the Wolfcamp beds. These genera have hitherto been considered as characteristic Permian fossils. Beede and Kniker[7] list from this same formation, about 200 feet above the *Uddenites* zone, the diagnostic foraminiferal species: *Schwagerina kansasensis, S. uddeni,* and *Fusulina longissimoidea,* which also mark the Neva limestone, lowest Permian of Kansas. Beede,[8] however, goes still further, and would put the *Schwagerina* zone of the upper Uralian in the Lower Permian.

At any rate, there seems to be little doubt that the zone of *Uddenites* of the Wolfcamp formation is the equivalent of the Neva limestone, which paleobotanists and vertebrate paleontologists agree in setting as the lower limit of the Permian of Kansas. The line is a purely artificial one, and must be drawn at the base of the *Uddenites*[9] faunal zone.

[6] Op. cit., p. 23.
[7] Beede, J. W., and Kniker, H. T., Species of the genus *Schwagerina* and their stratigraphic significance. Univ. Texas Bull. 2433, 27-30, 1924.
[8] Ibid., p. 60.
[9] Of course it was neither possible nor desirable to refigure and redescribe all of Boese's species from the Wolfcamp beds. Only those are described that are new, or show new facts concerning phylogeny or stratigraphy.

The fauna is clearly transitional from the Uralian stage of development to that of the Artinsk.

The great Paleozoic glaciation in India, Australia, South Africa, and Brazil is generally considered as being of Lower Permian age, though some writers place it in the Upper Coal Measures. No such great event could have happened anywhere near the Texas sea at the end of the Coal Measures or beginning of Permian, when Cephalopoda, Brachiopoda, and Fusulinidae could live through the transition unchanged, and when near-ammonites could live through with no generic and little specific modification. If any effect of glaciation is to be found in the southwestern states, it must be sought in the unconformity between the zone of *Uddenites* and the Hess formation, or above the Word formation, in the arid continental epoch. If found, it will probably be in the latter horizon, since the cephalopods show a virtually continuous genetic series from the Pennsylvanian through the Word (the American equivalent of the Sosio Permian of Sicily). Also the land floras show no decided break between Pennsylvanian and Permian, up to the arid epoch.

DESCRIPTION OF SPECIES.

Daraelites texanus Boese.

Fig. B, 17-26.

1917. *Daraelites texanus* Boese, Univ. Texas Bull. 1762, p. 52, pl. I, figs. 1-8.

Daraelites texanus is the first species of the genus to be described from North America, the fourth species of the genus to become known, and the oldest known representative of the group.

It is most nearly related to *D. elegans* Tchernow,[10] differing chiefly in the slightly more robust whorls and simpler septa. *D. texanus* has only the first lateral lobe slightly serrated, all the others are entire, contrary to Boese's statement, that the external lobe is slightly serrated on the side, and that the second lateral is also serrated. The writer has all of Boese's specimens before him, and several other good specimens, and the lobes are all as stated above.

At a diameter of about 4 mm. (Fig. B, 23-25), the shell is in a stage corresponding to *Prolecanites*. At diameter of

[10] L'Etage d'Artinsk, p. 374, pl. I, figs. 9a-o, Moscow, 1907.

American Upper Pennsylvanian and Lowest Permian Ammonoids.

	Permian	Upper Coal Measures				
	Wolfcamp	Undifferentiated	Cisco	Wewoka	Emporia	?Abo
Gastrioceras angulatum Girty				x		
" beedei Wiedey					x	
" excelsum Meek		x		x		
" globulosum M. & W.		x	x			
" hyattianum Girty				x		
" illinoisense M. & G. ..		x				
" kansasense M. & G. ..		x				
" modestum Boese	x					
" montgomeryense M. & G.		x				
" subcavum M. & G. ...	x	x	x	x		
" subtilicostatum Boese..						x
" venatum Girty				x		
" welleri Smith		x	x		x	?x
Paralegoceras incertum Boese	x					
Schistoceras diversecostatum Boese	x					
" fultonense M. & G. ...	x	x				
" hildrethi Morton	x	x	x			
" hyatti Smith	x		x			
" missouriense M. & G...		x				
Agathiceras ciscoense Smith			x			
" frechi Boese	x					
Shumardites irregularis Boese	x					
" simondsi Smith			x			
" uddeni Boese	x					
Marathonites ganti Smith			x		x	x
" j. p. smithi Boese	x					
" sulcatus Boese	x					
" vidriensis Boese	x					
Gonioloboceras discoidale Boese						x
" goniolobum Meek ..		x				
" welleri Smith		x	x	x		x
Neodimorphoceras lenticulare Girty					x·	
" oklahomae Girty					x	
" texanum Smith..			x	?x		
Prothalassoceras keytei Smith	x					
Daraelites texanus Boese	x					
" sp. indet. Girty				x		
Parapronorites boesei Smith	x					
Uddenites schucherti Boese	x					

11 mm., the form and septa correspond to what Sandberger called "*Goniatites mixolobus,*" and what Karpinsky[11] called

[11] Die Ammoneen der Artinsk-Stufe, etc. Mém. Acad. Imp. Sci. St.-Pétersbourg, 7th ser., 37, No. 2, p. 8, 1889 (= *Paraprolecanites sandbergeri* Schmidt, Die carbonischen Goniatiten Deutschlands. Jahrb. preuss. geol. Landesanst., 45, 544, 1924).

the *"Paraprolecanites* stage." Tchernow (loc. cit.) calls this the *"Prodaraelites"* stage, although no section or subgenus corresponding to this is known. Immediately after this the shell emerges into the early mature characters. and the first lateral lobe begins to be serrated. It goes no further, never reaching the specialization of the Artinsk species *D. elegans,* or of the Timor species *D. submeeki,* or of the Sosio species *D. meeki.*

This development shows *Daraelites* to be a member of the Pronoritidae, but to be descended from a side-branch, and not from the orthodox line of *Pronorites cyclolobus* Phillips. The wide distribution of this genus in the Lower Permian is important, because the development of certain Triassic genera demands the presence here of Pronoritidae with serrated instead of bifid lateral lobes. *Daraelites* fills this requirement in part at least, although it may not be the ancestor of these forms.

Horizon and locality.—Lowest Permian, Wolfcamp formation, at Wolfcamp, and 5 miles northeast of Wolfcamp, Glass Mountains, Brewster Co., Texas. Collection of I. A. Keyte.

Boese (loc. cit.) separates this horizon under the name of Wolfcamp, but Keyte[12] says that the zone of *Uddenites* is in the "Upper Gaptank" and not in the Wolfcamp horizon. It has been thought by most geologists that the Gaptank belongs to the Pennsylvanian and that the Wolfcamp is the basal Permian. The ammonoid fauna discussed in this paper shows that the so-called "upper Gaptank" is transitional to Permian, and is of Wolfcamp age.

Parapronorites boesei Smith, n. sp.

Fig. C, 22-27.

Form discoidal, moderately involute, with subrectangular cross-section, steep umbilical walls, flattened sides, flat venter, and slightly rounded ventral shoulders. Surface smooth, without constrictions or other ornamentation. The septa are in transition between the goniatite and ammonite stages, with all saddles entire, the ventral lobe trident, and the first lateral divided, with each prong having a small secondary indentation. The five other lobes (second lateral and four auxiliaries), all small and entire, decrease rapidly in size toward the umbilical suture. Inner septa unknown, as well

[12] Keyte, Blanchard, and Baldwin, op. cit., p. 175.

as length of the body-chamber, all specimens being entirely septate.

The height of the last whorl is less than one-half the diameter of the shell; the width is seven-eighths of the height; it embraces nine-tenths of the inner, and is indented by it to nearly one-third of the height. The width of the umbilicus is one-fourth of the diameter of the shell.

The shell in youth is very evolute, and the septa are more primitive, showing a regular development from *Prolecanites* (Fig. C, 27) to *Paraprolecanites* (Fig. C, 26), to *Pronorites* (Fig. C, 25); and at diameter 9 mm. the secondary indentations begin to show on the first lateral lobe, giving the transition to the adult *Parapronorites*.

Parapronorites boesei is very closely related to *P. skvorzovi* Tchernow[13] of the Artinsk horizon, Lower Permian of the Ural region of Russia. The American species differs from its European kinsman in being more evolute, with wider umbilicus, and lower whorls; also in having the ventral lobe shorter and more distinctly trident, shorter external saddle, much higher first lateral saddle; and in having five smaller lateral lobes instead of four; also in having the second lateral lobe entire instead of slightly divided as on *P. skvorzovi*. The American species is more primitive and slightly older than the Russian.

P. boesei is much simpler than *P. timorensis* Haniel[14] of the Permian Bitauni beds of Timor, which occurs in a geologic horizon slightly younger than the Artinsk, and has all the lateral lobes somewhat divided. It is also much less complex than Gemmellaro's species[15] from the Sosio Permian of Sicily. The species here described is the first of this genus to be found in North America, and is the oldest known representative of *Parapronorites*.

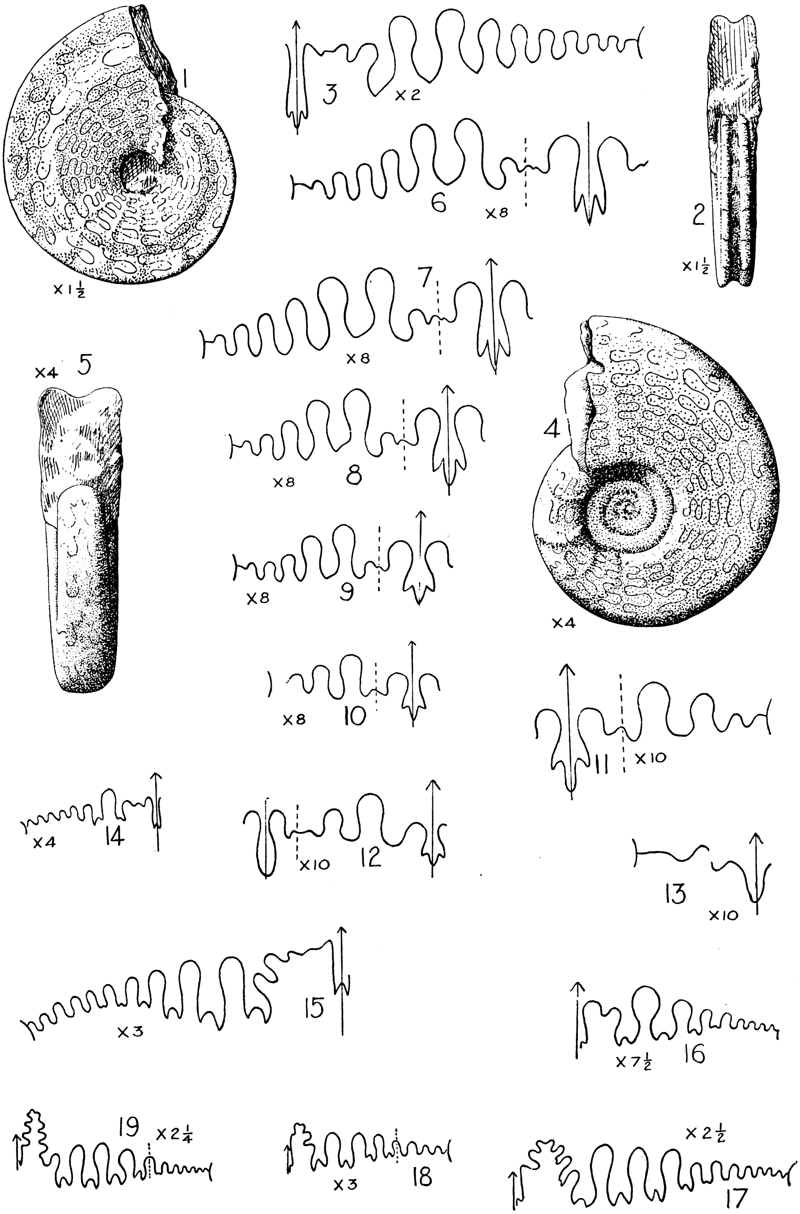
This is a very complete recapitulation of phylogeny in stages of growth, but not remarkable, since the geologic horizon is at the very base of the Permian, and the genera recapitulated are in the Mississippian and Coal Measures.

Horizon and locality.—Wolfcamp formation, lowest Permian, zone of *Uddenites*, 5 miles northeast of Wolfcamp,

[13] Op. cit., p. 250, pl. I, figs. 3a-f.

[14] Die Cephalopoden der Dyas von Timor. Pal. von Timor, III. Lief., p. 29, 1915.

[15] La fauna dei calcari con Fusulina della valle del Fiume Sosio nella Provincia di Palermo, p. 59, Palermo, 1887.


1
×1½
2
×1½
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9
×8
10
×8
11
×10
12
×10
13
×10
14
×4
15
×3
16
×7½
17
×2½
18
×3
19
×2¼

Fig. A.

Glass Mountains, Brewster Co., Texas. Associated with *Uddenites schucherti* B., *Prothalassoceras keyti* S., *Daraelites texanus* B., *Marathonites, Shumardites, Schistoceras, Gastrioceras*, etc. Collection of I. A. Keyte.

Named in memory of Dr. Emil Boese. The writer wishes to record here his profound admiration for the work of Dr. Boese, who upon the publication of his monograph on the Permian ammonoids of the Glass Mountains stepped at once

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Fig. A.

Uddenites schucherti Boese,

1-3, Adult stage, shell x 1.5, septa x 2.

4-10, Adolescent stage, diameter 10 mm., shell x 4, septa transitional from *Pronorites* (No. 10, x 5) at diameter 5.5 mm.; towards *Uddenites*, diameter 6.5 mm. (No. 9); initial development of the adventitious lobe, through modification of the outer branch of the bifid first lateral lobe, diameter 7.5 mm. (No. 8); advanced adolescent stage, diameter 8.5 mm., showing progress of *Uddenites* characters (No. 7); approaching mature characters, diameter 10 mm. (No. 6). This specimen was Boese's type of *Uddenites minor*, Univ. Texas Bull. 1762, pl. I, figs. 26, 32, 34.

11, Adolescent stage, diameter 5.5 mm., corresponding to *Pronorites*, septa x 10.

12, Larval stage, diameter 3 mm., corresponding to *Paraprolecanites*, septa x 10.

13, Larval stage, diameter 2.5 mm., corresponding to *Prolecanites*, septa x 10.

Propinacoceras simile Haniel.

14, Septum x 4, showing *Uddenites* stage of growth. From Permian of Bitauni, Timor, copied from C. A. Haniel, Ceph. Dyas Timor, text fig. 5d.

15, Septum x 3, showing beginning of *Propinacoceras* characters. From Permian of Bitauni, Timor. After Haniel, op. cit., text fig. 5b.

Artinskia artiensis Gruenewaldt.

16, Septum x 7.5, showing *Propinacoceras* stage of growth. From Artinsk Permian, Ural region, Russia, copied from Karpinsky, Ammoneen Artinsk-Stufe, pl. I, fig. 1 k, x ½.

17, Septum x 2.5, showing beginning of *Artinskia* characters. From Artinsk Permian, Ural region, Russia, after Karpinsky, loc. cit., fig. 1 l, x ½.

Medlicottia orbignyana Verneuil.

18, Septum x 3, showing *Propinacoceras* stage. From Artinsk Permian, Ural region, Russia, copied from Karpinsky, op. cit., pl. II, fig. 1 j, x ½.

19, Septum x 2.25, showing beginning of *Medlicottia* stage. From Artinsk Permian, Ural region, Russia, copied from Karpinsky, loc. cit., fig. 1 k, x ½.

All originals shown in Fig. A are from the lowest Permian, zone of *Uddenites*, or Wolfcamp beds, Glass Mountains, West Texas. Nos. 1-3, 11, 13 are from 5 miles northeast of Wolfcamp; Nos. 4-10, 12 are from Wolfcamp. All are in the collection of Prof. I. A. Keyte, of Colorado Springs, except the original of Nos. 4-10, which was the type of *Uddenites minor*, and is in the collection of the University of Texas.

into the inner circle of which Gemmellaro, Karpinsky, and Waagen were the leaders. His classification of the Permian is by far the most exact that we have, and applies to other regions quite as well as to America.

Uddenites schucherti Boese.

Fig. A, 1-13.

1917. *Uddenites schucherti* Boese, Univ. Texas Bull. 1762, p. 60, pl. I, figs. 9-23.

1917. *Uddenites minor* Boese, op. cit., p. 63, pl. I, figs. 24-40.

Additional specimens confirmed the suspicion, already existing, that *Uddenites minor* Boese is merely the young of *U. schucherti* Boese. They also showed that *Uddenites* is the most primitive Medlicottoid genus known, and is the probable immediate ancestor of that group. Boese (p. 55), in describing the genus, did not regard it as being in the direct line of descent of *Medlicottia,* but as an abortive side-branch. However, the better specimens figured in this paper show that *Uddenites* is like the young stages of *Propinacoceras, Artinskia,* and *Medlicottia,* the three main successive upward steps in the Permian development of this group or super-genus. The most primitive, *Propinacoceras,* is most like *Uddenites,* and probably the immediate descendant of it. The more specialized *Artinskia* and *Medlicottia s. str.* are successively less like *Uddenites,* but still preserve in their young stages, very strong reminiscences of it. And all three genera recapitulate to a remarkable degree the same early stages that *Uddenites* itself recapitulates, namely, *Prolecanites, Paraprolecanites,* and *Pronorites.*

The development of *Uddenites* shows that in the early larval stage, at diameter 2.5 mm. (Fig. A, 13), the septa correspond to *Prolecanites* of the early Mississippian. A little later, at diameter 3 mm. (Fig. A, 12), the septa correspond to *Paraprolecanites* Karpinsky (= *Pronorites mixolobus* Sandberger, and not *P. mixolobus* Phillips).

At diameter 5.5 mm. (Fig. A, 10, 11), the septa correspond to *Pronorites* Mojs., and so does the form at this stage.

At diameter 6.5 mm. (Fig. A, 9), the upper (outer) branch of the principal first lateral bifid "*Pronorites*" lobe takes on a slight indentation, and begins to subdivide secondarily. This is the beginning of the formation of the adventitious lobe which charaeterizes all the Medlicottoid genera. While this is going on, the primary external rounded saddle begins to broaden and flatten, as the adventitious lobe moves forward. This is shown in Fig. A, 8, at diameter 7.5 mm. This becomes more definite at diameter 8.5 mm. (Fig. A, 7), where the *Uddenites* characters are easily recognizable.

At diameter 10 mm. (Fig. A, 6), the end of this specimen, the generic characters of the septum are well established, though the specific characters in form and septation are not yet reached.

At maturity (Fig. A, 1-3), the resemblance to *Propinacoceras* Gemmellaro, of the Permian of Sicily, Artinsk, and Timor, becomes pronounced, but none of the lobes is secondarily bifid, as is the case with all typical Medlicottoid genera. This extreme simplicity of the lobes of *Uddenites* is its most diagnostic character, and in keeping with its greater age.

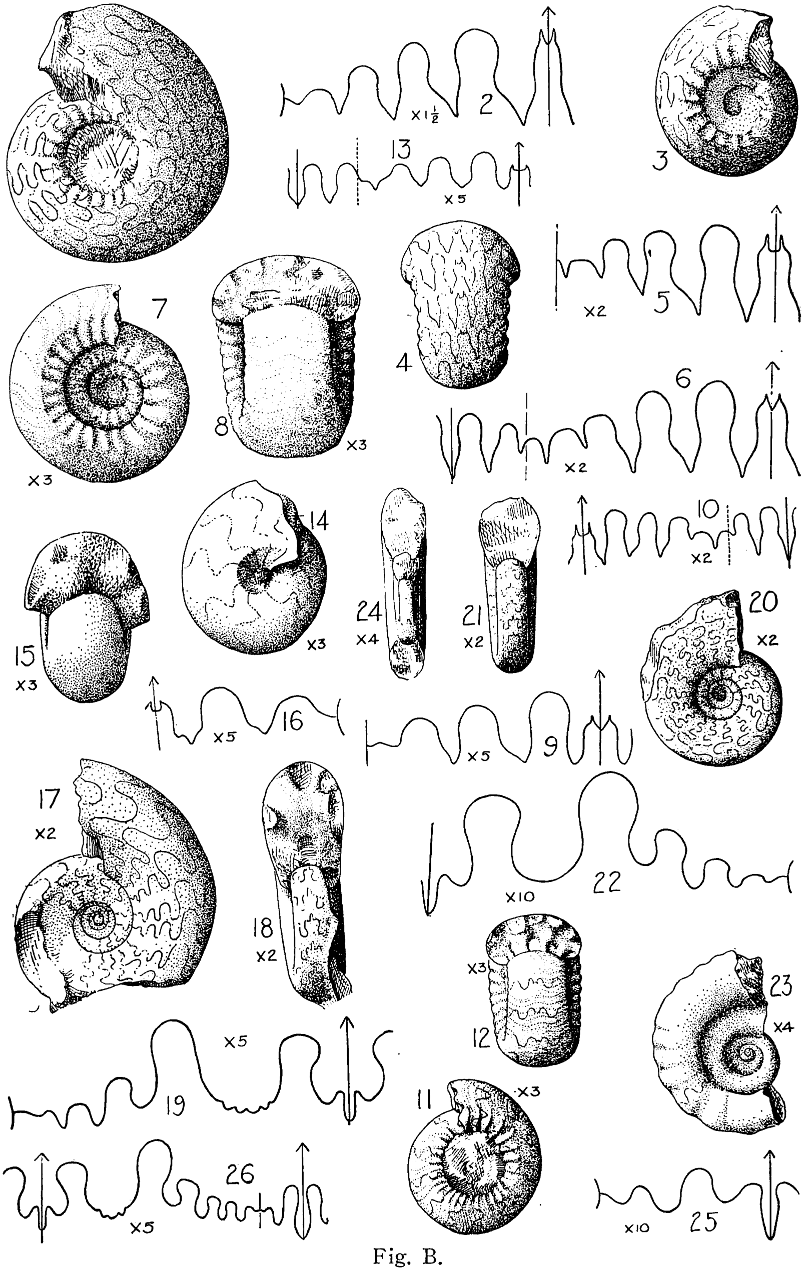
The septa of *Propinacoceras, Artinskia,* and *Medlicottia* are shown in Fig. A for comparison with those of *Uddenites*.

It was formerly thought that *Parapronorites* and *Sicanites* were in the direct ancestral line of *Medlicottia*. However, the writer has shown, in this paper and elsewhere, that *Parapronorites* is a side-branch, developing toward *Albanites* and the Noritidae. It is also extremely unlikely that *Sicanites,* with its uniformly bifid lobes, and total lack of the adventitious lobe, could be in the direct line of descent between *Pronorites* and *Propinacoceras*.

There has been in the past some controversy between Noetling and Diener[16] as to the origin and proper nomenclature of the adventitious or first lateral lobes of the Medlicottoid genera. The development of *Uddenites* shows that Noetling was more nearly right in his interpretation, but that Karpinsky, Noetling, and Diener were all wrong in supposing that the first lateral (Diener) or principal adventitious lobe (Noetling and Karpinsky) came from a primary indentation of the external saddle. It certainly came from the modification of the outer (upper) primary branch of the original bifid first lateral lobe of *Pronorites,* as shown in Fig. A, 6-10.

The hitherto rare and little known *Uddenites* becomes of great importance as an index fossil for a geologic horizon not discriminated previously. It becomes of even greater import-

[16] Noetling, F., Ueber *Medlicottia,* etc. N. Jahrb. f. Min., etc., Beil.-Bd. 19, 334-376, 1904.
Diener, C., Ueber Ammoniten mit Adventivloben. Denkschr. Kais. Acad. Wiss., Wien, 93, 165, 1915.


2
x1½
13
x5
3
5
x2
4
7
8
x3
x3
6
x2
14
x3
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x2
24
x4
21
x2
20
x2
15
x3
16
x5
9
x5
17
x2
18
x2
22
x10
12
x3
23
x4
19
x5
11
x3
26
x5
25
x10

Fig. B.

ance biologically, as furnishing a link between *Pronorites* of the Coal Measures (Pennsylvanian) and the Permian Medlicottoids. It also seems to show that this group was endemic in the Texan late Paleozoic sea, for *Pronorites* was already present in typical form in the same waters, in *Pronorites arkansasensis* and *P. siebenthali* in the Lower and Middle Coal Measures[17] respectively. It appears to have radiated out from this center, and when we next see it, in the Artinsk fauna, its characters have changed by increasing complication of the external saddle and adventitious lobe to the generic stage of *Propinacoceras*. From there on the distribution of the Medlicottoids becomes nearly world wide.

Horizon and locality.—Rather rare in the lowest Permian zone of *Uddenites*, Wolfcamp formation, at Wolfcamp, and 5 miles northeast of Wolfcamp, Glass Mountains, Brewster Co., Texas. The additional material was collected at the latter locality by Prof. I. A. Keyte, of Colorado Springs, to whose generosity the writer is indebted for the use of the specimens.

[17] Smith, J. P., The Carboniferous ammonoids of America. U. S. Geol. Survey, Mon. 42, 43, 47, 1903.

Fig. B.

Schistoceras diversecostatum Boese.
- 1, 2, Adult shell nat. size, septa x 1.5.
- 3-5, Adolescent stage, transitional from *Paralegoceras* to *Schistoceras;* shell nat. size, septa x 2.
- 6, Adolescent stage, diameter 25 mm., transitional from *Paralegroceras* to *Schistoceras;* septa x 2.
- 7-9, Late larval stage, diameter 9 mm., transitional from *Gastrioceras* to *Paralegroceras;* shell x 3, septa x 5.
- 10, Outer coil of specimen, Nos. 7-9, diameter 13 mm., showing primitive Schistoceran septa, x 2.
- 11-13, Larval stage, diameter 6.5 mm., corresponding to *Gastrioceras;* shell x 3, septa x 5.

Prothalassoceras keytei Smith, n. sp.
- 14-16, Type, shell x 3, septa x 5.

Daraelites texanus Boese.
- 17-19, Adult stage, shell x 2, septa x 5.
- 20-22, Adolescent stage, diameter 11 mm., corresponding to "*Prodaraelites*" or *Paraprolecanites;* shell x 2, septa x 10.
- 23-25, Larval stage, diameter 6 mm., corresponding to *Prolecanites,* shell x 4, septa x 10.
- 26, Early adult stage, diameter about 13 mm., septa x 5.

The originals of all specimens figured on this plate are from the lowest Permian, zone of *Uddenites,* or Wolfcamp beds, Glass Mountains, West Texas; the originals are in the collection of Prof. I. A. Keyte, Colorado Springs, Colorado. All are from the same locality, 5 miles northeast of Wolfcamp.

Thalassoceras (*Prothalassoceras*) *keytei* Smith, n. sp.

Fig. B, 14-16.

Shell small, involute, subglobose, deeply embracing, with very narrow umbilicus, steep umbilical walls, rounded flanks, and gently rounded venter, without pronounced umbilical shoulders. Septa with rounded entire saddles and weakly serrated lobes. There are three external saddles, a broad ventral with siphonal notch, a broader and higher first lateral, and a broad shorter second lateral; two external lobes, a broad long ventral (divided by the siphonal saddle), a broader and shorter first lateral. There is also a funnel-shaped lobe on the umbilical suture. The internal septa consist of a tongue-shaped anti-siphonal lobe, flanked by a shorter lateral on either side. The two internal saddles appear to be rather narrower than the lobes. It could not be made out whether there are serrations on the inner lobes.

This species has some resemblance to *Thalassoceras welleri* Boese,[18] from the Lower Permian of the Hess formation in western Texas, differing in its much smaller size, greater globosity, and simpler septation. However, *T. keytei* is immature, and might well be the young of *T. welleri*, of which the young stages are unknown, and the geologic horizon much higher in the column.

The section, or subgenus, *Prothalassoceras* is characteristic of the Lower Permian of the Artinsk, Texas, and Timor, and its occurrence in the fauna under discussion is additional proof of the Lower Permian age.

Horizon and locality.—Lowest Permian, zone of *Uddenites,* Wolfcamp formation, 5 miles northeast of Wolfcamp, Glass Mountains, Brewster Co., Texas. Collection of Prof. I. A. Keyte, Colorado Springs, in whose honor the specific name is given.

Schistoceras diversecostatum Boese.

Fig. B, 1-13.

1917. *Schistoceras diversecostatum* Boese, Univ. Texas Bull. 1762, p. 96, pl. IV, figs. 1-36.

This species was chosen for illustration because it shows the highest development of any goniatite in the lowest Permian. It is an index fossil for this horizon, which, along

[18] Univ. Texas Bull. 1762, p. 104, pl. V, figs. 14-18.

with the uppermost Pennsylvanian, has been called the "zone of *Schistoceras*." It shows the slower development of the direct Gastrioceran line as contrasted with the Arcestoidea, typified by *Marathonites,* also described in this paper. Although relatively large, it has not far to go in development, being still a goniatite at maturity, hence it goes slowly.

At a diameter of 6.5 mm. (Fig. B, 11-13), it is in the larval stage, and a perfect replica of the ancestral *Gastrioceras*. At a diameter of 9 mm. (Fig. B, 7-9), it is already adolescent, and shows a transition from *Gastrioceras* to *Paralegoceras*. At a diameter of 25 mm. (Fig. B, 3-5), it is beginning to show adult characters, though not nearly grown in size, and is transitional from *Paralegoceras* to *Schistoceras*. The mature stage is shown in Fig. B, 1 and 2.

As compared with its highly specialized kinsman, *Marathonites, Schistoceras* is a sort of "country cousin," simple, slow, backward—but coming. The stock to which it belongs played its part in the Triassic, when the Cyclolobidae had already gone the way of all super-specialized stocks.

Horizon and locality.—Rather common in the lowest Permian, zone of *Uddenites,* or Wolfcamp beds, at Wolfcamp, and 5 miles northeast of Wolfcamp, Glass Mountains, Brewster Co., Texas. The figured specimens are in the collection of Prof. I. A. Keyte, of Colorado Springs, Colorado.

Marathonites j. p. smithi Boese.

Figs. C, 1-21.

1917. *Marathonites j. p. smithi* Boese, Univ. Texas Bull. 1762, p. 135, pl. VI, figs. 77-89.

This species, which was Boese's type of *Marathonites,* is a very primitive member of the Arcestoid Cyclolobidae, and is so abundant and well preserved that its young stages could be studied satisfactorily and its phylogeny determined.

At diameter 1.5 mm. (Fig. C, 18-21), the larval shell is just leaving the stage corresponding to *Gastrioceras,* Fig. C, 21, at diameter 1 mm. showing the Gastrioceran septa; and Fig. C, 20, at diameter 1.5 mm. showing the development of three lobes by division of the principal lateral, giving a transition to some form like *Adrianites*. This is like the development of *Shumardites,* as shown by J. P. Smith[19] on a species

[19] Op. cit., p. 135, pl. III, figs. 3-13.

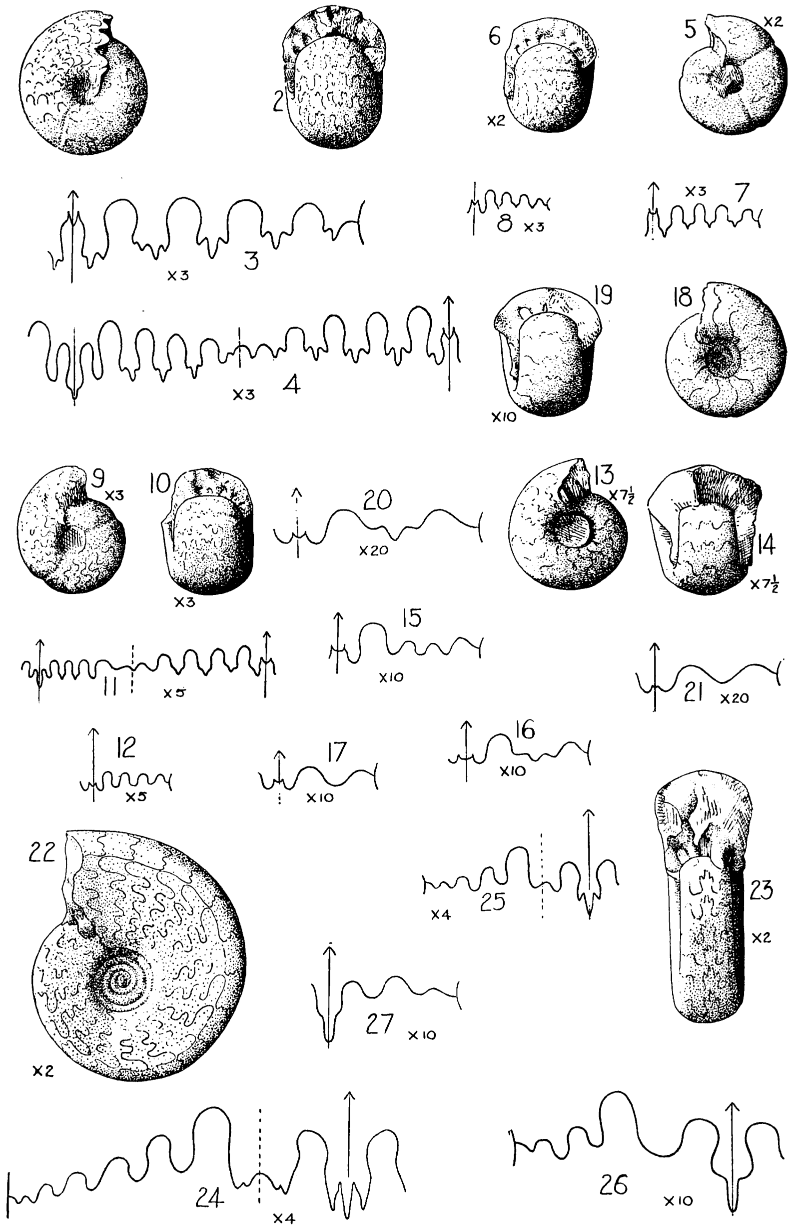
2
6
x2
5
x2
x3
7
8 x3
3
x3
x3
4
19
x10
18
9
x3
10
x3
20
x20
13
x7½
14
x7½
11
x5
15
x10
21
x20
12
x5
17
x10
16
x10
22
x2
25
x4
23
x2
27
x10
24
x4
26
x10

Fig. C.

from the Cisco, Upper Pennsylvanian, of Texas, only at a very much smaller size.

At diameter 2 mm. (Fig. C, 13-17), the shell shows the same development as the preceding specimen, but gets a little further along, ending with a rather decided *Adrianites*-like stage.

The next specimen, diameter 6 mm. (Fig. C, 9-12), takes up the development about where the preceding one left off. At diameter 3.5 mm. (Fig. C, 12), it corresponds to *Adrianites;* at diameter 6 mm. (Fig. C, 11), it has already reached the characters of *Shumardites.*

The next specimen, diameter 7 mm. (Fig. C, 5-8), is decidedly adolescent, and at full size (Fig. C, 7) shows the septation of a very primitive *Marathonites;* while at diameter 4 mm. (Fig. C, 8) it corresponds to *Shumardites.*

The normal mature characters are shown in Fig. C, 1-4, still primitive, with the saddles entire and rounded, and the lobes few in number and slightly serrated. It shows the peculiar trident antisiphonal lobe characteristic of all the

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Fig. C.

Marathonites j. p. smithi Boese.

1-3, Adult, shell nat. size, septa x 3.

4, Adult, diameter about 17 mm., septa x 3.

5-8, Adolescent stage, diameter 7 mm., shell x 2; septa at 7 mm., (No. 7), corresponding to primitive *Marathonites,* x 3; septa at 4 mm. (No. 8), corresponding to *Shumardites,* x 3.

9-12, Larval stage, diameter 6 mm., transitional from *Adrianites* to *Shumardites* (shell x 3; septa at 6 mm., corresponding to *Shumardites* (No. 11), x 5; septa at 3.5 mm., corresponding to *Adrianites* (No. 12), x 5.

13-17, Larval stage, diameter 2 mm., transitional from *Gastrioceras* to *Adrianites;* shell x 7.5; septa at 2 mm. (No. 15), corresponding to Adrianites, x 10; septa at 1.5 mm. (No. 16), transitional from *Gastrioceras,* but showing subdivision of first lateral lobe, x 10; septa at 1 mm. (No. 17), x 10, corresponding to *Gastrioceras.*

18-21, Larval stage, diameter 1.5 mm., transitional from *Gastrioceras* to *Adrianites,* shell (Nos. 18, 19) x 10; septa at 1.5 mm. (No. 20) x 20; septa at 1 mm. (No. 21) x 20.

Parapronorites boesei Smith, n. sp.

22-25, Type, shell x 2; septa at maturity (No 24) x 4; septa at 9 mm., corresponding to *Pronorites* (No. 25) x 4.

26, Septa at diameter 6 mm., corresponding to *Paraprolecanites* or the "*Pronorites mixolobus* group," x 10.

27, Septa at diameter 3 mm., corresponding to *Prolecanites,* x 10.

All specimens figured on this plate are in the lowest Permian, zone of *Uddenites,* or Wolfcamp beds, Glass Mountains, West Texas, 5 miles northeast of Wolfcamp. They are in the collection of Prof. I. A. Keyte, Colorado Springs, Colorado.

Cyclolobidae, which character makes its appearance with the beginning of the *Shumardites* stage, at a diameter of about 4 mm.

The development of *Marathonites,* a very primitive member of the Arcestidae, shows that this superfamily came from the *Gastrioceras* stock, which most paleontologists have believed.

This, and the other species of *Marathonites* in this transitional fauna, may well have developed in this region out of the antecedent *Marathonites ganti* Smith[20] from the Upper Coal Measures of Kansas and Texas. The Cyclolobidae are certainly autocthonous in the western American Carboniferous sea.

Horizon and locality.—Rather common in the lowest Permian Wolfcamp formation, zone of *Uddenites,* at Wolfcamp, and 5 miles northeast of Wolfcamp, Glass Mountains, Brewster Co., Texas. The writer has had for study the original types of Boese, and the very numerous and beautifully preserved specimens collected by Prof. I. A. Keyte, of Colorado Springs, in whose collection are the specimens figured in this paper.

Stanford University,
California.

[20] U. S. Geol. Survey, Mon. 42, p. 132, pl. XXI, figs. 14-16; and Prof. Paper 141, pl. XX, figs. 18-20.